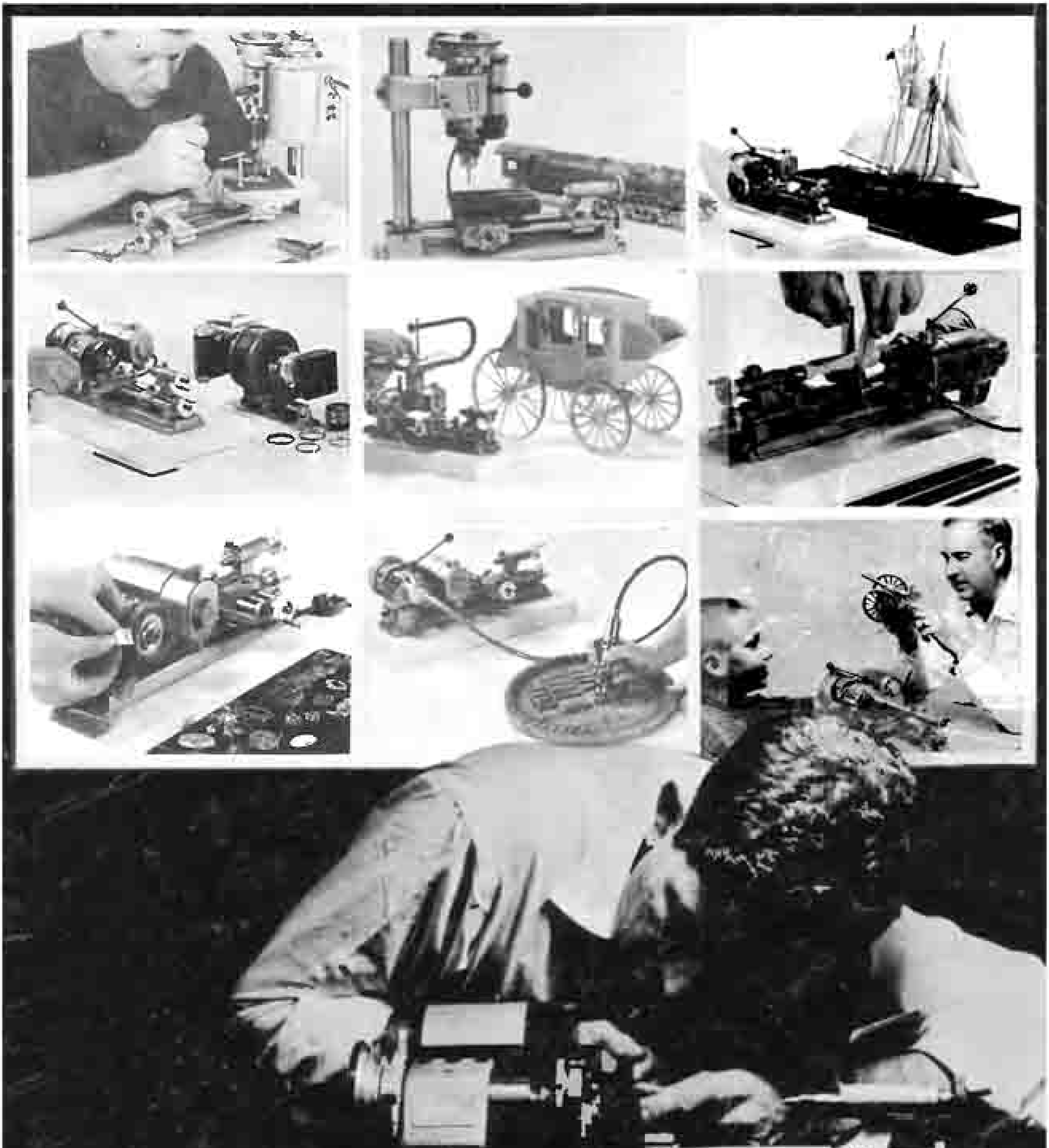
edelstaal UNIMAT MINIATURE MACHINING TECHNIQUES

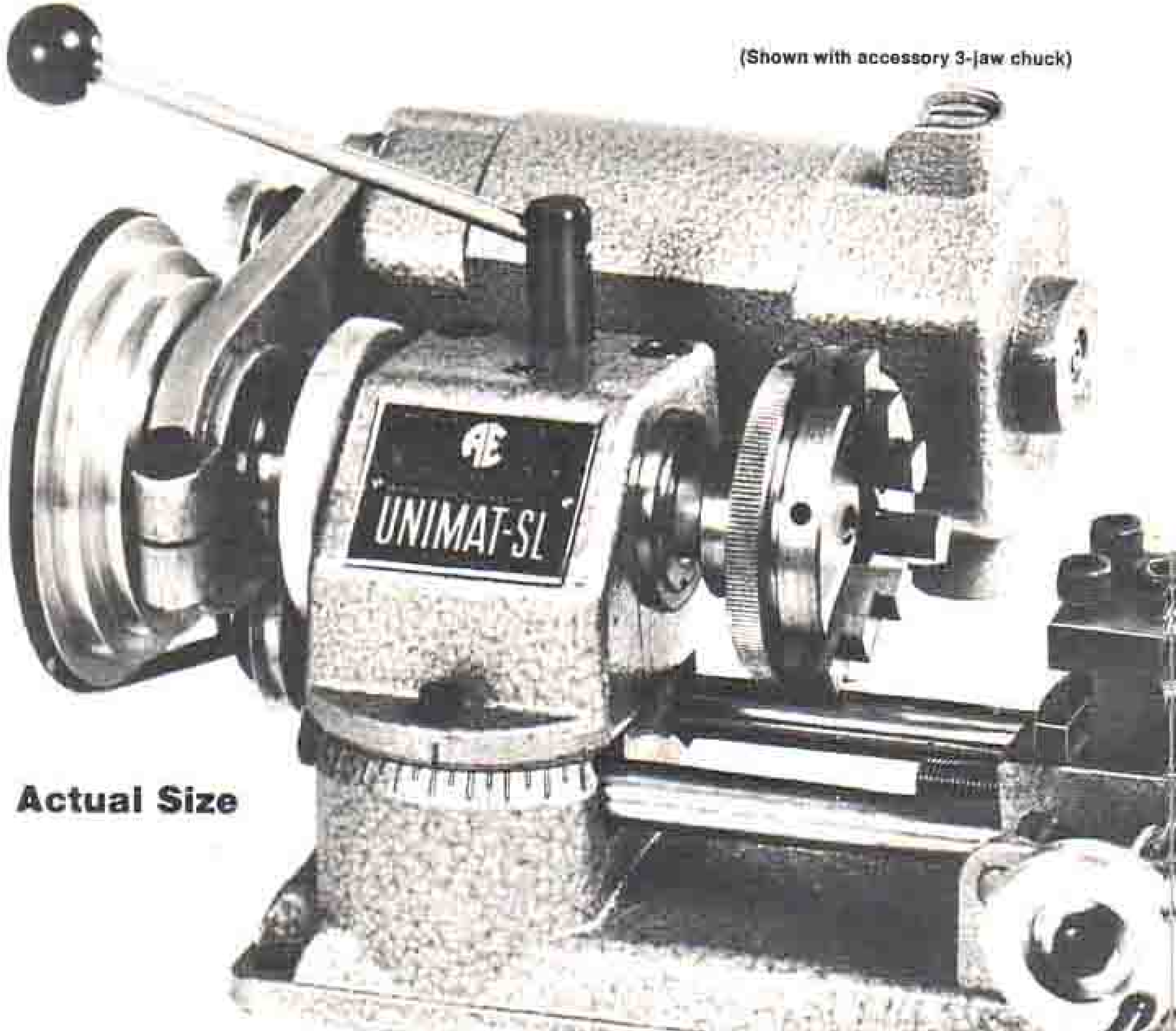
a general handbook and operator's manual



INCOMPARABLY VERSATILE MINIATURE

Five machine tools in one, the Unimat is not only a small precision metal lathe—it converts in a minute to a universal drill press, vertical milling machine, small-parts surface grinder, or grinding-polishing head. It performs ALL common machining operations, and it's capable of the finest precision work. The tool equips an amateur or professional craftsman to precision-machine his own small parts from any material, metal, plastic or wood. Thousands of hobbiests, commercial modelmakers, inventors, prototype labs, gunsmiths, camera repairmen, locksmiths and jewelers the world over use Unimats for a wide variety of miniature machining jobs. The basic Unimat's versatility—and the many accessories available—makes the machine's uses almost unlimited.

(Shown with accessory 3-jaw chuck)

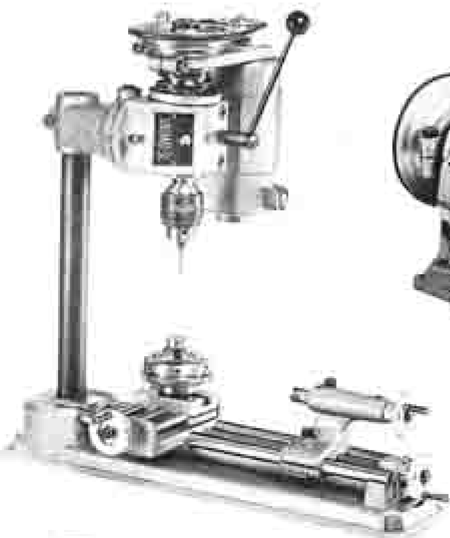


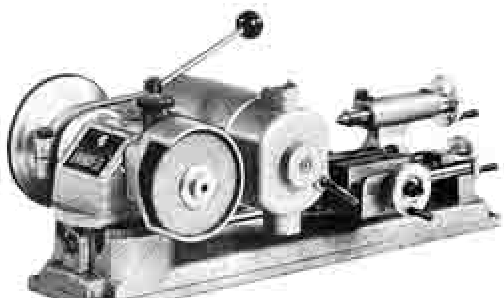
Actual Size

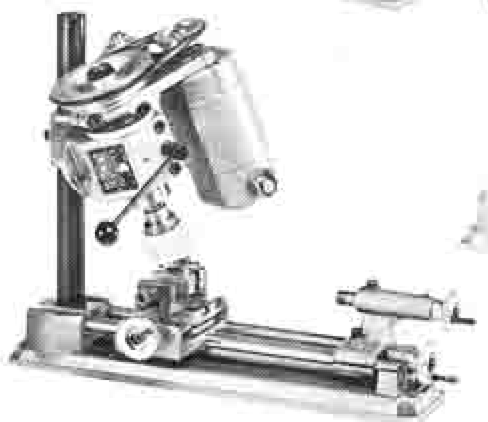
MACHINE TOOL

Surely the most fascinating little machine a craftsman could imagine, the Unimat is much more than simply an appealing little precision metal lathe. It's really a complete miniature machine tool system—a system of components that can be set up in various ways to perform on small scale *any* of the standard rotary metal-machining operations, turning, drilling, milling or grinding. More than that, the many accesories available for the tool extend its capabilities even further, and even include units to convert the basic machine to any of several woodworking power tools. All this makes the Unimat not merely a combination tool but a *universal* tool, a complete machine shop in itself. No other small shop machine compares with it. The Unimat is unique.

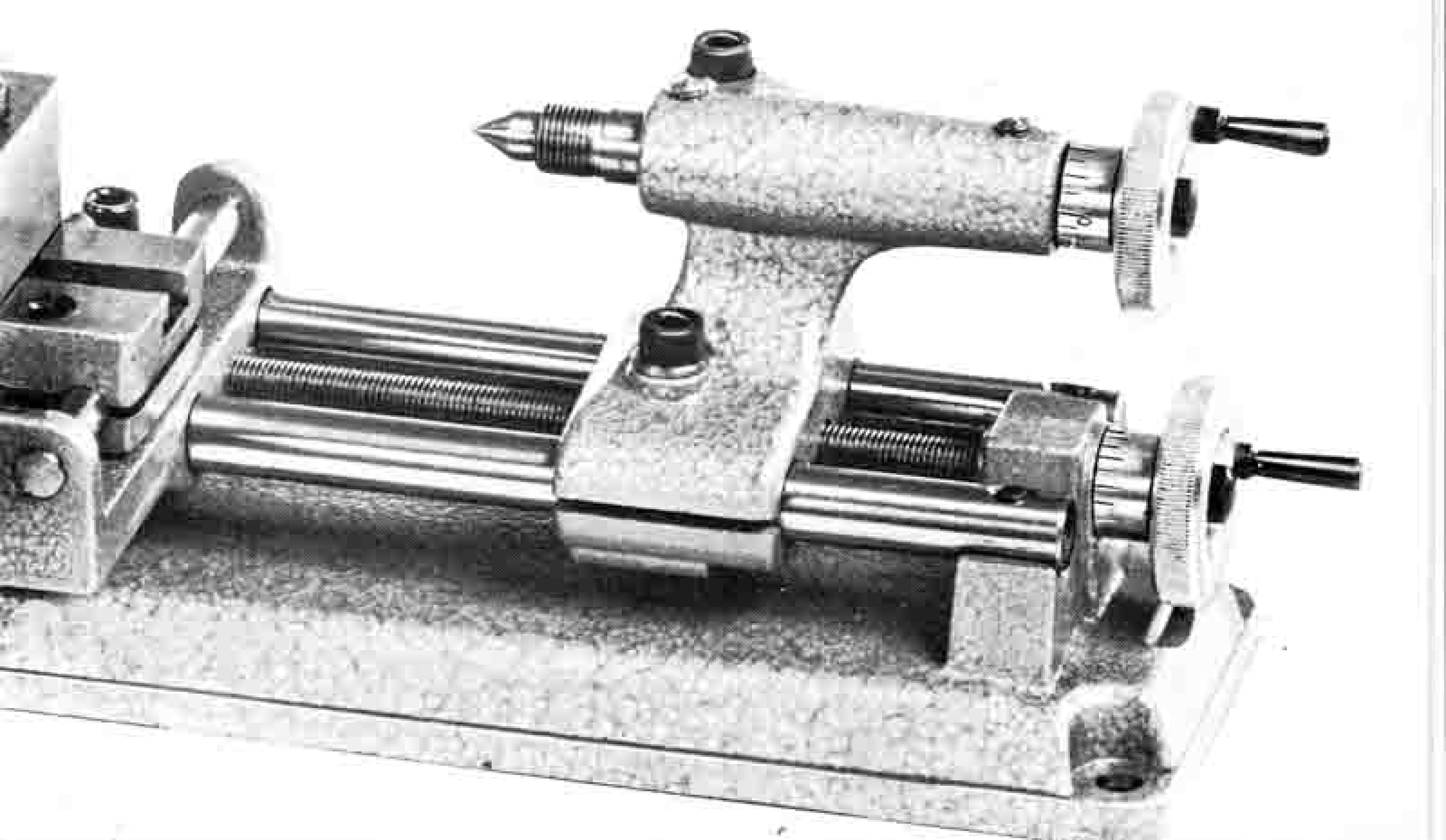
You can use it anywhere, even on a kitchen table. With the tool set up as a metal lathe, you're equipped to turn your own steel, brass or aluminum parts to split-thousandth tolerance. When you set up the machine as a drill press, you're able to perform on small scale any of the common drilling operations, including countersinking, counterboring, even "sensitive" drilling of extremely small holes with very tiny twist drills. When you set up the Unimat as a vertical milling machine, you're able to mill intricately-shaped metal parts you couldn't possibly make in any other way. With the machine set up as a surface grinder, you can precision-grind hardened steel parts

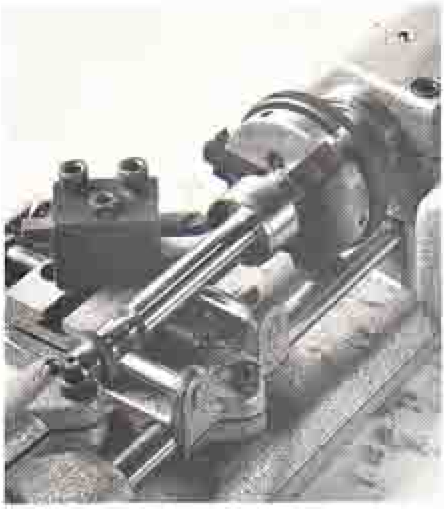


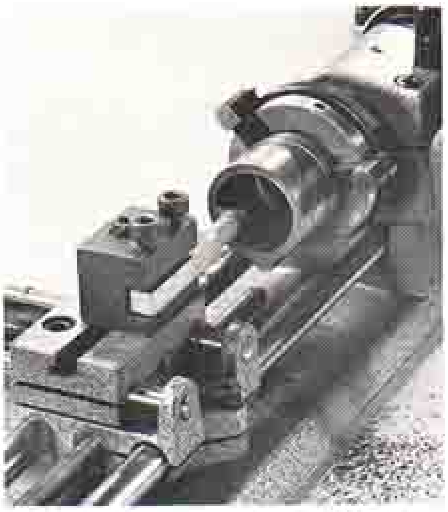


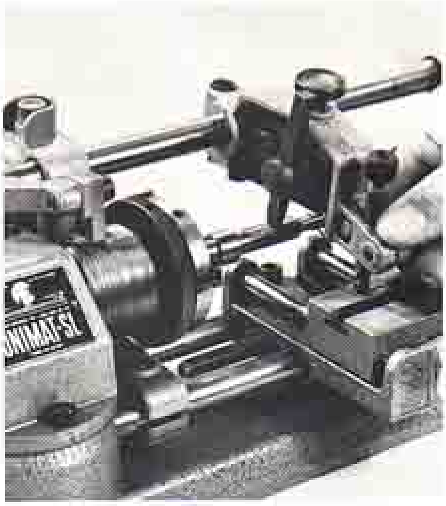


Here's The Basic Unimat




FOR METAL TURNING, lathe bit is held in tool block mounted on the carriage.


