Operation, Maintenance and Repair Parts

of the

No. 10 N

Cutter and Tool Grinding Machine

With Universal or Plain Equipment

For Machines Beginning Serial No. 1459

BROWN & SHARPE MFG. CO.

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

Printed in U. S. A. 525-10/1 1M-6-50

FOREWORD

The purpose of this book is to give a thorough practical working knowledge of the Brown & Sharpe No. 10N Cutter and Tool Grinding Machine with Universal or Plain Equipment.

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

This book is intended primarily to cover the Brown & Sharpe No. 10N Cutter and Tool Grinding Machine with universal or plain equipment in detail rather than cutter grinding in general.

It should be remembered always that a sharp cutter will produce a more highly finished surface than a dull one, and with greater accuracy, less power consumption, and less strain on the machine.

Experience has proved that in addition to impairing the efficiency of production, a dull cutter wears much more rapidly than a sharp one, and that more stock must be ground off to restore the cutting edge than would have been removed in keeping it sharp. A cutter that is kept in good condition by frequent regrinding will invariably outlast one that is not so cared for; and this saving, together with the better results obtained through the use of sharp cutters, more than compensates for the time spent in regrinding.

Manufacturers of grinding wheels are in a position to give excellent advice as to the correct wheel to use where the material, operating conditions and results required are known, and until the operator becomes proficient in selecting wheels, we believe that it is a good plan to rely upon the judgment of the wheel manufacturer.

CONTENTS

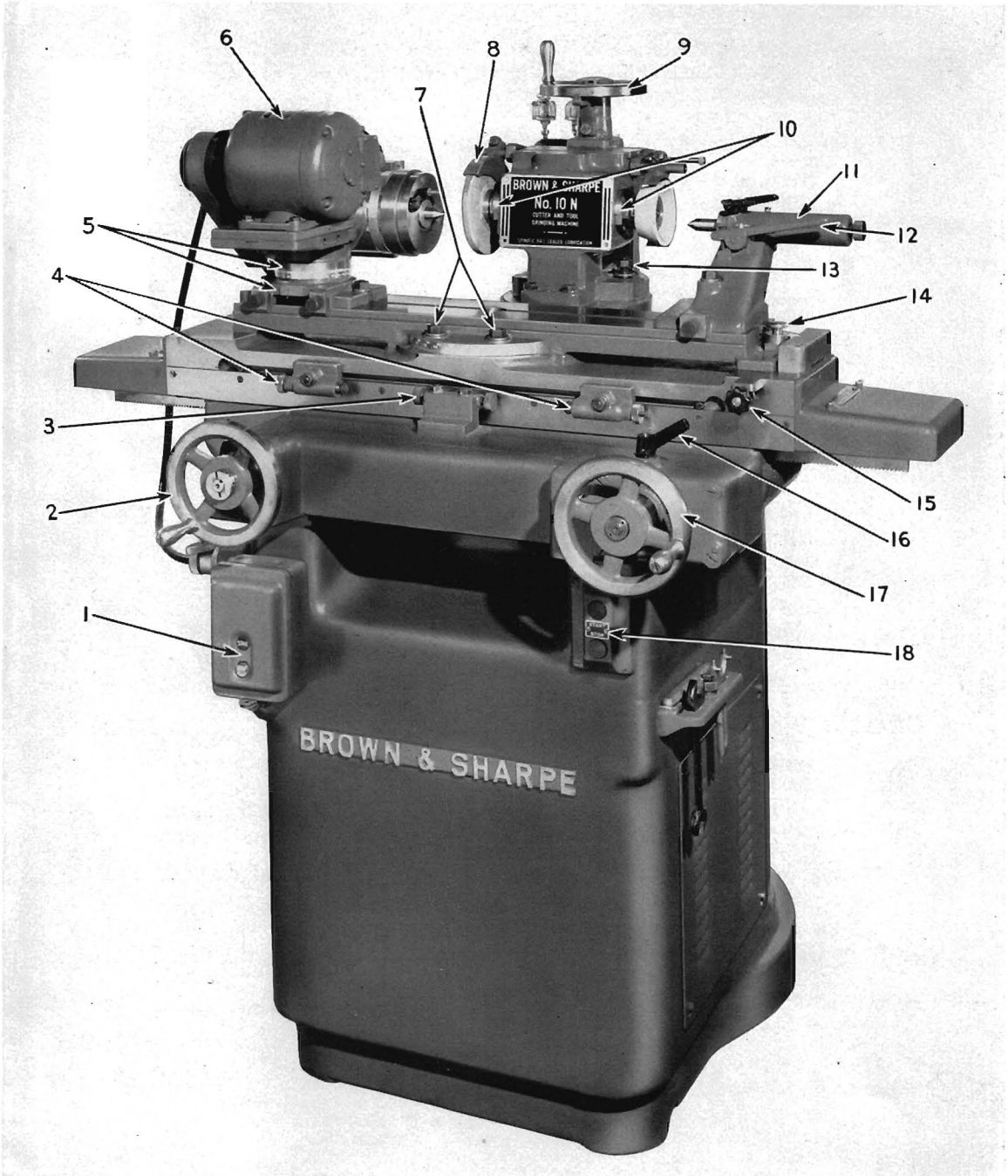
PART I — OPERATION AND MAINTENANCE

PART II — REPAIR PARTS

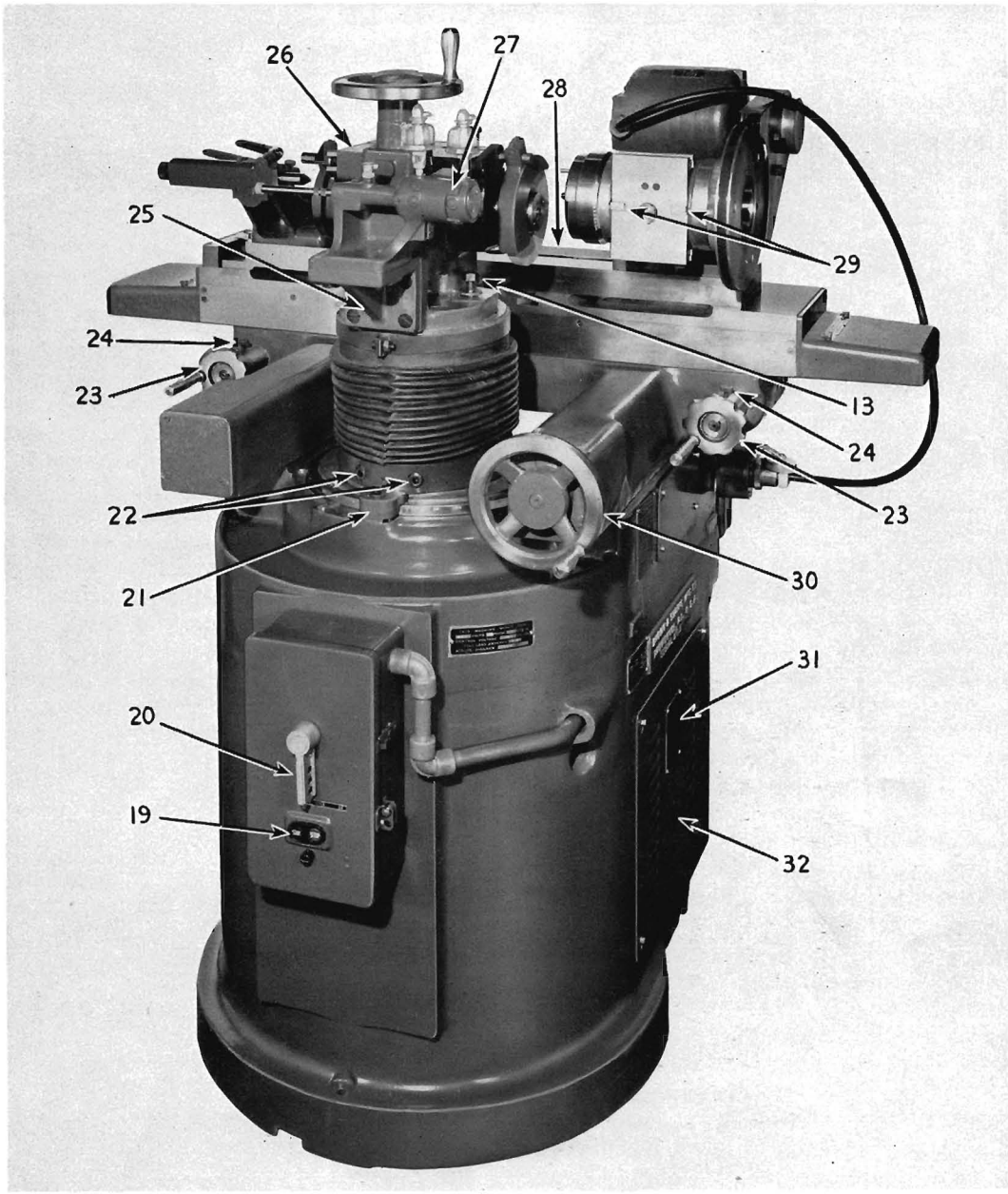
Operating Controls and Principal Parts of the No. 10N Cutter and Tool Grinding Machine

With Universal or Plain Equipment

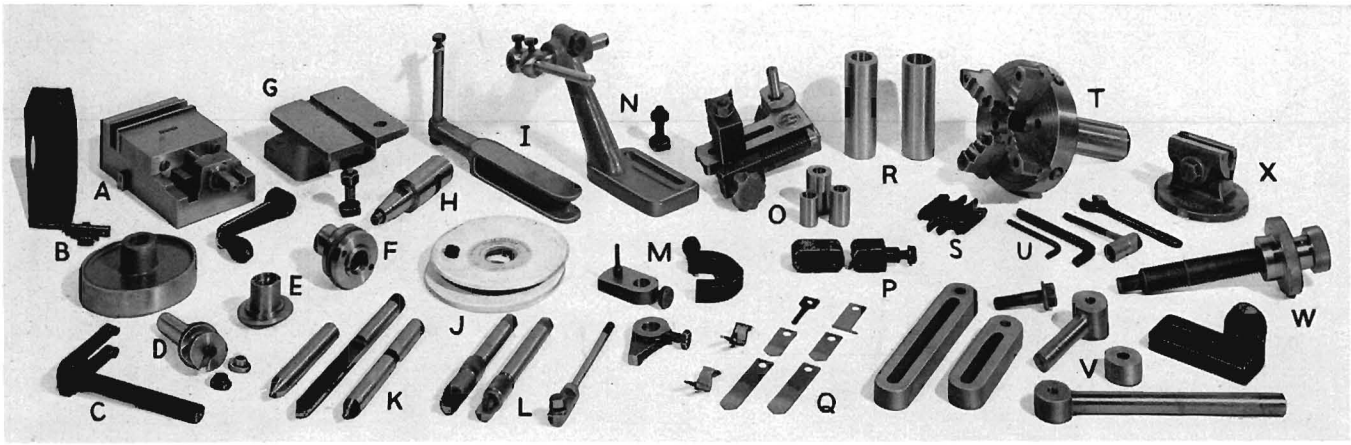
Machine with universal equipment shown. Machine with plain equipment the same except it does not have the revolving spindle headstock and internal grinding equipment.



1. Start-stop push button for headstock
2. Crossfeed handwheel, front
3. Table dog positive stop
4. Table dogs
5. Work head base and knee
6. Headstock motor
7. Swivel table clamp screws
8. Wheel guard
9. Handwheel for elevating wheel spindle
10. Notches for setting wheel spindle at height of work centers
11. Footstock



12. Footstock operating lever
13. Bolts for holding tooth rest holder bracket
14. Swivel table locking pin knob
15. Swivel table fine adjustment knob
16. Longitudinal feed throw-out lever
17. Longitudinal 2-speed handwheel
18. Start-stop push button for wheel spindle, for front operation
19. Start-stop push button for wheel spindle, for rear operation
20. Disconnect switch
21. Clamp for wheel swivel (3 equally spaced)
22. Clamping screws for vertical adjustment of wheel column
23. Longitudinal handwheels, rear
24. Screws for adjusting sliding table drag
25. Knee for internal grinding fixture
26. Wheel spindle head
27. Internal grinding fixture
28. Swivel table
29. Finished step for setting wheel spindle at height of work centers when using raising blocks
30. Cross feed handwheel, rear
31. Wheel spindle speed plate
32. Motor compartment for wheel spindle drive



STANDARD EQUIPMENT

*A Surface grinding vise

*B Driving pulley and belt guard for internal grinding fixture

C Bracket for wheel guard (3 furnished)

D Arbor with interchangeable bushings to take cutters with 7/8", 1" and 1 1/4" holes

E Wheel spindle guard

F Wheel sleeve (3 furnished)

G Tool rest

H Wheel spindle extension

I Center height gage

J Grinding wheels (6 furnished)
- 1-Straight 6" x 1/4" x 1 1/4"
- 1-Straight 6" x 1/2" x 1 1/4"
- *2-Straight 5/8" x 1/4" x 1/4" (Used on internal grinding fixture)
- 1-Flaring cup 4" x 1 1/2" x 1 1/4"
- 1-Dish 6" x 1/2" x 1 1/4"

K Centers (5 furnished)
- 1-Work head center
- 1-Center head center
- 1-Center head half-center
- 1-Footstock center
- 1-Footstock half-center

L 3 Tooth rest holders and 2 bodies

M Clearance setting gage (3 parts)

N Wheel truing fixture

*O Formed cutter sharpening attachment (In-Feed Type)

P Tooth rest holder swivel and clamp

Q 8 Tooth rests

R Collets for work head (3 furnished—For No. 7, No. 9 and No. 10 B&S tapers)

S Work driving dog

*T 4" 4-Jawed independent chuck

*U Set of wrenches

V Brackets and supports for tooth rests

W Draw-in bolt for work head

X Center head

Not shown above

Instruction booklet etc.

*These parts are Standard Equipment only with the machine having Universal Equipment.

CHAPTER I

Set-up Adjustments and Operating Controls

This chapter explains the purpose and use of each of the controls and adjustments used in setting up and operating the No. 10N Cutter and Tool Grinding Machine with Universal Equipment. Much of the following material also applies to the machine with Plain Equipment. Both machines are identical except the Revolving Spindle Headstock Equipment, Internal Grinding Fixture, Surface Grinding Vise and the Formed Cutter Sharpening Attachment (In-Feed Type) are omitted in the machine with Plain Equipment, but may be obtained at extra cost.

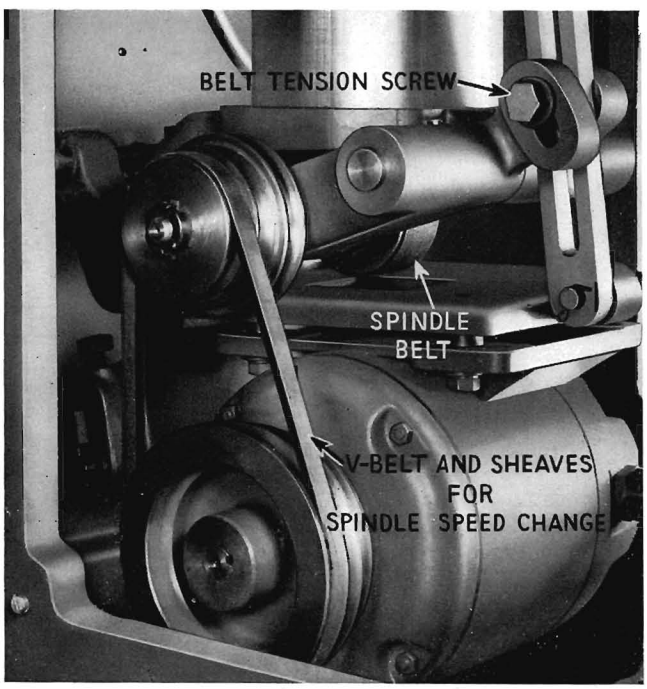
A general familiarity with the machine will be gained by a study of the introductory material on the pages immediately preceding.

Drive. The wheel spindle is driven by a flat belt, enclosed in the wheel column, through a pulley on an auxiliary shaft driven by a V-belt from a ¾ H.P. constant speed motor mounted on the base of the wheel column. These two belts are easily adjusted by simply loosening the belt tension screw (Fig. 1). The weight of the motor will automatically tighten the two belts and this adjustment is maintained by tightening the belt tension screw.

Starting the Machine. The start-stop push button units on the right-front and in the switch box on the rear of the base each controls the motor for the wheel spindle drive. Either push button may be used, depending on the operating position.

The headstock is started by a start-stop push button unit at the left-front of the machine.

Fig. 1. Wheel Spindle Drive Mechanism.



Wheel Spindle

This machine is furnished with an antifriction-bearing spindle mounted on super-precision permanently-sealed grease-lubricated anti-friction bearings.

Both ends of the spindle are tapered to receive wheel sleeves, and a wheel sleeve puller (furnished) facilitates their removal. The spindle end not in use should be protected with the wheel spindle guard provided. Two wheel guards are furnished and are designed to provide adequate protection for the machine operator. Never run a wheel unless it is properly guarded.

Three rates of spindle speed, 3000, 3750 and 4500 R.P.M., are obtained by changing the V-belt on the 3-stepped sheaves on the motor and auxiliary shaft (Fig. 1).

The wheel spindle head supporting the wheel spindle is fastened to the top of the wheel column which has a vertical movement of 7¾". The elevating handwheel is graduated to read to .001" with a swivel index finger which can be clamped by a knurled thumbscrew to any convenient operating position. Two socket head set-screws (Page 5 Rear View) are provided in the wheel swivel for positive clamping of the vertical setting. (One screw may be used when both are not accessible.) The wheel swivel can be swiveled horizontally to any angle, a scale showing the setting to 120° either side of zero. Three clamps provide for rigid clamping in the desired position.

A notch in the spindle bearing retainer at each side of the wheel spindle head (used with the center gage which will be explained later) provides a positive means of setting the wheel spindle at center height.

Swivel Table

The swivel table (Fig. 2) turns on a steel pivot, permitting angular settings to 90° in either direction and is clamped to the sliding table by two clamp bolts near the pivot. Settings are indicated in degrees from either side of two zero marks, by a graduated arc at the front, reading in each direction for zero to 90°. A plate on the right-hand has a scale (Fig. 2) for setting the table at an angle to grind tapers up to 3½" per foot. The scale gives the taper in inches per foot and reads the included angle by 1/16" graduations. To make a quick setting of the swivel table, release the clamp nuts, then

lift the locking pin (Fig. 2) next to the scale pointer at the right end of the table and turn it at right angles so that it will stay up. The table is now free and can be swiveled to 90° either side of zero. When setting to angles up to 3½" taper per foot the table is first swiveled to the approximate working position as described above. Then, after turning the pin and letting it down into one of the notches in the plate beneath, fine adjustment is obtained by turning the knob at the forward end of the plate.

The swivel table has a 9/16" wide T-slot for clamping the headstock and footstock and any attachments which may be used.

Sliding Table

The sliding table (Fig. 2) is traversed by three independent handwheels—a large handwheel mounted on the front-right, and smaller handwheels located at the rear-right and rear-left of the machine.

Length of table movement is controlled by adjustable dogs and positive stop with fine adjustment. Dogs (Fig. 2) have spring plungers for minimizing operating effort at table reversal. 16" maximum longitudinal table travel is obtained with plungers screwed up tight, dogs become positive stops. When both spring plungers are fully extended, table travel is reduced to 15".

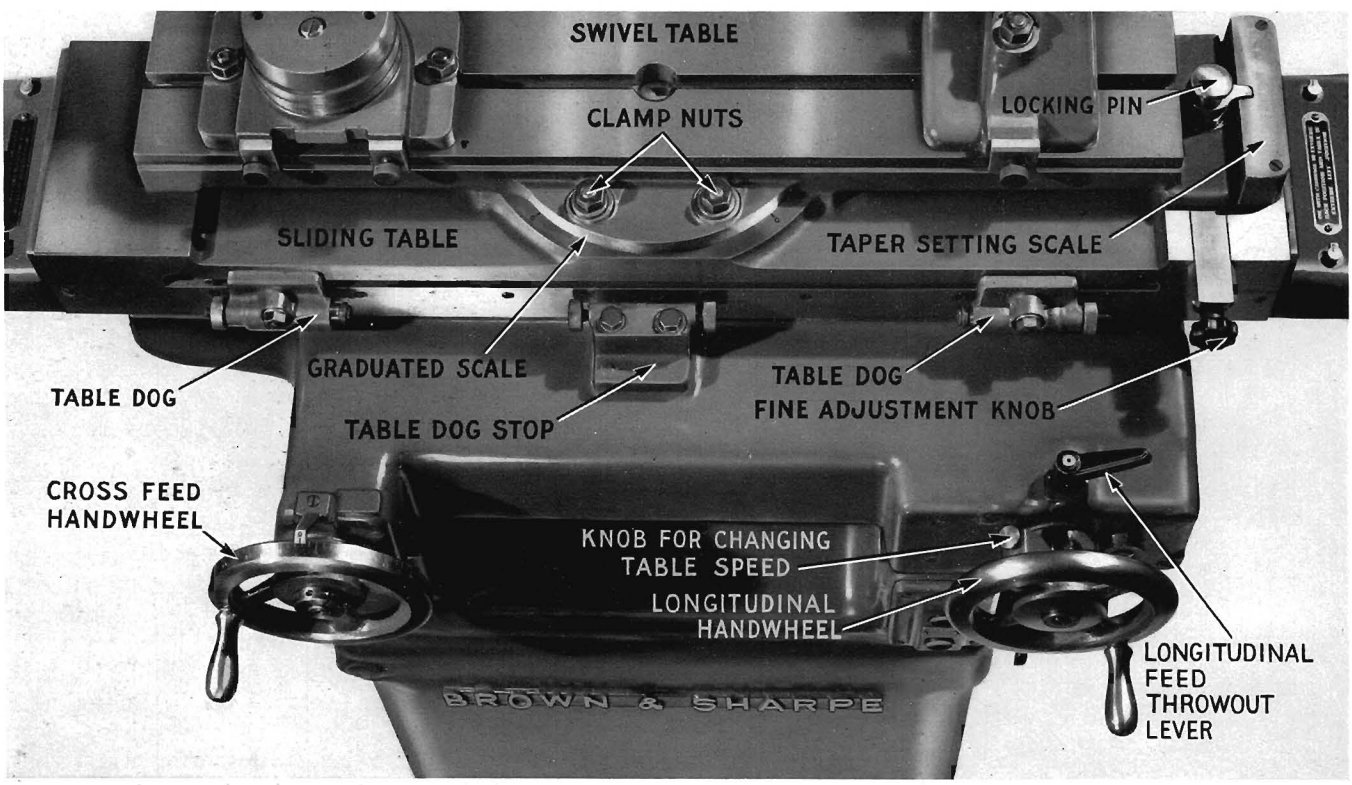
Using the front handwheel, table movement is available at either a fast or slow rate. With this handwheel in its extreme back position, the table will move approximately 6½" per revolution of the handwheel. Table movement of approximately ½" per revolution is obtained with the handwheel in its extreme forward position. To change from fast to slow speed, pull out the handwheel plunger knob and bring the handwheel forward.

Table movement of approximately 6½" per revolution of the handwheel is obtained with the smaller handwheels located at the rear of the machine. An adjustable drag (Page 5, Rear View) is provided which can be easily adjusted by the knurled screw. Clockwise rotation of this screw clamps a bushing which puts a drag on the table handwheel shaft, thus cutting down the free movement of the table.

When using handwheel in right-hand position, apply drag at left-hand end of table and when using handwheel in left-hand position apply drag at right-hand end of table. This procedure overcomes rack and pinion backlash.

This adjustable drag is helpful on such jobs as the sharpening of small straight-shank end mills.

Fig. 2. Operating controls and adjustments at front of machine.



Hand Cross Feed

Two cross feed handwheels (Page 5 Rear View and Fig. 2) are provided, one at the front and another at the rear of the machine. These handwheels are graduated to .001" and move the carriage transversely 8½". One turn of either handwheel gives .100" movement. Counter-clockwise rotation of the front handwheel or clockwise rotation of the rear handwheel moves the carriage inward.

Work Head

The work head (Fig. 3) provides for holding all varieties of cutters up to 10" diameter, with taper shanks or on arbors. It is particularly suited for sharpening shell end mills up to 6" diameter and face milling cutters up to 8" diameter.

This unit is adjustable for position along the swivel table and is accurately aligned by tightening the two knurled thumbscrews which draw the tongues in the base against the front side of the T-slot. Positive clamping is assured by tightening the two clamp nuts.

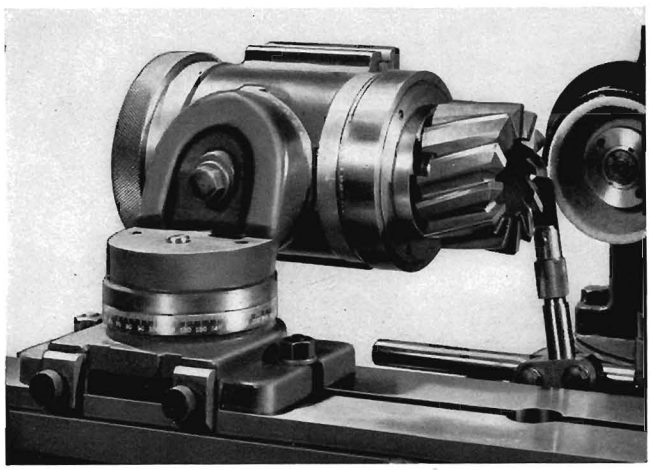


Fig. 3. The Work Head facilitates the easy sharpening of shell end mills.

Graduations in degrees on the circumference of the base and the swivel construction of the knee permits angular settings to 360° in the horizontal plane. Also, the knee provides for clearance on end or side teeth when grinding with a cup wheel. The swivel face of the knee, on which the work head is mounted, is graduated on its circumference in degrees to 90° each side of zero. One of two opposed zero marks on the work head indicates the setting. Clearance on peripheral teeth is obtained by means of either of two integral clearance gages, located 180° apart at the end of the spindle, which read to 30° each side of zero by degrees.

The spindle is mounted in ball bearings and can be clamped by means of a thumbscrew. Having a No. 12 B&S taper hole in one end and a No. 50 M.M. Std. taper hole in the other, it may be turned end for end. The collets furnished accommodate cutters having shanks of Nos. 7, 9 and 10 B&S tapers. The draw-in bolt is threaded 1"-8 N.C.R.H. and ⅝"-11-N.C.R.H.

Two finished stepped surfaces on the rear of the work head (used with the center gage which is explained on page 10) provide a positive means of setting the wheel spindle at center height when using the work head raising block.

A catalog describing in detail the Adapters and Collets most commonly needed for use in the work head will be furnished on request.

Revolving Spindle Headstock

The revolving spindle headstock, (Fig. 4) is composed of the No. 10N revolving spindle headstock equipment combined with the work head and provides a means of performing straight or taper cylindrical grinding operations. The centers will swing work up to 10" in diameter and take up to 16½" in length, while the maximum length of grinding stroke is 8" with the wheel on the left-hand end of the spindle and 13" with the wheel on the right-hand end. Miscellaneous chucking operations are made possible through use of the 4", 4-jawed independent chuck. This can be inserted in the work head spindle and held in place by the draw-in bolt after removing the work driving plate and the collet for holding the work center.

