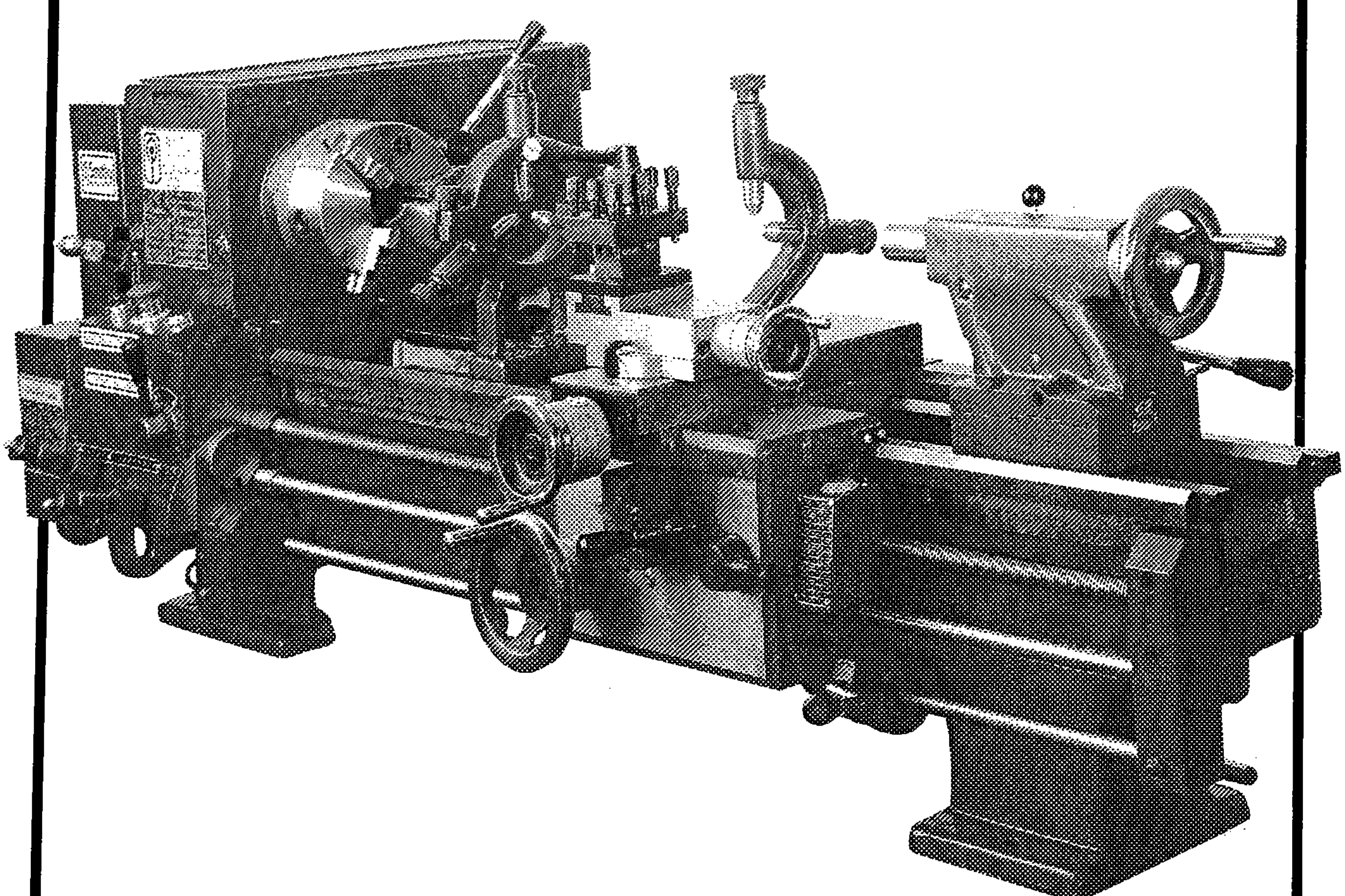
Smithy®

Operator's Manual



BZ-239G Gear-Driven Lathe

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SECTION ONE
INTRODUCTION

Congratulations on purchasing a Smithy BZ-239 G gear-driven lathe. We are pleased you chose Smithy to fulfill your machining needs.

The purpose of this manual is to give the machinist, beginning or advanced, the information he needs to operate the Smithy BZ-239. The manual will teach you about the lathe's parts and how to care for them. In fact, education is our primary goal. We'll explain how to grind cutters, set up lathe tools, hold workpieces, and do all basic lathe operations.

Please read this operator's manual carefully. If you don't understand how your machine works, you may damage it, your project, or yourself. If you want to learn more about machining practices, Smithy offers books that meet the needs of machinists at all levels of experience. We also suggest using your local library as a resource. Enrolling in a machining class will give you the best knowledge of machining.

If you have any questions not covered in this manual, please call Smithy. Our trained technicians will help you with any machining problems you may have. To reach them call—**1-734-913-9063**— Monday through Friday, 8 am – 5 pm Eastern time. Have the parts diagrams at the back of this manual handy when you call.