FOR BORING large holes in the lathe a boring tool is set parallel with bed.



FOR THREADING a master bushing advances the threading attachment's tool bit.

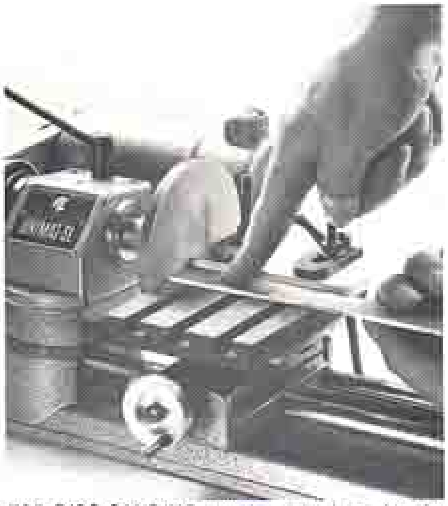

FOR DRILLING the headstock mounts on auxiliary column, lever advances spindle.

just as accurately as the world's leading toolmakers. Using appropriate accessories, you can also set up the Unimat as a small bench grinder, circular saw, jig saw, shaper, planer, flexible shaft tool, disc sander. On the one machine you can accomplish virtually any machining job in any common material, whether metal, plastic or wood, with the size of the work the only limitation. The accompanying photos show some—but by no means all—of the many ways the tool can be set up.

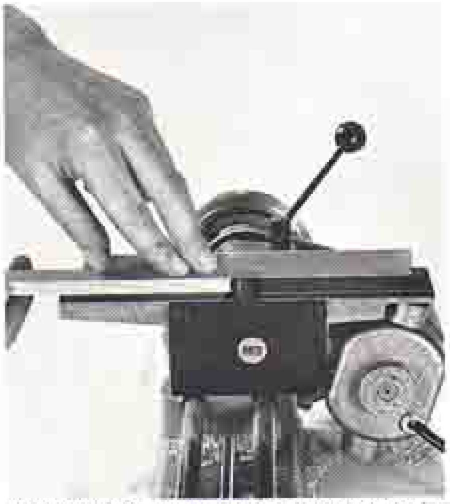
Since it can perform such a variety of machining operations on small workpieces, the Unimat is a simply marvelous tool for home-shop modelbuilding and craftwork. Using a Unimat an amateur modelbuilder can readily machine the special metal parts and fittings he needs to give his models professional finish. More than that, with a Unimat he's tooled up for projects he couldn't otherwise hope to tackle. He's able to machine model ship, locomotive, aircraft or automotive parts to exact scale from original blueprints. He can build his own working-model gas, steam or diesel engines right down to the last screw. If he wants to model an architectural structure, he can use the Unimat's woodworking accessories to cut and plane accurately-finished miniature timbers and planks. Because the Unimat itself is a scaled-down version of the actual production machines used to make the real equipment modelmakers model, it's possible with this remarkable little tool to build beautifully-detailed scale models of nearly anything.

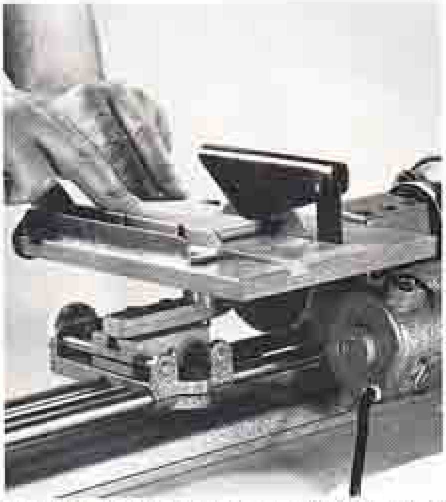
The Unimat makes precision metal-machining so simple that with only a few hours' practice an amateur modelbuilder having no previous machine-tool experience whatever will be able to turn out machined metal parts that compare in every way with parts made commercially on expensive automatic equipment. For amateur craftsmen, and particularly for youngsters, the Unimat offers both adventure and education. It opens an entirely new, wide-scope field of interest.

But while the machine is wonderful for hobbiests, a great many of the 100,000



FOR DISC SANDING wood or metal an abrasive disc is cemented to the sanding plate.


FOR PLANING wood, motor is tilted and planing attachment is clamped on spindle.


FOR CIRCULAR SAWING the saw attachment's table mounts on the cross slide.

FOR TOOL GRINDING many set-ups can be used. Headstock swivels to any angle.

FOR BUFFING a cloth buff is mounted on spindle and head is turned crosswise.

FOR GRINDING FLATS the spindle is set vertically. Vise holds work on cross slide.

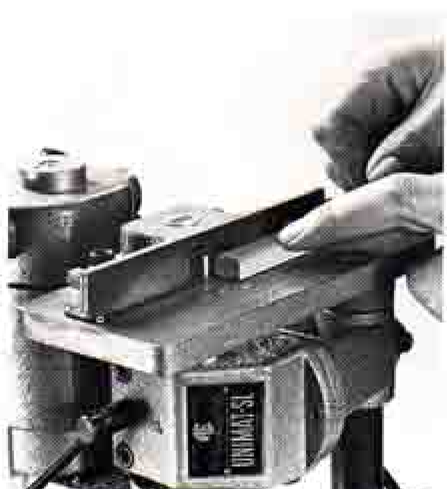
Unimats in use are used commercially. Inventors, designers, engineers, architects and physicists who build experimental models use Unimats to produce at practical cost small parts that if made on conventional machine tools would be quite expensive because of the set-up time involved. The Unimat is so adaptable that in industrial prototype labs the machine is often used for small work in preference to much higher-priced speed lathes. In pattern shops Unimats are used to machine intricate parts for foundry patterns. In optical instrument and electronics equipment repair shops the Unitmat has become standard equipment, since the machine gives an instrument repairman on small scale essentially the same manufacturing facility manufacturers have —and quite often with the Unimat he can rebuild damaged or worn instrument parts himself in less time than it would take to obtain factory replacements. Appliance repairmen often use Unimats instead of larger machines because the compact little tool is so much easier to set up and clean up. Gunsmiths, locksmiths, clockmakers, dental lab technicians, opticians, jewelers and lapidaries also use Unimats to make small parts for repairwork.

The Unimat's extraordinary versatility stems from the tool's four special design features.

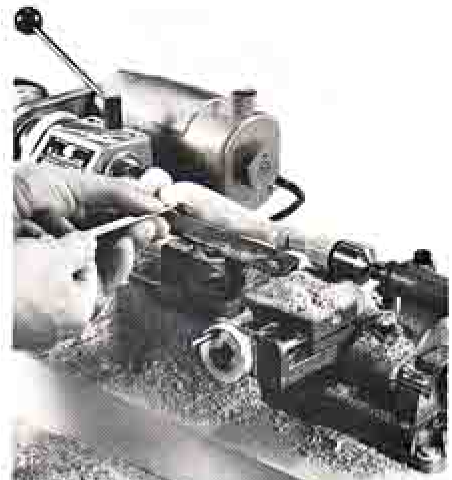
The first special feature is its convertible headstock. Conventional machine tools (reciprocating tools excepted) fall into two fundamental classes, horizontal-spindle machines and vertical-spindle machines. Metal lathes and bench grinders are horizontal-spindle tools. Drill presses, vertical milling machines and vertical surface grinders are vertical-spindle tools. All horizontal-spindle machine tools are basically much alike, and all vertical-spindle tools are basically alike. Because the Unimat's headstock can be mounted either on the machine's bed or on an auxiliary vertical column, the tool can be set up for *either* horizontal spindle machining jobs or vertical-spindle machining jobs, and this makes it possible to perform a wide variety of machining operations on the one

FOR MILLING, work can be clamped on the accessory T-slotted milling table.

FOR JIG-SAWING jig saw attachment's table clamps on spindle. Eccentric drives blade.



FOR SHAPING wood, shaper attachment's table is mounted above inverted head.



FOR WOODTURNING an accessory tool rest is clamped on the lathe's bedway.

machine. When the headstock is mounted horizontally on the bed, the Unimat becomes a metal lathe or grinding-polishing head. When the headstock assembly—spindle, motor, belt-drive and all—is mounted vertically on the auxiliary column, the machine becomes a drill press, vertical milling machine or surface grinder, depending upon how it's used. For drill press work, the tool's spindle can be raised and lowered drill-press-fashion with the spring-loaded spindle cartridge's rack-and-pinion advance. Work can be drilled at any angle, since the headstock can be swung 360° around the column and rotated 360° in the column mount. For vertical milling operations, the spindle's rack-and-pinion advance is locked, and the work to be milled is mounted on the carriage cross slide to permit precision-feeding the workpiece to a milling cutter chucked in the spindle. Set up similarly but with a grinding wheel on the spindle, the Unimat can also perform various precision-grinding operations, including surface grinding and tool-grinding.

SPECIFICATIONS

HORIZONTAL

Swing over bed	3"
Swing over cross slide	1-6/10"
Distance between centers	6-9/10"

VERTICAL

Spindle nose to cross slide	6-1/4"
Drill to center of circle	6-1/8"

COMPONENTS

Headstock rotation	360°
Headstock spindle bore takes	1/4"
Headstock spindle feed	5/8"
Tailstock travel	6-1/2"
Tailstock spindle travel	3/4"
Carriage travel	6-1/2"
Cross Slide Travel	2"
Tool post capacity—(centers standard 1/4" tool bits)	3/8"
Handwheel calibrations	.002"
Motor HP (110V-AC/DC)	1/10
Speed range (11 speeds)	310-5200 rpm.
Accuracy, spindle runout	.0005"
Over-all dimensions	14-1/2" x 4" x 5"
Weight	30 lbs.

The Unimat's second special feature is its high-rpm universal motor and 11-speed step-pulley drive, which gives a wide range and wide selection of spindle speeds. The drive provides both the very-high-rpm spindle speeds needed for such jobs as turning tiny shafts, drilling with very small-diameter drills or milling with small milling cutters, and, with the belts shifted, the powerful low-rpm speeds needed for rough-turning large-diameter work or drilling with large-diameter drills. The belt-drive also functions as a safety clutch, since the belts will stretch when severely overloaded and thus prevent damage to the machine if a cutting tool should wedge in a cut. Because the motor is bracketed on the spindle cartridge, the same wide selection of spindle speeds is available whether the headstock is used horizontally or vertically.

The third special feature contributing to the machine's versatility is the interchangeability of the Unimat's chucks and workplates. The tool's spindle nose, the threaded adapter stud that fits the carriage cross slide, and the tailstock ram all have the same thread, which makes it possible to mount any of the machine's chucks or workplates either on the spindle, on the cross slide or on the tailstock ram. This greatly simplifies making set-ups. Spindle chucks can be used either as workholding devices or as toolholding devices. A workpiece fixed on a plate first can be mounted on the lathe spindle for turning, and then later mounted plate and all on the carriage cross slide for drilling or milling. Workplates can be used in several ways. The accessory sanding plate, for example, can be used not only for sanding but also as a large lathe faceplate, as a carriage worktable for vertical drilling or milling, or as a tailstock pad to support a workpiece drilled in the lathe.

The fourth special feature contributing significantly to the Unimat's versatility is the tool's precision construction, since this makes it possible to accomplish accurate precision work with the machine. Because most machined parts needn't be finished to particularly close tolerance, precision performance isn't always really required. But whenever tolerances are critical, the Unimat provides high-precision capability. The tool's preloaded-ball-bearing-mounted spindle has less than .0005" runout. The spindle can be adjusted for perfect alignment with the bed in minutes. The cross slide travels precisely square with the ways. Feed screw handwheels are calibrated. Spindle collets are available for chucking small turned parts with perfect concentricity. Parts can be turned on the Unimat with the same exacting precision possible on the most expensive toolroom lathes, and flat work can be finish-ground with the same high precision possible with industrial precision grinding equipment.

Ultra-precise work of course demands a degree of skill on the part of the machinist. Anyone experienced in the use of larger machine tools will be able to set up the Unimat for any required machining job and perform critically precise work on the tool with no difficulty, since the Unimat is set up in much the same way and has essentially the same operational features as larger machines.

A complete novice using the Unimat for his first try at metal-machining will soon learn machining fundamentals by experience. This booklet briefs elementary procedures. While it's not a complete machinist's handbook, it will give a Unimat owner a survey of the many operations that can be performed with the machine, show the more commonly-used set-ups, indicate how the many accessores are used, and get him started in the right direction. Skill as a machinist, which is really a practical knowledge of cutting tools and the materials cut with them, comes with practice. The more you use a machine tool, the more you're able to do with it.

Keep in mind while exploring the Unimat's capabilities the sweeping range of work that machine tools accomplish. Machines larger than Unimat but performing the same operations in the same way make nearly all the consumer goods we use. Machine tools turn, drill, mill and grind, and these operations shape the output of the wealthiest nation on earth. With Unimat you can try them all on one machine in one afternoon—and then use the tool to do whatever kind of work interests you most. Metal-machining opens more possibilities than any other field of craftsmanship. When you're equipped to machine metal, you have the means to build anything you want to build—and do it just as well as anyone else could, even the largest corporations.