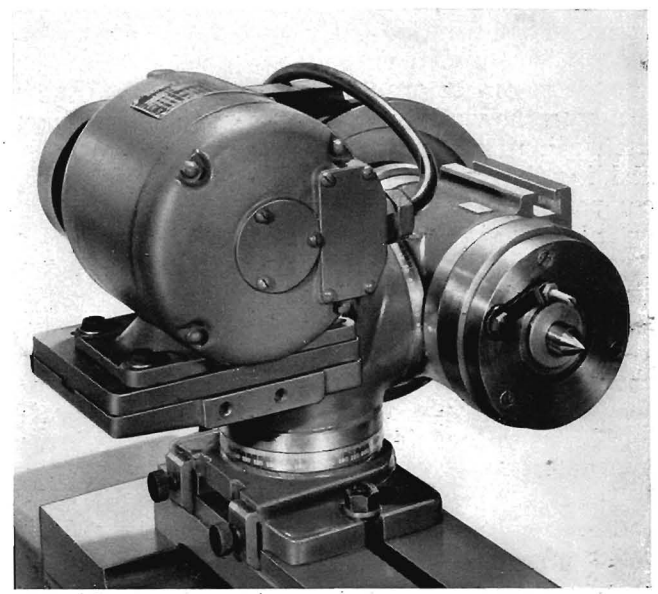


Fig. 4. Revolving Spindle Headstock

The spindle unit is driven by a single V-belt from a ⅙ H.P. constant-speed motor mounted on a plate adjustable on a bracket fastened to the work head knee by a bolt and two locating pins. The motor position is easily changed to give proper belt tension. The spindle speed is 300 R.P.M. The spindle sheave is fastened to the knurled end of the work

head spindle by three screws and the work driving plate is fastened to the opposite end in a similar manner. If desired, the work head can be swiveled end for end and the sheave mounted on the opposite end of the spindle; also, the motor can be swiveled 180° to provide a drive to the spindle nose.

A plug and socket at the left-hand side of the base provide for disconnecting the motor when removing the headstock from the machine.

Center Head

The center head is easily mounted on the work head knee and can be set to an angle in both horizontal and vertical planes. The center head has a ¾" straight hole which provides a means for holding a center, ¾" cutter bar, or bushing for ½" cutter bar.

Footstock

The footstock is adjustable along the swivel table in the same manner as the work head. The same accurate means for alignment is provided, and it has one knurled thumbscrew and one clamp bolt instead of two. The operating lever at the front is used to retract the center from the work. When the operating lever is brought to its extreme forward position, it moves the center approximately ½". This movement is resisted by a spring between the right end of the center and the knurled adjusting nut on the right end of the footstock body. This knurled adjusting nut allows the machine operator to vary the pressure of the center so that it will be great enough to hold the center firmly in the work but not so great that it springs the work piece or prevents it from turning easily. Holding the center in the work by spring pressure compensates for variations in the length of pieces.

The adjusting screw at the end of the operating lever is used to reduce center hole drag when sharpening small end mills also it limits the movement of the spindle.

The center is readily removed for changing or sharpening, by simply loosening the teated screw located in the top of footstock between the operating lever and center, then pull operating lever forward.

The clamp lever at the top of the footstock body can be used to hold the center away from the work while setting up.

Tool Rest

Use of the tool rest enables the machine to be used as a bench grinder for the off-hand grinding of lathe tools, drills, chisels etc. Also used for holding the No. 13A Formed Cutter Sharpening Attachment (In-Feed Type) and can be used with No. 1 Adjustable Vise to bring jaws at right angles to table T-slot. The slot in the tool rest provides for supporting the tool being ground, close to the wheel. When using the tool rest, the sliding table should be locked in position by moving the table dogs against the table dog stop.

Center Gage

To set the wheel spindle at the height of the work centers, set the center gage on the table as shown in (Fig. 5); adjust the position of the wheel spindle head until the notch in the spindle bearing retainer comes in contact with the ground step on the center gage.

The center gage is also used when setting the cutting edge of cutter teeth at the proper height for sharpening prior to angular adjustment. By placing the center gage on the table and adjusting the cutter until the cutting edge of the tooth comes in contact with the ground step on the gage.

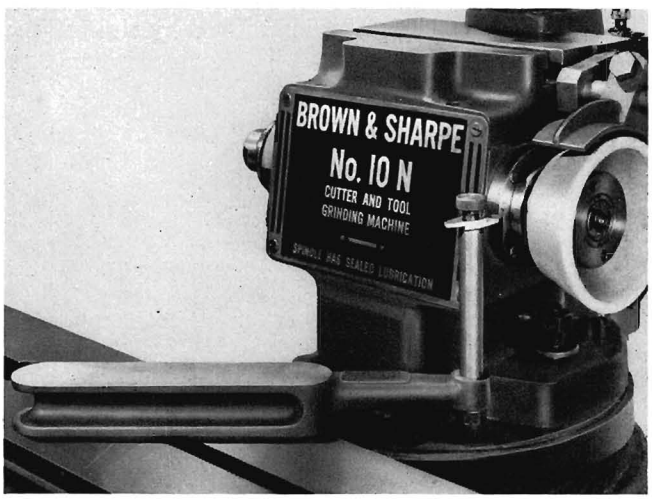


Fig. 5. Using Center Gage to set wheel spindle at center height.

The center gage can be inverted and placed on the top finished surface of the wheel spindle head for the following:

To obtain the proper setting of the wheel spindle in relation to the work head spindle when using work head raising block, adjust the wheel spindle head until the ground step on the center gage comes in contact with one of the finished steps on the rear of the work head.

For setting cutter teeth in line with wheel center prior to angular setting in cases where sharpening extends too far out from table, such as end teeth on long end mills.

To square up end teeth parallel to table movement.

When using Face Mill Sharpening Attachment.

To set the grinding wheel center, in line with the edge of the cutter being sharpened after clearance setting, when using a straight wheel.

Clearance Setting Gage

The clearance setting gage (Fig. 6) provides an easy and accurate means of setting the tooth rest to give the desired clearance in degrees for a cutter mounted between centers when sharpening with a cup wheel.

Place the indicator with the zero mark and the gage which is graduated in degrees to 20° each side of zero on the shank of the footstock or center head center.

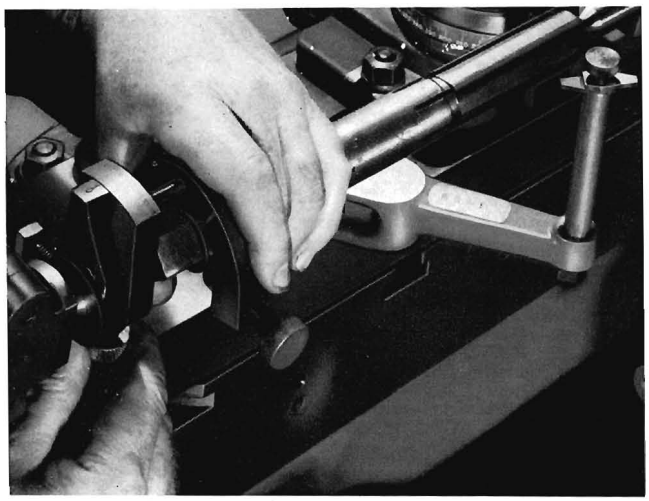


Fig. 6. Setting clearance angle for sharpening reamer using the Clearance Setting Gage.

Set the cutting edge of the tooth to be ground on the step of the center gage. Insert the clearance setting gage pin in the clearance setting gage dog, and clamp the dog to the cutter shank or arbor. Thus the cutter and the gage will turn together. Turn the indicator until the two zero lines coincide, then clamp. Remove the center gage from contact with the tooth, loosen the gage thumbscrew and turn the cutter until the scale on the clearance setting gage indicates the desired clearance angle. Clamp the work in this position by means of the gage thumbscrew, and fasten the tooth rest in working position in contact with the cutter tooth. The tooth rest is now set to give the desired clearance. Remove dog and proceed with the sharpening operation.

Tooth Rests and Holders

There are eight different tooth rests furnished, (shown at top of page 6). The straight blade type is used for sharpening most types of cutters. It may be used as furnished or readily altered to suit the operator.

The offset tooth rest blades are the most rigid, and providing clearer vision, are used for sharpening large face milling cutters.

The L shaped tooth rest blade is used for sharpening metal slitting saws and cutters where there is insufficient room between the grinding wheel and the tooth adjacent to the one being sharpened.

The tooth rest holder assembly consists of four parts; tooth rest holder, body, adjusting nut and clamp nut. After the assembly is clamped in approximate position in the bracket, about ½" fine adjustment of the tooth rest is obtained by turning the knurled adjusting nut. After obtaining the desired setting, tighten knurled clamp nut. The tooth rest holder is keyed to the body to prevent tooth rest from twisting out of position.

Three types tooth rest holders; solid, offset and ratchet. Also two bodies (one for ratchet type and one for offset and solid type) are provided.

No. 10N Internal Grinding Attachment

Used in conjunction with the revolving spindle headstock, the Internal Grinding Attachment (Fig. 7) permits the precision grinding of holes up to 3¾" in length and of ½" minimum diameter in work of 6¾" maximum swing. The spindle runs at 18,000 R.P.M. with the machine spindle running at 4500 R.P.M. and takes wheels of ½" and ⅜" diameter, ¼" thick and ¼" hole. It is driven by an endless canvas belt from a pulley on the machine spindle, which replaces the wheel sleeve. The flat belt should be run tight but not stretched.

Fig. 7. No. 10N Internal Grinding Attachment being set to center height of work with the center gage.

The spindle of the attachment is of comparatively small diameter, and is supported at the outer end by an adjustable bronze bearing carried by a pair of telescopic tubes of sufficiently large di-

ameter to give the required rigidity. The outer bearing supports the spindle close to the grinding wheel, and is adjustable for wear simply by loosening a clamp screw and screwing the outer telescopic tube onto the inner one. The spindle pulley runs on two ball bearings which take the pull of the belt, reduce friction to a minimum, and prolong the life of the attachment. Provision is made for excluding dust from all bearings.

The attachment is quickly and easily installed or removed from the machine and may be left mounted in position, ready for use, if desired. A flatted pin, on the front of the attachment, used in conjunction with the center gage furnished with the machine permits setting the spindle at exact center height.

No. 13A Formed Cutter Sharpening Attachment (In-Feed Type)

Formed cutters 2″ to 6½″ in diameter with straight teeth may be sharpened rapidly and accurately with this attachment. A dish wheel is used, with the wheel spindle set at right angles to the table; and the cutter is supported on its side in a horizontal plane and advanced into the edge of the wheel by feeding the table (Fig. 8). Since the inner edge of the tooth face area thus ground has a curvature caused by the circumference of the 6″-diameter wheel, this attachment is generally recommended for sharpening cutter teeth of not more than 1½″ in width.

The attachment consists of an adjustable tooth rest assembly and a body for supporting the cutter, mounted on a base plate which is bolted to the top of the tool rest regularly furnished with the machine. The upper part or body turns on a pivot extending through the base plate; and the cutter is placed on a vertical stud or on a bushing slipped over the stud (depending on size of hole in cutter). The tooth rest is carried by a block which is adjustable on the attachment body to accommodate cutters of various diameters and rake angles.

In operation, the tooth rest is located so as to touch the top of the cutter tooth close to the face being ground. The block which carries the tooth rest is adjusted transversely on the attachment body, allowing the tooth rest to be positioned for grinding the tooth radial or with hook or drag, while at the same time maintaining rigid support for the tooth rest. When the cutter is turned clockwise the tooth rest pivots to allow the cutter tooth to pass by, thus allowing the operator to quickly index the cutter with one hand while feeding the table with the other.

A knob at the front turns the attachment body on its pivot in order to rotate the cutter toward

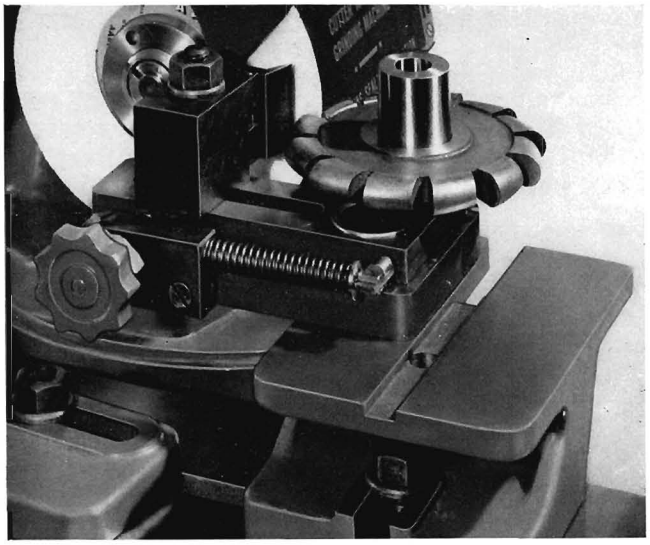


Fig. 8. The No. 13A Formed Cutter Sharpening Attachment allows the operator to quickly index the cutter with one hand while feeding the table with the other.

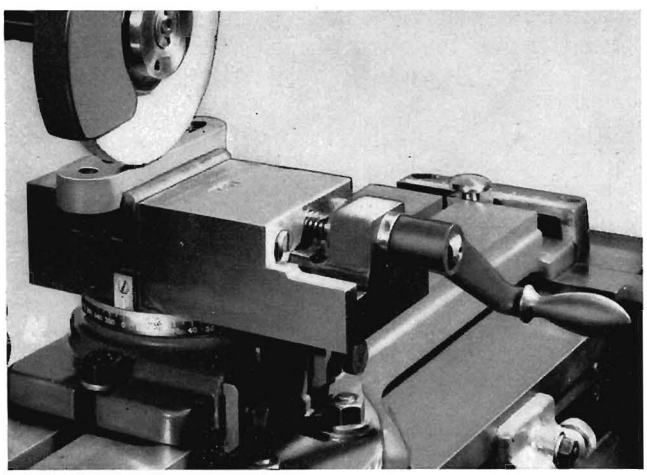
the grinding wheel to remove more stock. An adjustable positive stop permits taking two or more grinds with the wheel on those teeth that have an abnormal amount of stock to be removed and also permits producing duplicate diameters on cutters that are used in a gang.

The vertical stud for locating the cutter takes cutters with ⅝″ holes, and bushings regularly furnished accommodate cutters having ⅞″, 1″ and 1¼″ holes.

No. 10N Surface Grinding Vise

A plain vise with an index finger on either side is furnished for grinding small blades, lathe or form tools and various light work. The removable

Fig. 9. Surface Grinding Vise mounted on the work head base is very useful on single-piece toolroom work.



jaws are of tool steel, hardened and ground, 4⅛" wide, 1$\frac{1}{16}$" deep and open 2".

This vise may be mounted on the work head base, which can be swiveled to 360° (graduations in degrees) in the horizontal plane (Fig. 9) or mounted on the work head knee which permits the vise to be swiveled to any angle in the vertical plane to 90°, setting indicated by degrees each side of zero (Fig. 10).

For grinding double-compound angles, an extra knee is available at extra cost (Fig. 11).

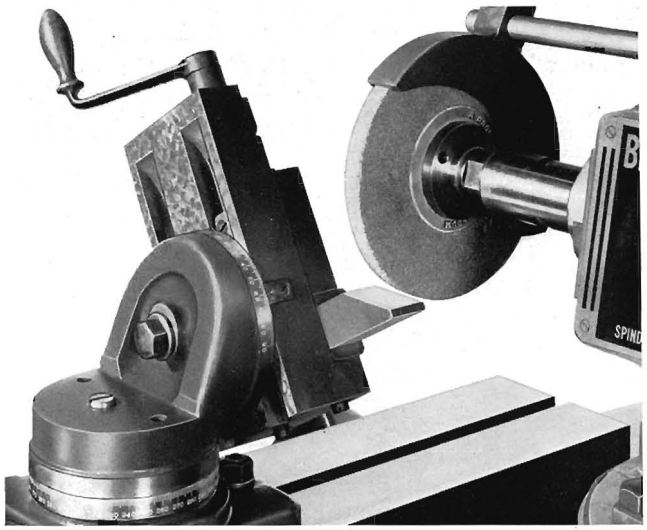


Fig. 10. Surface Grinding Vise mounted on the work head knee can be swiveled to grind a compound angle.

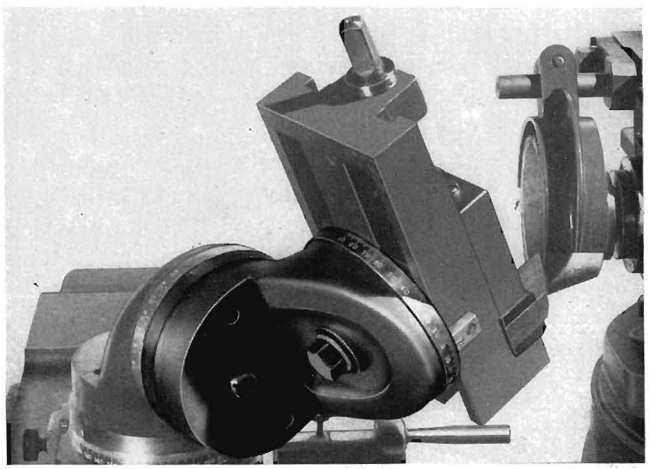


Fig. 11. Surface Grinding Vise mounted on the Double-Compound Knee allows grinding of double-compound angles.

Care and Use of Grinding Wheels

Selecting the Wheel. In order to produce the desired quality of work in the shortest time, real care is necessary in choosing the wheel which is best for the job at hand. The items to consider in making this choice are discussed in Chapter IV (page 29).

Mounting Wheels. Four general-purpose grinding wheels and three wheel sleeves are furnished with the machine. When additional wheels are used, extra wheel sleeves should be procured so that each wheel can be kept on its own sleeve. Thus, in changing from one type of wheel to another, the wheel and sleeve can be changed as a unit and will remain concentric, requiring only a minimum amount of truing.

The wheel should fit easily on the wheel sleeve, yet not loosely, for if it is loose it cannot be centered accurately and will consequently be out of balance. Do not wrap the sleeve with paper etc. to make a wheel fit when the hole is too large. It is better from all standpoints either to discard such a wheel or recast the core.

A wheel that fits a trifle tightly may crack if forced on the sleeve. If the hole is only a little under size it can easily be scraped out to fit.

Before mounting a wheel, hang it in the air on one finger; then lightly tap the edge of the wheel and see if it gives a clear ringing sound. A wheel that does not ring clear is probably cracked and should not be used.

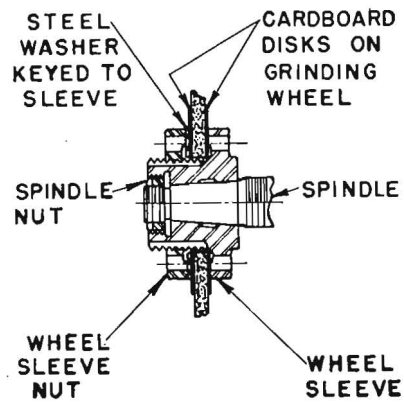


Fig. 12. Proper Mounting of Grinding Wheel.

The inner of the two flanges between which the wheel is mounted is a part of the wheel sleeve (Fig. 12). The outer flange consists of a steel disk or washer which is keyed to the wheel sleeve to keep it from turning and loosening the clamping nut.

To equalize the clamping pressure, washers of cardboard or rubber should be placed between the wheel and the two flanges. Most wheels of the size used on this machine have a ring of heavy blotting paper on each side, which serves the purpose.

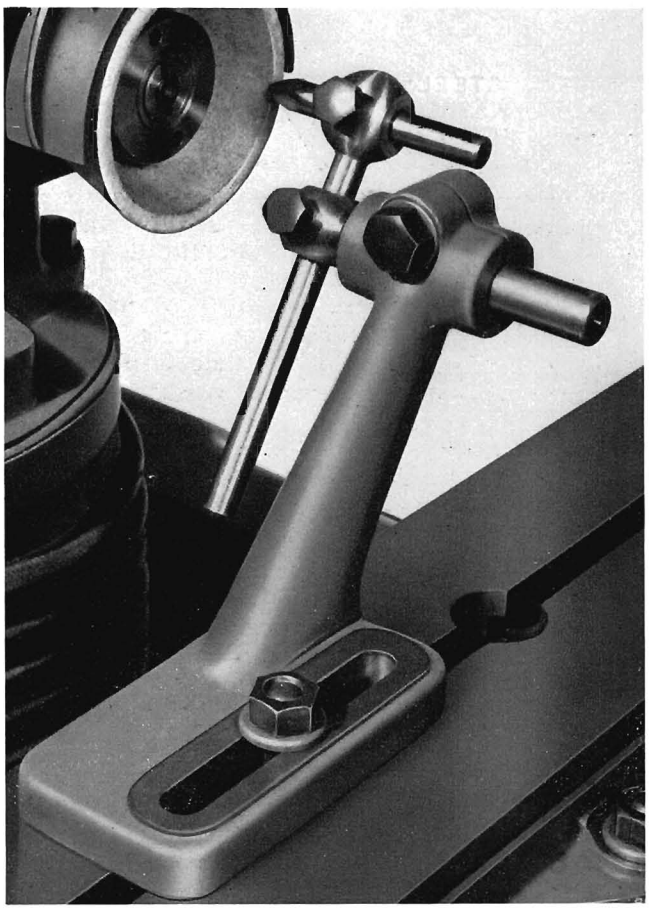
Using the pin wrench furnished, tighten the clamping nut enough to hold the wheel firmly in place on the sleeve. Do not tighten too much however, as excessive clamping pressure will crack the wheel.

Changing Wheels. In removing a grinding wheel from the spindle, always use the wheel sleeve puller (furnished with the machine) to avoid any chance of cracking the wheel or damaging the spindle bearings by pounding. Remove the spindle nut (the nut on the left end of the spindle has a left-hand thread and the nut on the right-hand end has a right-hand thread); then thread the outer member of the wheel sleeve puller into the wheel sleeve and tighten the inner screw against the spindle, thus loosening the wheel sleeve without harmful jarring.

In putting a wheel on the spindle, first see that both the wheel sleeve hole and the spindle end are perfectly clean. Then slip the sleeve onto the spindle, seat it by hand and tighten by means of the clamping nut and wrench.

Balance of Wheel. It is essential that the wheel run perfectly true and without vibration. Grinding wheels are balanced by the manufacturer and, in the case of wheels of the size used on this machine, should not require attention in this respect other than truing. A wheel that runs badly out of balance after truing should be discarded or returned to the wheel manufacturer—though in cases of necessity the condition may be corrected by digging out part of the wheel beneath the flange and filling with lead as indicated by a test for static balance.

Fig. 13. Truing a cup wheel with Wheel Truing Fixture



Wheel Truing. A wheel truing fixture is furnished with the machine. In the case of a straight wheel the truing diamond (not furnished) may be applied to any line on the lower half of the wheel circumference, though preferably at the bottom of the wheel.

Cup wheels are trued as shown in Fig. 13.

The wheel should be trued each time it is put on the spindle and whenever it becomes loaded, dull or glazed. Pass the diamond across the wheel with a slow, steady longitudinal movement.

In truing a wheel take a cut about .0005″ deep in one pass of the diamond across the wheel and finish with a similar cut .00025″ deep. The figures stated are approximate and under some conditions should be varied somewhat to give desired results.

Cutter Sharpening

Sharpen Cutters Often. A sharp cutter will produce a more highly finished surface of greater accuracy and finer finish than a dull one. It also has the advantage of consuming less power and subjecting the machine to less strain. A dull cutter, in addition to impairing production efficiency, wears more rapidly. In fact, more metal must frequently be removed from a dull cutter to restore its cutting efficiency than would have been ground off by proper sharpening as soon as signs of dullness appeared.

Tests have shown that cutters kept in good condition by frequent sharpening will invariably outlast those that are allowed to become unduly dull between regrinding operations. Thus, the savings realized from keeping cutters properly sharpened, together with the advantages obtained by this practice, more than compensate for the time spent in regrinding.

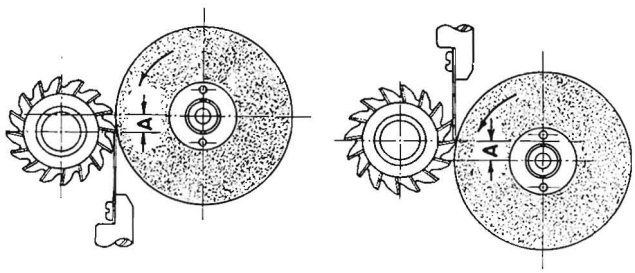
Methods Used in Sharpening Plain and Helical Milling Cutters

Either a straight grinding wheel (disk-shaped), or a cup-wheel, may be employed for sharpening straight- or helical-tooth cutters, as well as angular cutters, face mills, end mills, saws, and reamers. Both kinds of wheels are used to sharpen these types of cutters by grinding the tops (lands) of the teeth back of their cutting edges.

Three methods, or set-ups, for grinding the lands to give the desired clearance angle may be used.

A straight wheel is used for sharpening a straight milling cutter in which the land is ground to the primary clearance angle at C Fig. 14 and the direction of rotation is away from the cutting edge. With this set-up, the rotating wheel tends to hold the front face of the tooth being ground in contact with the tooth rest as the cutter is fed past the wheel, and there is no tendency of the tooth to dig into the wheel. This method, however, leaves a slight burr on the cutting edge.

With the cutter position reversed, at *D* Fig. 14 the direction of wheel rotation is toward the cutting edge, and with the center of the wheel lower than the center of the cutter, to give the desired relief, there is a tendency of the cutter to dig into the wheel. However, when this method of sharpening is employed by a careful, skilled workman, it produces a keener cutting edge without burrs, and is generally believed to be less likely to burn or check the cutting edge.



C D

Fig. 14. Using a straight wheel, and with tooth rest at center height, clearance is governed by difference in elevation of axes of wheel and cutter.

The use of a straight wheel results in the production of a concave land as shown somewhat exaggerated at *O* Fig. 15. Since the width of the land on new cutters is about $\frac{1}{32}$ to $\frac{1}{16}$ inch, this concavity is practically negligible, especially when a grinding wheel of the diameter ordinarily employed is used. When the width of the land has been increased by resharpening to a point where the heel interferes with the work, the teeth can be ground at the back of the land to a secondary clearance angle, as indicated in Fig. 15, to reduce the land to its original width.

The proper clearance angle depends on the diameter of the cutter, as well as the material to be milled, and must be greater for small cutters than for large ones. For most milling jobs on steel and cast iron, the clearance on the teeth of plain milling cutters should be from 4 to 5 degrees for cutters over 3 inches in diameter, and about 6 to 7 degrees for cutters from 3 inches down to $\frac{1}{2}$ inch in diameter. Small end mills usually require a larger clearance angle, depending on their diameter.

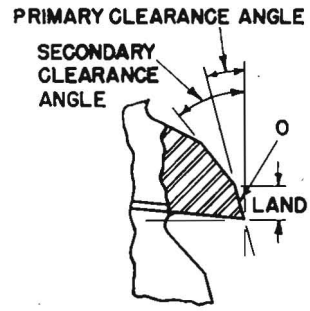


Fig. 15. Section of cutter showing clearance angles.

In sharpening a cutter, unless there is reason to doubt the correctness of the existing clearance, the accuracy of the set-ups can be tested by taking a very light trial cut and noting whether or not the old clearance is followed.

All the teeth of a cutter must be ground to the same height to insure a good finish and efficient operation. Unevenness in the height of teeth, particularly in those of the larger cutters, is often caused by wearing of the wheel as successive teeth are ground, less metal being removed from the last teeth ground than from the first. To overcome this difficulty, the machine should be set to take a light cut (about 0.001 to 0.002 inch) off the first tooth, and then to sharpen all teeth in succession. Next, the cutter should be indexed about 180 degrees and ground completely around again, taking a very light cut. This procedure will generally result in a properly ground cutter. If any unevenness still exists, it can be corrected by a very light finishing cut.

Care should be taken not to draw the temper of the cutter teeth. This may result from taking too deep a cut; using a wheel that is too hard to wear freely; or using a dirty or glazed wheel.

The tooth rest, which serves to position the tooth properly for sharpening, must bear on the tooth being ground. It can be mounted either on the machine table or on the spindle head, depending on whether straight or helical teeth are to be sharpened. In any case, it should be so mounted that the distance between the end of the rest and its base is at a minimum, in order to provide a support of maximum rigidity for the tooth. The clearance between the tooth rest and the grinding wheel should not exceed $\frac{1}{32}$ inch.

In grinding straight-tooth cutters or reamers which are mounted so that the table traverse is employed to feed them past the grinding wheel, the tooth rest is preferably mounted on the

table, where the tooth can bear steadily against it instead of sliding along the rest.