We are always interested in your suggestions to improve our products and services. Feel free to contact us by phone or in writing. If you have comments about this manual, or if you have any projects you'd like to share with other Smithy owners, contact the Communications Director, Smithy Co., 170 Aprill Drive, PO Box 1517, Ann Arbor, MI 48106-1517.

We look forward to a long working relationship with you. And thank you again for putting your trust in Smithy.

1.1 Customer Information

This manual should remain with the BZ-239. If ownership changes, please include the owner's manual with the machine.

Model #______________________________

Serial #______________________________
(on the front of the headstock)

Purchase Date______________ **Delivery Date**______________

Sales Technician______________________________

1.2 BZ-239 specifications[1]

General dimension: 63" L x 24" W x 24" H
Crate size: 70" L x 30" W x 30" H
Shipping weight: 1100 lb
Machine weight: 850 lb
Motor: 1.5 hp, 110 V
Distance between centers: 39"
Bed length: 48"
Bed width: 7.2"
Spindle bore: 1.44"

Swing
- Over bed: 12"
- With gap: 19.8"
- Over table: 6.5"

Travel
- Tailstock spindle: 4.5"
- Cross slide: 5.5"
- Toolpost: 3.5"
- Carriage: 33"

Taper
- Headstock: Morse taper #5
- Tailstock: Morse taper #2

Spindle speeds
- BZ-239: 12 (50–1200 rpm)
- BZ-239 G: nine (64–1500 rpm)

Threading
- Cuts left and right-hand threads
- Standard: 50 threads (4–112 tpi)
- Metric: 24 threads (0.25–7.5 mm)

Chucks
- Three-jaw: 6.3"
- Four-jaw: 7.9"

[1] Specifications are subject to change.

SECTION TWO
SAFETY

Your workshop is only as safe as you make it. Take responsibility for the safety of all who use or visit it. This list of rules is by no means complete, and remember that common sense is a must.

- *Know your machine.* Read this manual thoroughly before operating the lathe-mill-drill. Don't try to do more than you or your machine can handle. In particular, remember never to change speeds or setups until the machine is completely stopped, and never to operate it without rolling up your sleeves or tying them at your wrists.

- *Ground your machine.* The BZ-239 has a three-conductor cord and a three-prong grounding-type receptacle. Never connect the power supply without properly grounding the machine.

- *Remove all adjusting keys and wrenches before operating the machine.* A chuck key or misplaced Allen wrench can be a safety hazard.

- *Keep your work area clean and organized.* Cluttered work areas and benches invite accidents. Have a place for everything and keep everything in its place.

- *Keep children away while machine is in use.* Childproof your shop with padlocks, master switches, and starter keys, or store the machine where children do not have access to it.

- *Wear appropriate clothing.* Avoid loose-fitting clothes, gloves, neckties, or jewelry that could get caught in moving parts. If you have long hair, keep it from getting into the machine.

- *Use safety glasses, goggles, or a face shield at all times.* Use glasses designed for machinery operation; regular glasses will not do. Have extras for visitors. Know when to wear a face mask and earplugs, as well.

- *Check for damaged parts.* Make sure the machine will run properly before operating it.

- *Disconnect the machine before servicing and when changing accessories.* Shut power off before making changes, removing debris, or measuring work. Don't reach over the machine when it's in operation. Keep your hands out of the way.

- *Avoid accidental starts.* Turn switches to Off before plugging in the machine.

- *Secure your work.* Flying metal is dangerous. Loose work can also bind tools.

- *Use the recommended accessories.* Understand how to use them before trying them out.

- *Use the correct tool for the job.* Don't try to make a tool into something it isn't.

- *Keep your mind on your work.* Pay attention to these simple rules and you will spend many safe, enjoyable hours in your workshop.

Remember, your safety depends largely on your practices.[2]

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[2]Modifying your machine may void the warranty and create potential hazards.

SECTION THREE
CARING FOR THE BZ-239

The BZ-239 is a delicate, precision tool with hardened ways and hand-scraped bearing surfaces under the table and carriage. Any rust spot or battering, any chips or grit between close-fitting parts, is certain to affect the accuracy of this fine tool. Follow these guidelines whenever you use your Smithy machine:

- When you finish working, wipe machined surfaces of the BZ-239 with an oily rag. Never leave it without this thin film of protective oil over all parts that might rust, especially ground finished parts.