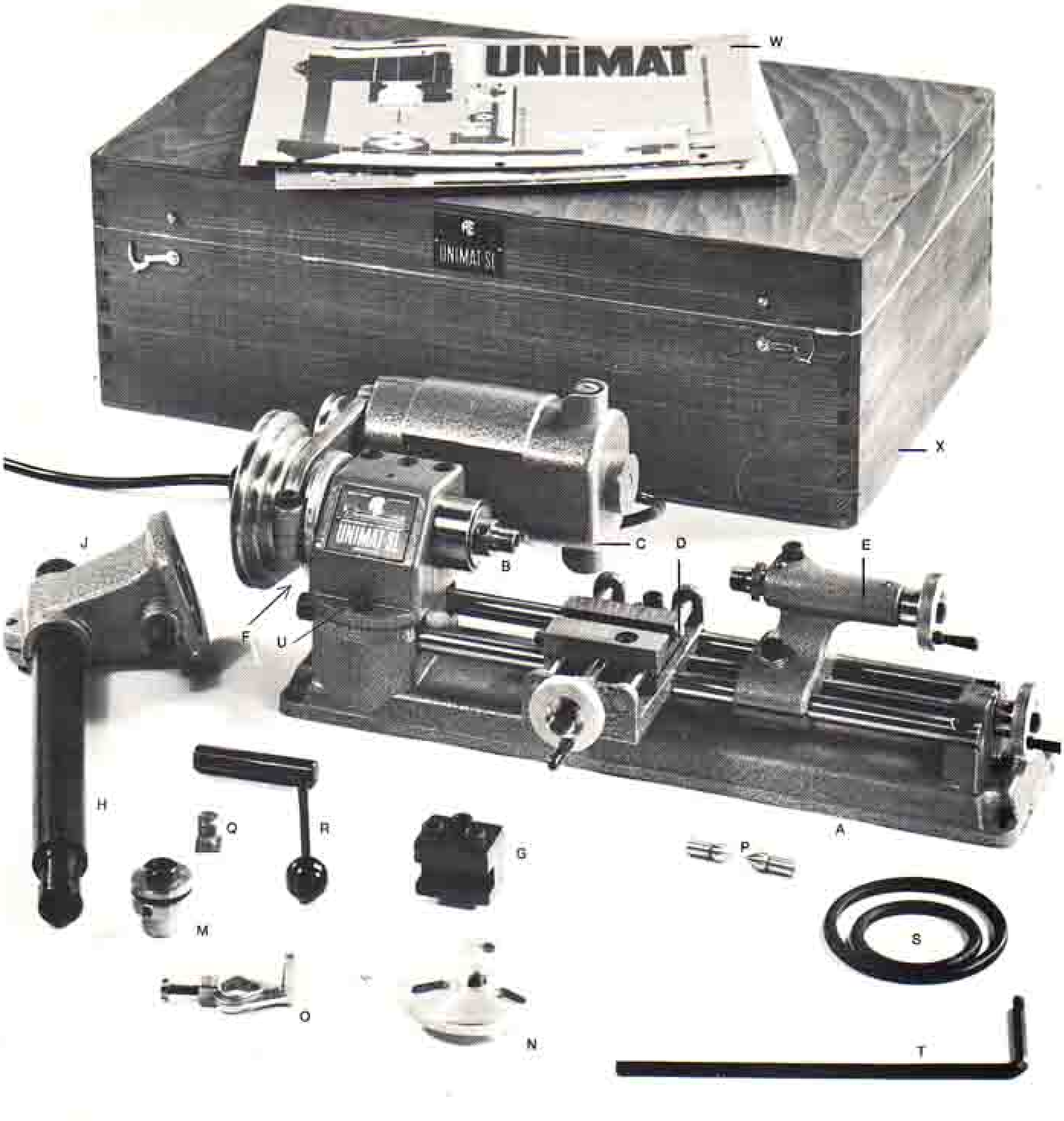
The Unimat gives you, on small scale, this facility. It's a universal tool, the most versatile machine a craftsman could imagine.

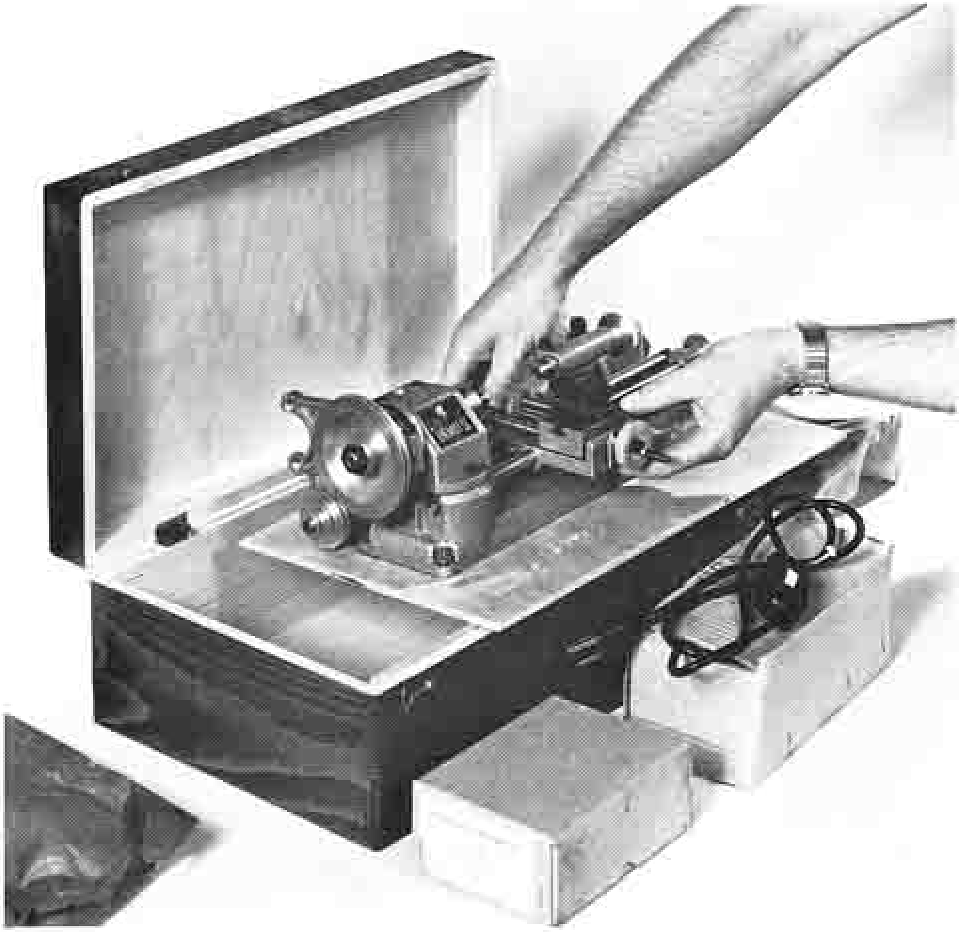
A COMPLETE MACHINE SHOP IN A BOX

A. Ribbed Lathe Bed
B. Ball Bearing Headstock Spindle
C. 1/10 hp AC/DC 110V Motor
D. Carriage Assembly
E. Tailstock
F. Ball Bearing Idler Pulley
G. Tool Post
H. 12" Steel Vertical Column
J. Vertical Column Headstock Adapter
K. Jacobs-type Drill Chuck & Key
M. Grinding Wheel Arbor
N. Face Plate
O. Lathe Dog
P. Dead Centers (two)
Q. Slotted Adapter
R. Spindle-feed Hand Lever & Pinion
S. Set of Drive Belts
T. Allen Wrench
U. Headstock Alignment Pin
V. Roughing Tool Bit
W. 44 Page Instruction Manual
X. Wood Storage Chest

OPERATING INSTRUCTIONS

The Unimat is easy to set up and operate. Even an inexperienced amateur will soon learn to use it like an experienced machinist. But before you operate the tool, read these instructions. They show how to assemble the machine, how to perform simple metal-turning jobs, how the various special lathe operations possible on the tool are accomplished, and how to use the headstock on the auxiliary column for drilling, milling and surface grinding. Exploring the Unimat's capabilities is a fascinating adventure, since it can perform on small scale virtually any machining operation that can be performed on full-size machine tools. Following the basic procedures outlined, you'll find it easy to make the appropriate set-up for any precision metal-machining job you might want to do.





Setting Up Your Unimat

Each Unimat is shipped in a sturdy wooden storage chest enclosed in a heavy cardboard outer carton. Two small boxes, one containing the motor and the other containing small parts, are packed with the machine in the chest.

Be sure to mail the guarantee card packed with the tool promptly. This card validates the machine's warranty, registers you as a Unimat owner and assures that you will receive catalogs and any other supplemental literature issued on the tool.

Before shipment from the factory every Unimat passes meticulous inspection. If when unpacking your machine you find that a part has been damaged in shipment—or in the event a part should become defective within the warranty period—write to the Customer Service Department, American Edelstaal, Inc., One Atwood Avenue, Tenafly, New Jersey 07670, and describe exactly what is wrong, referring to the part by the name and number indicated on the parts list. If it is necessary to return the part to us for replacement, we will mail you a special shipping ticket. Our repair department cannot accept parcels not previously authorized in this way.

For shipment the Unimat is bolted to a thin plywood baseboard, with the vertical column (H) secured in two blocks behind the lathe. Wipe the machine with a rag dampened in solvent to clean off the sticky rust-inhibiting preservative compound protecting the tool. Then immediately oil all bright-metal surfaces with light machine oil. Loosening the two large Allen-head spindle lock screws in the top of the headstock casting will permit sliding the spindle cartridge back and forth with the ball-handled pinion lever for cleaning and oiling.

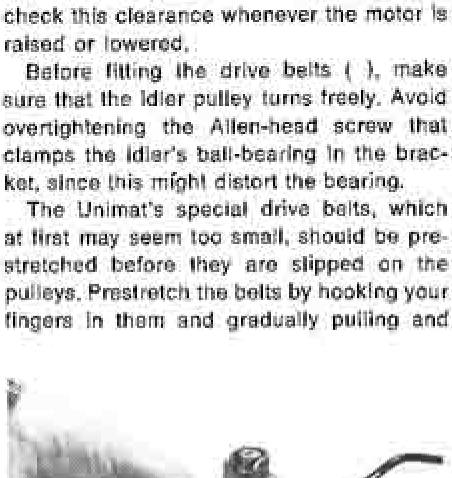
Mount the motor behind the headstock on its bracket with the two flat-head screws provided, cord leading to the rear. Then slip the 3-step pulley on the motor shaft and align the slot in the pulley with the shaft's crosspin. As you tighten the filister-head screw and washer that secures the pulley on the shaft, the crosspin will bend into the semi-circular slot and key the pulley.

The motor bracket, which clamps on the spindle cartridge, can be positioned as desired to raise or lower the motor. Whenever the motor bracket's clamp screw is loosened, however, the coil spring that retracts the spindle cartridge pushes the bracket against the inner face of the spindle pulley, and this will prevent the pulley from turning. Slight clearance between bracket and pulley—about .010", or the thickness of tin can stock—is required to allow the pulley to turn freely. To adjust this clearance, first fully retract the spindle cartridge in the headstock with the ball-handled pinion lever . Next loosen the motor bracket's clamp screw, pull the bracket back along the spindle cartridge (against the tension of the spring) enough to provide clearance, and then retighten the clamp screw. Recheck this clearance whenever the motor is raised or lowered.

PRESTRETCH the rubber drive belts before slipping them on the pulleys.

Before fitting the drive belts ( ), make sure that the idler pulley turns freely. Avoid overtightening the Allen-head screw that clamps the idler's ball-bearing in the bracket, since this might distort the bearing.

The Unimat's special drive belts, which at first may seem too small, should be prestretched before they are slipped on the pulleys. Prestretch the belts by hooking your fingers in them and gradually pulling and



MOUNT THE MOTOR on its bracket with the two machine screws provided.

CROSS PIN in motor shaft bends into semicircular slot in the step-pulley.

stretching them, working around each belt several times. Then slip the smaller belt on the smallest step of the motor pulley and the largest step of the idler pulley. Slip the larger belt on the middle step of the idler and the middle step of the spindle pulley. This belting arrangement drives the spindle at its second-slowest speed, with ten other combinations possible. Run in new belts at this speed for ten minutes before shifting to higher speeds.

Like other quality universal-motor tools, the Unimat has a 3-conductor cord with a 3-prong plug. The plug's third prong safely grounds the machine and eliminates hazard in the rare event of an electrical breakdown. The tool's bronze-bearing AC-DC motor, which is fully enclosed to keep out dirt, heats somewhat when run continuously under load, which is normal. When pulling load a universal motor's speed drops, with the motor delivering full rated power when shaft speed falls to about half the no-load speed. When shaft speed drops to less than half the no-load speed, the motor is overloaded. You can easily judge when the Unimat's motor is delivering full power by its sound; the full-power speed is the point beyond which the machine sounds labored. Avoid repeatedly overloading the machine's motor. If a heavy cut or snagged drill stalls the motor, switch off power immediately and correct the situation before restarting.

If you mount your Unimat permanently on a bench-top, be sure that the mounting surface is perfectly flat, since screwing the machine down on an uneven surface might twist the bed casting. Many Unimat owners mount their machines on Formica-faced or white-enameled wooden baseblocks measuring about 11″ x 18″, which makes the tool readily portable. A piece of ¾″-thick Formica-covered plywood will serve, but a heavier base about 1½″-thick is preferable. A light-colored base will be easier to keep clean and will make small parts easier to see.

When you have your machine set up, familiarize yourself with its operating controls. Turning the longitudinal feed screw's calibrated handwheel slides the lathe carriage back and forth along the ways. When a cutting tool is mounted on the carriage, the longitudinal feed moves the point of the tool along a line of travel precisely parallel with the lathe's centerline. In this way work mounted in the lathe can be machined accurately cylindrical.

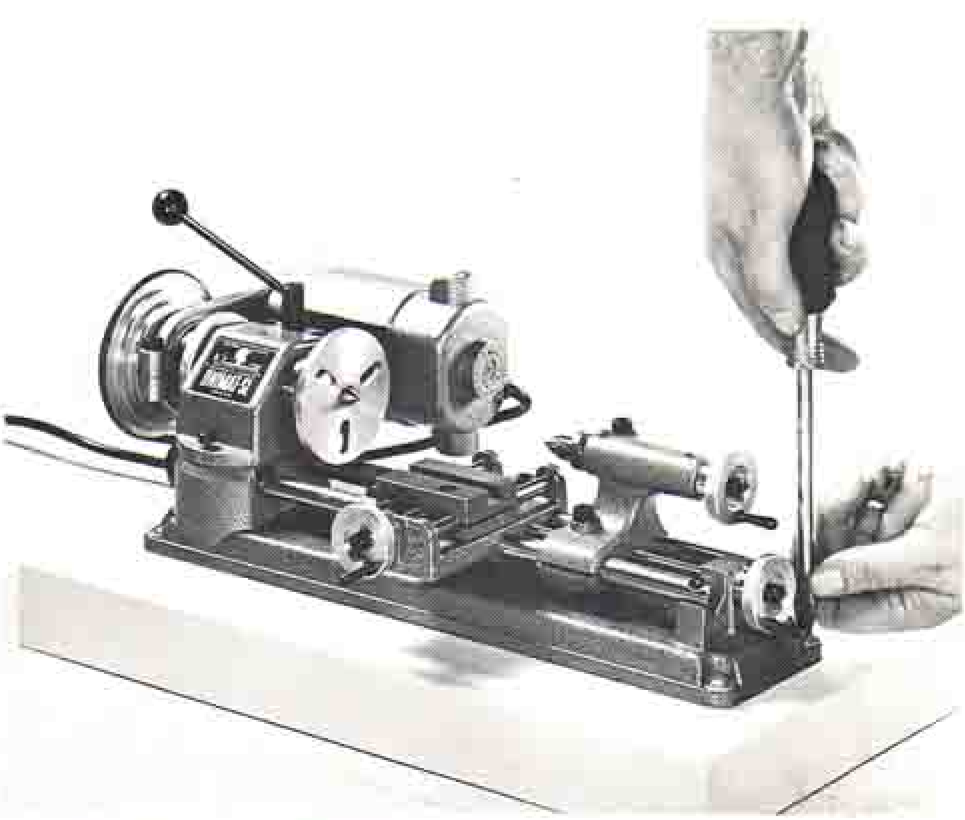
The cross feed screw's calibrated handwheel moves the carriage cross slide along a line of travel precisely square—at a 90° angle—with the lathe's centerline. The cross feed screw feeds the tool bit in or out to control depth of cut for cylindrical turning, and it is used for facing square shoulders and squaring the ends of workpieces.

Both longitudinal and cross feeds have Allen-head tensioning screws. When fully tightened these screws lock the feed movements. When partially tightened they tension the movements to provide the sliding action desired—tighter or freer.

The Allen-head screw in the base of the tailstock clamps the tailstock wherever desired along the ways. The tailstock ram can be advanced with its calibrated handwheel and locked in position with the Allen-head lock screw at the top of the tailstock casting. All lock screws on the Unimat have the same size heads, and the machine's large Allen wrench fits them all. When the Unimat is set up for lathework the two Allen-head lock screws in the top of the headstock casting should be tightened enough to clamp the spindle cartridge immovable, but do not overtighten them. The ball-handled pinion lever, which slips loosely into its hole in the headstock, ordinarily isn't used for metal-turning. You can position the lever with the ball over the drive belts to serve as a belt guard, or you can remove the lever.

It's important to keep a metal lathe cleaned and oiled, since accumulated dirt, chips and swarf from grinding wheels or sanding discs cause unnecessary wear. You can clean metal chips from your Unimat in seconds with a shop vacuum, or you can

CLEARANCE is required between motor bracket and spindle step-pulley.