In grinding helical cutters, as shown on page 22, Fig. 29, the tooth rest must remain in line with the center of the cutting edge of the wheel, and must, therefore, be attached to the spindle head, except when the cutter is so mounted that it is free to revolve and move longitudinally while the table remains stationary. In the latter case, the tooth rest may be attached to the table, if desired. When the tooth rest is mounted on the spindle head, it moves up and down with the wheel. Thus, in using a straight wheel, care must be taken to adjust the tooth rest to the proper center height after the wheel has been positioned vertically, to give the correct clearance.

Sharpening Cutters with Straight Wheels

The first method of sharpening the peripheral teeth of a plain milling cutter having straight teeth, the lands of the teeth are ground to the primary clearance angle with a straight wheel set the required distance *A*, Fig. 14, above the horizontal center line of the cutter. Distance *A* depends on the diameter of the grinding wheel and the primary clearance angle desired.

A step on a center gage is used to set the cuting edge of the first tooth to be ground on the horizontal line passing through the center of the cutter. The tooth rest, with its holder mounted on the machine table, is then adjusted to support the tooth in this position. The rest should support the cutter tooth very close to the edge to be ground.

The grinding wheel is next adjusted vertically, using a center gage on the table and vertical handwheel graduations, so that its center is the required distance *A* above the horizontal center line of the cutter. This distance is obtained from the table, on Page 33, which gives distance *A* for primary clearance angles from 4 to 12 degrees when using grinding wheels ranging from 3 to 6 inches in diameter. Assuming, for example, that a cutter is to be ground with a 4-degree primary clearance angle, using a wheel 6 inches in diameter, it will be seen by referring to the table that the height setting *A* would be 0.209 inch.

The grinding wheel is brought forward, so that the wheel will take a light roughing cut on the traversing movement of the table. This movement carries the tooth being sharpened completely across the grinding face of the wheel. On the return movement, the wheel takes a very light finishing cut. The cutter can then be quickly indexed, counter-clockwise, into position for grinding the next tooth, the spring section of the tooth-rest permitting the succeeding tooth to deflect it sufficiently to facilitate indexing.

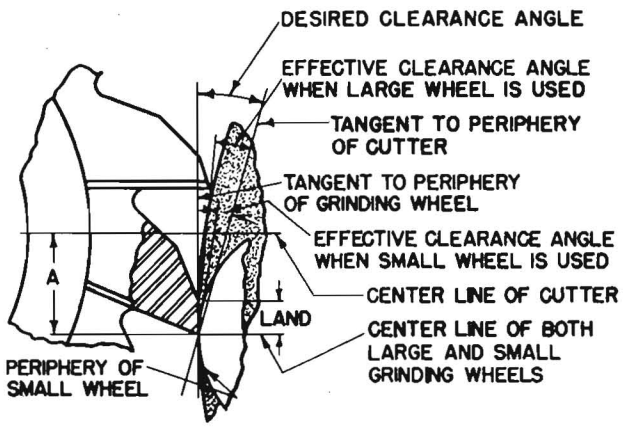


Fig. 16. Diagram illustrating effect of using large and small straight wheels in grinding pheripheral clearance.

There are certain limitations to the use of a straight wheel. As previously noted, the land of a milling cutter tooth sharpened by grinding with a straight wheel has an arc-shaped contour. This contour corresponds to the arc of a circle having the same diameter as the grinding wheel. Thus the desired clearance, indicated in diagram Fig. 16, is obtained only at the tip of the cutter tooth next to the cutting edge.

The desired clearance angle, as indicated in the diagram, is formed by lines tangent to the peripheries of the cutter and the grinding wheel which intersect at the point representing the cutting edge of the tooth. Since the center of the grinding wheel is on a line passing through this point at right angles to the line tangent to the wheel, it follows that the effective clearance decreases as the heel of the arc-shaped contour of the land is approached from the cutting edge.

As the width of the land is increased by regrinding, the effective clearance angle decreases until it may reach the zero point, where any further grinding will result in interference of the heel of the land with the work milled. When a small grinding wheel is used, the effective clearance angle is reduced, and the cutter can be resharpened only a comparatively few times before it becomes necessary to reduce the width of the land. A reduction in the width of the land is accomplished by grinding a secondary clearance in back of the primary clearance, such as indicated in Fig. 15, in order to avoid interference between cutter and work. While a straight wheel

can be used for most primary angles, it cannot be used for steep angles, such as are required for soft materials, nor for secondary angles, due to wheel interference with the next tooth.

A second method of setting the cutter, using a straight type wheel for grinding the primary clearance on the cutter teeth, Fig 17. This method does not require the use of tables or formulas (although tables are sometimes provided), and is somewhat easier to apply than the previous method. For this set-up, the cutter to be sharpened is mounted on an arbor held between headstock and footstock centers.

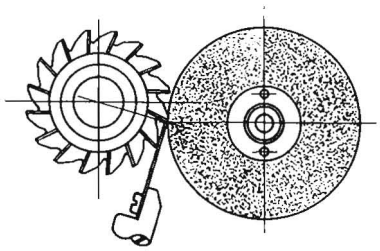


Fig. 17. Cutter positioned by using clearance setting gage and center of grinding wheel set in a vertical position in line with tooth.

Using the gaging step on the center gage, the cutting edge of the tooth to be ground is first set on a horizontal line passing through the center of the cutter, or to the same height as the axis of the mandrel on which the cutter is mounted. The clearance setting gage is then used as explained on Page 11. Graduations and means of clamping are provided on the work-head for making a similar set-up. The grinding wheel is then adjusted vertically to bring its center to the same height as the cutting edge of the cutter tooth. This adjustment is easily made with the aid of the center gage, Page 10, Fig. 5, resting on the seat provided on the spindle head.

The tooth rest is now adjusted to support the cutter tooth in the sharpening position. The cutter arbor can then be unclamped to permit indexing each successive tooth into the sharpening position. The sharpening cuts are taken in the usual manner.

Sharpening Cutter with Flaring Cup-Wheel

A third method of sharpening straight milling cutters is illustrated in Fig. 18, the procedure for setting the cutter to obtain the primary clearance. In this set-up, the column on which the cutter-grinding spindle is mounted is swung around 90 degrees, to bring the grinding wheel spindle at right angles to the arbor on which the cutter is mounted.

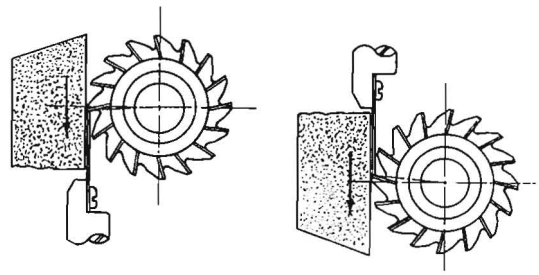


Fig. 18. With a cup wheel, clearance is obtained by setting the tooth rest with the cutter tooth rotated from horizontal an amount equal to the desired clearance angle.

The first step in positioning the cutter for grinding the primary clearance is to set the first tooth to be ground on the horizontal line passing through the center of the arbor and cutter. This is accomplished easily by the use of the center gage, Page 10, Fig. 5. Next the tooth is set to the desired clearance angle by using the clearance setting gage explained on Page 11. The tooth rest is then set under the tooth to be ground in a position normal to the tooth face. The sharpening cuts are now taken in the usual manner.

In cases where the length of the cutter is such that it extends across both rims of the flaring cup grinding wheel, the column carrying the wheel is swung slightly beyond the 90-degree position, so that the wheel rim opposite the side doing the sharpening will clear the cutter. Setting up for sharpening cutters by the use of a flaring cup-wheel, as just described, is simpler than the set-ups previously described, since close height adjustment of the grinding wheel is not necessary.

Sharpening Helical Milling Cutters

For helical-cutter grinding, the tooth rest must be kept in line with the center of the cutting edge of the wheel. Hence, the tooth rest must be mounted on the spindle head, except when the cutter is so mounted that it is free to revolve and to move longitudinally while the table is held stationary. In the latter case, the tooth rest can be attached to the table.

In grinding helical milling cutters, the axes of both the cutter and grinding wheel are parallel, regardless of the helix angle of the cutter when using a straight wheel. When a steep-angle cutter is being ground, the cutting edge of the wheel should be rounded to approximately a 1/16-inch radius and tapered back at the sides, as indicated at *W*, Fig. 19.

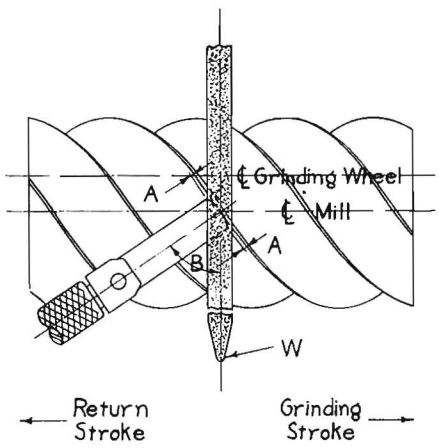


Fig. 19. Shape and position of tooth rest, and shape of wheel at cutting edge, for sharpening a helical cutter using a straight wheel.

The top of the tooth rest, which should be about 3/4 inch wide, should be shaped and mounted so that when the rest is in contact with the cutter tooth there will be a clearance *A* at each side of the rest equal to approximately 1/32 inch. The angle *B* is easily determined by trial, although it is the same as the helix angle of the cutter.

In grinding a helical-tooth cutter with a flaring cup-wheel, the grinding-wheel spindle is, of course, positioned at an angle of 90 degrees to the axis of the work, or at a slightly greater angle if necessary, to allow the cutter to clear the side or rim of the wheel opposite the one doing the grinding. The rim or grinding edge of the cup-wheel used in sharpening steep helix-angle cutters is dressed to a 1/16-inch radius, as in the case of a straight wheel. The tooth-rest is also shaped and set the same as in using a straight wheel.

Grinding Angular or Tapered Cutters. The work is mounted on centers or in the work head, and the swivel table or work head is swiveled to such an angle that the teeth being ground will be parallel to the direction of table movement.

When a straight wheel is to be used, with the tooth rest at center height, the correct setting is with the work swiveled to the angle of taper. Note, however, that when a cup wheel is to be used, requiring that the tooth rest be above or below center height (i. e., with the tooth rotated away from the horizontal), the work must be swiveled to an angle somewhat *less* than the angle of taper, in order for the tooth being ground to be parallel to the direction of table movement.

Grinding Spiral Cutting Edges of Staggered Tooth Milling Cutters. A simple and effective method of grinding staggered tooth cutters consists of first rotary-grinding, and then backing-off the teeth by using a double-angled tooth rest.

The cutter is rotated against the wheel to grind it cylindrically and leave all teeth the same height. This truing operation is followed by the backing-off described below, which gives the cutter uniform teeth with lands .003″ to .004″ wide.

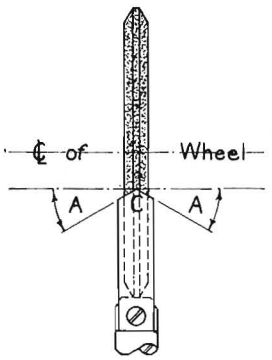


Fig. 20. Diagram of pointed tooth rest.

For backing-off, the machine is fitted with a pointed tooth rest whose apex (*C*, Fig. 20) is set in the center of the cutting edge of the grinding wheel and enough below the center of the spindle to give the teeth the necessary clearance. The tooth rest is ground so that the angles (*A* and *A′*) on both sides are equal to or greater than the spiral angles of the teeth, so that the spiral tooth edge is either parallel with the corresponding edge of the tooth rest or rests on the central high point *C*.

It is essential that the high point *C* of the tooth rest be placed in the center of the cutting edge of the grinding wheel. Best results in getting the teeth ground uniformly will be obtained by using a fairly narrow wheel with not over 1/8″ cutting edge.

In grinding the clearance, pass the cutter across the wheel with the spiral edge of the tooth resting on the corresponding angle of the tooth rest. In grinding the next tooth, whose spiral angle is in the other direction, use the other angle of the tooth rest and pass the cutter in the opposite direction.

CHAPTER II

Typical Operations

The operations shown in this chapter are representative of the various types of work performed on this machine. While no attempt has been made to describe each job in detail, the main features of set-up and operation are outlined as a guide to good grinding practice.

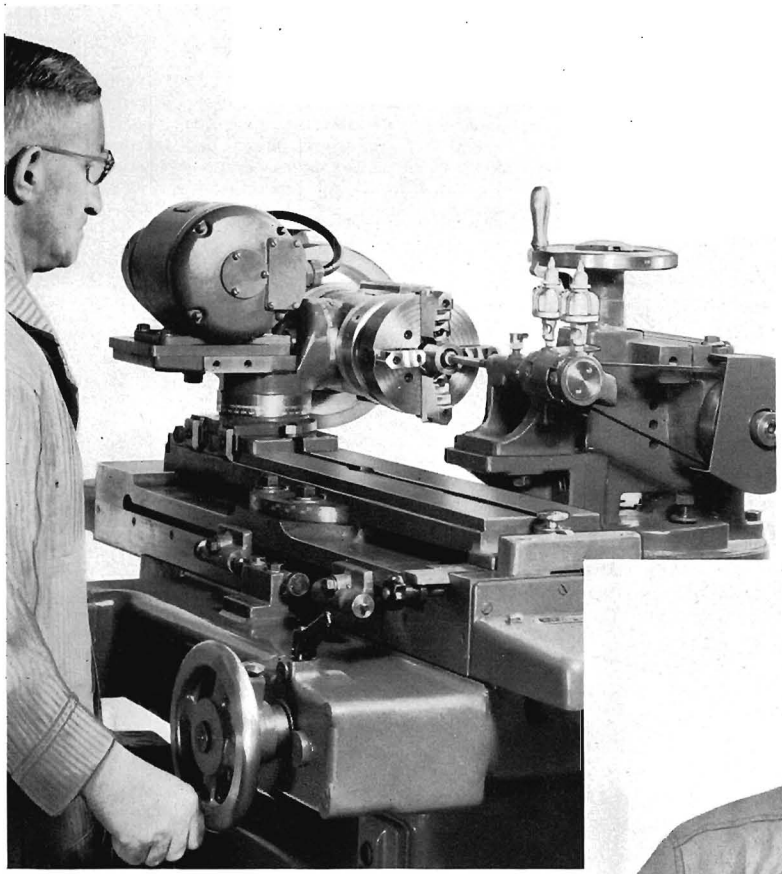


Fig. 21. Grinding a straight hole using the No. 10N Internal Grinding Fixture, the No. 10N Revolving Spindle Headstock and the 4-jawed chuck. The fastest machine spindle speed is used so that the attachment wheel will run at the proper surface speed.

Fig. 22. Operator grinding the secondary clearance angle of a shell end mill using the rear table operating position. The cutter is mounted on an arbor held in the work head. Since a cup wheel is being used, tooth clearance is obtained by swiveling the work head. The tooth rest is mounted on the wheel spindle head with the blade in contact with the tooth being ground. Indexing for the next tooth is accomplished by simply turning the work head spindle.

Fig. 23. Sharpening a straight finishing reamer. The reamer is mounted between the centers of the center head and footstock. The cup wheel is positioned so there will be no interference with the center head and proper clearance is obtained on the cutting edge of the reamer by using the center gage and the clearance setting gage when adjusting the height of the tooth rest. Table movement is by handwheel from the rear-of-table operating position where the sharpening operation can be most easily observed.

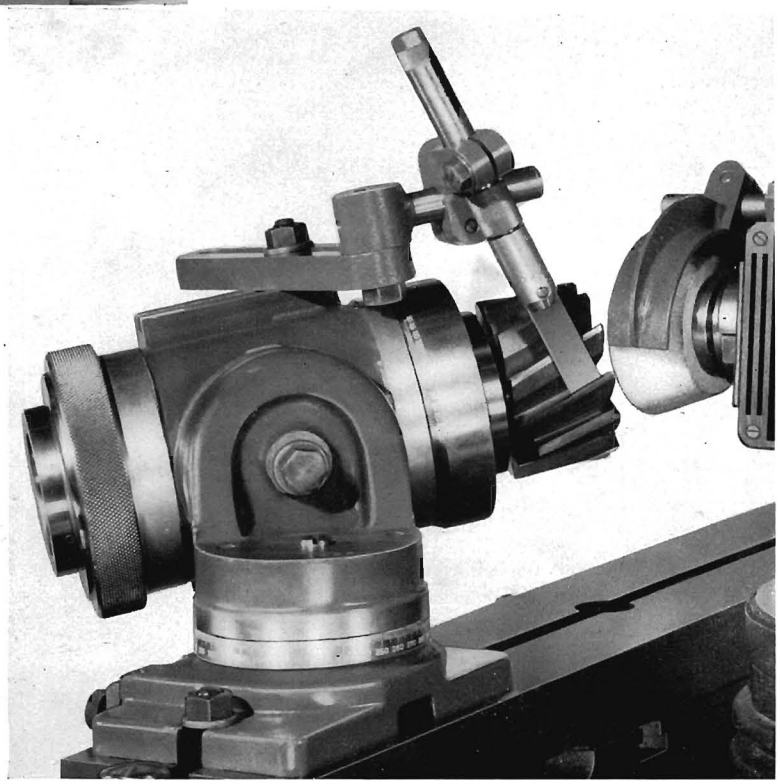


Fig. 24. Sharpening the tooth corners of a shell end mill. The cutter is mounted on an arbor held in the work head which is swiveled to give the angle desired for the corners of the teeth. The tooth rest is mounted on the top of the work head. The grinding wheel spindle is set at right-angles to the table T-slot; and tooth clearance is obtained by using the scales incorporated in the work head.

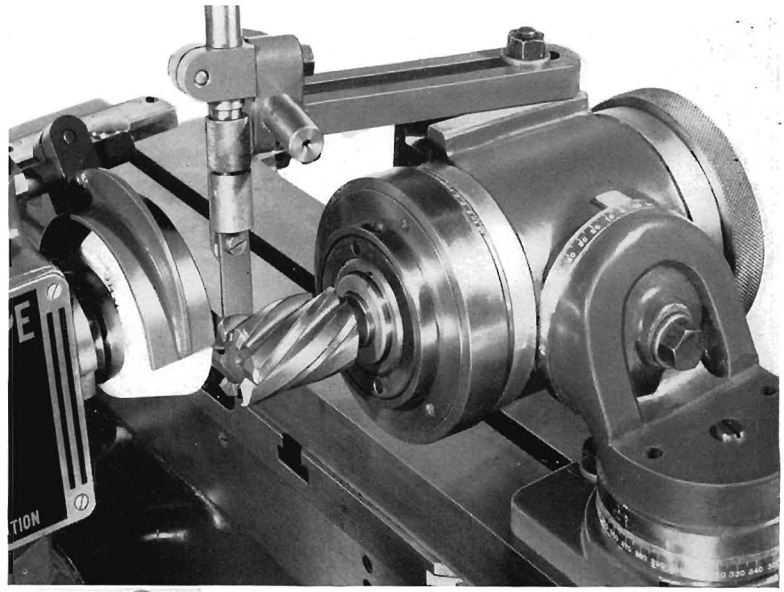


Fig. 25. Sharpening the end teeth of an end mill. The end mill is held in a collet mounted in the work head. The tooth rest is mounted on the top of the work head with the blade in contact with the tooth being ground. Since a cup wheel is being used, tooth clearance is obtained by swiveling the work head. Indexing for the next tooth is accomplished by simply turning the work head.

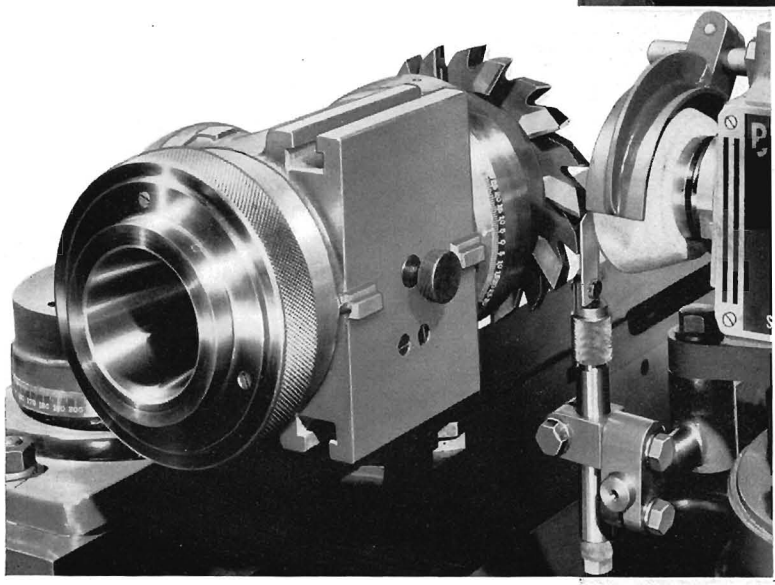


Fig. 26. Sharpening the peripheral teeth of a staggered-tooth milling cutter. The cutter is mounted on an arbor in the work head. The tooth rest is shaped to a double angle somewhat greater than the angle of spiral of the cutter teeth, and the teeth are ground by moving the table with the spiral edge of the tooth in contact with the corresponding angle of the tooth rest.

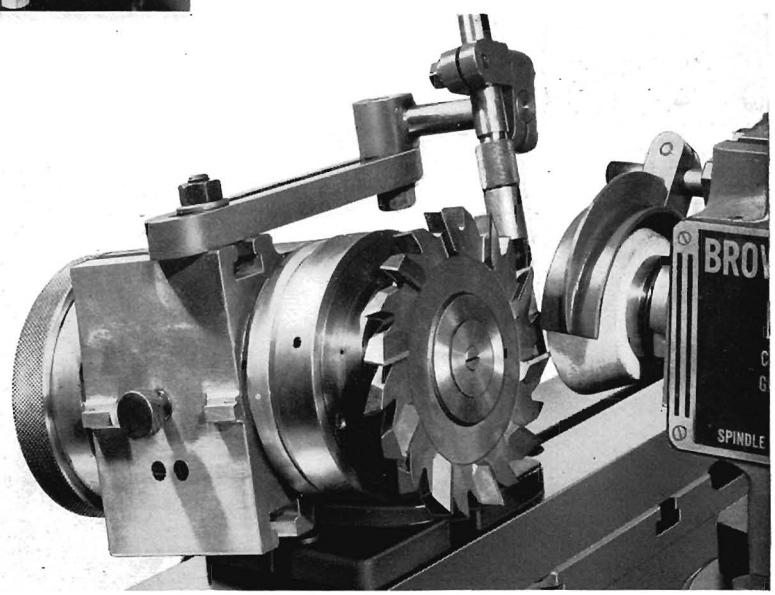


Fig. 27. Staggered-tooth side milling cutter held in work-head for grinding primary or secondary angle clearance on side teeth with flaring cup wheel. The cutter is mounted on an arbor in the work head at 90° to the table T-slot. Cutter clearance is obtained by swiveling the work head in the vertical plane. The rear-of-table operating position is used to advantage with this set-up.

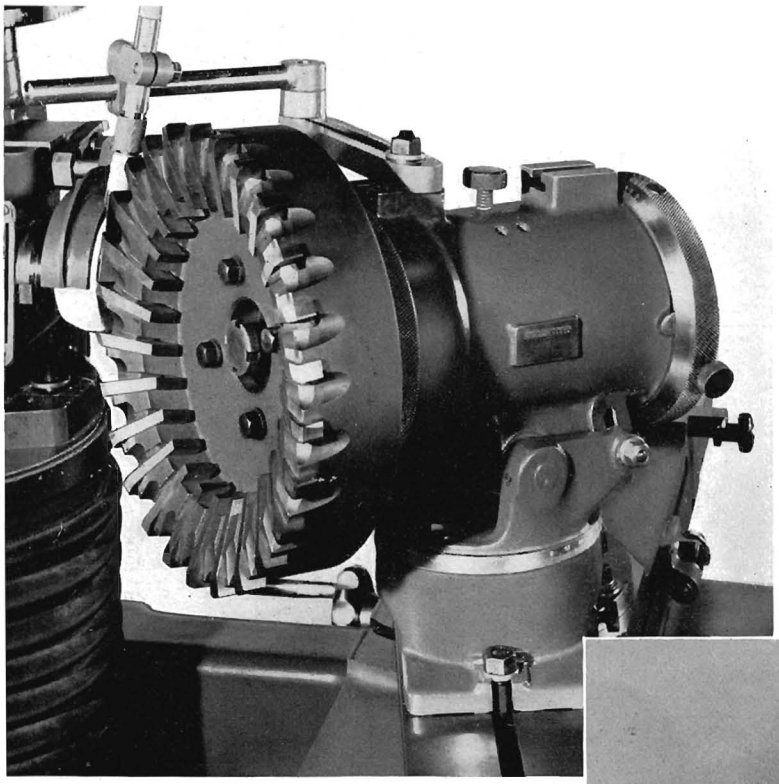


Fig. 28. Sharpening the tooth corners of a large face milling cutter. The cutter is mounted on a work holding arbor and the No. 10N Face Mill Sharpening Attachment is swiveled to give the angle desired for the corners of the teeth. The grinding wheel spindle is set at right angles to the table ways; and tooth clearance is obtained by using the gages incorporated in the attachment.

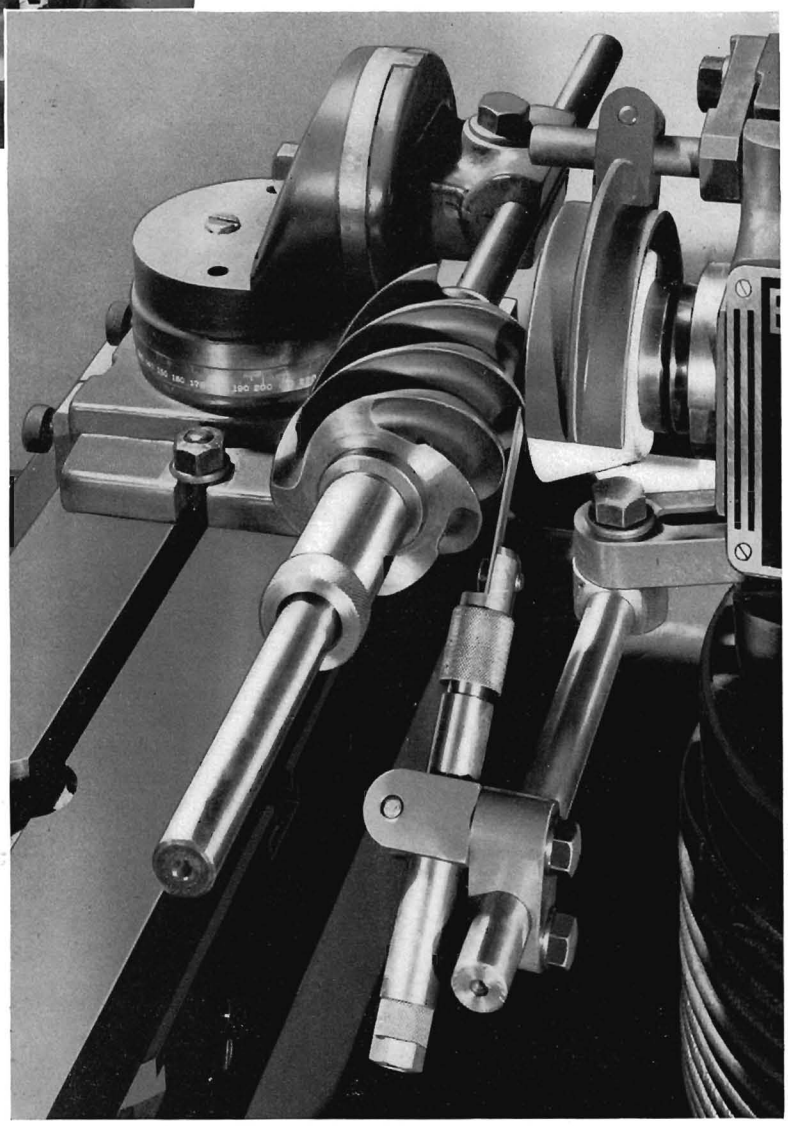


Fig. 29. Sharpening a helical milling cutter. The cutter is mounted on the sliding shell and cutter bar and the bar is held in the center head in place of the center. The tooth rest is attached to the wheel spindle head and both table dogs are brought into contact with the positive stop to eliminate table movement. The tooth is sharpened by keeping it in contact with the tooth rest while moving the sliding shell and cutter along the cutter bar.