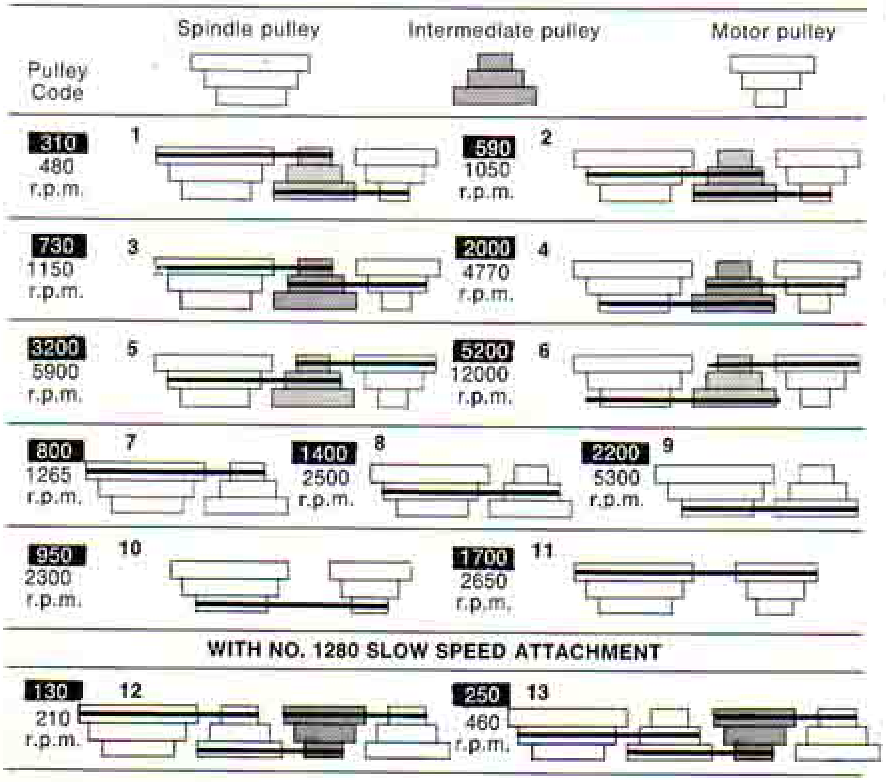
MOUNTING your Unimat on a wooden baseblock makes the machine easily portable. Make the base about 11″ x 18″ x 1½″ with white finish.

SPINDLE SPEEDS

(with motor — 3450 r.p.m.)

Standard Spindle (r.p.m. indicated as **000**)

"WW" Watchmaker Spindle (r.p.m. indicated as 000)

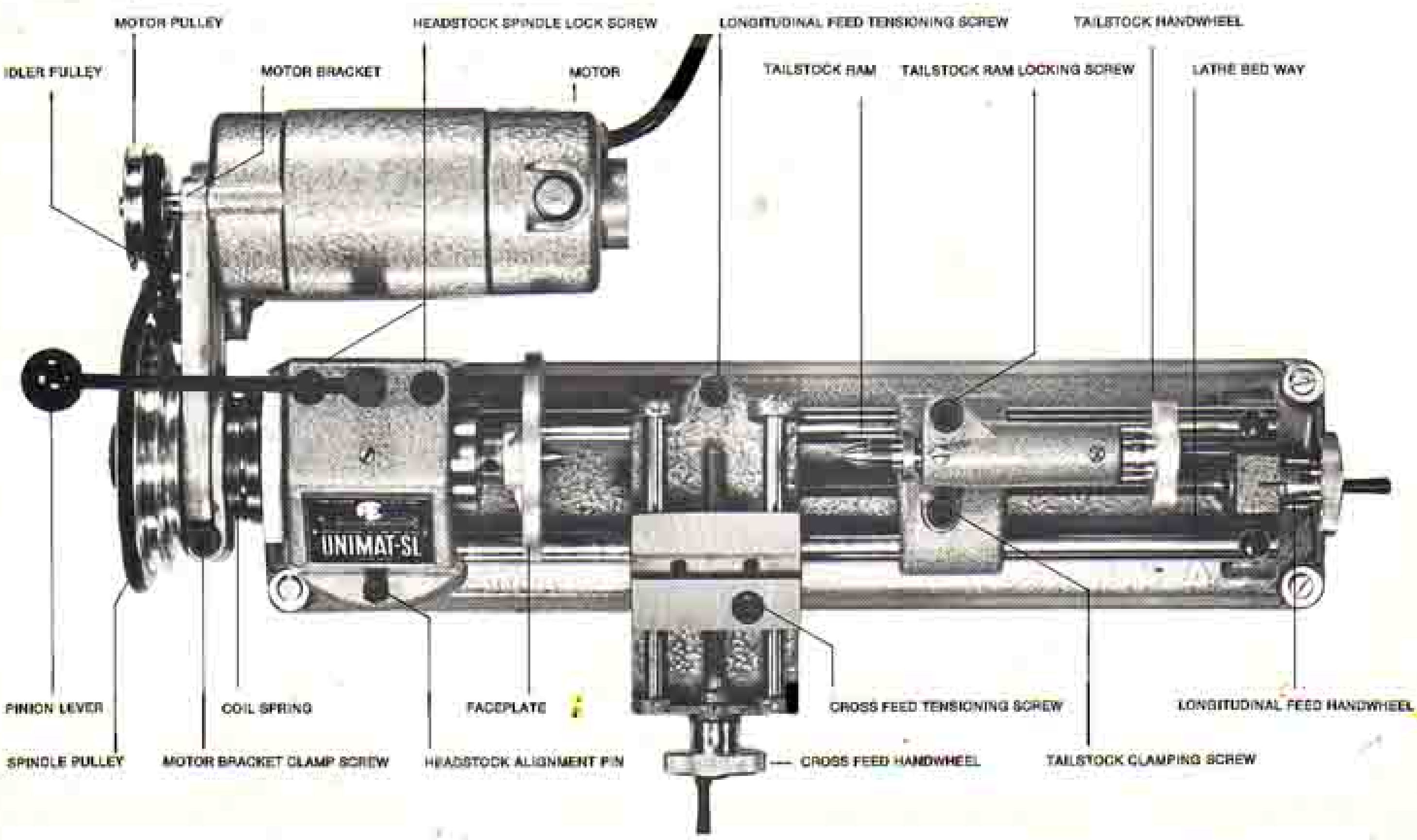


brush the tool clean with a paintbrush. After each use oil the ways and wipe down all bright working surfaces with the machinist's best friend, an oily rag, to prevent rust. Keep the tool's feed screws clean, and lubricate them regularly with light machine oil.

Remember to observe sensible safety precautions when using your Unimat. Any machine tool cutting at high speed throws flying chips that may endanger the user's eyes, and the fact that the Unimat is so often used for close precision work—with the operator's face close to the action—makes it particularly important to keep this hazard in mind. Wear protective safety glasses when performing any machining operation that produces flying chips, especially when machine-grinding or disc-sanding on the machine.

When the Unimat is used for special work, a special base for the machine may be desirable. In instrument repair shops Unimats are sometimes screwed to small cast iron surfaces plates. The surface plate provides a true surface behind the bed on which to use a magnetic-base dial indicator.

THE UNIMAT'S operating controls are much like the controls on larger machine tools. Take a few moments to become familiar with them before mounting work in the machine for turning.



Turning Work Between Centers

In most metal lathe operations the lathe revolves the work to be machined against a fixed cutting tool that peels off shavings. It takes considerable force to pare chips from solid metal. The workpiece must be mounted very securely in the lathe to make the tool bit's cutting edge cut the work instead of lifting it out of the machine.

The most elementary way to hold work is to mount the workpiece between centers. Two 60° centers (P)—hardened and ground can be inserted in the lathe spindle and tailstock ram. They are supplied with the Unimat. If each end of the stock to be turned is first centerdrilled with a 60° countersink centerdrill, the work then can be supported between the two hardened points. The center in the lathe's spindle, termed "live" because it rotates, keeps the work aligned. The center in the tailstock ram, termed "dead" because it doesn't turn, serves as a conic bearing on which the workpiece can revolve. Usually work mounted between centers is rotated with a dog (O) which is a bent-tailed fixture clamped on the spindle end of the work in such a way that the dog's tail engages a slot in a faceplate (N) screwed on the spindle.

STRAIGHT TURNING

Turning work mounted between centers to simple cylindrical shapes, termed "straight" turning, is the most basic metal lathe operation. Mounting between centers is also the most accurate way to turn precision work. Work turned between centers can be removed from the lathe for other machining operations and later replaced for additional turning without loss of precision. Or the workpiece can first be machined half its length, then turned end-for-end and machined the rest of its length with perfect concentricity.

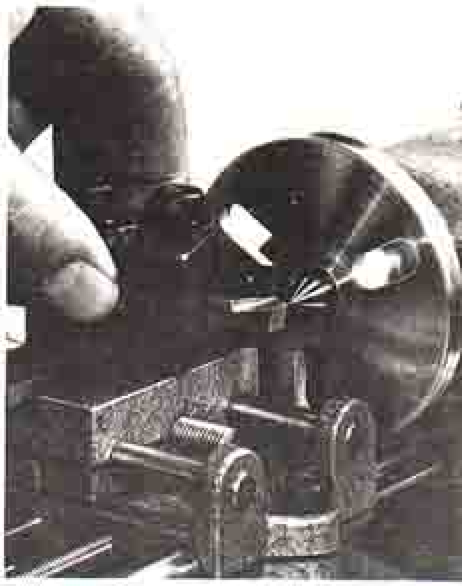
Before attempting critical work with your Unimat, however, it's advisable to try some practice turning on scrap stock to get the "feel" of the machine. If you've never before used a metal lathe, you'll find this a revealing experience. Aluminum is perhaps the most suitable metal for practice turning, since it turns freely. You can get some ½"-diameter rod stock at a hobby shop, or you may be able to obtain some scrap aluminum.

Having squared the ends of a piece of aluminum about 8" long, centerpunch both ends exactly on center. You can locate the centers accurately with a small combination square's centerhead or with dividers. To centerdrill the stock, screw the Unimat's drill chuck (K) on the spindle, insert a 60°-centerdrill in the chuck, and with the spindle operating at slow speed, advance the tailstock ram to feed the stock against the rotating drill. Feed the work slowly. Drill the centerholes to nearly the full diameter of the centerdrill—but not deep enough to leave a ridge around the countersinks. Although cutting oil should be used when centerdrilling steel, no lubricant is needed to drill non-ferrous metals.

After drilling, clean out the centerholes and fill them with machine oil. Then clamp the dog firmly tail-outwards on one end of the stock, screw the faceplate on the lathe spindle, and with the tailstock positioned as needed on the ways, advance the ram enough to support the work between the points of the centers. Be sure the dog's tail enters one of the three slots in the faceplate.

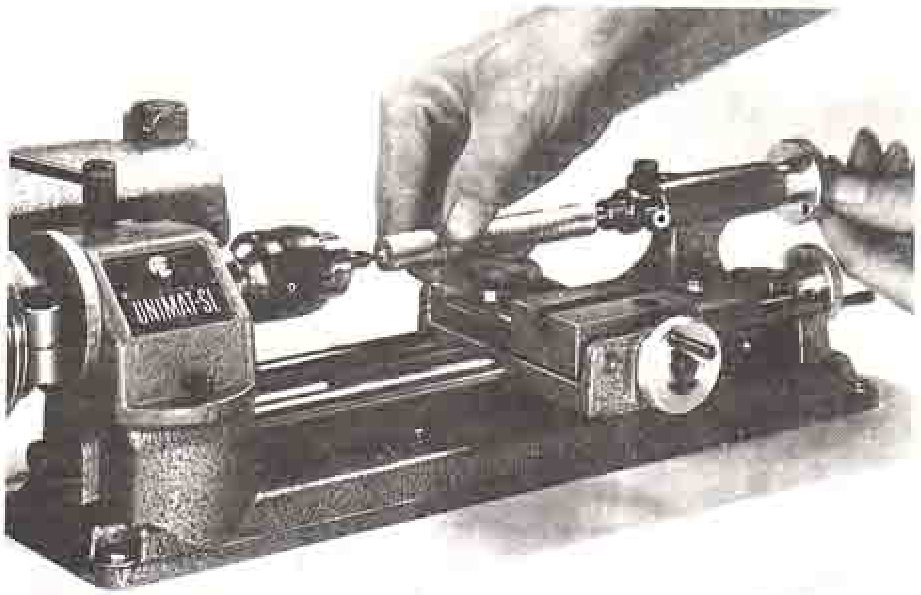
The dog supplied with the Unimat will drive work up to ½" in diameter. For larger

LOCATE CENTER POINTS on each end of stock with square or dividers and center punch.

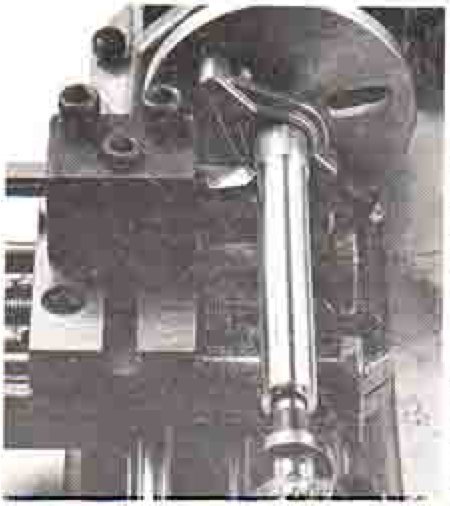


THE TOOL BIT'S POINT must be at exactly center height. Align tool with point of center.

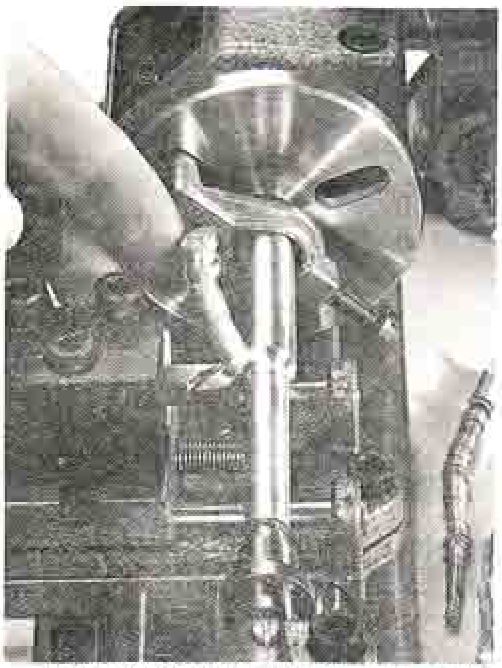
LUBRICATE THE DEAD CENTER with light machine oil and adjust it carefully.



CENTERDRILL THE STOCK with a 60° countersink centerdrill chucked in the drill chuck. Feed the work to the rotating drill with the tailstock's handwheel.



A LIGHT CUT along the stock will give you the feel of the longitudinal feed.



HEAVY CUTS remove metal faster but leave the workpiece with rougher finish.

DRIVE LARGE WORK with a steel pin set in one end of stock. Pin engages faceplate.

workpieces you can machine a similar but larger dog, or to drive even larger work you can set a steel pin in one end of the stock.

MOUNTING CUTTING TOOL

Next remove the work temporarily from the lathe and mount the cutting bit. The ready-ground ¼"-square bit supplied with the machine (V), a general-purpose (roughing) turning-facing tool sharpened on its left edge, is a "right-hand" tool. Fed into the work *from* the operator's right, it cuts leftwards—towards the lathe spindle.

The Unimat's open-side tool block (G), the same type of tool-holder used on large industrial lathes, mounts on the T-slotted carriage cross slide with a screw and T-nut. It can be angled in any way most convenient, and by rotating the block the tool can be mounted on either side. Generally for cuts towards the headstock the tool should be mounted on the left side of the block, and the block should be set square with the bit's shank at a 90° angle to the workpiece.

For best cutting action the bit must be mounted with the point of its cutting edge exactly at center height, level with the axis of the work. Use a sheetmetal shim of the thickness required to align the bit's point with one of the centers, inserting the shim under the tool's shank. For maximum rigidity the bit should overhang the block as little as possible.

With the bit mounted, feed back the cross slide and replace the work in the lathe, adjusting the dead center carefully with the tailstock handwheel and locking the adjustment. Since the tailstock center functions as a bearing, adjust it just tightly enough to eliminate end play but not tightly enough to bind. The center will require periodic relubrication and readjustment as the workpiece is machined. After each few cuts the lathe should be stopped, the center partially withdrawn, the work's centerhole refilled with machine oil and the center then readjusted. Relubing and readjusting the dead center at short intervals is especially important when you're turning work at high spindle speed. It's also important when you're roughing long stock to size with cuts that heat and expand the workpiece, for unless the center is frequently readjusted the work's expansion will cause binding and the friction will soon burn the center.

Taking a light truing cut along the scrap aluminum workpiece will give you the feel of the Unimat's longitudinal feed. After moving the tool bit beyond the work's right-hand end, position the bit with the cross feed for a cut about 1/32" deep and tighten the cross feed tensioning screw to lock the movement. Also partially tighten the longitudinal feed's tensioning screw enough to give smooth carriage glide when you turn the handwheel. Then, having revolved the workpiece in the lathe once by hand to make sure it turns freely, set the drive belts for medium spindle speed and switch on the motor.

If you turn the longitudinal feed handwheel steadily and evenly when making the cut, the bit will pare off a continuous light chip and accurately machine the work to a beautifully smooth finish. You can continue the cut until the carriage nears the rotating dog. At this point stop the lathe, unlock the cross feed and withdraw the tool.

Next try a deeper cut, setting the tool bit to pare off a chip about 3/32" deep. Shift the belts for slow spindle speed, and crank the longitudal feed handwheel fast enough to make the bit cut a thick, curled chip. As you'll see, this heavier cut will remove metal much faster but will leave a rougher finish on the work.

Ordinarily any metal-turning operation is performed with first a series of deep roughing cuts and then a light finishing cut. Roughing cuts are taken as needed at slow spindle speed to reduce the work to slightly more than finish diameter; then a light cut is taken at higher spindle speed to finish the work to exact size. Roughing cuts are always made towards the headstock. They can be made as deep as the lathe will pull at slow speed without excessive laboring. The allowance left for finishing generally should be about .010", for a finish cut about .005" deep.

The depth of the roughing cuts the lathe can pull, which you'll soon learn to judge by experience, depends upon a number of factors: the metal being machined, the work's diameter, the spindle speed, the feed rate, the rigidity with which the work is mounted, and the shape and sharpness of the cutting bit. The Unimat can pull deeper cuts when machining soft, easily-cut metals than when machining tough, hard-to-cut metals. You can take deeper roughing cuts when turning soft aluminum than when turning brass. You can take deeper cuts when turning brass than when turning steel or cast iron.

SELECTING SPEEDS

The optimum spindle speed for a particular cut depends both on the work's machinability and its diameter. Small aluminum or brass parts can be turned at high speed. But when turning large-diameter steel workpieces it's necessary to use slow spindle speed and take very light cuts. Deep cuts on large-diameter work will stall the motor. If you do stall the motor, immediately switch off the machine, back out the tool and try a slower, lighter cut.

Slow spindle speed also minimizes tool chatter. When the tool vibrates in the cut and leaves a corrugated finish on the work, it's an indication that the set-up isn't sufficiently rigid to resist the cutting forces involved. Chatter is often a problem when turning slender work that springs away from the bit's cutting edge. When a tool chatters, reset it at another angle and take a lighter cut at slower speed.

FACING

Try some practice facing cuts before discarding your scrap aluminum workpiece. To face the end of the work, set the tool at the angle required to make its point cut cleanly slightly more than 45°, lock the longitudinal carriage feed, and make the cut with the cross feed handwheel. If the tool chatters, increase the bit's angle. Although on larger lathes facing cuts are usually made from the center of the work outwards, facing cuts made on the Unimat often will have smoother finish if made from the work's periphery towards the center. When facing large-diameter work center-out, take very light cuts to avoid overloading the motor. A heavy cut that the lathe can pull easily near the center of the work will stall the motor as the diameter of the cut increases.

The opposite end of the workpiece can be faced by turning the stock end-for-end and clamping the lathe dog on the other end. Use pads cut from thin fiber or sheet metal softer than the work under the dog's screw to avoid marring the finish on finish-turned work.

Many parts turned between centers will have stubs at one or both ends that must be cut off after the part is turned. While a specially-ground tool bit can be used for cutting-off in the lathe, it is usually simpler to turn a V-shaped notch at the end of the part and to cut off the stub with a hacksaw after the work is removed from the machine. When turning down the stock beyond the part, particularly when machining brass or aluminum, avoid turning it so small in diameter that the stub might break off before the part is completely finished.

Perhaps with another piece of scrap stock you'll want to try machining work accurately to size. For precision work you'll of course need a precision measuring instrument, either a micrometer (preferable) or vernier caliper.

ALIGNING THE SPINDLE

For precision turning the Unimat's spindle must be very accurately aligned with the ways. The headstock's hex-head aligning pin (U) provides only moderately accurate alignment. To align the spindle more precisely, mount a workpiece between centers, take a light cut along its length, and then measure the diameter of the turned work at each end with a micrometer. Chances are you'll find that the two ends differ in diameter by a few thousandths, which indicates that the lathe is cutting a very slight taper. This can be corrected by loosening the headstock's Allen-head clamping screw and rotating the headstock very slightly to make the lathe's line of centers (the axis around which the work revolves) precisely parallel with the ways (which guide the cutting tool along its line of travel). If after the trial cut along the workpiece the work's spindle end is larger in diameter than its tailstock end, turn the headstock a hair's-breadth clockwise, which will shift the spindle end of the workpiece towards the cutting tool. If the spindle end of the workpiece is smaller in diameter than the tailstock end, rotate the headstock slightly counterclockwise, which will shift the spindle end of the workpiece away from the cutting tool. Several trial cuts with minor readjustments may be needed to align the spindle so exactly that the lathe will turn a perfect cylinder. When the headstock is precisely aligned, scribe witness marks on the headstock and bed casting to facilitate resetting.

Although less accurate, a faster way to align the lathe spindle is to advance the tailstock and then adjust the headstock until the dead center will seat squarely in the spindle's bore.

HANDWHEEL CALIBRATIONS

The Unimat's longitudinal feed and cross feed screws have identical metric 8x1mm threads. Turning the handwheel on either feed screw moves the cutting tool exactly one millimeter. The hub of each handwheel is calibrated with 20 divisions, each 1/20th-revolution mark indicating a feed of .05mm.

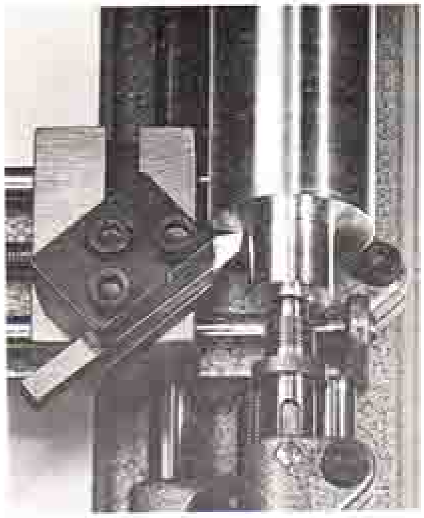
While camera and instrument parts are made to the metric system of measurement, for other work you'll want to use inch-system measurement, measuring in thousandths of an inch. With the Unimat this is no problem. One millimeter equals .03937", or (rounded off) .040". One full turn of either feed handwheel advances the tool forty thousandths, with each of the 20-division hub calibrations indicating a feed of two thousandths. Simply remember that one mark feeds .002" and reduces the diameter of the workpiece twice that, or .004". If you should want to reduce the diameter of a workpiece .012", for example you would feed the tool in three marks.

For smooth operation all machine feed screws must have some backlash, or play, normally about 1/8th turn. You can adjust the backlash of either of the Unimat's feed screws by loosening the lock nut holding the handwheel, tightening or loosening the wheel, and then retightening the lock nut. When machining cast iron, which produces powdery chips that are quite abrasive, protect the feed screws and the lathe bed with aluminum wrapping foil.

Together the feed screw backlash adjustments and the tensioning of the carriage movement tensioning screws determine the "stiffness' of the feed controls. You'll soon learn to judge the feed tension most appropriate for particular machining jobs by experience. "Easier" feed permits faster work when you're turning soft aluminum, plastic or other easily-cut material. The lathe should be set up more tightly for machining steel or cast iron, and small parts to precision tolerance. Feed adjustments that are too slack will cause tool chatter.

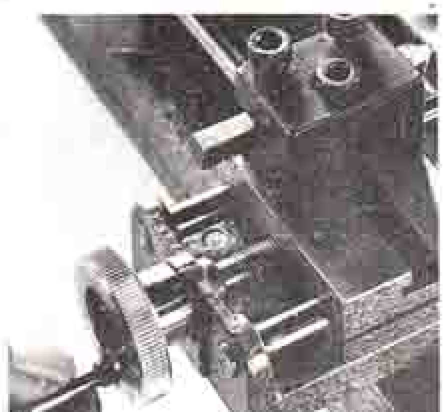
CUTTING TOOL TECHNIQUES

Keep your lathe tools sharp. As you'll

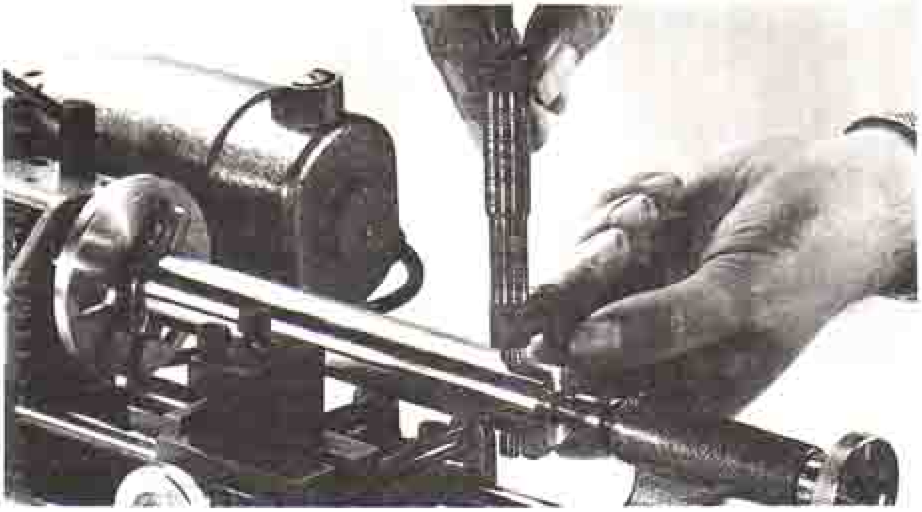


FOR FACING CUTS angle the tool to make its point cut cleanly. On large work take light cuts.

PARTS MAY BREAK before they're finished if you turn end stubs too small in diameter.



EACH CALIBRATION on the hubs of the feed handwheels indicates a feed of .002".



FOR PRECISION WORK the lathe spindle must be precisely aligned with the ways. Machine a test bar, measure both ends, then adjust headstock until lathe cuts true.

A "FALSE EDGE" gradually builds up on the bit's cutting edge. Whetting removes it.

notice in the course of your practice turning, a deposit of metal being machined gradually builds up along the top of the cutting edge, forming a pressure-welded "false edge." In rough turning this false edge does no harm, but for finish-turning the built-up metal should be removed by rubbing the bit's faces flat on a fine-grit oilstone. If you avoid rounding over the cutting edge, a lathe tool can be resharpened by whetting many times before it will require regrinding.

But when a tool's cutting edge finally becomes chipped and dulled, the bit needs regrinding. You can grind lathe tools on the Unimat itself with the headstock set up for grinding, or you can use any bench grinder. Regrind the bit's faces slowly on a medium-grit wheel enough to renew the edge, maintaining the tool's original shape. Avoid overheating the steel.

There are a number of fairly standard shapes of lathe tools that have proved efficient for the more common turning operations, and machinists soon learn to grind special bits for special jobs. A novice at machinework probably would be well advised to buy a set of ready-ground bits. Unimat tool bits are ground exactly like bits used in large industrial lathes—but smaller. If you can buy unground ¼"-square tool bits and grind them yourself, keep in mind the two important requirements for all metal-cutting cutting tools — clearance and rake.

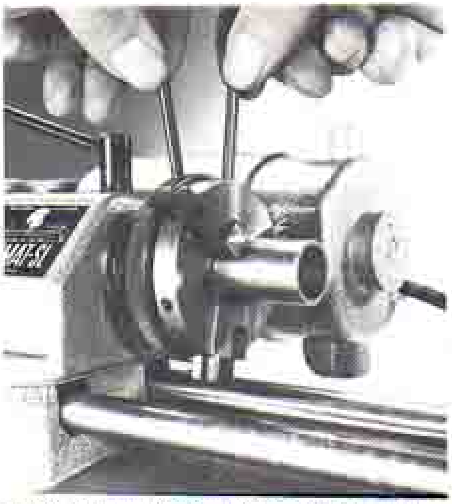
Both are angles expressed in degrees. Clearance is the angle at which the bit is ground for relief *under* its cutting edge. This relief, which usually should be about 10°, allows the sharp edge to advance into the work without rubbing. A lathe tool's cutting edge must have both side clearance and end clearance.

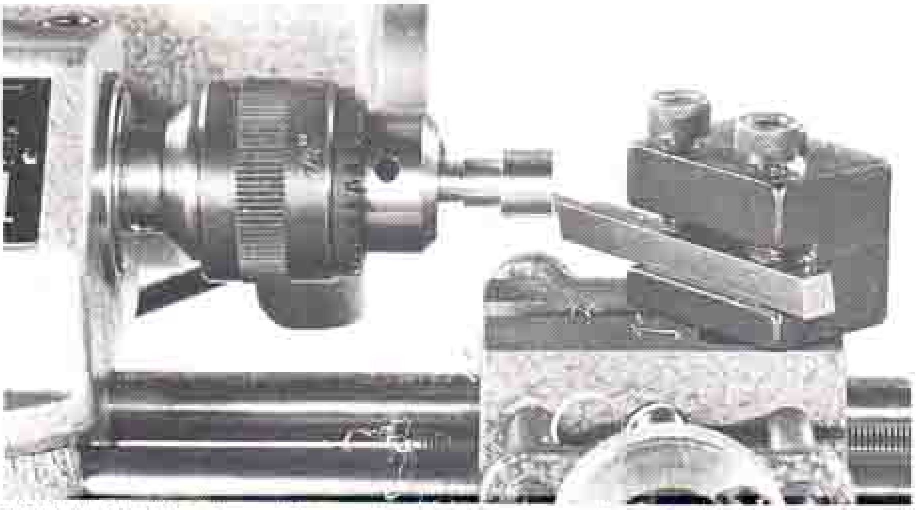
Rake is the angle of slope across the top of the tool. The rake may slope either sideways away from the edge or backwards from the edge. Side rake gives the cutting edge its shearing action. Back rake directs chips away from the work. In general tools with smaller rake angles (with squarer, beefier cutting edges) are used to machine hard-to-cut metals, and tools with larger rake angles (giving more acute cutting edges) are used to machine easier-to-cut metals. For turning hard cast iron, tool bits with about 10° rake usually give best results. For tools to turn soft steel, a 19° rake angle is most efficient. For turning soft aluminium, bits should be ground with 35° rake.

Tools for turning brass are an exception. Because a cutting edge with rake digs into brass and causes the tool to chatter, brass-cutting bits are always ground with standard clearance but with 0° rake—perfectly square across the top. Machinists usually keep a separate set of tools for brass-turning.

YOU CAN RESHARPEN lathe bits by whetting on an oilstone many times before they will require regrinding. Rub the bits' three ground faces flat on the stone.

REGRIND BITS on a medium-grit wheel, maintaining the tool's original shape.


THE 3-JAW UNIVERSAL CHUCK centers work up to 2" in diameter automatically.


THE DRILL CHUCK can be used to mount small workpieces as well as twist drills. Tighten the chuck evenly, using the key in all three pinion holes.

Other Ways To Mount Work

A metal-machining operation always involves two steps: first fixing the work in the machine rigidly enough to withstand the force required to shear off chips, and then, with a reasonably efficient cutting tool, applying that force. The machinist mounts the workpiece, making an appropriate "set up", and the machine then does the work.

Workpieces of any shape can be mounted in metal lathes for turning with various special workholding devices, most of which screw on the spindle's threaded nose. Two of the most commonly-used devices, a drill chuck (used to hold workpieces as well as twist drills) and a face plate, are supplied with the Unimat. A number of other workholding devices are available as accessories.