CHAPTER III

Additional Equipment (Furnished at Extra Cost)

This chapter describes and illustrates the various items of additional equipment available as extras for machines with Universal or Plain Equipment. It also gives instructions on their set-up and use.

The following items which are regularly furnished with machines with Universal Equipment are also available for machines with Plain Equipment: No. 10N Revolving Spindle Headstock Equipment (Described on Page 9), No. 10N Internal Grinding Attachment (Described on Page 11), No. 13A Formed Cutter Sharpening Attachment (In-Feed Type) (Described on Page 12) and the No. 10N Surface Grinding Vise (Described on Page 12).

Cutter Bars with Shells

These cutter bars are for use in the center head of the machine when the operator prefers to sharpen the peripheral teeth of cutters having arbor holes, without using the machine table movement.

This equipment consists of a $\frac{3}{8}$" cutter bar, bushing to adapt cutter bar to the $\frac{3}{4}$" hole in the center head, $\frac{1}{2}$" sliding shell with set of collars (including 2 stepped collars), and a $\frac{3}{4}$" cutter bar and $\frac{7}{8}$" sliding shell with set of collars (including 4 stepped collars).

The cutter to be sharpened is mounted on the proper size stepped collars on the sliding shell with plain collars used to fill the rest of the shell. A knurled nut holds the assembly firmly together. In operation, the shell is mounted on the cutter bar and is moved along the bar while the tooth being ground is kept in contact with the properly adjusted tooth rest. (See typical operation on page 22, Fig. 29.)

No. 10N Formed Cutter Sharpening Attachment (Through-Feed Type)

This attachment (Fig. 30) gives a straight cut across the entire tooth face, and provides for the efficient and accurate sharpening of formed cutters up to 6" in diameter with straight teeth. A dish wheel is used, with the wheel spindle at right angles to the table; and the cutter is supported on a horizontal arbor between the centers of the machine as illustrated, and is passed across the face of the wheel by traversing the table.

The attachment consists of a rigid, adjustable tooth rest assembly mounted at the top of a sturdy column which is adjustable vertically to accommodate cutters up to 6" in diameter. A rack and pinion provide easy, positive adjustment, and the rack

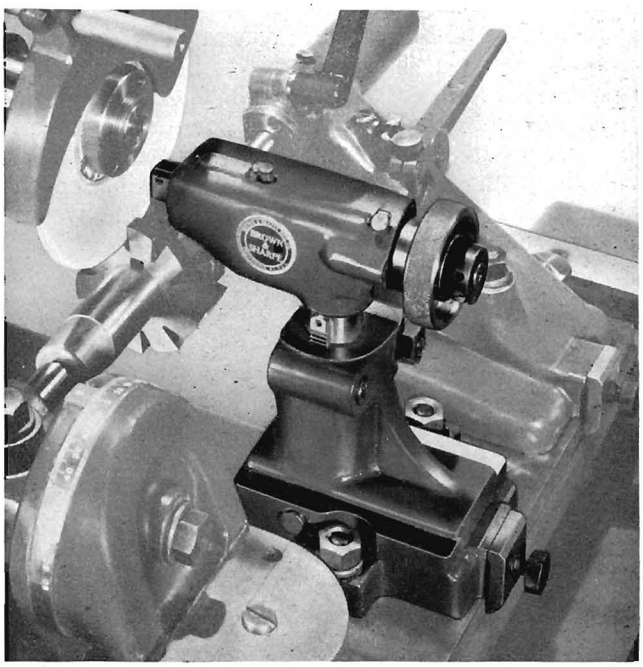


Fig. 30. No. 10N Formed Cutter Sharpening Attachment (Through-Feed Type).

serves as a key to maintain angular alignment. The supporting bracket which carries the column is adjustable transversely along dovetail ways in a solid base; and the base, in turn, is tongued for accurate alignment and is bolted to the machine table.

In operation, the tooth rest is located so as to touch the top of the cutter tooth close to the face being ground. The transverse adjustment of the attachment on its base allows the tooth rest to be positioned for grinding the tooth radial or with hook or drag, while at the same time keeping the tooth rest close to its supporting body for maximum rigidity.

A knurled nut at the upper front of the attachment advances the tooth rest slightly in order to rotate the cutter toward the grinding wheel to remove more stock. Another nut, concentric with the first one, serves as a positive stop to determine the end of this movement, facilitating the grinding of duplicate cutters to uniform size.

No. 10N Indexing Equipment

This indexing equipment (Fig. 31) permits accurate indexing of the more common circular divisions, facilitating the grinding of taps, reamers, formed cutters and similar work. The centers are mounted on the adapter plates which in turn are

clamped in position by T-bolts and are aligned by tightening the knurled thumb screws which draw the tongues against the side of the T-slot.

A spring-loaded locking pin on an adjustable arm, together with six rows of holes in the face of the combined index plate and worm wheel, provide for indexing all divisions from 2 to 14 and all even-numbered divisions from 18 to 28. The index worm wheel can be turned by the worm, or the worm can be thrown out of mesh and the index worm wheel turned by hand. To disengage the worm, loosen the adjacent clamp screw and swing the worm downward.

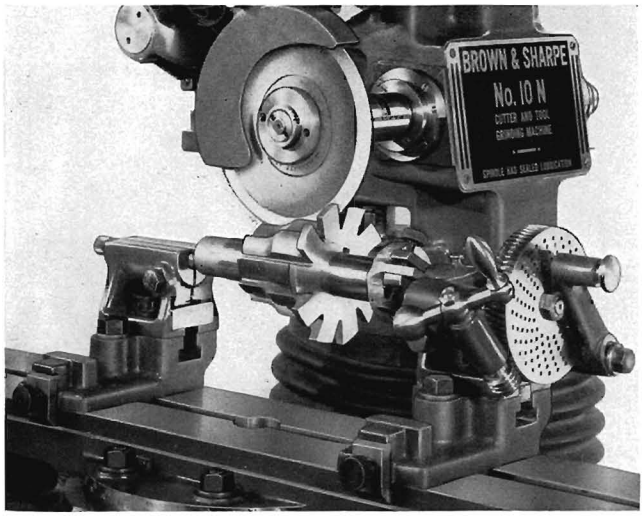


Fig. 31. The No. 10N Indexing Equipment is useful for sharpening wide formed cutters and other jobs requiring accurate indexing.

In using the indexing equipment for sharpening formed cutters or similar work having radial tooth faces, first turn the cross feed handwheel to bring the centers in line with the face of the grinding wheel. Then, with the work mounted between centers, disengage the index pin and turn the worm to feed the face of a tooth into the grinding wheel, feeding the work a small amount and running the table back and forth by hand in successive steps until that tooth is properly sharpened. Next loosen the index pin arm, insert the pin in a hole in the proper circle and securely clamp the arm.

In sharpening the rest of the teeth where a considerable amount of stock is to be removed from each tooth face, feed the work to the grinding wheel by means of the worm to take the necessary number of successive cuts on each face until the index pin enters the proper hole. In case the grinding wheel requires dressing before all of the teeth are sharpened, readjust the position of the index centers relative to the grinding face of the wheel after dressing the wheel. Moving the wheel to bring the face of the last tooth ground into contact with it is often sufficient. After sharpening the remainder of the teeth a final adjustment of the wheel may be necessary for required accuracy, after which a light finishing cut all around will compensate for errors due to wheel wear.

The centers as illustrated in Fig. 31 swing work to 8″ diameter overtable; 6″ under wheel. Centers have reversible tongues for T-slots ½″ or 9/16″ wide.

Work Head Raising Block

This raising block is for use under the work head when a flaring cup wheel is used to grind secondary angles on the end teeth of end mills (Fig. 32) or for sharpening large diameter cutters.

A knurled thumbscrew at the front of the block is used to bring the tongues against the front edge of the machine T-slot for accurate alignment. Two T-bolts secure it to the machine table.

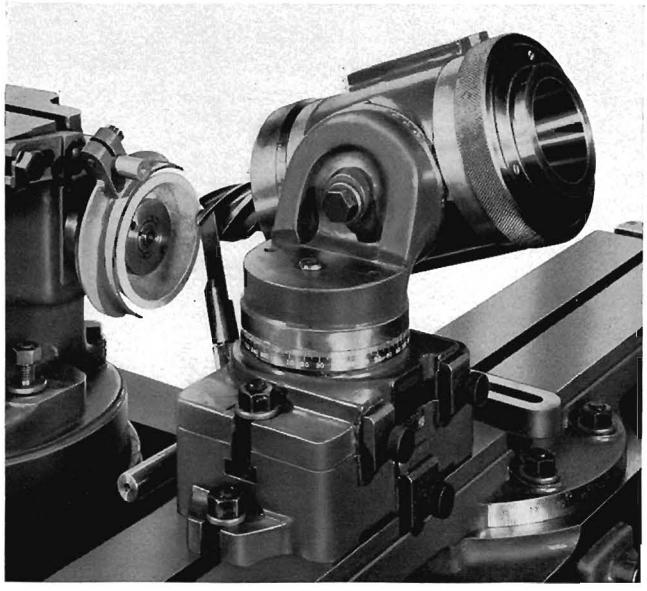


Fig. 32. Sharpening the secondary angle on the end teeth of a left-hand end mill using the work head and raising block.

No. 1 Adjustable Vise

This vise (Fig. 33) has tongues for aligning on either the machine table or the tool rest furnished with the machine. Thus, it may be used with the jaws either parallel with, or at right angles to the table T-slot. The vise proper is mounted on a hinged base and can be set and clamped at any angle in the vertical plane up to 90°, a dial graduated to degrees indicating the setting.

The removable jaws are of tool steel, hardened and ground, 4⅛″ wide and 1 1/16″ deep, and open 2″. Distance from bottom of base to top of jaws with vise horizontal is 4 7/16″.

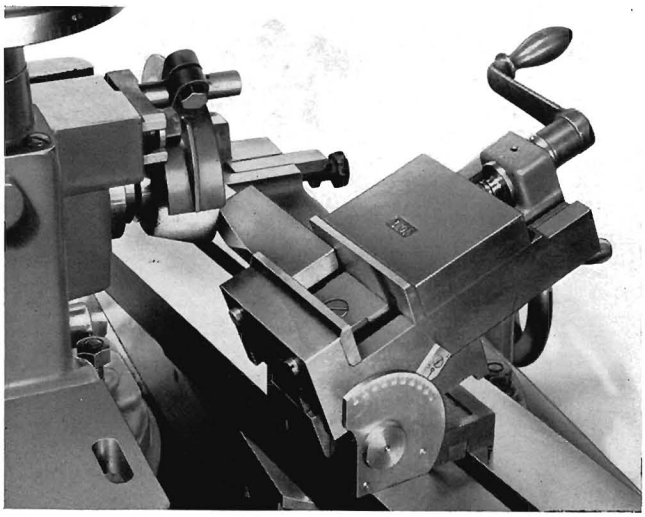
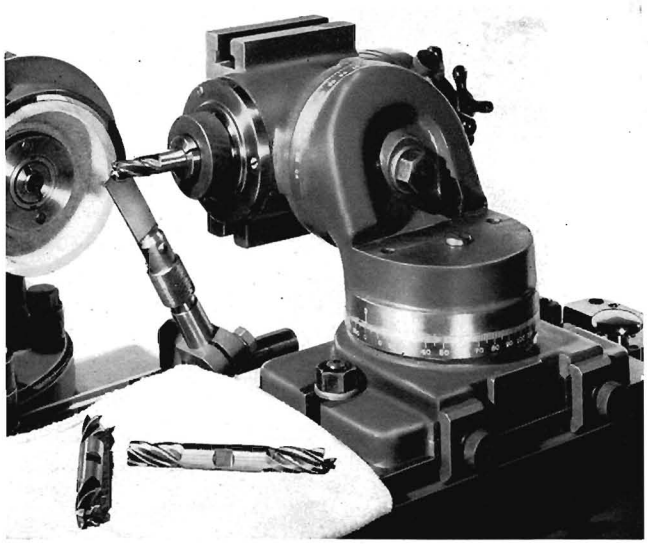


Fig. 33. Grinding an accurate compound angle is simple with this attachment. The vise is set at one angle and the swivel table at the other.

No. 10N End Mill Sharpening Attachment

Designed for sharpening both the peripheral and end teeth of end mills, this attachment (Fig. 34), is of particular value in sharpening the peripheral teeth of steep spiral end mills having straight or taper shanks. For the latter work, a knob at the rear end of the attachment spindle makes it an easy matter to hold the tooth being ground in contact with the tooth rest while feeding the cutter across the wheel by longitudinal table movement; and mounting of the spindle on antifriction bearings provides a sensitive, free-turning unit that is of especial advantage when sharpening very small end mills having a steep spiral.

Fig. 34. Double-end end mills are quickly and easily sharpened using the No. 10N End Mill Sharpening Attachment.



The attachment spindle is carried in a body which is easily mounted on the work head knee and permits an angular setting reading in degrees to 90° each side of zero in the vertical plane, and 360° in the horizontal plane, with rigid clamping provided for both adjustments. The spindle itself has a setting in degrees to 20° either side of zero for sharpening spiral end mills when using a flaring cup wheel.

Zero marks 180° apart on the spindle body provide for sharpening both right-hand and left-hand cutters.

End mills having a No. 9 B & S taper shank will fit directly into the attachment spindle; while cutters having shanks of other B & S tapers, as well as cutters with M. M. Std. taper shanks and straight shanks, are accommodated by stock collets and adapters regularly available at extra cost. A draw-in bolt can be furnished for use with spring collets for holding straight shank end mills.

Collets for No. 5 or No. 7 B&S Taper Shanks

End mills having No. 5 or No. 7 B & S taper shanks are conveniently held by means of these collets. A shoulder on each collet permits it to be held in place by the knurled nut on the end of the attachment spindle when the end mill is removed. Each collet is available separately.

No. 10N Face Mill Sharpening Attachment

This attachment (Fig. 35) is designed primarily for grinding the periphery, sides and corners of teeth of face milling cutters up to 18" diameter. Its sturdy construction assures the rigidity necessary to support the heavier cutters.

The spindle, mounted in antifriction bearings, is exceptionally free-moving and accurate, and may be clamped by means of a thumbscrew. A No. 12 B&S taper hole is provided in one end and a No. 50 M. M. Std. taper hole in the other, thus suiting the attachment for a wide range of work.

To provide for clearance on side teeth when grinding with a cup wheel, the spindle body has an angular adjustment in a vertical plane to 15° each side of zero, by scales reading to degrees. Clearance on peripheral teeth is set by means of an integral clearance gage (shown at left end of attachment spindle), graduated in degrees to 15° each side of zero.

The spindle body and swivel bracket are mounted on a substantial base which is tongued for accurate alignment and is bolted to the machine table. Graduations in degrees on the circumference

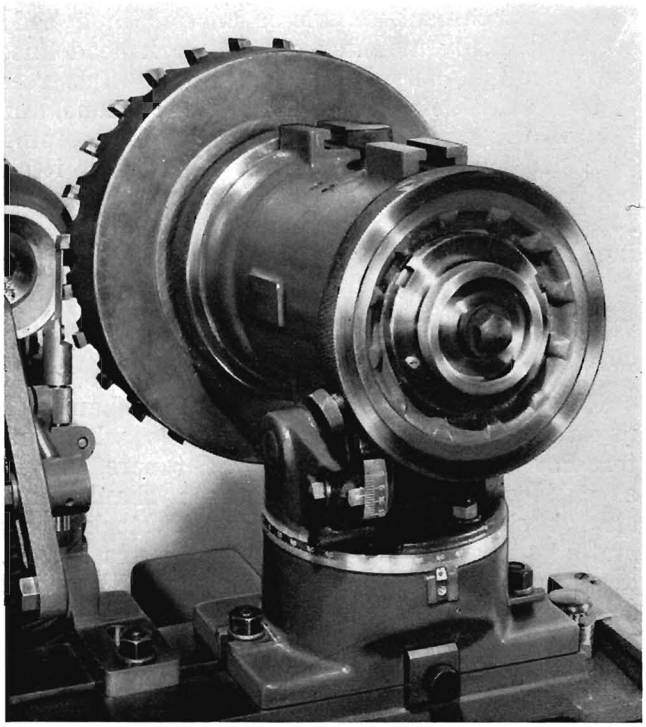


Fig. 35. Sharpening sides of teeth of a face milling cutter using the No. 10N Face Mill Sharpening Attachment. The spindle body is swiveled vertically the amount desired for proper clearance, the setting being read directly from a vertical scale, graduated to degrees.

of the swivel bracket to 90° each side of two opposed zero marks permit setting to any angle in the horizontal plane.

Included in the equipment furnished are a work holding arbor (No. 50 M. M. Std. taper), a draw-in bolt (threaded, 1″-8-N.C., R.H. and ⅝″-11-N.C., R.H.), four cutter holding screws and an arbor screw and wrench. Additional arbors, collets and adapters listed in our catalogs are available at extra cost for handling a variety of styles and sizes of cutters.

No. 10N Radius Grinding Attachment

The Radius Grinding Attachment (Fig. 36) is designed for grinding convex cutter teeth up to 4½″ radius, concave cutter teeth up to 2″ radius, the radii on the corners of cutter teeth, and similar operations.

The attachment consists of a base and swivel on which are mounted two adjustable slides at right angles to each other. The upper, or work slide, has a crosswise adjustment on the lower or work slide base and this in turn has a lengthwise adjustment on the swivel.

The swivel swings on a central stud which is hardened and ground. Adjustable stops control the arc of swing.

The work slide base is provided with an arrangement for fine adjustment and a scale on the side, graduated to 64ths of an inch, indicates the setting.

The work slide is provided with a scale graduated to 64th of an inch which indicates the position of a taper shank holder up to 2″ either side of the center of the work slide. A fine adjustment is provided for the work slide by screws 8, Figs. 37 and 38.

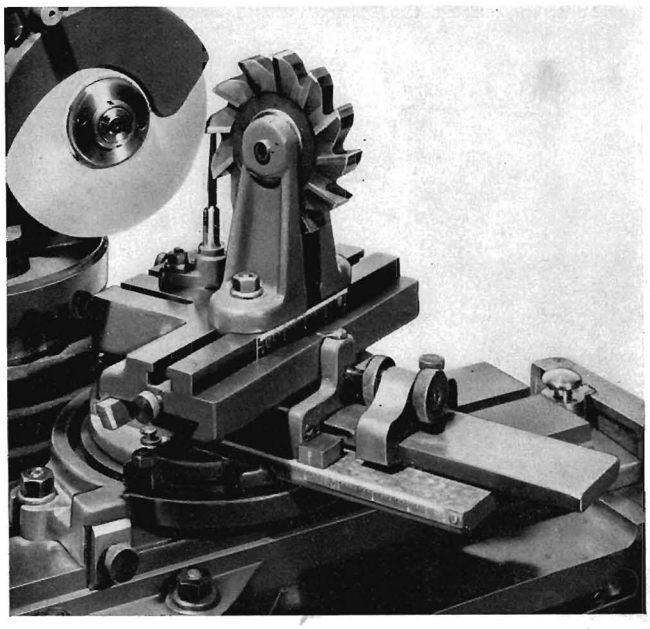
The work holders take 5″ in length and swing 8″ in diameter. A spring washer is provided to hold the work against the positive holder. The washer can be depressed to allow the work to be indexed when the form is a half-circle and will not swing clear of the wheel.

The taper shank holder has a bushing with a No. 10 taper hole and is used for grinding radii on end mills and shank cutters.

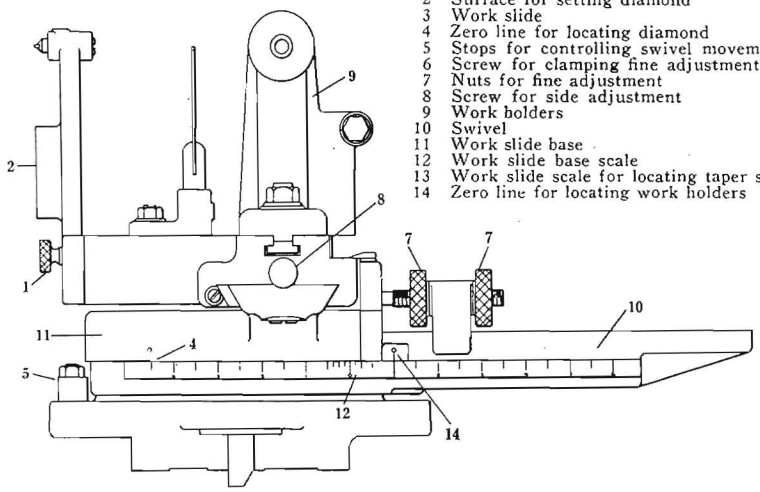
The diamond holder, a detachable bracket on the front of the work slide, in addition to providing a means for truing a radius on the wheel when a formed wheel is desired, provides a means of locating the face of the wheel in position in relation to the center of the pivot of the attachment. This distance from the face of the wheel to the pivot of the attachment is, of course, the radius to be ground on the cutter and is indicated on the work slide base scale 12, Fig. 37, by zero line 4.

When zero line 4 is in line with the zero on the work slide base scale 12, the surface 2 on the diamond holder bracket is directly over the pivot and this surface is used for locating the diamond point.

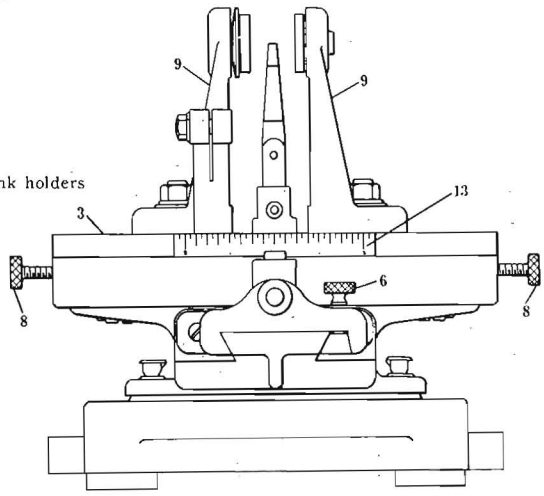
Fig. 36. Grinding an accurate radius on the corners of the teeth of a milling cutter using the No. 10N Radius Grinding Attachment.



1 Screw for fastening diamond holder in position
2 Surface for setting diamond
3 Work slide
4 Zero line for locating diamond
5 Stops for controlling swivel movement
6 Screw for clamping fine adjustment
7 Nuts for fine adjustment
8 Screw for side adjustment
9 Work holders
10 Swivel
11 Work slide base
12 Work slide base scale
13 Work slide scale for locating taper shank holders
14 Zero line for locating work holders



Side Elevation
Fig. 37



Rear Elevation
Fig. 38

Radius Grinding Attachment

After the wheel has been located in proper relation to the pivot the diamond holder bracket is removed.

This relative position between the wheel and pivot is changed only by wear of the wheel or adjustments of the machine. Adjustments in the attachment itself do not affect it. (See Fig. 39.)

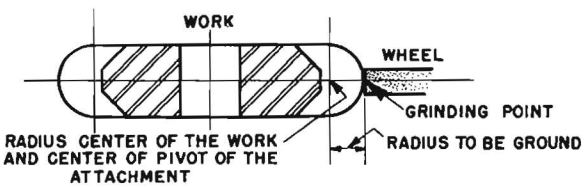


Fig. 39. Relation between work, wheel and pivot of attachment.

The position of the grinding point in relation to the pivot of the attachment must be maintained during the grinding operation. Thus, as the grinding operation progresses and the work and wheel are reduced in size, adjustments must be made on both work and wheel. These adjustments of the work are always made on the work slide base 11, Fig. 37, by means of the fine feed arrangement provided by fine feed nuts 7.

Adjustments of the wheel are always made through the hand adjustments of the machine.

The above applies to both convex and concave work, the only difference being that adjustments of the wheel and work slide base for convex work are in the opposite directions to adjustments for concave work.

All work that can be ground on the attachment falls into one of the four different classes shown in Fig. 40.

In all cases the work slide base is adjusted to bring the work to the wheel, after which the work slide is adjusted to bring the radius center of the work over the pivot of the attachment. In the case of a shank cutter with spherical end, shown at *C*, Fig. 40, the work slide scale and zero line on the taper shank holder are used to bring the radius center of the work over the pivot of the attachment, for the axis of the cutter passes through the radius center in this case.

After the work and wheel have been brought together at the grinding point, the grinding proceeds as described. Further adjustments of the work and wheel are made as the work and wheel are reduced in size due to grinding.

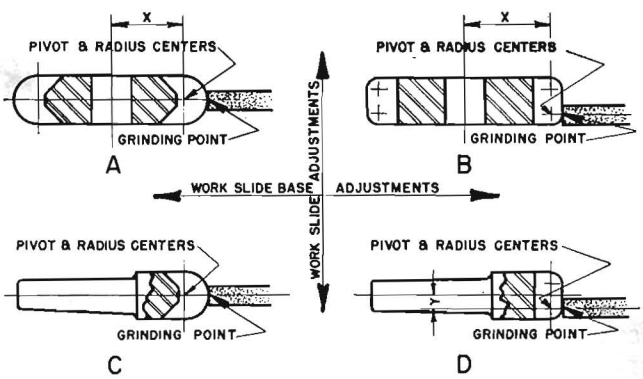


Fig. 40. Classes of work ground with the Radius Grinding Attachment.

Method of Adjustment

If the wheel face is to be trued to a radius—

First: Set the wheel spindle to the same height as the center of the work, using the center gage on top of the wheel spindle slide.

Place the diamond holder in position and fasten securely with thumb screw 1, Fig. 37. (It is important that the diamond be on a line with the surface 2. A straight edge can be used in making this adjustment.)

Next, set the work slide base 11 to the radius required using zero line 4. The most convenient method to employ in making this adjustment is as follows: Loosen clamp screw 6, Fig. 38, move the slide until the zero line is approximately correct: tighten screw 6 and adjust the nuts 7 until the zero line 4 coincides with the reading of the scale for the required radius. To true a convex wheel the zero line 4 should be moved to the right of the zero on the scale and to true a concave wheel, it should be moved to the left.

With the wheel spindle parallel to the table ways move the wheel transversely until it nearly touches the diamond.

Lock the table of the machine by means of the table stop and adjustable dogs to prevent longitudinal movement. Start the grinding wheel and move the wheel towards the diamond until it begins to cut, then swivel the work slide base and feed the wheel to the cut until the wheel is trued to the required radius.

If the wheel is to be trued with a straight face—proceed as in regular truing.

Another method of truing the wheel either to a radius or with a straight face may be employed. In this method, the wheel spindle is set at right-angles to the table and the diamond fed to the wheel by the table feed. *If the wheel face is to be trued to a radius* the attachment is swiveled as the diamond is fed to the wheel by the table feed.

If the wheel is to be trued to a straight face the swivel is locked in a central position by means of the adjustable stops and the wheel moved back and forth past the diamond by means of the transverse feed of the machine.

After the wheel is trued, release screw 6, Fig. 38, draw back the work slide and remove the diamond holder. Do not change the vertical adjustment of the wheel after truing except as noted in the following paragraphs.

With the cutter in position and the tooth rest set, feed the work slide base forward until the cutter nearly touches the wheel. It is important that the cutter be located on the work slide to bring the center of the radius to be ground directly over the center of the pivot of the lower slide as shown in the diagrams in Fig. 40. For example: To set a convex cutter, swivel the attachment to bring first one side and then the other toward the wheel and using the work slide adjustment, move the cutter sideways until each side shows the same distance from the wheel.