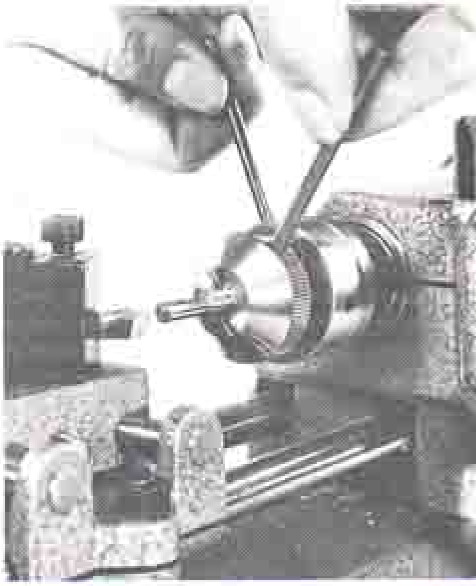
The Unimat's drill chuck centers small round work up to ¼" in diameter to within about .002". In order to grip very small-diameter drills the drill chuck's three hardened jaws have very narrow ground faces, and the jaws will bite deeply into a soft-metal workpiece if overtightened. Always tighten the chuck gradually and evenly on the work, using the key in each of the three pinion holes, and tighten it only enough to hold the work firmly. Work that hangs beyond the jaws enough to whip should be centerdrilled and supported with the tailstock center.

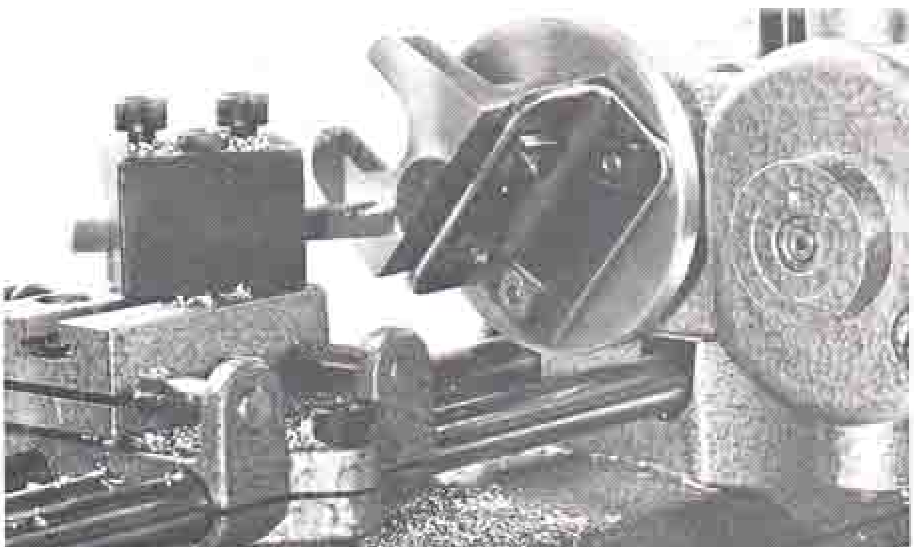
USING THE 3-JAW CHUCK

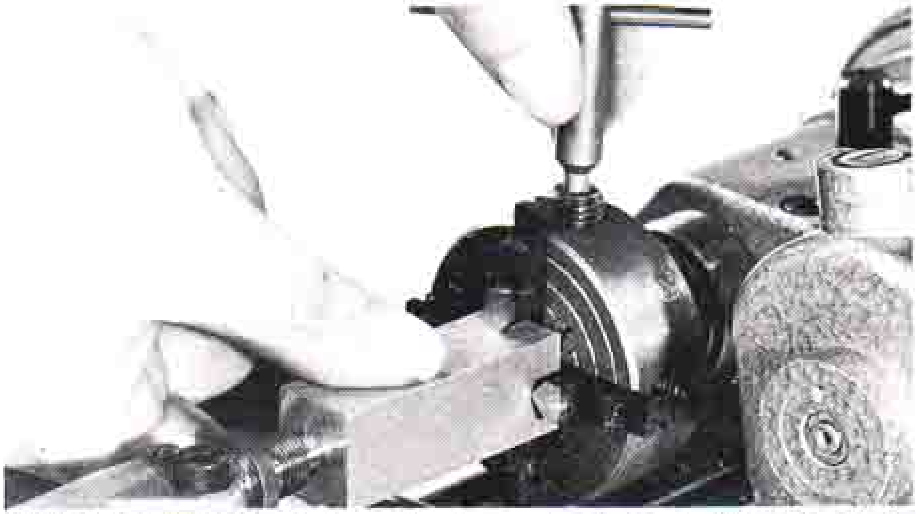
The simplest way to hold most large-diameter round workpieces for turning is to mount the work in the 3-jaw universal chuck, which is perhaps the most generally useful of all the Unimat's accessories (pg. 26). The 3-jaw chuck is supplied with its mounting plate finish-machined and attached, ready to screw on the spindle. The chuck holds work from .118" to more than 2" in diameter. Its three hardened jaws close simultaneously, centering the workpiece automatically as the chuck's knurled outer ring is rotated with pins inserted in the ring and chuck body. A scroll on the knurled ring screws the three jaws in or out. Jaws and jaw-slots are numbered. If you should screw the jaws out beyond the scroll, reengage them in 1-2-3 order.

For chucking work larger than 15/16" in diameter the jaws can be reversed and work gripped in their steps. To reverse the 3-jaw chuck's jaws, turn the ring to screw out the jaws until they disengage, remove them from their slots, and replace them in this order: jaw #3 in slot #1, jaw #2 in slot #2, and jaw #1 in slot #3. Then re-engage the reversed jaws with the scroll in reverse order—3-2-1.

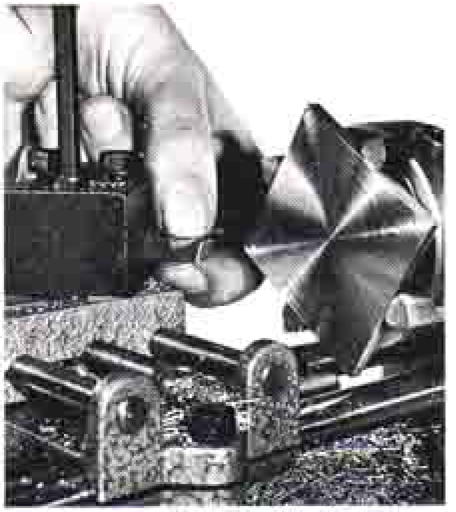
Besides round and hex stock, this chuck


THE COLLET CHUCK centers drill rod or small parts with extremely high precision.

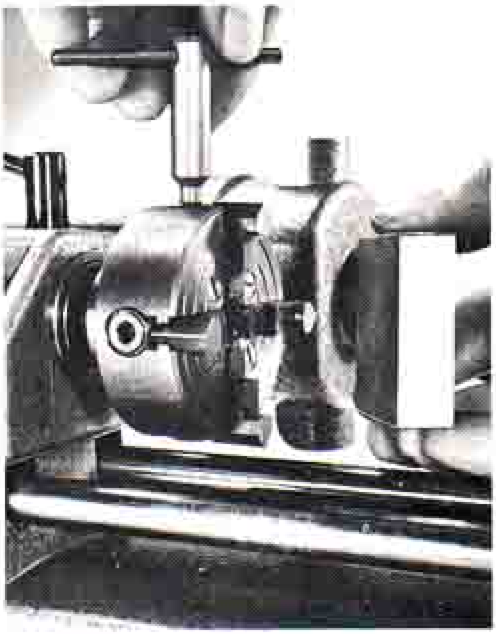

IRREGULARLY-SHAPED WORK can be mounted on the faceplate for turning. Angle plate or other special fixture may be needed to mount some workpieces.



WORK THAT OVERHANGS a chuck more than four times its diameter should be centerdrilled and supported with the tailstock. Avoid overtightening chucks.



SQUARE PLATES as large as lathe's full swing can be accurately faced in the 4-jaw chuck.



THE 4-JAW INDEPENDENT CHUCK holds round, square or irregular workpieces.

will also hold large work that has been bored or recessed. For this the jaws are opened to make the steps grip inside the bore.

The 3-jaw chuck centers workpieces to within less than .003". Since the jaws are tightly fitted, a new chuck at first may work quite stiffly, but the jaws soon wear in and thereafter if kept cleaned and oiled slide very smoothly. For consistently accurate centering make sure that the jaws grip with even purchase as they close on the workpiece. Use jaw pads cut from soft sheet metal to prevent the jaws from marring finish-turned work.

USING COLLET EQUIPMENT

Toolmakers and instrument repairmen when turning small parts that must be centered with extremely high precision usually hold the work in a split spring collet, which centers small-diameter round stock more accurately and grips more securely than any other workholding device. The accessory collet chuck available for the Unimat (pg. 27) uses precision-ground double-tapered spring steel collets that are alternately split to close full-length and grip with even pressure. The body of the chuck screws to a mounting plate that is supplied slightly oversize. The mounting plate is first screwed on the lathe spindle and accurately finish-turned to accept the chuck, and the chuck is then screwed to it. The chuck's threaded nose-piece has a precision-ground internal taper that when the nose-piece is tightened squeezes the collet back into the ground taper in the body of the chuck. Collets, purchased separately, are available in inch or metric sizes. Because they can spring closed only about 1/64th inch, the collet used must be no more than 1/64" larger than the work. A full set of collets is needed to handle work from 1/64" through 5/16" in diameter, the chuck's capacity. The collet chuck is especially useful when you're turning a quantity of small precision parts from drill rod or other smooth-finish rod stock. Avoid closing a collet on work that isn't perfectly round. Long stock up to ¼" in diameter can be fed through the lathe spindle's through-bore. Since both the collet chuck and its collets are extremely high-precision devices, handle them with care to avoid nicking them, keep them scrupulously clean, and lightly oil them regularly with an oily rag.

USING THE FACEPLATE

Odd-shaped work that can't readily be mounted in a chuck often can be screwed, bolted or clamped on the Unimat's faceplate for turning. Flat work as large as the lathe's full swing can be bolted directly to the plate. L-shaped work can be bolted to an angle fixture cut from angle iron and bolted on the faceplate.

When faceplate work must be turned with exacting precision, true the plate—taking a light cut across it with a sharp tool—before mounting the work, and when fixing the workpiece make sure that the mounting screws or bolts do not spring the plate. Ordinarily faceplate turning should be performed at moderate spindle speed. When irregularly-shaped work will be turned on a plate at high speed, counterbalance it to prevent vibration. Using the accessory T-slotted fixture plate on the Unimat's spindle as a faceplate simplifies mounting some workpieces.

USING THE 4-JAW CHUCK

The spindle workholding device that can hold the widest variety of work shapes is the 4-jaw independent chuck, which has four reversible step-jaws that screw-adjust individually with a square key. The 4-jaw chuck holds round, square, rectangular or irregular work, and the jaws grip very securely. Work can be centered in the chuck, or it can be offset for turning eccentrics. This chuck's only disadvantage is that it does not center the workpiece automatically. The work must be centered by hand. To accomplish this you first center the stock in the chuck roughly by eye, using the concentric rings on the face of the chuck for guidance, and you then make corrections by adjusting opposite jaws—loosening one jaw and tightening the jaw opposite—to shift the work as needed. The point of the tool bit will indicate which way the work requires shifting if the tool is set close to the workpiece and the lathe spindle is revolved by hand. For exacting work a dial indicator can be used to indicate runout. Although it takes patience, it's possible to center work in the 4-jaw chuck with extremely close precision.

The 4-jaw chuck's body screws to a mounting plate supplied oversize to permit finish-machining on the lathe spindle (as shown in the accessories section pg. 26), which insures that the chuck will run perfectly true. Always tighten the four jaws firmly and evenly on the work, but avoid

overtightening them. Since the key screws in the jaws with enormous force, severe overtightening can strip the threads in the chuck's cast iron body. When chucking tubing or bushings that might be distorted by the jaw pressure, first turn a closely-fitted metal plug and insert it in the work. Stock that overhangs the chuck's jaws more than four times its diameter should be center-drilled and supported with the tailstock center.

Quite often the 4-jaw chuck is used to hold square or rectangular stock to be turned round, and this involves interrupted cuts—with the lathe bit cutting only the corners of the workpiece. Such cuts should be made at slow spindle speed to avoid excessive hammering, and the lathe's feed controls should be set up fairly tightly.

SPECIAL WORK HOLDERS

Some work because of its shape or the machining operation required can neither be held in a chuck nor mounted on a faceplate. A brass washer to be accurately finish-turned on all sides would be an example. Often such parts can be fixed on a piece of scrap metal and the scrap metal can be chucked. The washer could be soft-soldered on a piece of scrap brass, and with the brass chucked could be machined on three sides; it then could be melted off and resoldered on the brass other-face-out for turning on the fourth side.

A wheel-shaped workpiece is generally first gripped in a chuck, bored, and then remounted for additional machining on an arbor or mandrel. The work can be pressed on a specially-turned tapered mandrel and the mandrel mounted between centers. Easily turned from scrap steel, the special mandrel should have a taper of about .001" per inch of length (machined by offsetting the Unimat's headstock slightly). When pressed on the mandrel's taper firmly enough to prevent slippage, the wheel-shaped workpiece can be turned on both faces and its diameter with exact precision. For some work the mandrel can be threaded and the workpiece secured with a nut. A wheel-shaped part with a hub often can be fixed on a straight mandrel with a set-screw.

When you encounter work that can't be satisfactorily mounted with any of the standard workholding devices, it's nearly always possible to improvise a special fixture of some sort that will do the job. For example, you might turn a special split chuck—turned to accept the work, split with a hacksaw, and closed with screws or a tapered clamping ring. You might put an irregularly-shaped workpiece in a turned ring with Plaster of Paris. You might devise special lug-clamps to secure odd-shaped work on a fixture plate. You might drill and tap a large workpiece with counterbored 12x1 metric threads and screw the work directly on the Unimat's spindle nose.

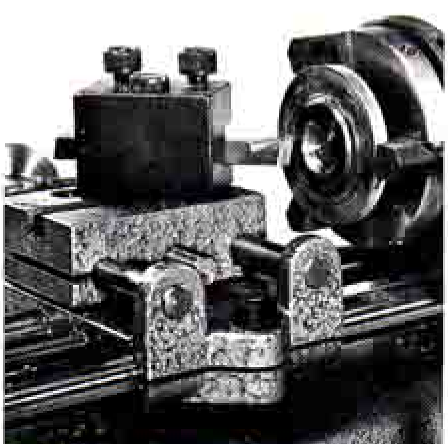
Special tooling-up may also be required when you have occasion to machine a number of duplicate parts. To make special set-ups easier, unhardened steel jaws that can be machined as required are available for the Unimat's 3-jaw universal chuck, and soft steel collets that can be bored to any size needed are available for the collet chuck. After machining either soft chuck jaws or soft collets to suit the work, you can harden them with *Kasenit* or other surface hardening compound. Arbors or mandrels turned from mild steel can be similarly case-hardened.

Since the various chucks and work plates all screw on the machine's threaded spindle nose, to maintain the Unimat's precision it's important to protect the spindle threads both from unnecessary wear and from accidental damage. Always clean and oil the threads and the spindle's shoulder before screwing on a chuck or plate. To avoid accidentally nicking the threads, it's good practice to keep either the faceplate or other device screwed on the spindle whenever using the machine.

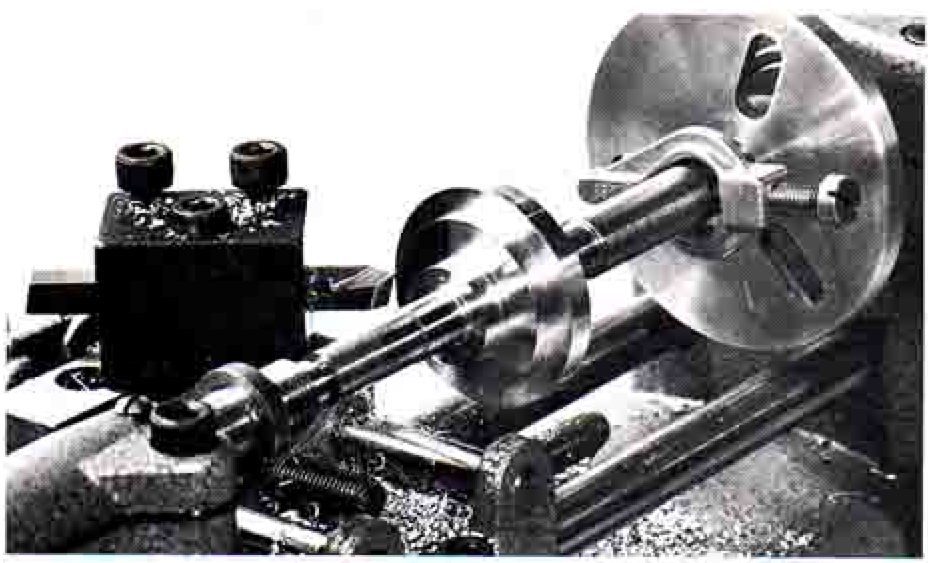
When chucking lathework that must be turned with exacting precision, be sure to mount the work in such a way that you can finish-turn critical surfaces without rechucking. If a workpiece is bored and faced with one chucking, for example, the face will be machined precisely square with the bore. But if the piece were bored and then rechucked for facing, you could not expect perfect accuracy. It wouldn't be possible to remount the work in the chuck without losing some precision.

Spindle chucks should be cleaned and lightly oiled after each use. Avoid overoiling, however, for when overoiled a chuck throws black spray when run at high speed. Wipe the oil from the chuck's ground jaw faces before chucking a workpiece.

SOME WHEEL-SHAPED WORK can be mounted on the grinding wheel arbor for turning.



SMALL WASHERS can be soft-soldered on scrap brass, turned, then melted off.



PULLEYS AND WHEELS can be pressed on a tapered mandrel for finish-turning. Turn the mandrel to suit work from scrap steel and mount it between centers.

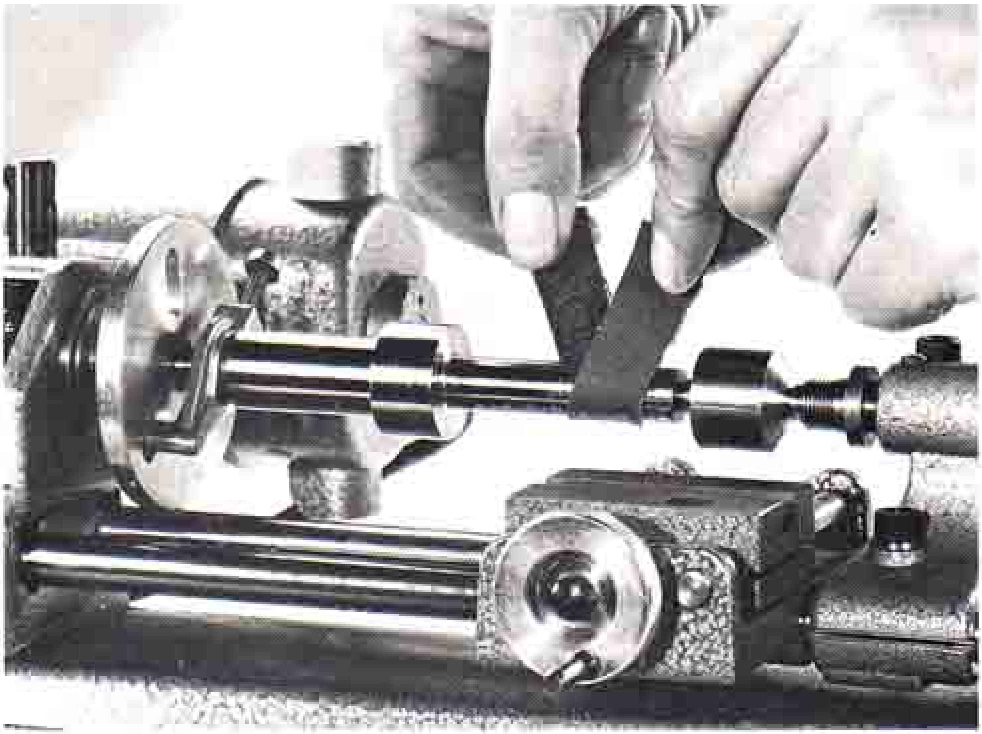
Special Lathe Operations

Of all machine tools the metal lathe is the most versatile. Many operations other than plain turning can be performed on lathes, and all of these special jobs can be accomplished on small scale with the Unimat. This section surveys some of them.

FINISHING

Lathework often requires one or more finishing operations. To remove burrs or round sharp edges, turned work can be filed as it revolves in the machine. For filing use the slowest spindle speed, angle the file for best cutting action, and file with slow strokes.

Any turned work can be polished with strips of abrasive paper or cloth to as high a finish as desired. Use extra-fine wet-or-dry silicon carbide paper for an attractive soft polish on small parts. To polish larger workpieces use strips of aluminum oxide cloth, oiling a worn strip for final mirror-finishing. Since for polishing the lathe is run at high spindle speed, the dead center must be adjusted somewhat loosely and relubricated frequently to prevent it from binding and burning. Using a ball-bearing center in the tailstock that rotates with the work eliminates the risk of burning center points.



YOU CAN POLISH turned work to high finish with strips of abrasive cloth. Using a ball-bearing live center in the tailstock makes frequent readjustment unnecessary.

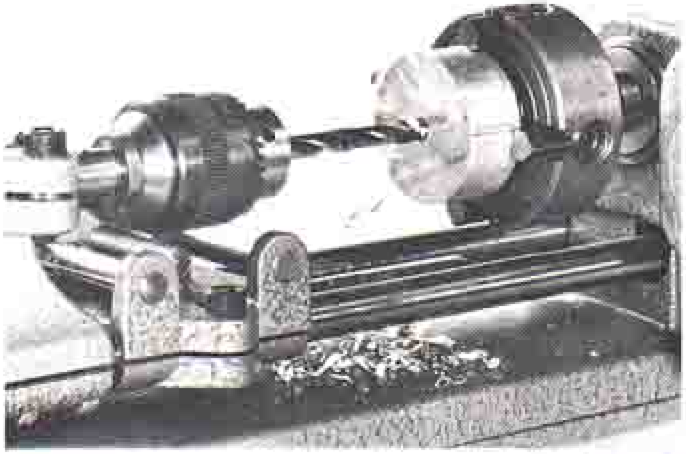
HORIZONTAL DRILLING & REAMING

A metal lathe is an excellent horizontal drill press, and drilling is one of the more commonly performed operations. Ordinarily the drill is mounted on the tailstock ram and revolved in a spindle chuck. Either the drill fed with the tailstock handwheel into work chuck or the collet chuck (for precision small-hole drilling) can be screwed on the Unimat's tailstock to hold small straight-shank twist drills. Large drills with straight shanks can be held in the 3-jaw universal chuck screwed on the tailstock.

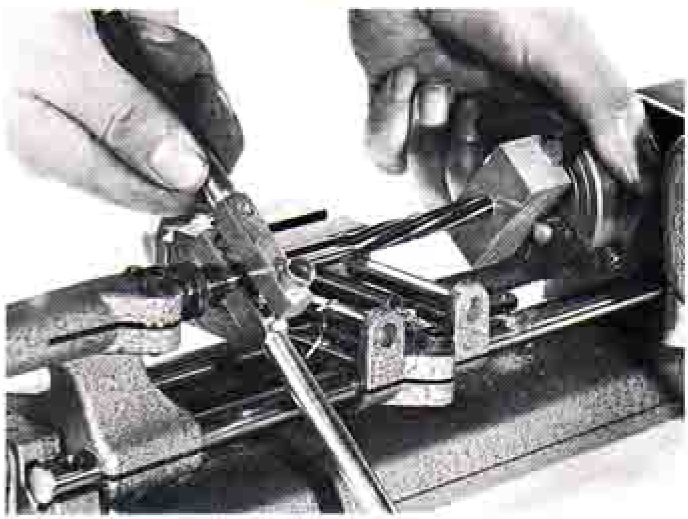
In order to start a twist drill cutting without wobble, turn a small starting dimple in the work with a sharp-pointed lathe bit. The feel of the drill in the work will indicate proper feed rate. Advance the drill with the tailstock handwheel just fast enough to make it cut smoothly, using cutting oil liberally when drilling steel. Withdraw it from the hole as often as necessary to prevent chips from packing in the flutes.

Except when drilling with very small drills, use the slowest spindle speed for drilling in the lathe. Each lip of a twist drill cuts exactly like a lathe bit, and forcing the lips to bite into hard metal takes considerable power. The larger the hole, the more the power required. To avoid overloading the motor when drilling a large-diameter hole with the Unimat, enlarge the hole in steps—first drilling a small pilot hole, then enlarging the pilot hole with a larger drill, then enlarging the hole again with a still larger drill, and so on. Drilling an extra-deep hole is also likely to overload the motor, since friction increases as the hole deepens. Don't try to drill a deep hole with a drill that has worn margins. For deep holes use new drills.

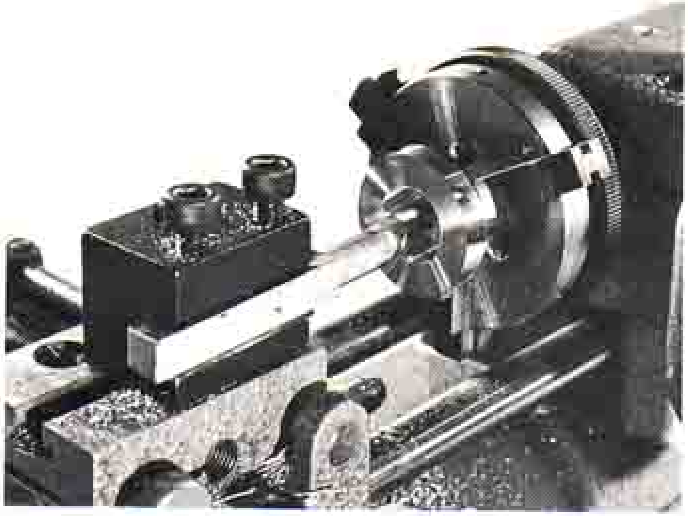
A twist drill drills a hole a few thousandths larger than the drill's nominal size. When the diameter of a hole must be exact, the hole is drilled slightly undersize and reamed to finish size with a reamer. When reaming in the Unimat, support the reamer in alignment with the hole with the tailstock



FOR DRILLING work held in a spindle chuck, screw the drill chuck on the tailstock ram. Ram's handwheel feeds the drill.



WHEN REAMING HOLES in the lathe support the reamer with the dead center. Hold the reamer and turn the spindle by hand.



TO BORE ACCURATELY-FINISHED HOLES, set a boring tool in the tool block parallel with the ways. Bore with light, continuous cuts.

WHEN CUTTING THREADS with taps or dies, turn the work by hand, holding tap or die in a tap wrench or die holder.

center, and feed it into the work slowly with the tailstock handwheel while revolving the lathe spindle by hand. When reaming holes for tapered pins with a tapered reamer, avoid feeding the reamer at too fast a rate. Never back a reamer in the hole, which would nick its teeth. Flood the hole with cutting oil when reaming steel.

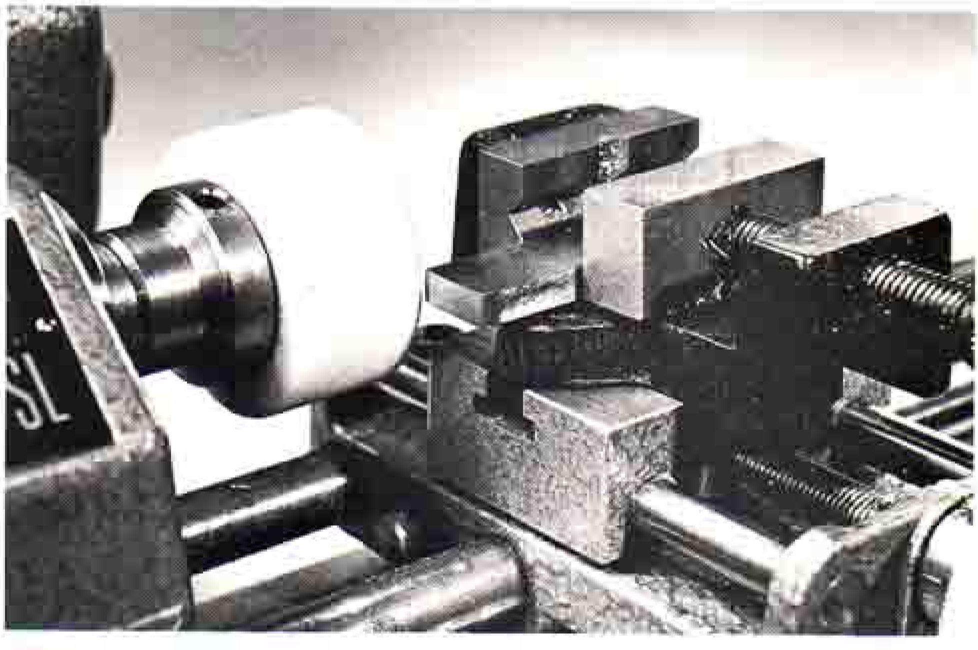
BORING

Boring in the lathe—simply internal turning with an extended cutting tool— is the easiest way to finish large-diameter holes accurately to size. The boring tool is advanced by screwing the cross-feed out; then run through the hole with the longitudinal feed. When making a boring set-up be sure that the tool's cutting edge has sufficient clearance to prevent the bit's heel from rubbing in the hole. The lathe's feed controls should be set up snugly, and the boring tool positioned in the tool block with no more overhang than necessary. Since all boring tools spring somewhat, use lighter cuts for boring than you would for turning. When boring a hole to close tolerance, be sure that the Unimat's headstock is accurately aligned, and having honed the boring tool very sharp, finish the hole with very light cuts, making the final finish cut continuous.

Work requiring precision through-boring can be fixed on the Unimat's carriage and bored with a small fly-cutter boring bar (which you can make yourself) mounted between centers.

THREADING

Many parts turned in lathes require threading. Usually the easiest way to cut small-diameter threads in turned work is to use a tap or die, revolving the workpiece in the lathe by hand as the tap or die is kept from turning with a tap wrench or die holder. A tap with a centerdrilled shank can be supported to start it squarely with the tailstock center. When taps or dies are used to cut threads larger than ¼" in diameter, the threads are started in the lathe, and the work is then removed from the machine and gripped in a bench vise for the rest of the operation. Use cutting oil when threading steel.



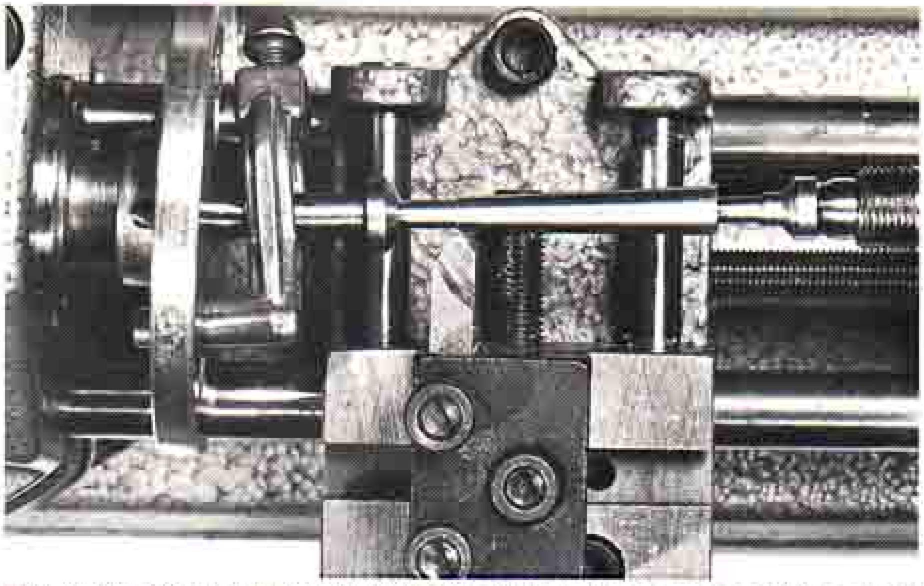
MACHINE GRINDING with a cup grinding wheel on the lathe spindle and the work held in the machine vise is an easy way to finish-grind the edges of small parts.

Screw threads can also be cut wtih the Unimat's accessory threading attachment (pg. 30), which is used whenever it's not practical to cut the thread required with a tap or die. With this attachment threads can be cut to a shoulder, for example, or fine threads can be cut on instrument bezel rings. Unimat's threading attachment employs a precision-threaded pattern bushing to lead a 60° threading bit. Threads are cut to finish depth with successive light cuts.