The work should then be brought forward again until it just touches the wheel. The wheel slide should now be raised the proper amount to give the desired clearance on the teeth.

To compensate for this adjustment of the wheel slide the table of the machine should be adjusted so as to bring the work forward until it again just touches the wheel.

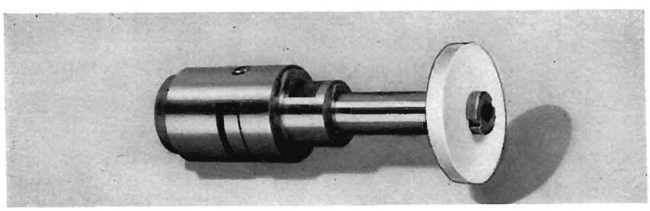
Now adjust the work slide base so the work will just clear the wheel and set the stops 5, Fig. 37, to control the swivel movement of the attachment. Tighten screw 6, start the wheel, and feed the cutter to the wheel by means of the nuts 7. Should the radius obtained not be correct, move the machine table to compensate for the inaccuracy. As the grinding progresses both work and wheel must be adjusted as explained above to maintain the proper distance from the center of pivot to grinding point.

To grind a radius on the corner of a cutter tooth, as shown at *D* in Fig. 40, the taper shank holder should be set off the center so that the reading of the work slide scale will be equal to the distance *Y* from the radius center to the axis of the cutter. A fine feed for final adjustment is provided by screws 8, Figs. 37 and 38. The axial adjustment of the cutter is obtained by bringing the end of the cutter to the wheel.

When setting work on the attachment such as shown at *A* and *B*, Fig. 40, the swivel scale and zero line 14 may be used, the distance *X* being indicated on the scale.

Wheel Arbors—Nos. 101 and 102 (Fig. 41) for mounting small wheels can be furnished at extra cost. A wheel arbor and small wheel are used to prevent interference with the cutter while grinding with the No. 10N Radius Grinding Attachment. Arbor No. 101 is for use on the right-hand end of the machine wheel spindle and No. 102 is for use on the left-hand end. Each arbor is furnished with a wheel 2″ diameter, ¼″ thick, with a ¼″ hole.

Fig. 41. Wheel Arbors Nos. 101 and 102.



CHAPTER IV

Grinding Wheels and How to Select Them

Grinding wheels are made of crushed abrasive or cutting grit held together by a substance know as the bond.

Abrasive. The most common abrasives are aluminum oxide and silicon carbide.

Aluminum oxide crystals, though not particularly hard, are tough and hence are usually preferred for grinding materials of high tensile strength such as alloy and high-speed steels. This abrasive is known by such trade names as Aloxite, Alundum, Borolon and others.

Silicon carbide crystals are very hard but quite brittle; hence wheels of this material are used in grinding easily-penetrated materials such as copper, rubber and celluloid, and hard materials of low tensile strength such as cast iron and cast bronze. This abrasive is known by the trade names Carborundum, Crystolon, Electrolon and others.

Bond. Differences in bond give the grinding wheels varied characteristics.

Vitrified clay is the bond most commonly used. Wheels of this type are usually preferred for general production and toolroom grinding, for they are unaffected by heat, cold, water and oils and have many other advantages. They are usually not as strong as wheels of other bonds, however, and have practically no elasticity; consequently it is not advisable to attempt a heavy side cut with wheels of this type.

Silicate or semi-vitrified wheels (bonded with sodium silicate) as a rule cut smoothly and with little heat, hence are suitable for work requiring a delicate edge such as cutter or tool grinding.

Shellac forms a strong bond, and very thin wheels made of it are safe. These wheels produce a smooth finish and deep side cuts can be taken.

Rubber forms a bond of great strength, and wheels bonded with this material are used to cut grooves and for similar work.

Grain. This term refers to the size of the particles of abrasive used in the wheel. A 46-grain wheel, for example, is made of abrasive that will just pass through a screen having 46 meshes or openings per linear inch.

Several sizes of abrasive are often combined to produce a wheel of special characteristics. Such a wheel is called a *combination* wheel.

The grains commonly used for cutter and tool grinding range from 60 to 120. For rough grinding, when the finish is not important, coarse-grain wheels are used. When the finish is more important or the surface to be ground is narrow and requires a sharp edge, fine-grain wheels are used. Combination wheels usually cut fast yet leave a good finish.

Wheel Structure. This term refers to the spacing between the abrasive particles in the wheel. Since the chips produced from soft, ductile materials will be relatively large, a wheel of open structure is needed in order to give enough chip space to prevent the wheel from becoming loaded; while hard, brittle materials, yielding smaller chips, are ground most efficiently with a wheel of denser structure. In most cases a wheel of medium structure will be satisfactory, although a change in structure may often result in better grinding and longer wheel life.

Grade. Wheels from which the grit is readily torn are known as soft bond or soft grade wheels, while those that strongly retain the grit are called hard bond or hard grade. Note that the term *grade* refers to the breakdown resistance of the wheel and not to the hardness of the abrasive.

The grade of grinding wheels is usually designated in accordance with Grinding Wheel Manufacturers' Association standards.

In general, hard grade wheels are used in grinding soft steel and similar metals and soft grade wheels are used on the very hard metals. Also, the greater the contact between work and wheel the softer the grade should be. The faster a wheel runs, the harder it will act.

Selection of Grinding Wheels

As indicated above, a most important consideration in the selection of grinding wheel is the nature of the material to be ground. Surface speeds of wheel and work, amount of material to be removed, and accuracy and quality of finish desired are also matters to be considered.

The abrasive, grain, structure, grade and bond of the wheels regularly furnished with the Brown & Sharpe No. 10N Cutter and Tool Grinding Machine are such as to suit these wheels to general-purpose grinding. However, the material, finish requirements or volume of work may often make desirable the use of a wheel more perfectly suited to the particular job at hand. The various wheel manufacturers publish literature which will be of particular help in selecting grinding wheels of their own make; or, if desired, all details of the grinding operation may be submitted to the wheel manufacturer for advice and recommendations.

Maintenance

CHAPTER V

Installing or Relocating the Machine

In lifting or moving the machine it is recommended that the rope be rigged as shown in Figs. 42 and 43. Place wooden blocks between the rope and the machine wherever the rope is liable to damage any part.

Given a firm and level floor, this machine can be located wherever most convenient, no special foundation being necessary. It is well, however, not to set the machine too near a source of heavy vibration; and a rigid floor is essential to good work.

When the machine has been positioned on the floor, the lag screws should be screwed down until they are nearly tight. Drive an ordinary wooden shingle under any corner (or corners) of the machine that may be low, until a spirit level placed on top of the table shows the table to be level both longitudinally and trasversely; then bring the screws up solidly. It is well, after tightening, to test the table surface once more, as the tightening may throw the machine slightly out of level.

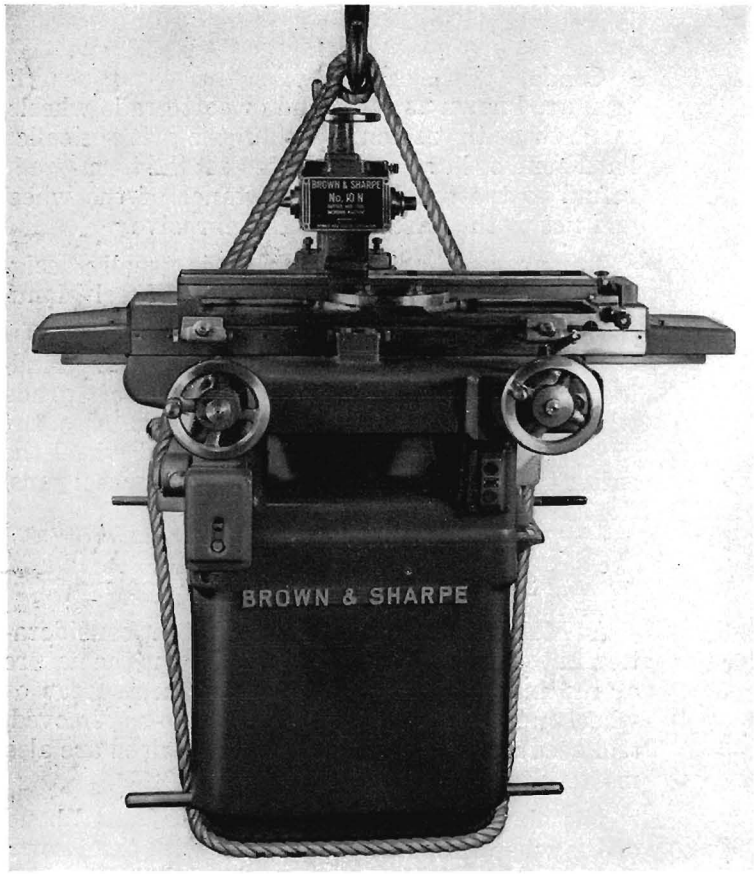


Fig. 42. Proper method of rigging machine.

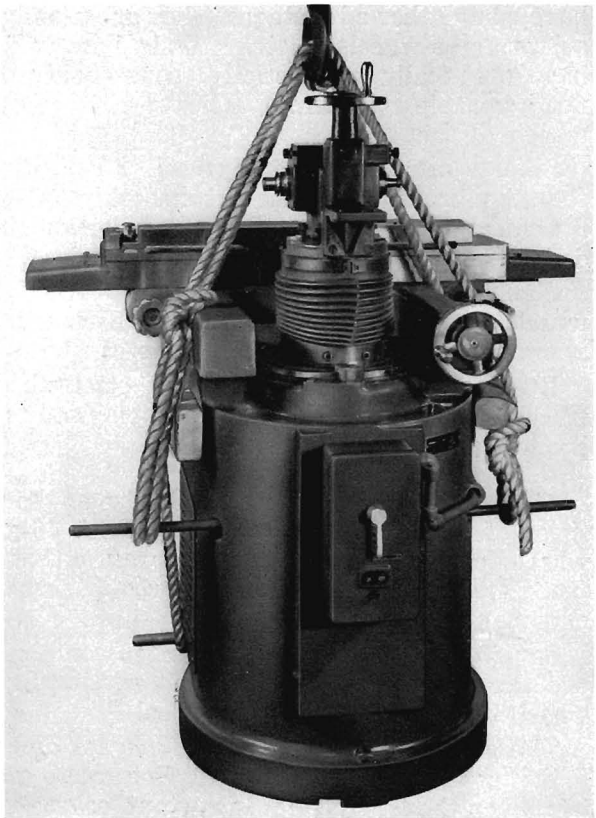


Fig. 43. Rear view of machine.

Wheel Spindle

This spindle unit has the spindle mounted on super-precision, preloaded antifriction bearings. Sealed lubrication is used and the spindle's cool running temperature is quickly reached. The unit is sealed and requires no additional lubrication after it leaves our factory. As dirt cannot enter past the seal, this spindle has a long trouble-free life.

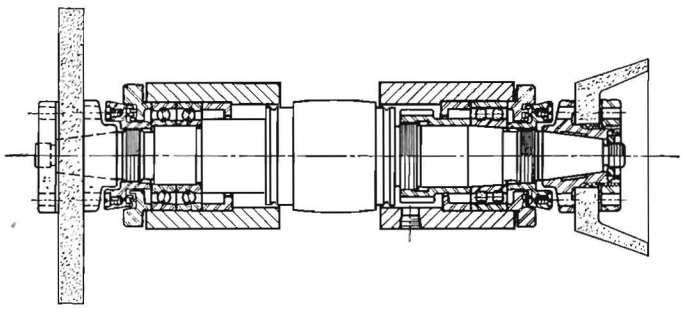


Fig. 44. Section through antifriction bearing wheel spindle with sealed lubrication.

Lubrication. All the spindle bearings are packed with a special grease at our factory and the unit requires no further lubrication.

Maintenance. Because of the extreme care required in disassembling and reassembling this spindle, we strongly recommend that any Spindle Unit which needs repair be returned to our factory for reconditioning.

Care and Overhaul

Keep Machine Clean. All bearing surfaces exposed to dust, dirt, or grit should be cleaned frequently, to prevent scoring and excessive wear. The table top, wheel spindle head and other bearing surfaces should be kept clean of dirt and grit.

Overhaul. After any machine tool has been in active service for a considerable period (depending on conditions of service), it is advisable, in the interest of accuracy and economy, to clean and inspect it thoroughly. This requires that the machine be taken apart to some extent, as it is impossible to reach some of the more important bearings (such as the table and carriage ways) in any other way.

Because of the danger of parts being put together incorrectly and alignments being made imperfectly, only good mechanics who thoroughly understand the construction of the various parts, should be permitted to take apart and reassemble the machine. The latter part of this book which contains the "Repair Parts" should be helpful to the mechanic assigned to this job.

Connecting to Power Supply. The electrical circuit is connected with the power supply through the switch box at the rear of the base and for safety reasons the electrician should ground the machine.

Checking Motor Rotation. Before running a newly-connected machine, check the motor rotation as follows:

Press the Start button, immediately press the Stop button and observe the direction of rotation of the wheel spindle. The spindle should rotate clockwise as seen from the left side of the machine. If the direction of rotation is counterclockwise, reverse one phase of the power supply. (This is conveniently done by transposing two of the wires in the switch box.)

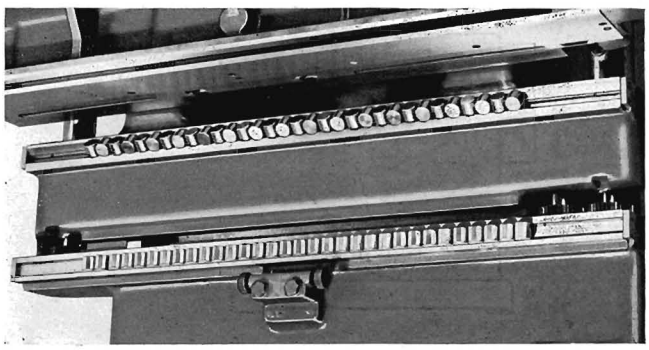


Fig. 45 Unique arrangement of precision-ground rollers gives exceptionally easy table movement.

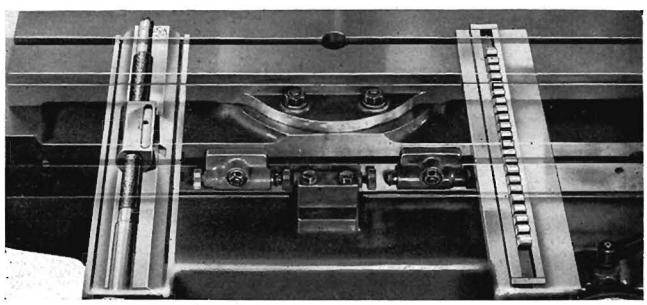


Fig. 46. Carriage is mounted on one V and one flat way. Precision-ground rollers on flat-way reduce friction to the minimum. This together with location of the transverse movement screw directly above the V-way, eliminates any tendency of the carriage to "twist" on its ways. Also gives absolute protection against grit.

Table and Carriage Rolls. The sliding table rests on 64 precision ground rollers. The rolls at the front of the table are mounted in a flat channel while those at the rear are in a V channel.

The carriage is mounted on a V-way below the cross feed screw on the left, while at the right it

rests on 22 precision ground rollers mounted in a flat channel, thus any tendency of the carriage to "twist" on its ways is eliminated. Due to this construction, the wear which may occur with time is distributed evenly to the bearing surfaces. Therefore maintenance of the sliding table is held to a minimum and extensive repairs are not necessary.

Lubrication

Following is a lubrication diagram which shows the location of oil cups, points to be greased and when to service them under ordinary conditions. A machine which has not been run for some time will probably require more frequent attention for a while than the diagram calls for.

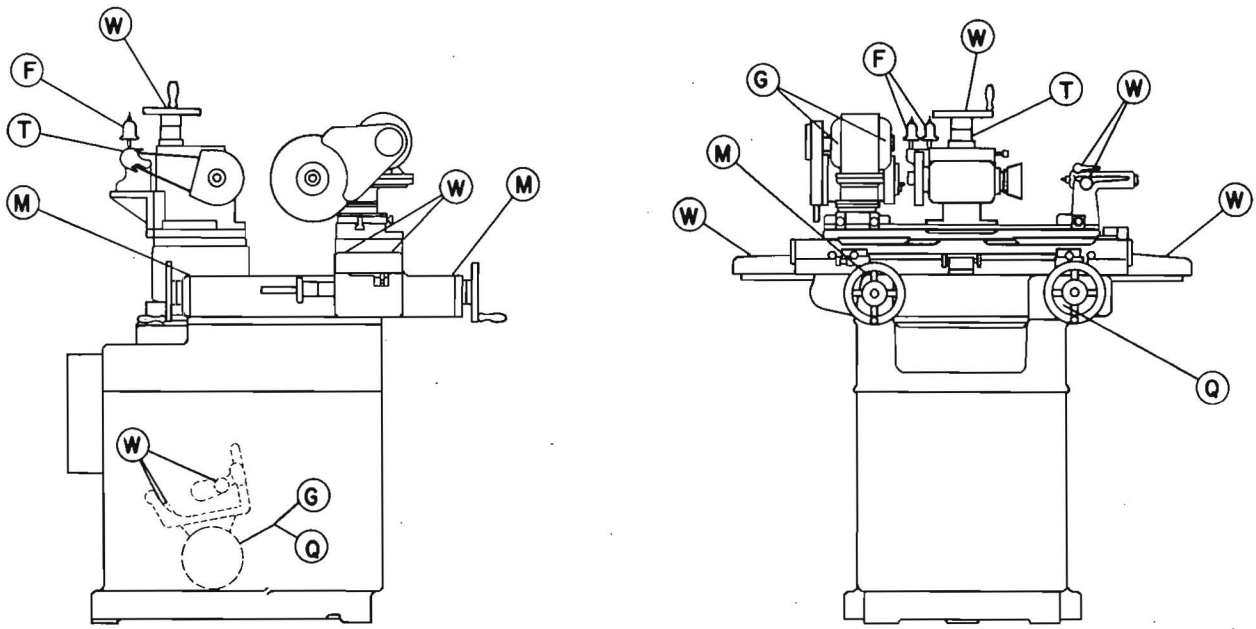


Fig. 47. Lubrication Diagram.

T—Oil twice daily—good grade machine oil 300 S.S.U. at 100°F.

W—Oil weekly good grade machine oil 300 S.S.U. at 100°F.

F—Fill when necessary—good grade spindle oil 100 S.S.U. at 100°F.

M—Oil monthly good grade machine oil 300 S.S.U. at 100°F.

Q—Inspect every month—fill when necessary—good grade machine oil 300 S.S.U. at 100°F.

G—Clean & grease every two years (ball bearing motors)—good grade ball bearing grease.

Tables

Cutter Clearance (Peripheral Teeth)

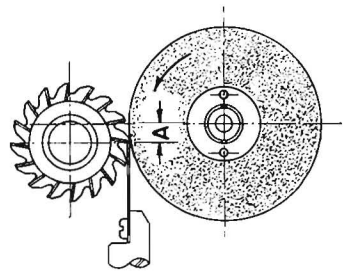
The clearance angles listed at right have been found most suitable for average conditions when milling cast iron and steel.

On non-ferrous materials such as brass, aluminum, and magnesium alloys, these angles should be approximately doubled.

Cutter Diam., Inches	Clearance Angle	Cutter Diam., Inches	Clearance Angle
¼	10°	2	6°
½	8°	3	5°
1	7°	over 3	4°

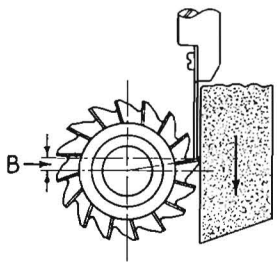
Straight Wheel Clearance Table

Diameter of wheel (Inches)	"A" for Clearance Angle of						
	4°	5°	6°	7°	8°	10°	12°
3	.105	.131	.157	.183	.209	.260	.312
3¼	.113	.142	.170	.198	.226	.282	.338
3½	.122	.153	.183	.213	.244	.304	.364
3¾	.131	.163	.196	.229	.261	.326	.390
4	.140	.174	.209	.244	.278	.347	.416
4¼	.148	.185	.222	.259	.296	.369	.442
4½	.157	.196	.235	.274	.313	.391	.468
4¾	.166	.207	.248	.289	.331	.412	.494
5	.174	.218	.261	.305	.348	.434	.520
5¼	.183	.229	.274	.320	.365	.456	.546
5½	.192	.240	.287	.335	.383	.478	.572
5¾	.201	.251	.301	.350	.400	.499	.598
6	.209	.261	.314	.366	.418	.521	.624



"A" = Distance in inches to set wheel spindle center above or below center of work.

Cup Wheel Clearance Table



"B" = Distance in inches to set end of tooth rest above or below center of cutter.

Diameter of Cutter (Inches)	"B" for Clearance Angle of						
	4°	5°	6°	7°	8°	10°	12°
¼	.009	.011	.013	.015	.017	.022	.026
½	.017	.022	.026	.030	.035	.043	.052
¾	.026	.033	.039	.046	.052	.065	.078
1	.035	.044	.052	.061	.070	.087	.104
1¼	.044	.054	.065	.076	.087	.109	.130
1½	.052	.065	.078	.091	.104	.130	.156
1¾	.061	.076	.091	.107	.122	.152	.182
2	.070	.087	.105	.122	.139	.174	.208
2½	.087	.109	.131	.152	.174	.217	.260
3	.105	.131	.157	.183	.209	.260	.312
3½	.122	.153	.183	.213	.244	.304	.364
4	.140	.174	.209	.244	.278	.347	.416
4½	.157	.196	.235	.274	.313	.391	.468
5	.174	.218	.261	.305	.348	.434	.520
5½	.192	.240	.287	.335	.383	.478	.572
6	.209	.261	.314	.366	.418	.521	.624
6½	.227	.283	.340	.396	.452	.564	.676
7	.244	.305	.366	.427	.487	.608	.728
7½	.262	.327	.392	.457	.522	.651	.780
8	.279	.349	.418	.487	.557	.695	.832

Table of Grinding Wheel Speeds

Diameter of Wheel (Inches)	Wheel Speed, R.P.M., for Surface Speed of				
	4000'/min.	4500'/min.	5000'/min.	5500'/min.	6000'/min.
3	5093	5730	6366	7003	7639
4	3820	4297	4775	5252	5730
5	3056	3438	3820	4202	4584
6	2546	2865	3183	3501	3820

PART II

REPAIR PARTS

for

No. 10N CUTTER AND TOOL GRINDING MACHINE

With Universal or Plain

Equipment

For Machines Beginning Serial No. 1459

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

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

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

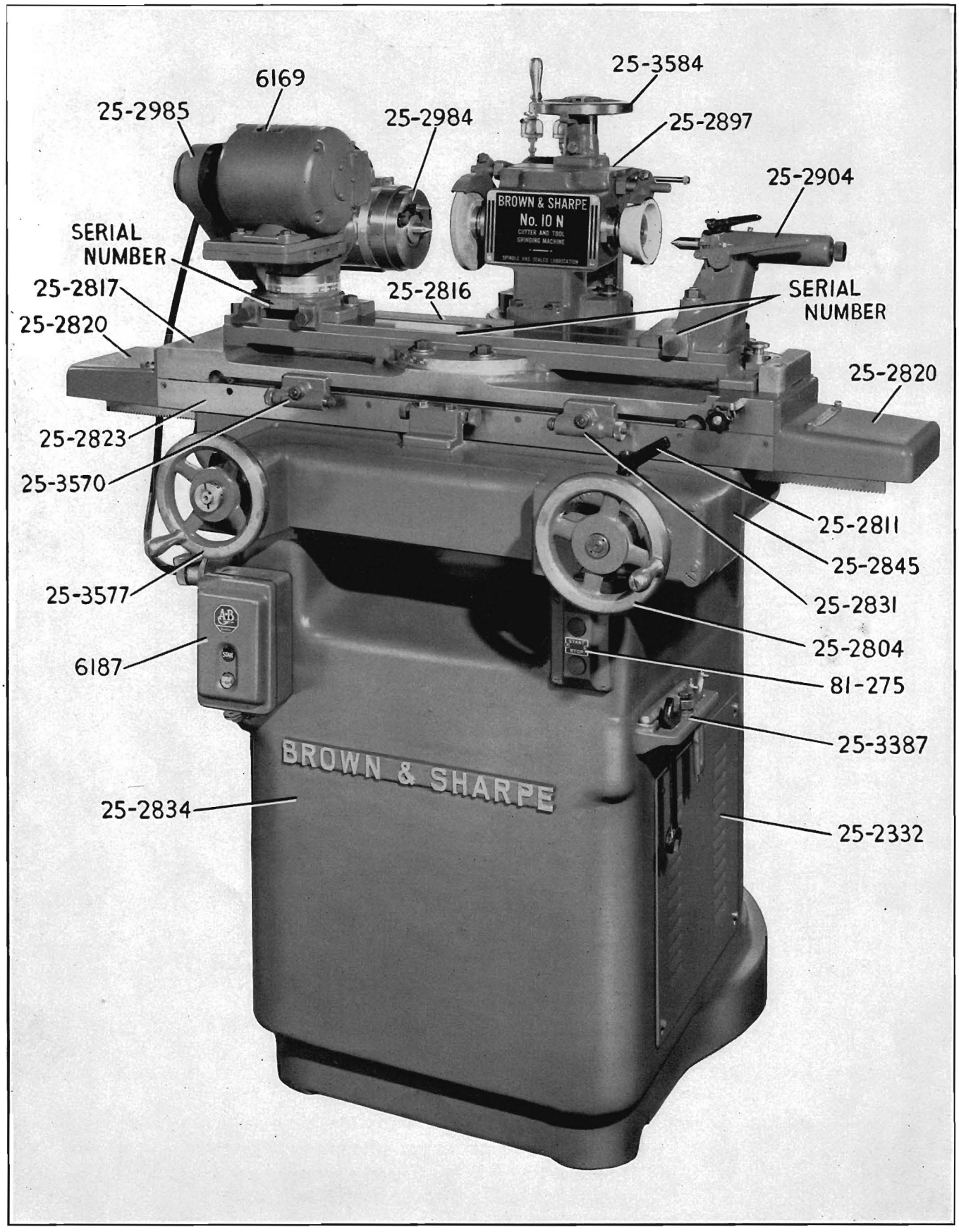
HOW TO ORDER REPAIR PARTS

This information is essential:

1 — Quantity, Part Number and Name

2 — Size and Name of Machine
This will be found on the front of the machine.

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



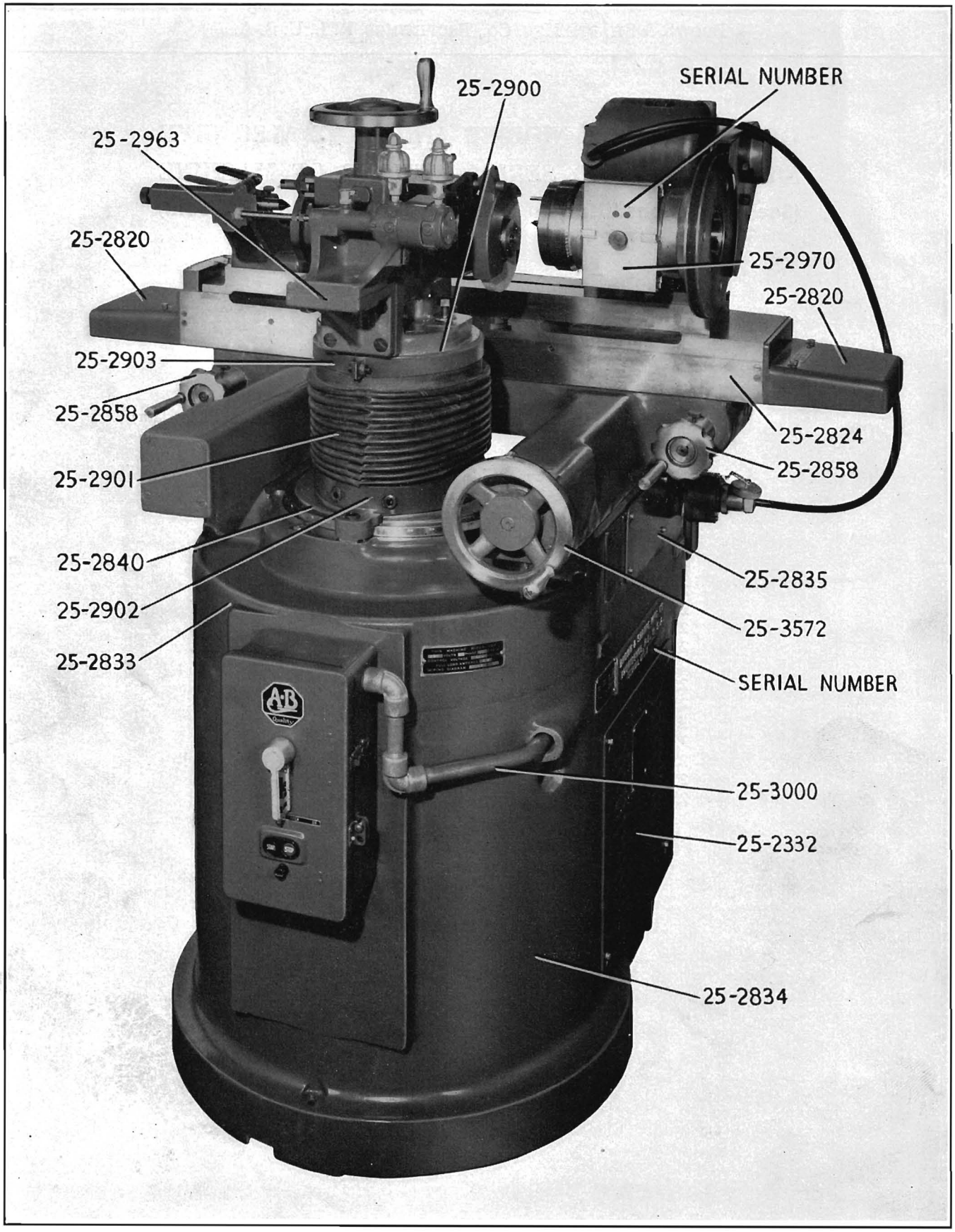
Front View
(Machine with Universal Equipment, Shown)

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE

(See instructions "How to order Repair Parts" in this book.)

Front View

6169	**Headstock Motor** (Give Complete Motor Name Plate Data)
6187	**Hand Switch** (Specify Phase)
25-2332	**Base Cover, Side**
25-2804	**Table 2-Speed Handwheel**
25-2811	**Table 2-Speed Throwout Cam Lever**
25-2816	**Swivel Table**
25-2817	**Sliding Table**
25-2820	**Table Guard**
25-2823	**Table Guard, Front**
25-2831	**Table Dog, Complete Right Hand**
25-2834	**Base**
25-2845	**Carriage**
25-2897	**Wheel Spindle Head**
25-2904	**Footstock**
25-2984	**Work Driving Plate**
25-2985	**Spindle Pulley Belt Guard**
25-3387	**Wrench Rack**
25-3570	**Table Dog, Complete Left Hand**
25-3577	**Cross Feed Handwheel, Front**
25-3584	**Elevating Screw Handwheel**
81-275	**Push Button, Complete**



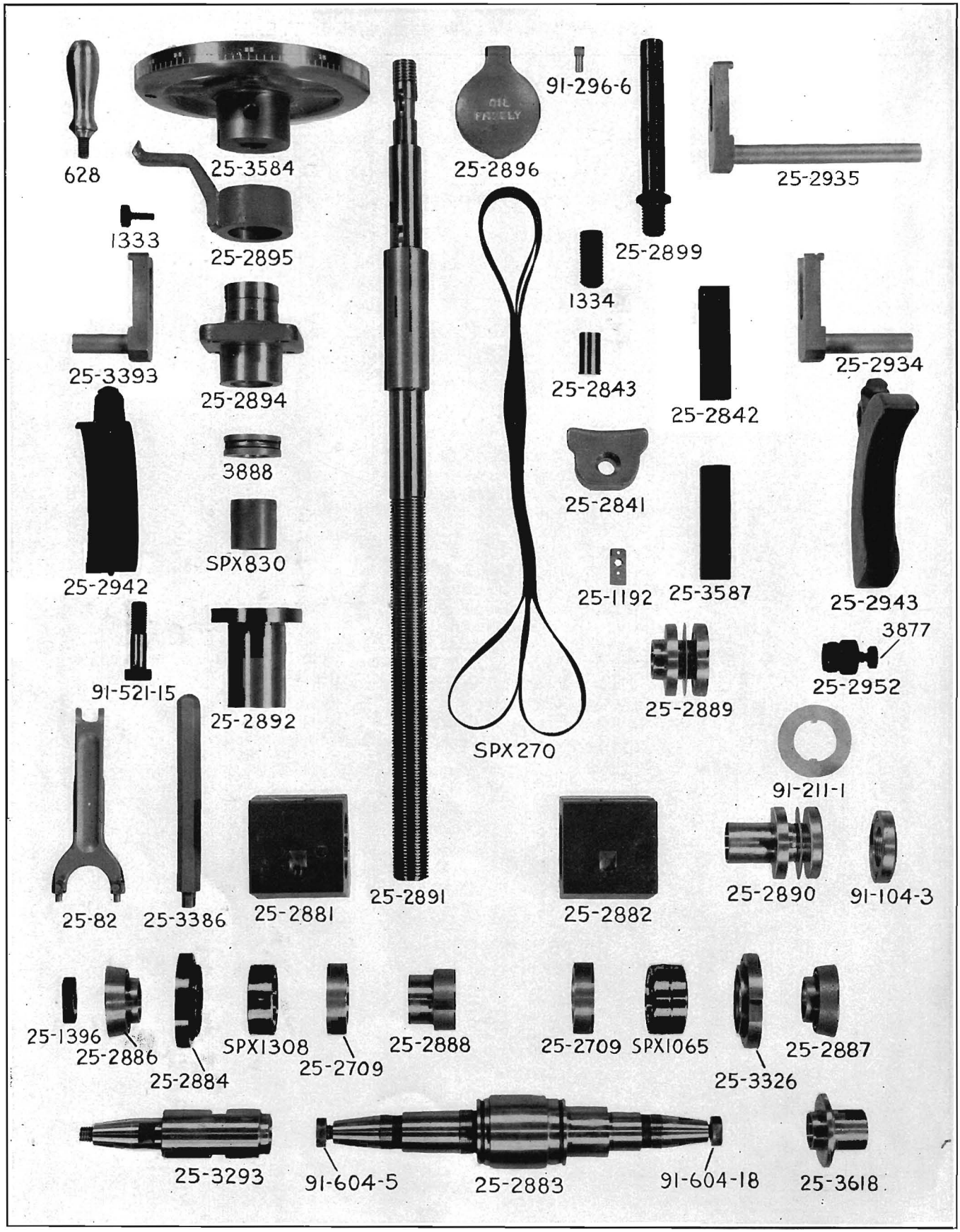
Rear View
(Machine with Universal Equipment, Shown)

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE

(See instructions "How to order Repair Parts" in this book.)

Rear View

25-2332	Base Cover, Side
25-2820	Table Guard
25-2824	Table Guard, Rear
25-2833	Bed
25-2834	Base
25-2835	Bed Opening Cover
25-2840	Wheel Swivel
25-2858	Table Handwheel, Rear
25-2900	Wheel Column
25-2901	Column Guard
25-2902	Column Guard Clamp, Bottom
25-2903	Column Guard Clamp, Top
25-2963	Internal Grinding Fixture Knee
25-2970	Work Head
25-3000	Headstock Conduit
25-3572	Cross Feed Handwheel, Rear



Elevating Mechanism and Wheel Spindle Parts

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

Elevating Mechanism and Wheel Spindle Parts

628	Elevating Screw Handwheel Handle
1333	Elevating Screw Index Finger Clamp Screw
1334	Wheel Column Clamp Screw
3877	Wheel Sleeve Puller Screw
3888	Elevating Screw Thrust Bearing
25-82	Wheel Sleeve Wrench
25-1192	Wheel Swivel Indicator
25-1396	Spindle Extension Clamp Nut
25-2709	Bearing Grease Retainer
25-2841	Wheel Swivel Clamp
25-2842	Wheel Column Guide Shoe
25-2843	Wheel Column Clamp Shoe
25-2881	Roller Bearing Housing
25-2882	Ball Bearing Housing
25-2883	Wheel Spindle
25-2884	Bearing Retainer, Left Hand
25-2886	Roller Bearing Clamp Nut
25-2887	Ball Bearing Clamp Nut
25-2888	Roller Bearing Removing Nut
25-2889	Wheel Sleeve, Complete
25-2890	Wheel Sleeve, Long Complete
25-2891	Elevating Screw
25-2892	Elevating Screw Nut
25-2894	Elevating Index Finger Clamp Bushing
25-2895	Elevating Screw Index Finger
25-2896	Elevating Screw Oil Well Cover
25-2899	Column Swivel Handle
25-2934	Wheel Guard Support, Intermediate
25-2935	Wheel Guard Support, Long
25-2942	Wheel Guard (Type No. 11 Wheel)
25-2943	Wheel Guard (Type No. 1 and No. 12 Wheel)
25-2952	Wheel Sleeve Puller
25-3293	Wheel Spindle Extension
25-3326	Bearing Retainer, Right Hand
25-3386	Wheel Swivel Clamp Wrench
25-3393	Wheel Guard Support, Short
25-3584	Elevating Screw Handwheel
25-3587	Wheel Column Guide Shoe, Back
25-3618	Wheel Spindle Guard
91-104-3	Wheel Sleeve Nut
91-211-1	Wheel Sleeve Washer
91-296-6	Oil Well Cover Pivot Stud
91-521-15	Tooth Rest Holder Bracket Stud
91-604-5	Spindle Nut, Left Hand
91-604-18	Spindle Nut, Right Hand
*SPX270	Spindle Belt
SPX830	Spindle Head Bushing
SPX1065	Spindle Ball Bearing
SPX1308	Spindle Roller Bearing

*Endless Woven Belt 1¼" Wide; Inside Cir. 72½" 4 Ply medium.

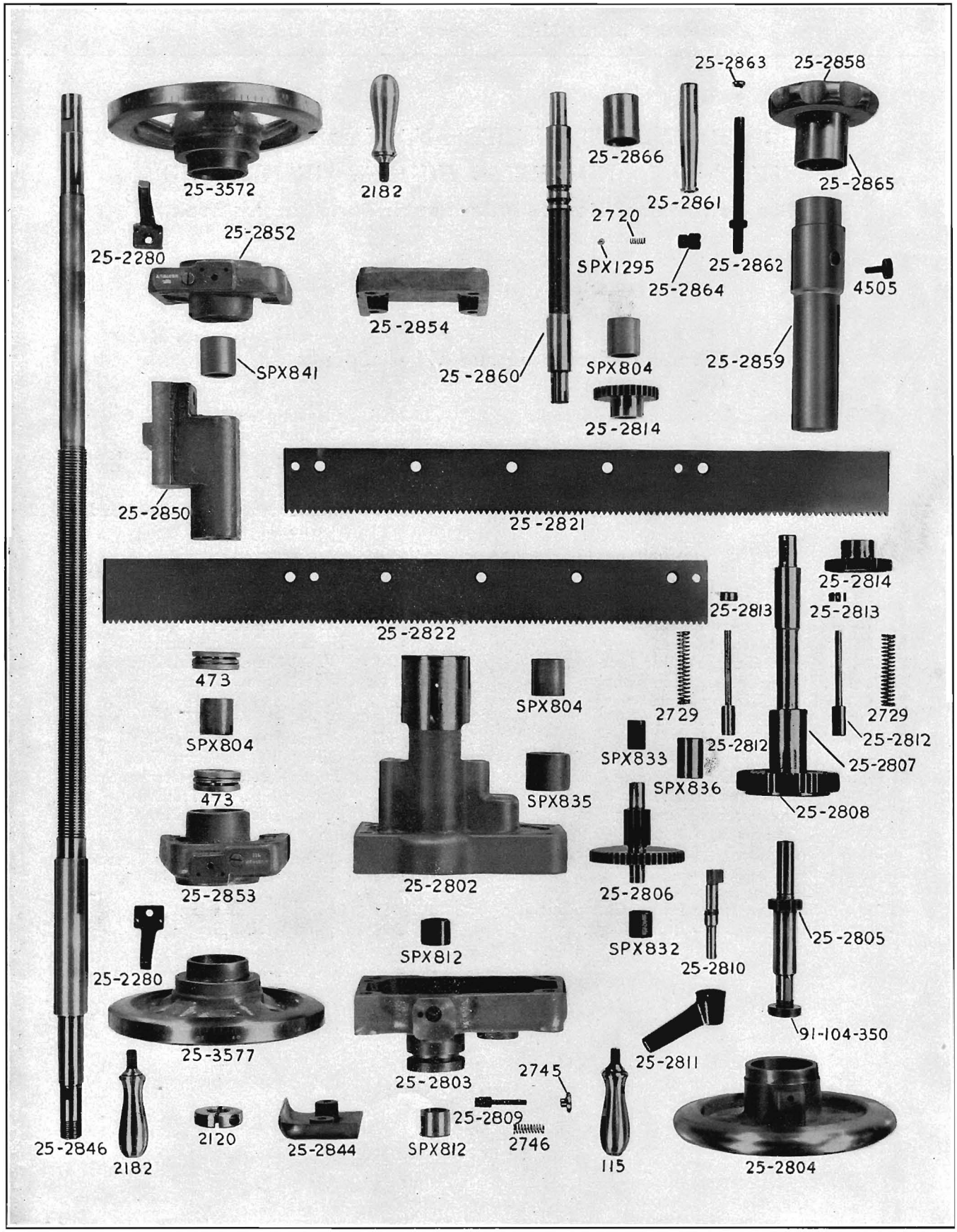


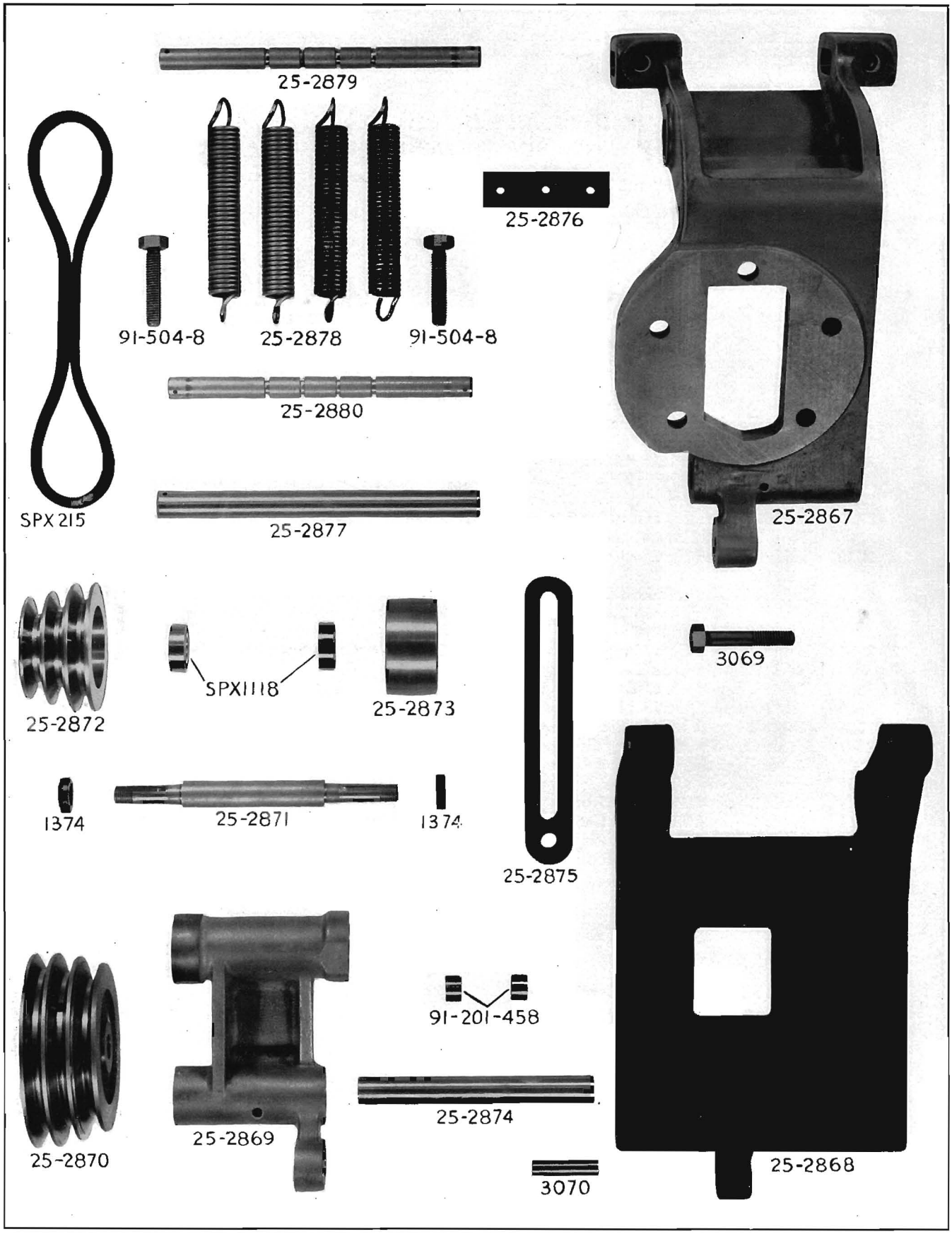
Table and Speed Gear Case Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE

(See instructions "How to order Repair Parts" in this book.)

Table and Speed Gear Case Parts

115	Table 2-Speed Handwheel Handle
473	Cross Feed Screw Thrust Bearing
2120	Cross Feed Handwheel Nut
2182	Cross Feed Handwheel Handle
2720	Table Handwheel Shaft Detent Spring
2729	Table 2-Speed Engaging Plunger Spring
2745	Table 2-Speed Handwheel Plunger Knob
2746	Table 2-Speed Handwheel Plunger Spring
4505	Table Handwheel Shaft Drag Screw
25-2280	Cross Feed Index Finger
25-2802	Table 2-Speed Gear Case
25-2803	Table 2-Speed Gear Case Cover
25-2804	Table 2-Speed Handwheel
25-2805	Table 2-Speed Driving Pinion
25-2806	Table 2-Speed Intermediate Gear
25-2807	Table Low Speed Driving Gear
25-2808	Table High Speed Driving Gear
25-2809	Table 2-Speed Handwheel Plunger
25-2810	Table 2-Speed Throwout Cam
25-2811	Table 2-Speed Throwout Cam Lever
25-2812	Table 2-Speed Engaging Plunger
25-2813	Table 2-Speed Engaging Plunger Collar
25-2814	Rack Pinion
25-2821	Table Rack, Right
25-2822	Table Rack, Left
25-2844	Carriage End Way Cap, Front
25-2846	Cross Feed Screw
25-2850	Cross Feed Screw Nut
25-2852	Cross Feed Handwheel Bearing, Rear
25-2853	Cross Feed Handwheel Bearing, Front
25-2854	Carriage End Way Cap, Rear
25-2858	Table Handwheel, Rear
25-2859	Table Handwheel (Rear) Shaft Sleeve
25-2860	Table Handwheel Shaft
25-2861	Table Handwheel (Rear) Handle
25-2862	Table Handwheel (Rear) Handle Stud
25-2863	Table Handwheel (Rear) Handle Washer
25-2864	Table Handwheel Shaft Detent Holder
25-2865	Table Handwheel (Rear) Dust Guard
25-2866	Table Handwheel Shaft Sleeve Bushing, Outer
25-3572	Cross Feed Handwheel, Rear
25-3577	Cross Feed Handwheel, Front
91-104-350	Table 2-Speed Driving Pinion Nut
SPX804	Cross Feed Handwheel Bearing Front Bushing
SPX804	Gear Case Bushing, Rear
SPX804	Table Handwheel Shaft Sleeve Bushing, Inner
SPX812	Gear Case Cover Bushing
SPX832	Intermediate Gear Bearing, Front
SPX833	Intermediate Gear Bearing, Rear
SPX835	Gear Case Bushing, Front
SPX836	Table Low Speed Driving Gear Bushing
SPX841	Cross Feed Handwheel Bearing Rear Bushing
SPX1295	Table Handwheel Shaft Detent Ball



Motor Bracket Parts

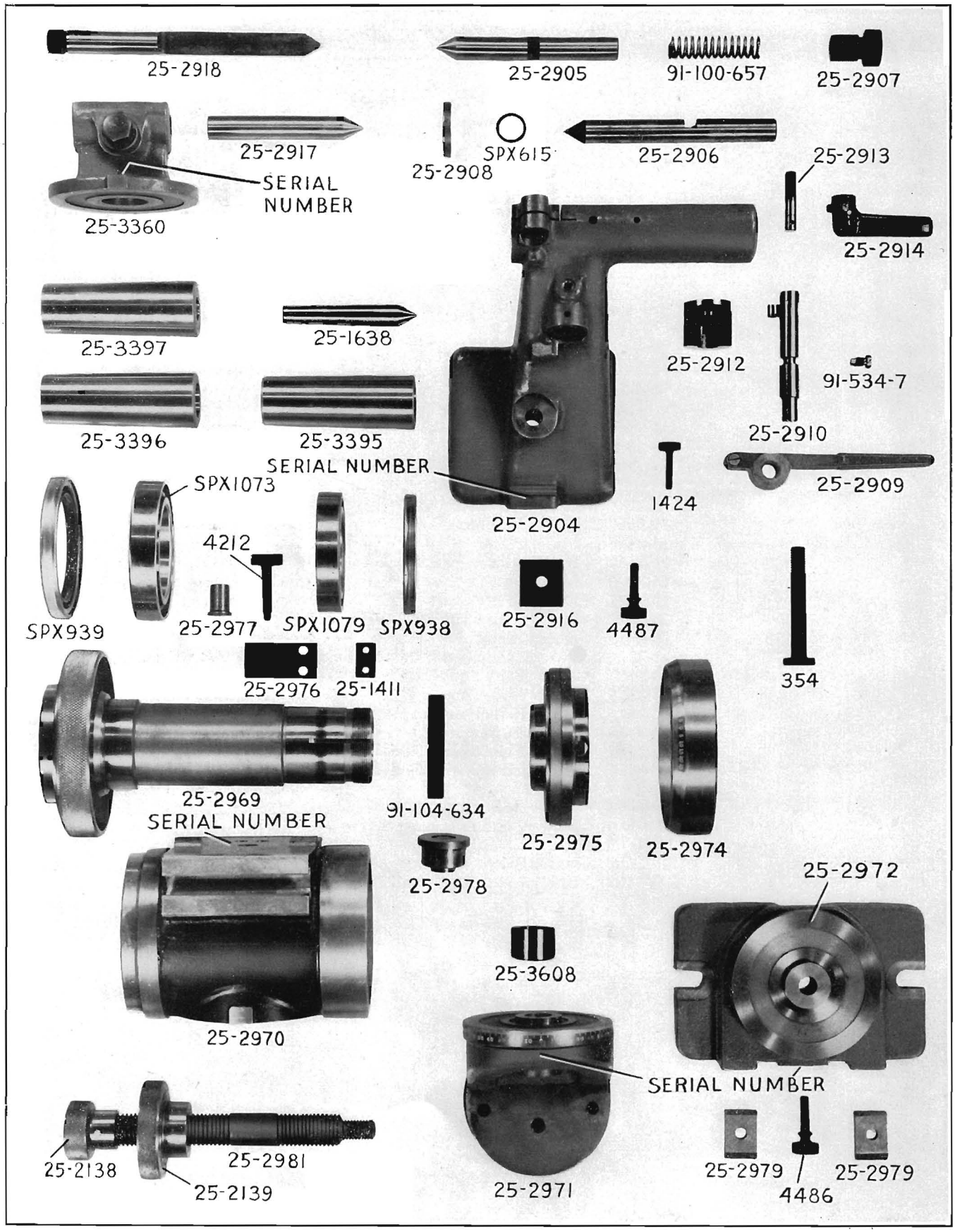
ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE

(See instructions "How to order Repair Parts" in this book.)

Motor Bracket Parts

1374	Intermediate Shaft Nut
3069	Belt Tension Screw
3070	Motor Plate Pin
5595	Spindle Motor (Not Shown, Give Complete Motor Name Plate Data.)
25-2867	Motor Bracket
25-2868	Motor Plate
25-2869	Intermediate Shaft Bracket
25-2870	Motor Sheave
25-2871	Intermediate Shaft
25-2872	Intermediate Shaft Sheave
25-2873	Intermediate Shaft Pulley
25-2874	Intermediate Shaft Bracket Fulcrum
25-2875	Motor Plate Support
25-2876	Motor Plate Stop
25-2877	Motor Plate Fulcrum
25-2878	Motor Plate Spring
25-2879	Motor Plate Spring Rod, Upper
25-2880	Motor Plate Spring Rod, Lower
91-201-458	Motor Spacer
91-504-8	Motor Plate Adjusting Screw
*SPX215	Motor Belt
SPX1118	Intermediate Shaft Ball Bearing

*F.H.P. V-Belt "A" Cross Section ½" Wide x $1\frac{1}{32}$" Thick;
Inside Circumference 26", Outside Circumference 28"



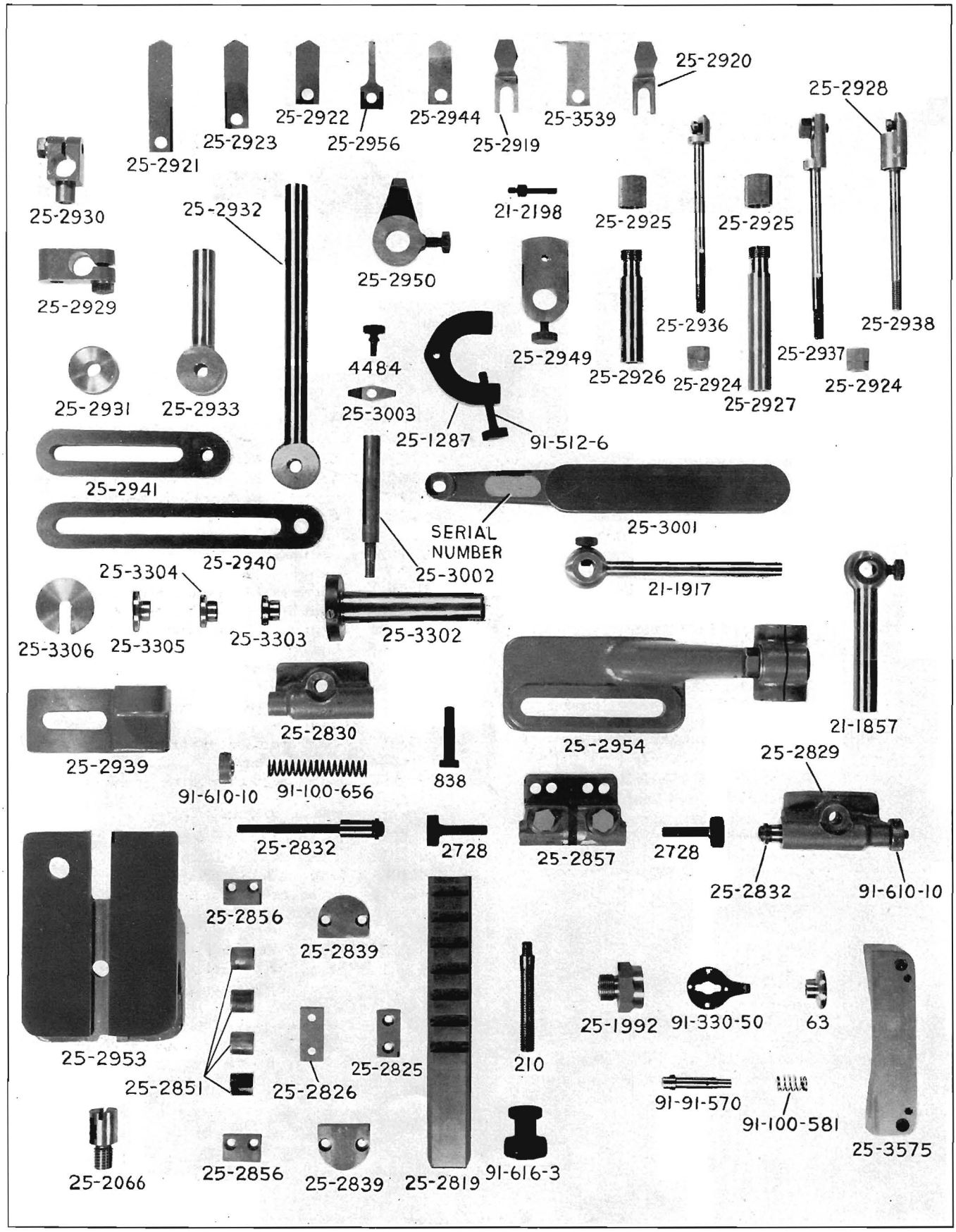
Work Head, Center Head and Footstock Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE

(See instructions "How to order Repair Parts" in this book.)