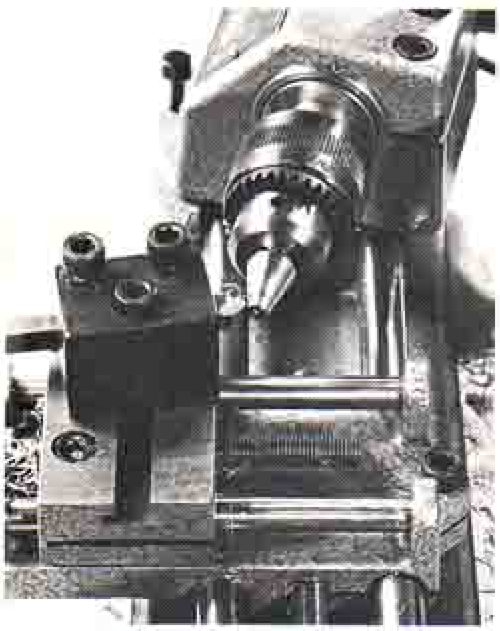
SPECIAL TECHNIQUES

A number of useful machining operations can be performed on the Unimat with a rotary cutting tool mounted on the lathe

HAND GRINDER can be used on cross slide to machine-grind hardened parts.



TO TURN TAPERS, rotate the Unimat's headstock to offset the spindle center one-half the amount of taper required. Be sure the lathe dog revolves freely.



FOR STEEP TAPER, simply mount work in a chuck and rotate the headstock.

spindle and the workpiece held on the carriage in the accessory machine vise. Grinding wheels, end mills or rotary files can be used in this way. A cup grinding wheel on the spindle will beautifully finish-grind the edges of small parts. If the workpiece is blocked to height in the vise, an end mill held in a spindle chuck can be used for slotting, spot-facing, or squaring the ends of rough-cut stock. Rotary files are useful for grooving or recessing. Although end mills and rotary files can be chucked in the drill chuck, the collet chuck centers them more accurately and grips them more securely.

If you mount a small hand grinder on the Unimat's cross slide wtih an improvised clamp—or simply hold the neck of the grinder down firmly in the cross slide's T-slot with your fingers—you'll be able to accurately finish-grind hardened steel parts chucked in a spindle chuck. When grinding in this way belt the lathe's spindle for slowest speed and take very light cuts, advancing the cross slide only a thousandth or two at each pass.

TAPER TURNING

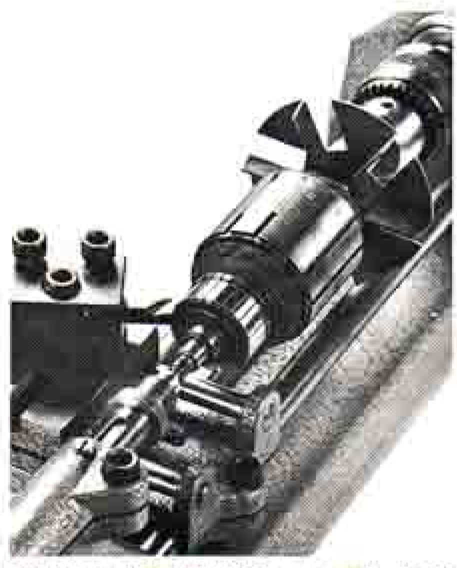
If a lathe's line of centers is not precisely parallel with the ways, the machine turns a taper rather than a true cylinder. When you want to turn tapered pins, shaft ends, fittings and seats or other tapered work on the Unimat, set up the machine to cut the required taper by rotating the headstock. To turn a gradual taper on long work, mount the workpiece between centers, and then rotate the headstock to offset the spindle center half the amount of taper. Shifting the spindle center towards the rear of the lathe makes the taper larger at the spindle end. Shifting the spindle center towards the front of the lathe makes the taper larger at the tailstock end. The amount of spindle center set-over can be measured from the tailstock center, but usually tapers are turned by trial and error—by making trial cuts and correcting set-over as needed. An easy way to find the set-over required to turn a tapered pin that must fit a hole reamed with a tapered reamer is to mount the reamer in the lathe and then adjust the headstock until a tool bit travels parallel with the reamer's cutting edges.

By rotating the headstock you can also cut short, steep tapers on work held in spindle chucks. Tapered holes can be bored similarly. Cones and sockets or conic fittings and seats that are turned and bored with the same set-up will match exactly. Be sure when cutting tapers to set the point of the tool bit exactly at center height.

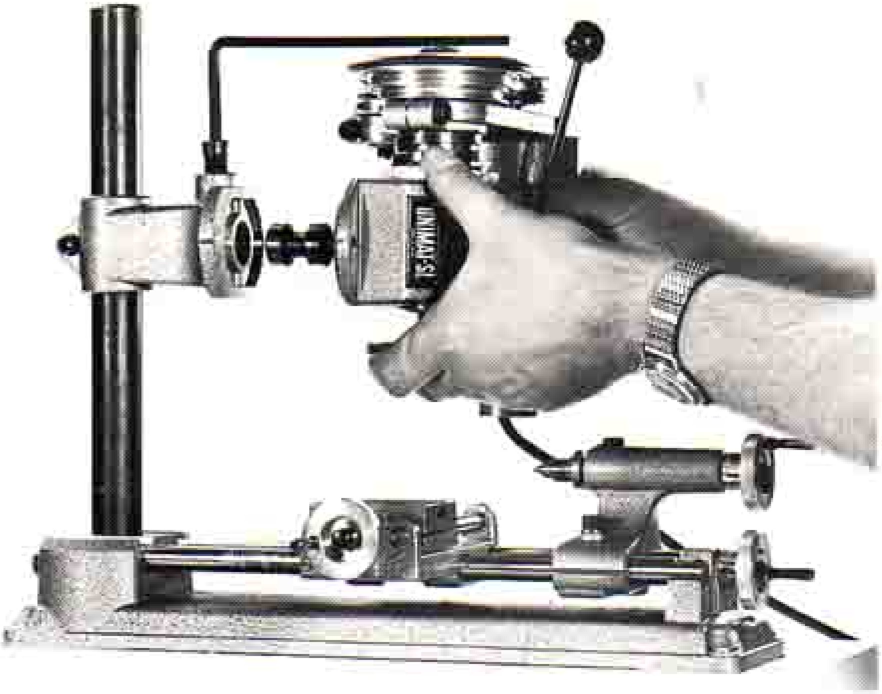
Truing worn commutators on small brush-type AC-DC motor armatures is a common repair job that can easily be accomplished on the Unimat with nice precision. If the armature's shaft is centerdrilled, the armature can be mounted in the lathe between centers. If not, chuck one end of the shaft in the drill chuck and support the commutator end in a brass cup center turned to fit the tailstock ram. Operating the lathe at slow spindle speed, take a light finish cut across the commutator using a very sharp round-nose tool bit having a 1/32" radius, and then polish the copper segments with fine flint sandpaper. After turning, undercut the mica between the commutator's segments using a piece of hacksaw blade with the teeth ground down to proper thickness. Make sure that no metal chips remain in the commutator's slots.

A few special lathe jobs that would otherwise present difficulties are no problem at all when you have the appropriate lathe accessory. A steady rest (pg. 29), for example, makes it possible to turn work longer than the lathe bed. Other special jobs can be performed if you make or adapt suitable accessories yourself. You can knurl turned work with knurling rolls, for example, if you machine a holder to mount standard rolls on the Unimat's cross slide. Or you can use the lathe to wind coils for electronics work if you make a coil from mandrel and wire guide.

Broaching is still another special lathe operation you occasionally may want to perform on the Unimat. A broach is simply a hooked scraping tool drawn repeatedly lengthwise through a hole to scrape a groove. With suitably-ground broaches you can cut square keyways in pulley holes, broach round holes square, or broach internal splines. Mount work to be broached in a spindle chuck and wedge the spindle's step-pulley to prevent the work from turning. Pull the broach with the lathe's longitudinal feed.



REFINISH COMMUTATORS of small AC-DC motors, with a sharp round-nose tool.



Vertical-Spindle Machining

Although in one way or another it's possible to accomplish any metal-machining job in a lathe, a number of machine operations, particularly drilling, milling and surface grinding, usually can be performed more conveniently on a machine that has a vertical spindle. The Unimat can be set up for *either* horizontal-spindle or vertical-spindle jobs—either horizontally for lathework, or vertically, with the headstock on the auxiliary column, for drilling, vertical milling or surface grinding. The changeover takes only half a minute.

To make the conversion, pull out the headstock's alignment pin and unscrew the headstock clamping screw enough to permit lifting the entire headstock from the bed. In its place insert the auxiliary column and retighten the clamp screw, making sure the screw seats in the column's tapered hole.

The column's adapter casting slides along the column and can be positioned wherever needed. Inserting the headstock's tenon in the adapter and tightening the adapter's clamp screw mounts the head. The easiest way to align the spindle accurately perpendicular with the machine's bed is to screw the faceplate on the spindle nose, lower the headstock on the column until the plate rests on the carriage cross slide, and then adjust the head until the plate touches squarely. Having aligned the head, raise it and loosen its two spindle lockscrews just enough to permit advancing the spindle cartridge with the ball-handled pinion lever. When these screws are nicely adjusted, the spindle's coil spring will retract the spindle smoothly as the pinion lever is released. The lever advances the spindle about 5/8". When more vertical movement is needed, the return spring can be removed to increase travel to 1".

With the drill chuck screwed on the spindle, the Unimat is now set up for 90° drilling. When you want to drill at some other angle, insert a length of drill rod in the chuck and set the head as required with a protractor.

While inexpensive plain carbon steel twist drills are satisfactory for drilling wood, plastic or soft metal, high-speed steel drills, which hold their hardness even at near-red heat, are needed for drilling steel or cast iron. You can buy them singly or in sets, in fractional-inch sizes, numbered wire-gauge sizes, letter sizes or metric sizes. Sets usually are packaged in cases with sized holes that simplify keeping the drills in order. Drills commonly sold in hardware stores are termed "jobber length." "Short sets," which are screw machine drills with shorter shanks and flutes, are available from industrial supply firms, and because they're more rigid at the tip these shorter drills are preferable for use in the Unimat.

MOUNTING THE WORK

Any work drilled should always be securely fixed on the cross slide, both for safety's sake and to avoid drill breakage. Rectangular work can be held conveniently in the accessory machine vise (pg. 32), which bolts on the cross slide with T-nuts. Position the work in the vise in such a way that when the drill breaks through it will clear the vise body. Work awkward to grip in the vise can be mounted in a spindle chuck or on a work plate, and the chuck or plate then can be mounted on the cross slide with the Unimat's T-head adapter stud. Since this stud has the same thread as the spindle nose, any of the Unimat's spindle chucks can be used on the cross slide as circular drilling vises. This makes it possible to unscrew chucked work turned in the lathe, mount it chuck and all on the cross slide for a drill press operation, and then remount it on the lathe spindle for additional turning, all without removing the work from the chuck.

The Unimat's faceplate serves as a drill press table for small work, but mounting either the accessory sanding plate (pg. 38) or the T-slotted fixture plate on the cross

TO ALIGN SPINDLE perpendicular with bed, screw on faceplate and lower head.

COIL SPRING retracts the spindle when you release the pinion feed lever.

ROUND WORKPIECES can be held for drilling in the 3-Jaw or 4-Jaw chuck.

SPIRAL END MILLS are used for milling recesses. Take light cuts with even feed.

slide as a drilling table gives a more rigid set-up for drilling larger workpieces. Work can be secured on the sanding plate with 1" C-clamps. Wipe the cross slide clean before screwing the plate on the adapter stud, and after centering the plate's hole under the spindle, tighten the carriage feed tensioning screws to make the set-up rigid. Long or odd-shaped work that can't readily be mounted on a round plate can be clamped on the accessory milling table for drilling (pg. 32). A 5"x5" piece of ½"-thick hardwood plywood secured on the cross slide with bolts makes a handy table for drilling woodwork—and often metalwork, since small parts can be fixed on the table easily with wood screws.

SELECTING DRILLING SPEEDS

Twist drills can cut soft materials faster than hard materials. For each material drilled there is most efficient drilling speed, and this speed, termed "surface speed," is always expressed in surface feet per minute or sfm. Average surface speeds for drilling common materials with high-speed drills are:

Alloy or stainless steel	20-40sfm
Mild steel or cast iron	80-100sfm
Bakelite	100-150sfm
Brass or aluminum	200-300sfm
Wood	300-400sfm

The formula that relates surface speed to spindle rpms is:

$$\text{Rpms} = \frac{3.8 \times \text{desired sfm}}{\text{drill diam. in inches}}$$

Rounding off the 3.8 to 4 simplifies calculating the approximate spindle speed needed to give a required surface speed. To find the rpms needed to drill mild steel at 100sfm with a ⅛" drill, for example, you'd figure:

$$\text{Rpms} = \frac{4 \times 100\text{sfm}}{⅛"}, \text{ or } \frac{400}{.125}$$

or 3200 rpms. A machinist soon learns to solve this equation in his head without bothersome arithmetic. He'd simply reason that (in the example given) if 400 is ⅛th of the speed needed, the total rpms would be 8 times that, or 3200.

DRILLING TECHNIQUES

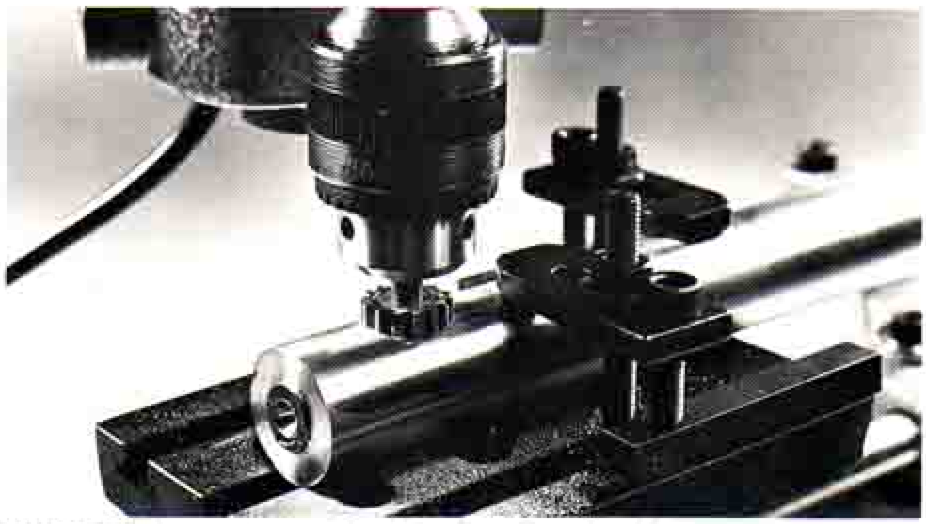
When a hole must be located with exact precision, lay out and accurately center-punch its center point before mounting the work in the machine. Then fix the work-piece on the cross slide with the punch-mark accurately aligned with the axis of the spindle. To do this, unscrew the drill chuck, insert a lathe center in the spindle bore, and carefully position the carriage until the point of the center seats exactly in the punchmark. Then remove the center, replace the chuck and insert the drill. Enlarging the punchmark with a centerdrill before drilling the hole insures that the drill used will start concentrically.

Use cutting oil liberally when drilling steel. The cutting oil functions both as coolant and lubricant. Light machine oil is the most satisfactory lubricant for drilling mild steel. Use turpentine or kerosene to drill tough alloy steel. Brass and aluminum ordinarily are drilled dry. Cast iron always should be drilled dry, since fine chips of cast iron are abrasive and when mixed with oil form a compound that laps the drill dull.

Feed the drill into the work with enough pressure to keep it cutting, but avoid excessive feed, which can chip the cutting edges or even break off the tip. A sharp drill drilling mild steel at correct feed rate produces two identical curled spiral chips.

Drilling deep holes—deeper than five times their diameter — presents special problems. When a drill cuts a shallow hole its flutes lift chips clear. But when the hole is deep the chips pack in the drill's flutes, and this makes it necessary to withdraw the drill periodically to clear the cutting edges. Most other deep-drilling problems are caused by lack of clearance. A twist drill's flute margins are ground to a very slight taper (the flutes are about a thousandth larger in diameter near the tip than near the

USE TWO-FLUTE CUTTERS like woodworking router bits but at slower speed.



MILLING TABLE supports long work for milling. Mount the work as rigidly as possible, clamping it down with T-head bolts inserted in table's T-slots.