Work Head, Center Head and Footstock Parts

354	Footstock Clamp Bolt
1424	Footstock Lever Screw
4212	Spindle Clamp Screw
4486	Work Head Locating Screw
4487	Footstock Locating Screw
25-1411	Clamp Screw Spring Shoe Support
25-1638	Work Head Center
25-2138	Drawing-In Bolt Knob
25-2139	Drawing-In Bolt Collar
25-2904	Footstock
25-2905	Footstock Center
25-2906	Footstock Half Center
25-2907	Footstock Center Spring Retainer
25-2908	Footstock Center Dust Guard
25-2909	Footstock Lever
25-2910	Footstock Lever Shaft
25-2912	Footstock Lever Shaft Bushing
25-2913	Footstock Center Clamping Stud
25-2914	Footstock Center Clamping Stud Lever
25-2916	Footstock Clamp
25-2917	Center Head Center
25-2918	Center Head Half Center
25-2969	Work Spindle
25-2970	Work Head
25-2971	Work Head Knee
25-2972	Work Head Base
25-2974	Cutter Clearance Dial
25-2975	Cutter Clearance Dial Body
25-2976	Clamp Screw Spring Shoe
25-2977	Clamp Screw Bushing
25-2978	Spindle Head Pivot Bushing
25-2979	Work Head Base Clamp
25-2981	Drawing-In Bolt
25-3360	Center Head
25-3395	Collet, No. 10 B&S Taper
25-3396	Collet, No. 9 B&S Taper
25-3397	Collet, No. 7 B&S Taper
25-3608	Center Head Pivot Bushing
91-100-657	Footstock Center Spring
91-104-634	Spindle Nut
91-534-7	Footstock Lever Shaft Screw
SPX615	Footstock Ring
SPX938	Spindle Oil Seal, Large
SPX939	Spindle Oil Seal, Small
SPX1073	Spindle Ball Bearing, Large
SPX1079	Spindle Ball Bearing, Small



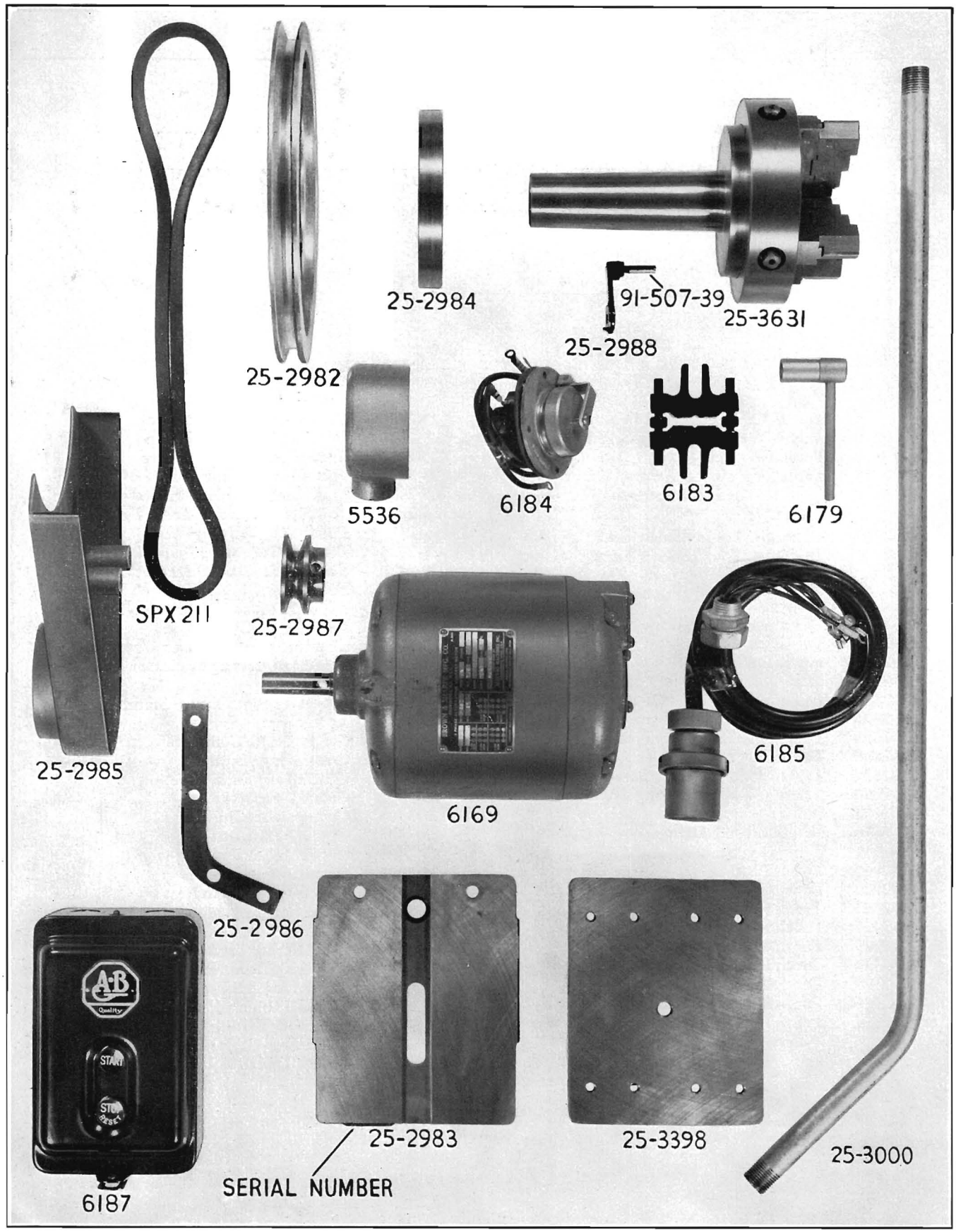
Standard Equipment and Miscellaneous Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE

(See instructions "How to order Repair Parts" in this book.)

Standard Equipment and Miscellaneous Parts

63	Swivel Table Locking Pin Knob
210	Swivel Table Adjusting Screw
838	Table Dog Bolt
2728	Table Dog Stop Adjusting Screw
4484	Center Gage Indicator Clamp Screw
21-1857	Diamond Tool Holder, Short
21-1917	Diamond Tool Holder, Long
21-2198	Clearance Setting Gage Pin
25-1287	Clearance Setting Gage Dog
25-1992	Swivel Table Locking Pin Bushing
25-2066	Swivel Table Pivot
25-2819	Table Adjusting Plate
25-2825	Table V-Way Roller Bearing Stop
25-2826	Flat-Way Roller Bearing Stop
25-2829	Table Dog Bracket, Right
25-2830	Table Dog Bracket, Left
25-2832	Table Dog Adjusting Screw
25-2839	Carriage Roller Bearing Retaining Plate
25-2851	Rollers
25-2856	Table Roller Bearing Retaining Plate
25-2857	Table Dog Stop
25-2919	Tooth Rest, Offset—Large Diameter
25-2920	Tooth Rest, Offset—Small Diameter
25-2921	Tooth Rest, Long
25-2922	Tooth Rest, Short
25-2923	Tooth Rest, Medium
25-2924	Tooth Rest Holder Nut
25-2925	Tooth Rest Holder Body Nut
25-2926	Tooth Rest Holder Body, Ratchet Type
25-2927	Tooth Rest Holder Body, Offset & Solid Type
25-2928	Tooth Rest Holder, Ratchet Type
25-2929	Tooth Rest Holder Swivel
25-2930	Tooth Rest Holder Clamp
25-2931	Tooth Rest Holder Spacer
25-2932	Tooth Rest Holder Arm, Long
25-2933	Tooth Rest Holder Arm, Short
25-2936	Tooth Rest Holder, Solid Type
25-2937	Tooth Rest Holder, Offset Type
25-2938	Tooth Rest Holder Pivot, Ratchet Type
25-2939	Tooth Rest Holder Bracket Support
25-2940	Tooth Rest Holder Bracket, Long
25-2941	Tooth Rest Holder Bracket, Short
25-2944	Tooth Rest, Chamfered
25-2949	Clearance Setting Gage
25-2950	Clearance Setting Indicator
25-2953	Tool Rest
25-2954	Wheel Truing Fixture Stand
25-2956	Tooth Rest
25-3001	Center Gage, Complete
25-3002	Center Gage Stud
25-3003	Center Gage Indicator
25-3302	Cutter Arbor
25-3303	Cutter Arbor Bushing ⅞"
25-3304	Cutter Arbor Bushing 1"
25-3305	Cutter Arbor Bushing 1¼"
25-3306	Cutter Arbor Washer
25-3539	"L" Shaped Tooth Rest
25-3575	Table Scale
91-91-570	Swivel Table Locking Pin
91-100-581	Swivel Table Locking Pin Bushing Spring
91-100-656	Table Dog Adjusting Screw Spring
91-330-50	Swivel Table Index Finger
91-512-6	Clearance Setting Gage Dog Screw
91-610-10	Table Dog Adjusting Screw Nut
91-616-3	Swivel Table Adjusting Knob



No. 10N Revolving Spindle Headstock Equipment

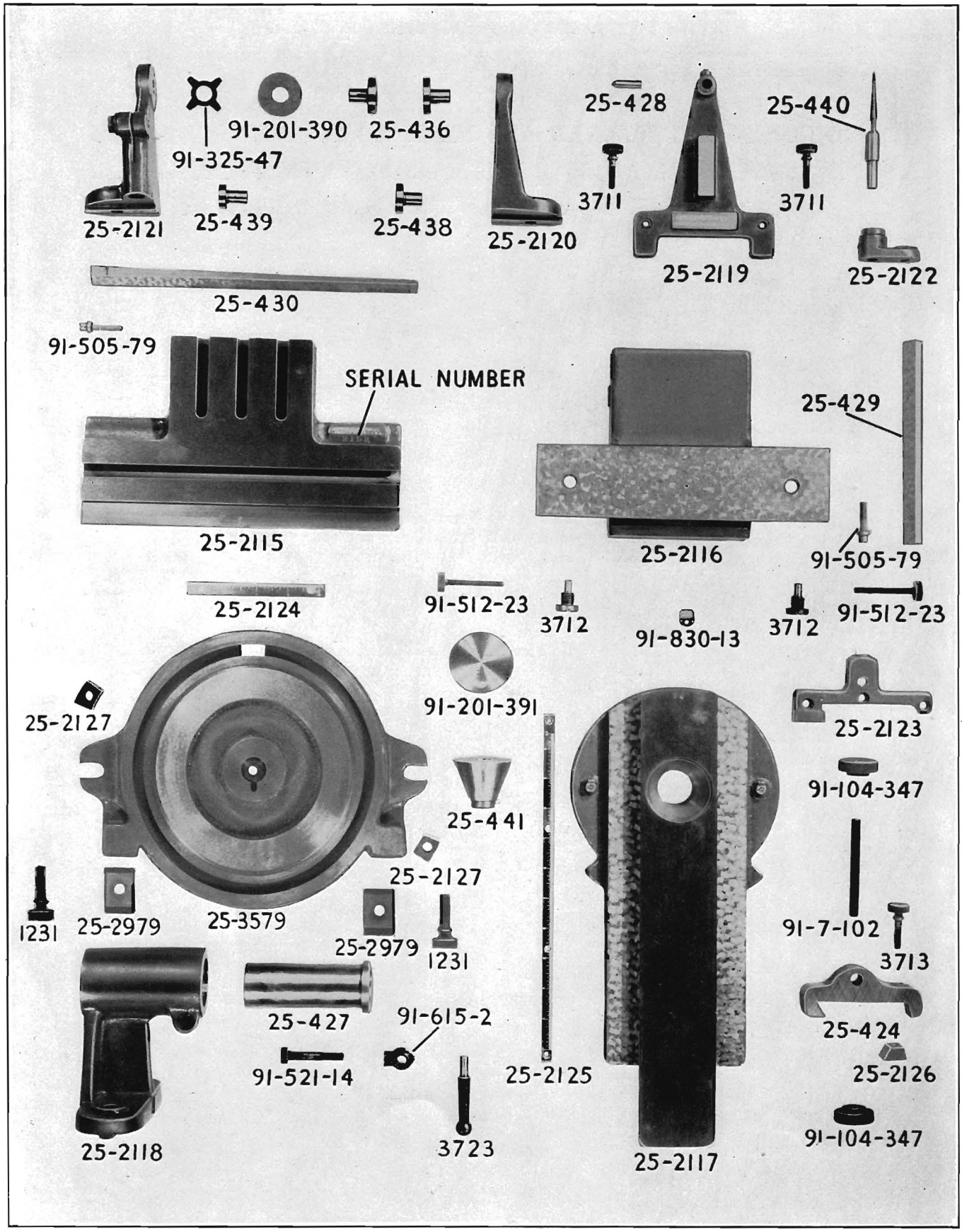
ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N Revolving Spindle Headstock Equipment

5536	Junction Box
6169	Motor (Give Complete Motor Name Plate Data)
6179	Chuck Wrench
6183	Work Dog
6184	Headstock Receptacle and Wires (Specify Phase)
6185	Headstock Motor Cable and Plug (Specify Phase)
6187	Hand Switch (Specify Phase)
25-2982	Headstock Spindle Sheave
25-2983	Headstock Motor Support
25-2984	Work Driving Plate
25-2985	Spindle Sheave Belt Guard
25-2986	Belt Guard Bracket
25-2987	Headstock Motor Sheave
25-2988	Work Driving Arm
25-3000	Headstock Conduit
25-3398	Headstock Motor Plate
25-3631	4" 4-Jaw Chuck
*SPX211	Driving Belt
91-507-39	Work Driving Arm Screw

*F.H.P. V-Belt "A" Cross Section (½" Wide x $1\frac{1}{32}$" Thick); Inside Circumference 35", Outside Circumference 37".



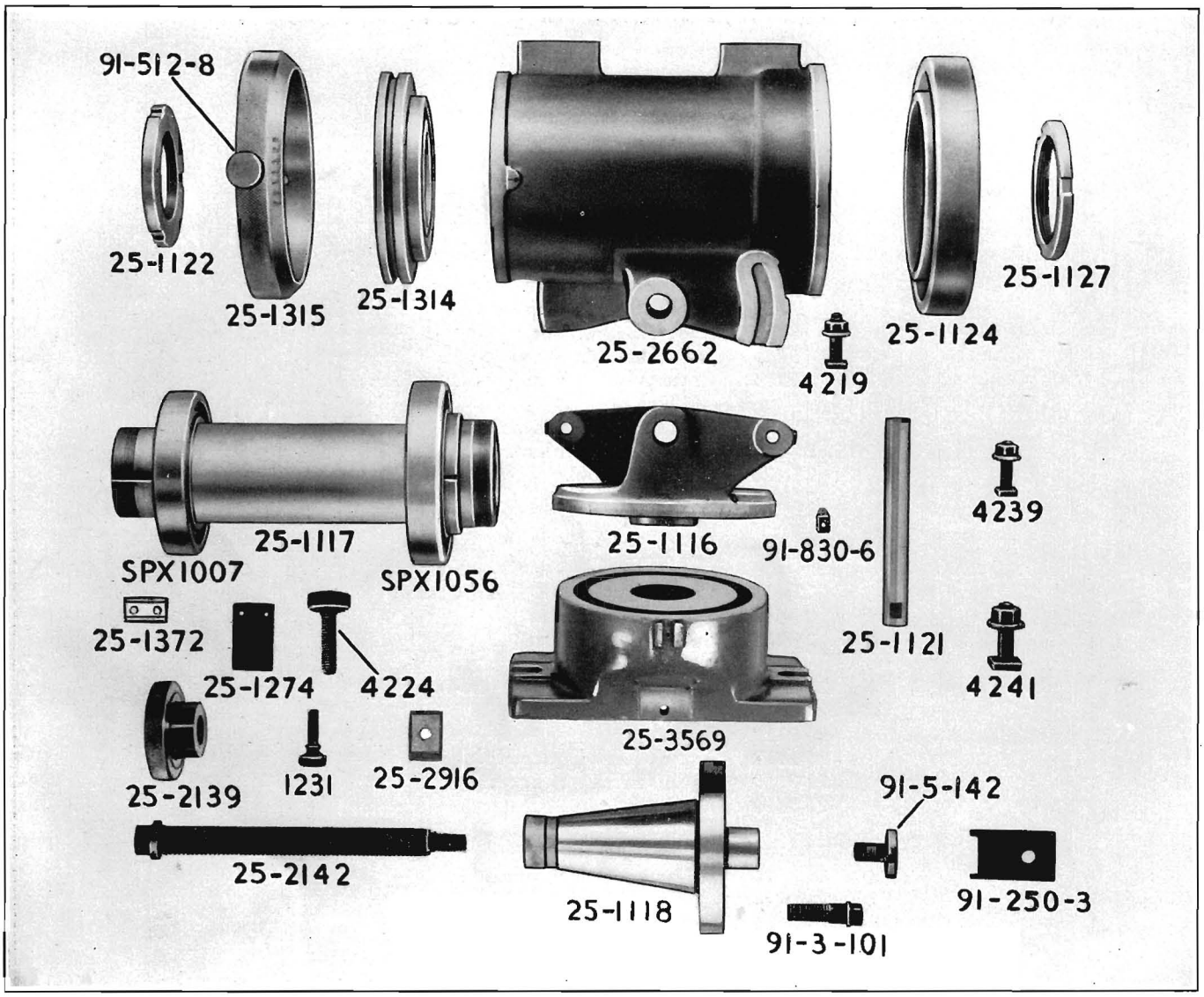
No. 10N Radius Grinding Attachment

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N Radius Grinding Attachment

1231	Base Clamp Adjusting Screw
3711	Radius Setting Bracket Clamp Screw
3712	Slide Base Screw
3713	Adjusting Screw Block Clamp Screw
3723	Cutter Holder Bushing Clamp Handle
25-424	Adjusting Screw Block
25-427	Taper Shank Cutter Holder Bushing
25-428	Diamond Tool
25-429	Slide Base Gib
25-430	Slide Gib
25-436	Center Bushing, 1¼" Diameter
25-438	Center Bushing, 1" Diameter
25-439	Center Bushing, ⅞" Diameter
25-440	Tooth Rest Holder
25-441	Swivel Center
25-2115	Slide
25-2116	Slide Base
25-2117	Swivel
25-2118	Table Shank Cutter Holder
25-2119	Radius Setting Bracket
25-2120	Knee, Right
25-2121	Knee, Left
25-2122	Tooth Rest
25-2123	Adjusting Screw Bracket
25-2124	Slide Scale
25-2125	Swivel Scale
25-2126	Adjusting Screw Block Gib
25-2127	Stop Dog
25-2979	Base Clamp
25-3579	Base
91-7-102	Adjusting Screw
91-104-347	Adjusting Screw Nut
91-201-390	Center Bushing Washer
91-201-391	Dust Guard
91-325-47	Spring Washer
91-505-79	Gib Adjusting Screw
91-512-23	Slide Adjusting Screw
91-521-14	Cutter Holder Bushing Clamp Screw
91-615-2	Cutter Holder Bushing Clamp Nut
91-830-13	Adjusting Screw Bracket Index Finger



No. 10N Face Mill Sharpening Attachment

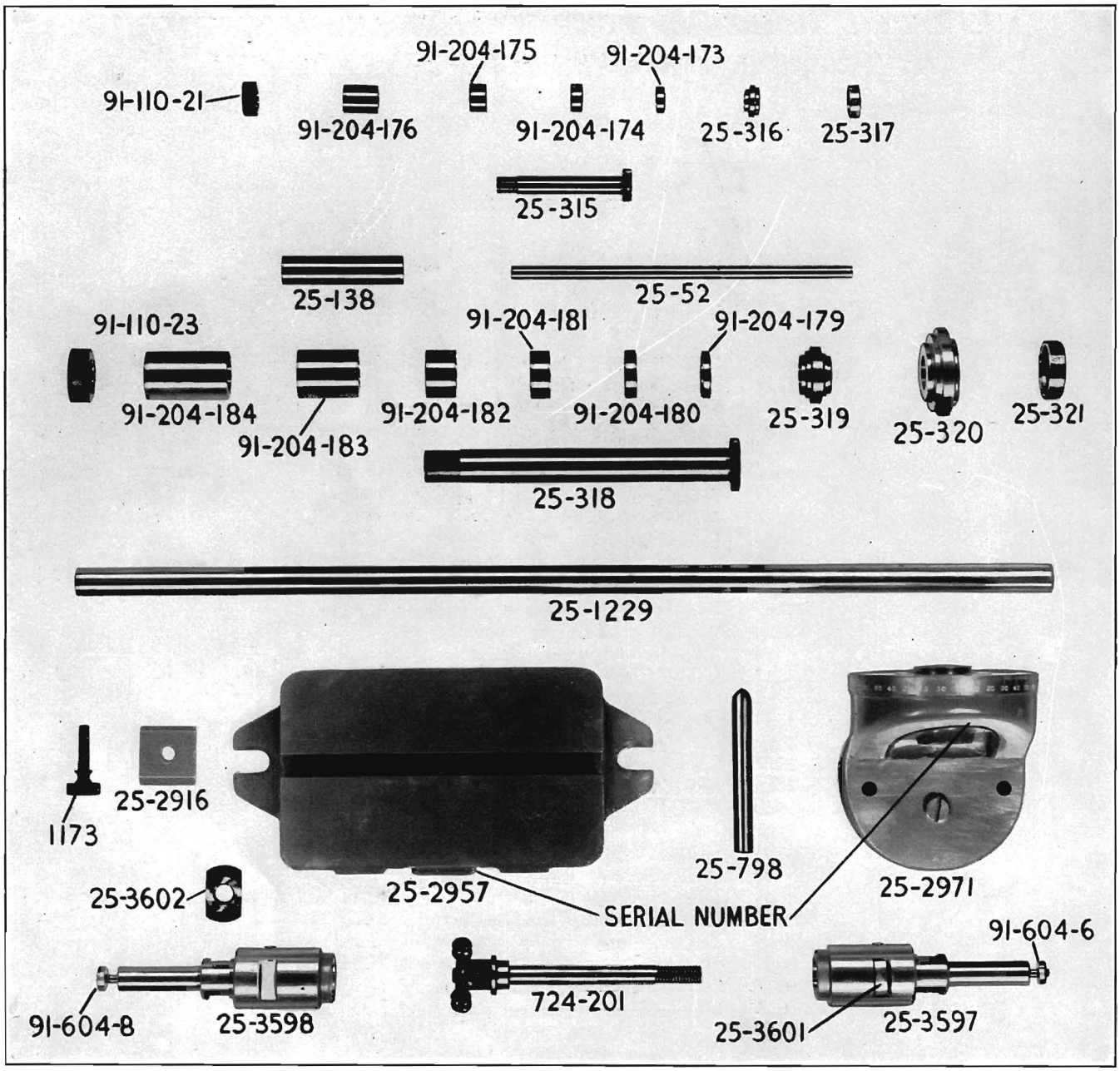
ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N Face Mill Sharpening Attachment

1231	Base Clamp Adjusting Screw
4219	Spindle Head Clamp Bolt (Includes Nut and Washer)
4224	Spindle Clamp Screw
4239	Swivel Clamp Bolt (Includes Nut and Washer)
4241	Base Clamp Bolt (Includes Nut and Washer)
25-1116	Swivel
25-1117	Spindle
25-1118	Work Holder
25-1121	Swivel Stud
25-1122	Spindle Bearing Adjusting Nut
25-1124	Spindle Handwheel, Large
25-1127	Handwheel Clamp Nut
25-1274	Clamp Screw Spring Shoe
25-1314	Spindle Handwheel, Small
25-1315	Cutter Clearance Dial
25-1372	Clamp Screw Spring Shoe Support
25-2139	Drawing-in Bolt Collar
25-2142	Drawing-in Bolt
*25-2662	Spindle Head
25-2916	Base Clamp
25-3569	Base
91-3-101	Cutter Holding Bolt
91-5-142	Arbor Screw
91-250-3	Arbor Screw Wrench
91-512-8	Cutter Clearance Dial Screw
91-830-6	Index Finger
SPX1007	Spindle Bearing, Small
SPX1056	Spindle Bearing, Large

*Serial number stamped on this part.



Sliding Shells and Miscellaneous Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

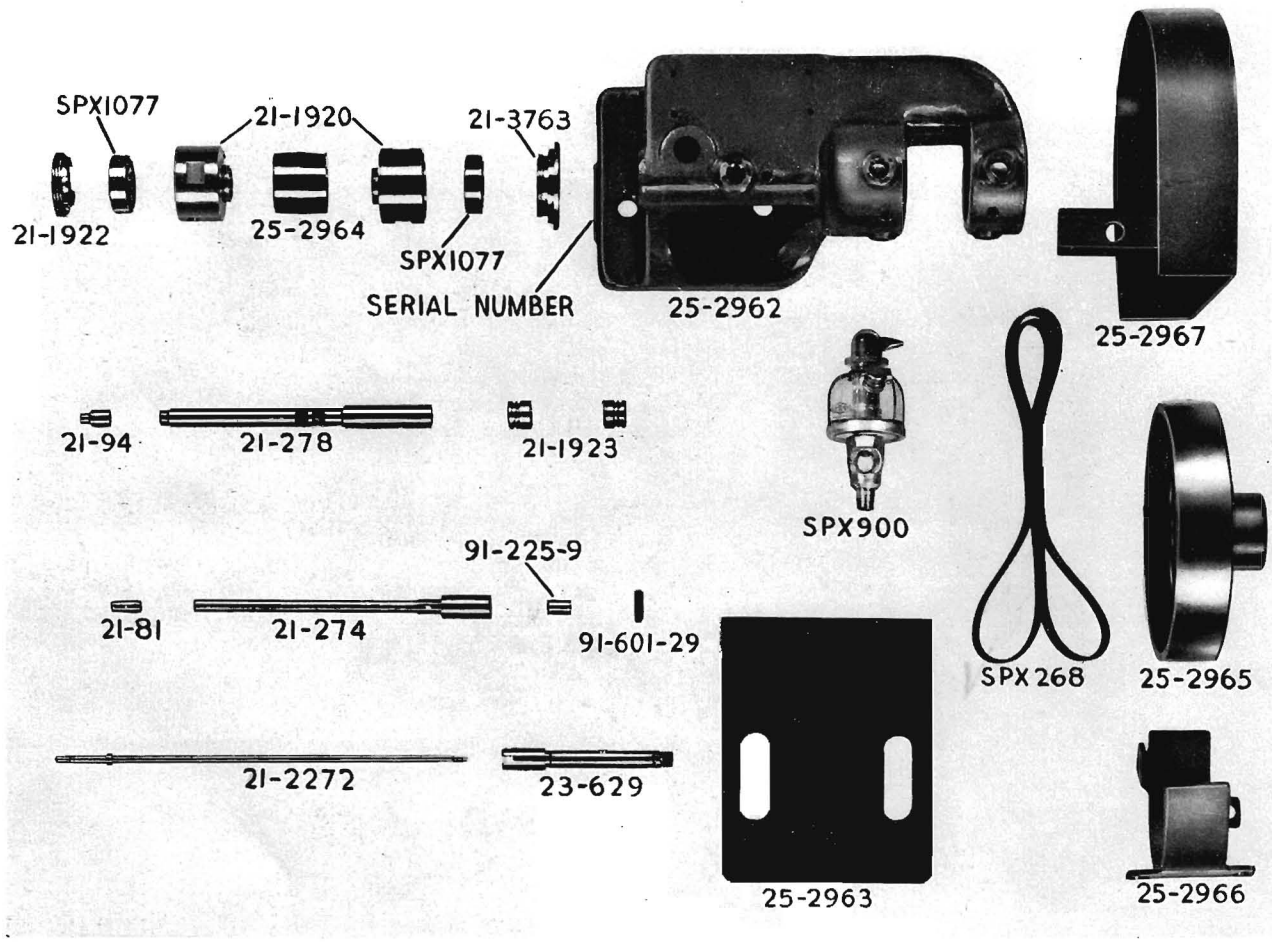
Sliding Shells and Miscellaneous Parts

1173	Raising Block Clamp Screw
25-52	3/8" Cutter Bar
25-138	Small Cutter Bar Bushing
25-315	1/2" Sliding Shell
25-316	1/2" Sliding Shell Step Collar
25-317	1/2" Sliding Shell Collar, Recessed
25-318	7/8" Sliding Shell
25-319	7/8" Sliding Shell Step Collar, Small
25-320	7/8" Sliding Shell Step Collar, Large
25-321	7/8" Sliding Shell Collar, Recessed
25-798	Diamond Tool
25-1229	3/4" Cutter Bar
25-2916	Raising Block Clamp
25-2957	Work Head Raising Block
25-2971	Work Head Knee
25-3597	1/4" Wheel Arbor, Right Hand
25-3598	1/4" Wheel Arbor, Left Hand
25-3601	Spindle Clamp Nut, Right Hand
25-3602	Spindle Clamp Nut, Left Hand
91-110-21	1/2" Sliding Shell Collar Nut
91-110-23	7/8" Sliding Shell Collar Nut
91-204-173	1/2" Sliding Shell Collar, 3/16" Long
91-204-174	1/2" Sliding Shell Collar, 5/16" Long
91-204-175	1/2" Sliding Shell Collar, 7/16" Long
91-204-176	1/2" Sliding Shell Collar, 7/8" Long
91-204-179	7/8" Sliding Shell Collar, 3/16" Long
91-204-180	7/8" Sliding Shell Collar, 5/16" Long
91-204-181	7/8" Sliding Shell Collar, 1/2" Long
91-204-182	7/8" Sliding Shell Collar, 3/4" Long
91-204-183	7/8" Sliding Shell Collar, 1 1/2" Long
91-204-184	7/8" Sliding Shell Collar, 2" Long
91-604-6	Wheel Arbor Nut, Right Hand
91-604-8	Wheel Arbor Nut, Left Hand
724-201	Draw-in Bolt

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N Internal Grinding Attachment



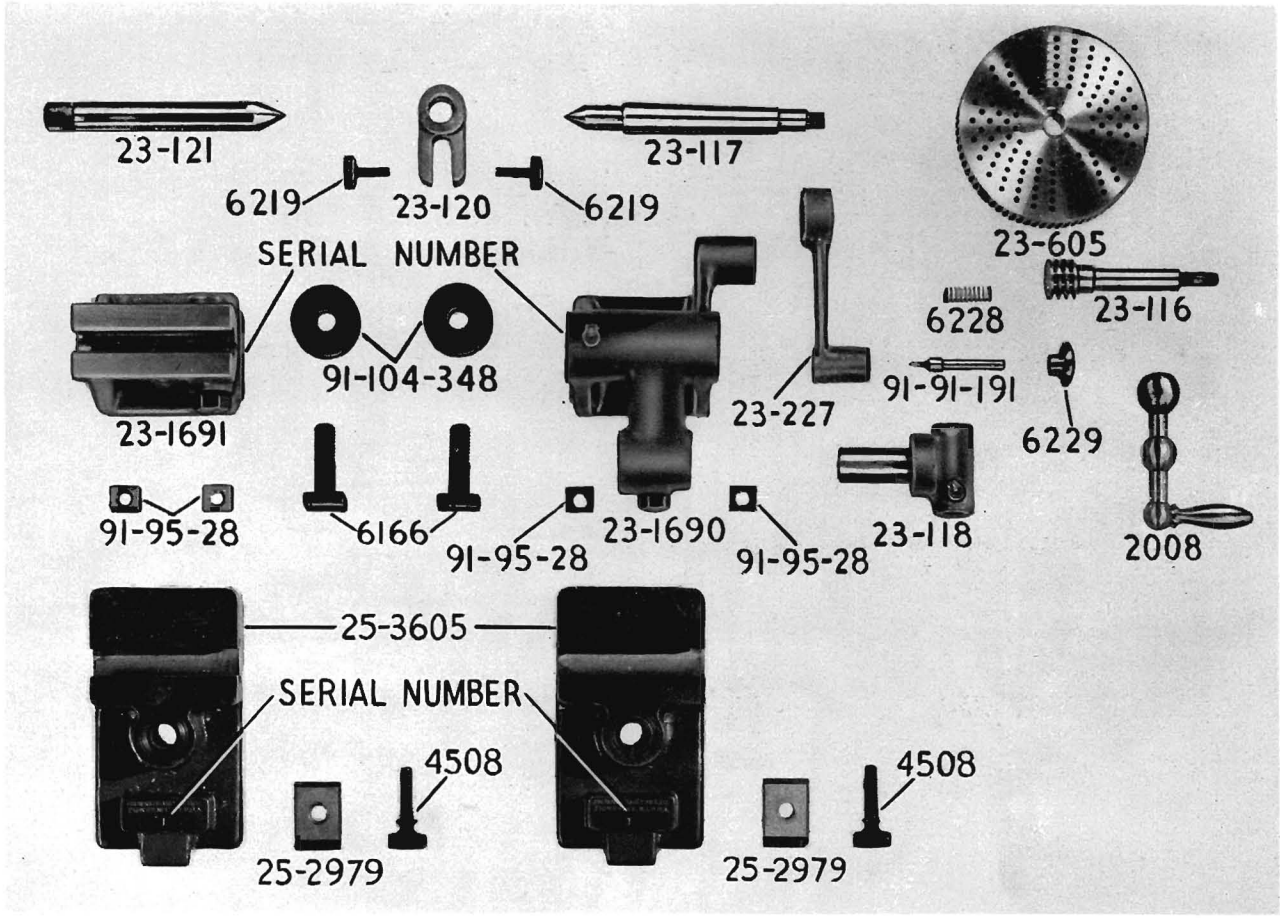
21-81	Wheel Spindle Box	25-2962	Stand
21-94	Wheel Bushing	25-2963	Knee
		25-2964	Pulley
21-274	Inner Shell	25-2965	Driving Pulley
21-278	Outer Shell	25-2966	Belt Guard
		25-2967	Driving Pulley Belt Guard
21-1920	Bearing Case		
21-1922	Ball Bearing Clamp Nut	91-225-9	Inner Shell Bushing
21-1923	Pulley Spindle Sleeve	91-601-29	Wheel Spindle Nut
21-2272	Wheel Spindle		
21-3763	Bearing Case Cap	*SPX268	Belt
		SPX900	Sight Feed Oiler
23-629	Pulley Spindle	SPX1077	Spindle Ball Bearing

*Endless Woven Flat Belt 4 Ply Medium 7/8" Wide x 30" Long

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N Indexing Equipment

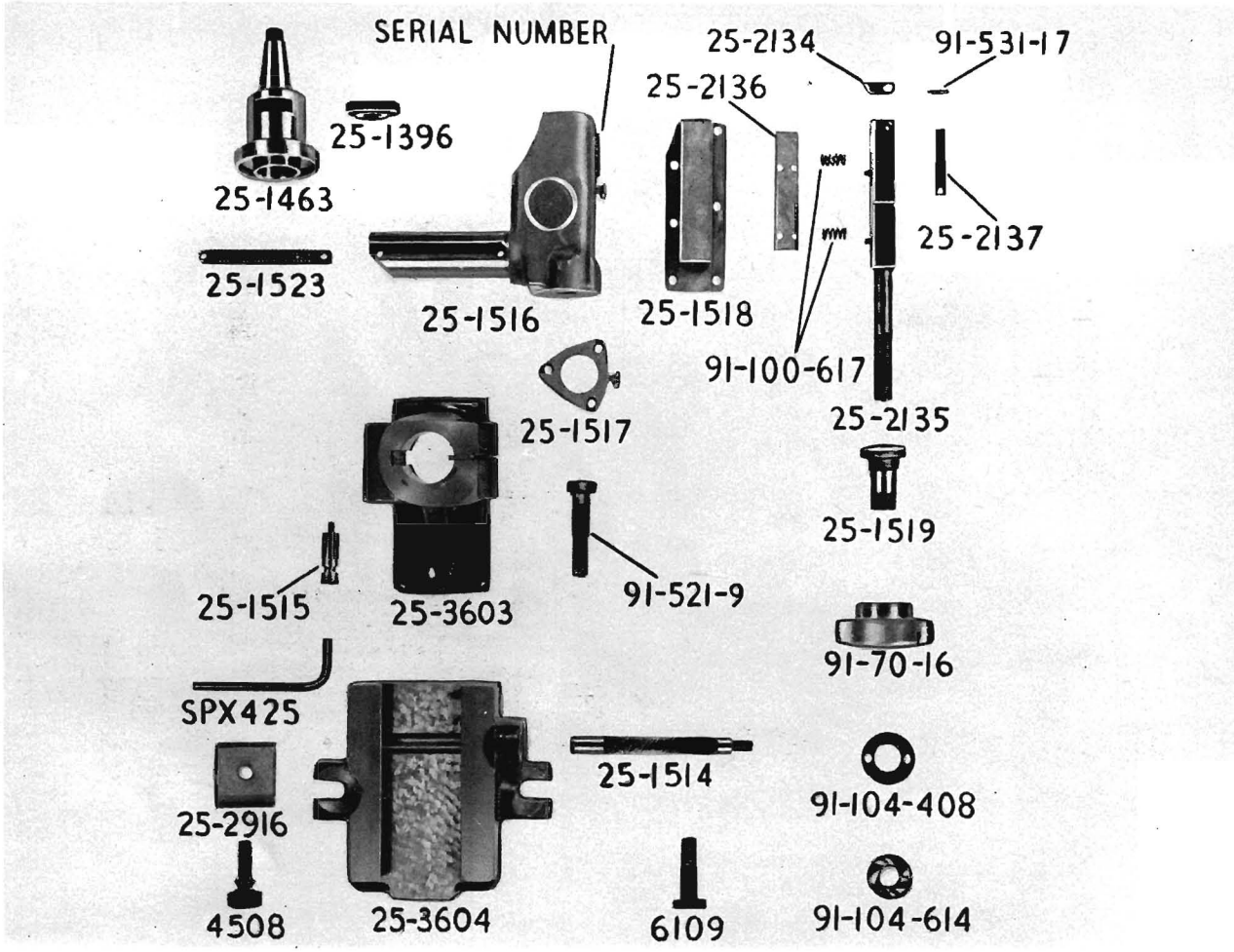


2008	Index Worm Handle	23-227	Index Finger
4508	Adapter Plate Clamp Screw	23-605	Index Worm Wheel
6166	Headstock and Footstock Clamp Bolt		
6219	Work Driving Dog Clamp Screw	23-1690	Headstock
6228	Index Pin Spring	23-1691	Footstock
6229	Index Pin Knob		
		25-2979	Adapter Plate Clamp
23-116	Index Worm	25-3605	Adapter Plate
23-117	Headstock Center		
23-118	Index Worm Bearing	91-91-191	Index Pin
23-120	Headstock Center Driver	91-95-28	Headstock and Footstock Tongue
23-121	Footstock Center	91-104-348	T-Clamp Bolt Nut

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N Formed Cutter Sharpening Attachment (Through-Feed Type)

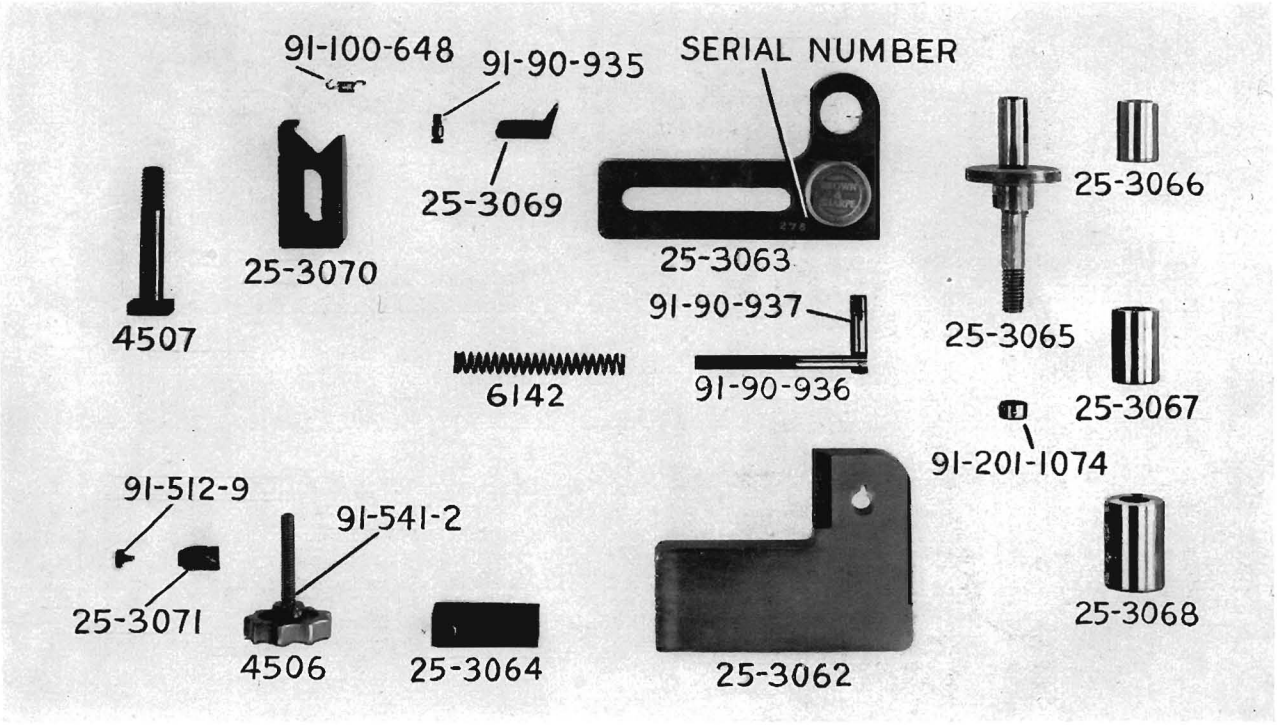


4508	Adapter Clamp Locating Screw	25-2136	Cutter Stop Rod Friction Plate
6109	Sliding Base Adapter Clamp Bolt	25-2137	Cutter Stop Rod Tooth Spring
		25-2916	Adapter Clamp
25-1396	Spindle Extension Clamp Nut	25-3603	Sliding Base
25-1463	Wheel Spindle Extension	25-3604	Sliding Base Adapter
25-1514	Clamping Bolt		
25-1515	Adjusting Pinion	91-70-16	Cutter Stop Rod Adjusting Knob
25-1516	Cutter Stop Bracket	91-100-617	Cutter Stop Rod Spring
25-1517	Cutter Stop Rod Sleeve Retainer	91-104-408	Adjusting Knob Clamp Nut
25-1518	Cutter Stop Bracket Plate	91-104-614	Cutter Stop Rod Check Nut
25-1519	Cutter Stop Rod Nut	91-521-9	Cutter Stop Bracket Clamp Bolt
25-1523	Adjusting Rack	91-531-17	Cutter Stop Rod Stud
25-2134	Cutter Stop Rod Tooth		
25-2135	Cutter Stop Rod	SPX425	Adjusting Pinion Wrench

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 13A Formed Cutter Sharpening Attachment (In-Feed Type)

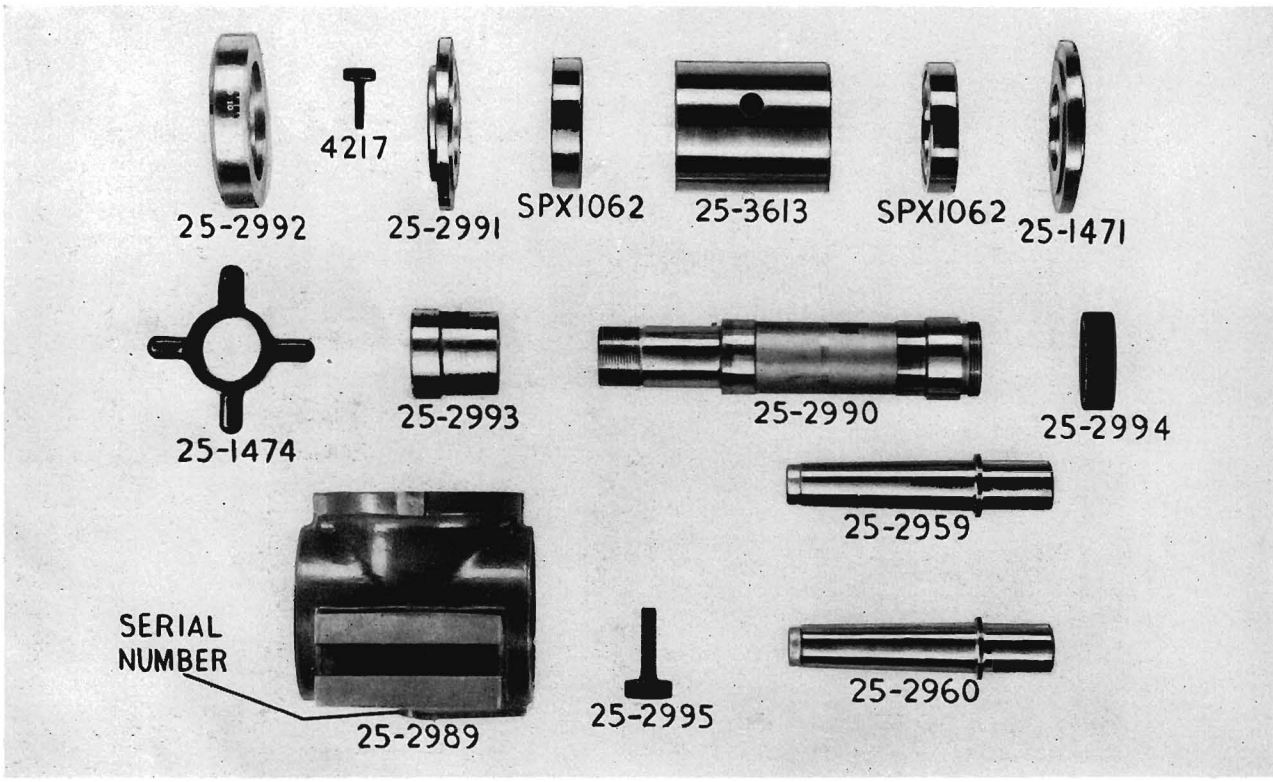


4506	Connecting Bracket Screw Knob	25-3069	Tooth Rest
4507	Tooth Rest Support Clamp Screw	25-3070	Tooth Rest Support
6142	Bracket Spring	25-3071	Bracket Screw Stop
25-3062	Fixed Bracket	91-90-935	Tooth Rest Spring Pin
25-3063	Adjusting Bracket	91-90-936	Bracket Spring Pin
25-3064	Connecting Bracket	91-90-937	Adjusting Bracket Pin
25-3065	Cutter Arbor	91-100-648	Tooth Rest Spring
25-3066	Arbor Bushing, 7/8" Diameter	91-201-1074	Cutter Arbor Collar
25-3067	Arbor Bushing, 1" Diameter	91-512-9	Clamp Screw
25-3068	Arbor Bushing, 1¼" Diameter	91-541-2	Connecting Bracket Screw

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N End Mill Sharpening Attachment

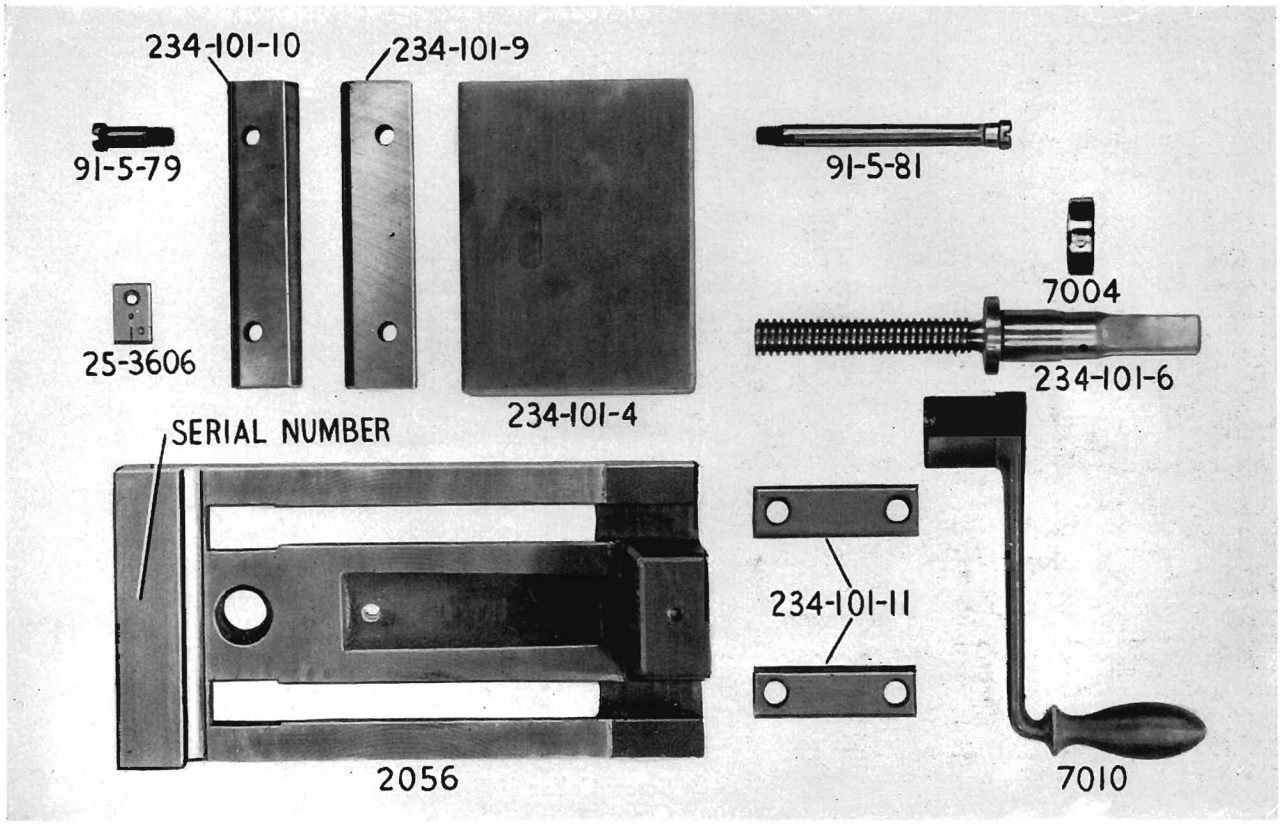


4217	Clearance Setting Dial Screw
25-1471	Bearing Dust Guard
25-1474	Spindle Knob
25-2959	Cutter Adapter, No. 5 B&S Taper
25-2960	Cutter Adapter, No. 7 B&S Taper
25-2989	Body
25-2990	Spindle
25-2991	Left Bearing Dust Guard
25-2992	Clearance Setting Dial
25-2993	Bearing Clamp Collar
25-2994	Spindle Nut
25-2995	Spindle Clamp Screw
25-3613	Bearing Spacer
SPX1062	Spindle Ball Bearing

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 10N Surface Grinding Vise

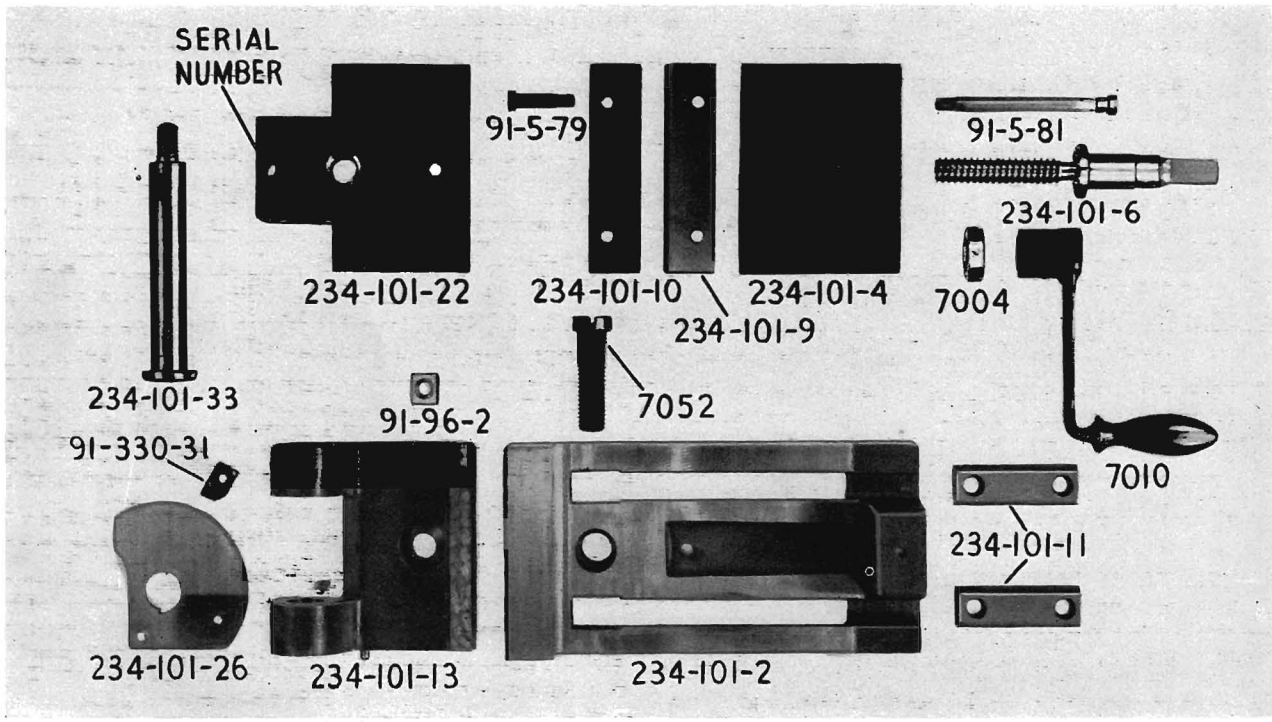


2056	Bed
7004	Screw Collar
7010	Crank
25-3606	Vise Index Finger
91-5-79	Fixed Jaw Screw
91-5-81	Loose Jaw Screw
234-101-4	Slide
234-101-6	Screw
234-101-9	Loose Jaw
234-101-10	Fixed Jaw
234-101-11	Strap

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF BOTH MACHINE AND ATTACHMENT.

(See instructions "How to order Repair Parts" in this book.)

No. 1 Adjustable Vise



7004	Screw Collar
7010	Crank
7052	Bed Screw
91-5-79	Fixed Jaw Screw
91-5-81	Loose Jaw Screw
91-96-2	Base Tongue
91-330-31	Index Pointer
234-101-2	Bed
234-101-4	Slide
234-101-6	Screw
234-101-9	Loose Jaw
234-101-10	Fixed Jaw
234-101-11	Strap
234-101-13	Base
234-101-22	Bed Carriage
234-101-26	Dial
234-101-33	Hinge Bolt