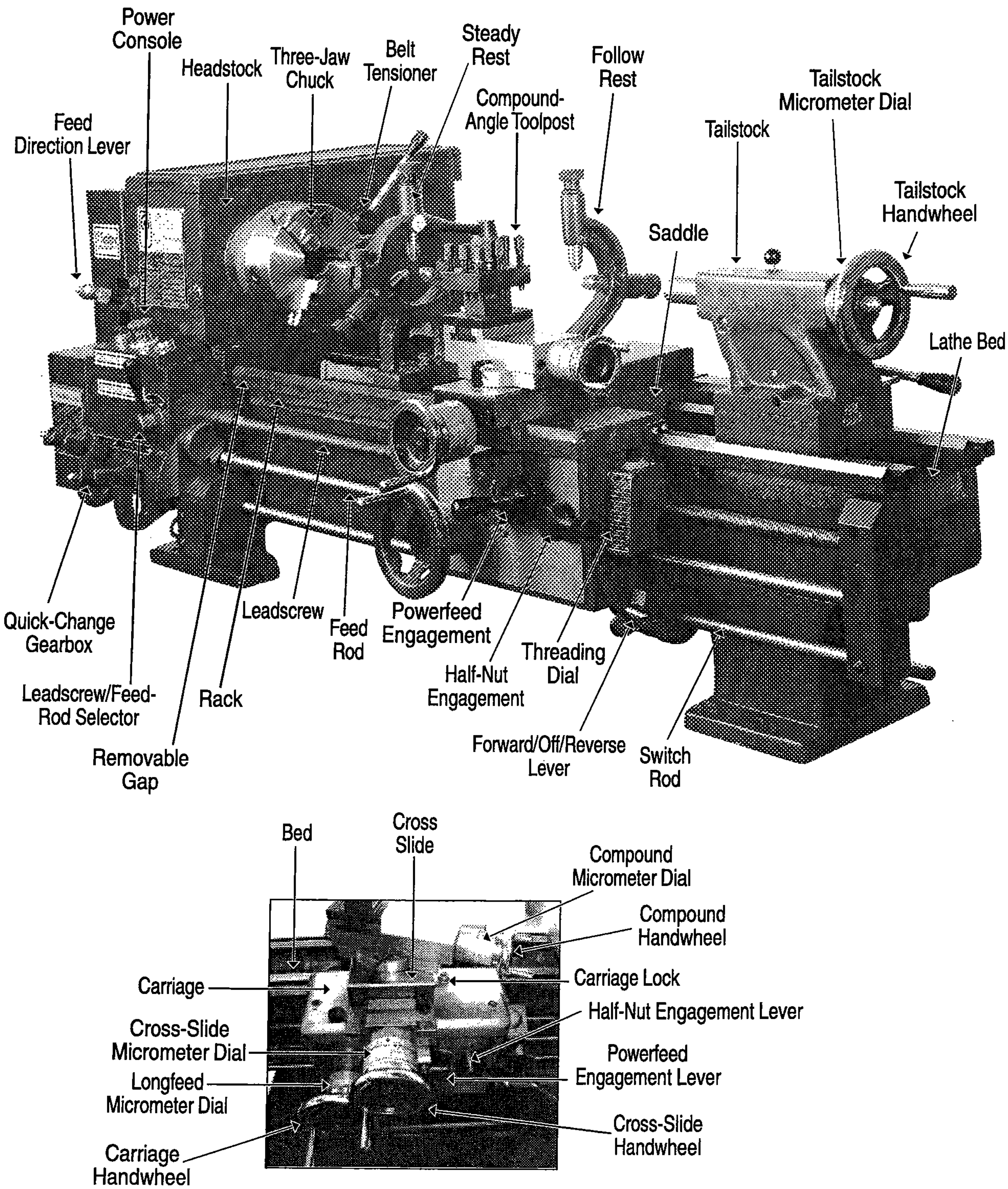
- Never lay wrenches, cutting tools, files, or other tools across the ways of your lathe. The slightest dent or burr will impair its accuracy.

- Before inserting collars, centers, adapters, or drawbar attachments in either the spindle or tailstock spindle, wipe them with a clean, oily rag. Also, wipe all internal surfaces carefully with an oily rag on a ramrod. Chips or dirt on the centers or in the spindle nose can scratch or mar surfaces and interfere with the assembled part's alignment.

- Lubricate the machine before each use (see *Section* 5.4).

SECTION FOUR
BASIC PARTS OF THE BZ-239

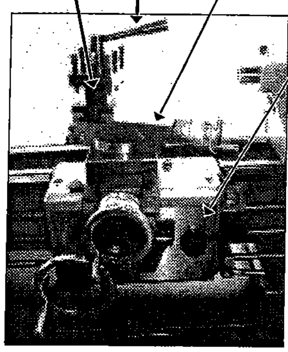
To learn the operations of the lathe, it's best to know the names and functions of its basic units (*Figure* 4.1).



4.1 Major controls of the BZ-239.

• *Apron.* The lathe apron (*Figure* 4.1), the part of the carriage facing the operator, contains longitudinal handfeeds, cross-feed handwheel controls, the powerfeed engagement lever, gearing for the powerfeed, and the thread-cutting half-nut engagement lever.

• *Bed.* The bed (*Figure* 4.1) is the lathe's foundation. It is heavy, strong, and built for absolute rigidity. The two ways on the top are the tracks on which the carriage and tailstock travel. To maintain an exact relationship between toolpoint and workpiece from one end of the lathe to the other, the ways must be absolutely true and accurately aligned to the line of centers and to one another.



4.2 Upper carriage and apron features.

• *Carriage.* The carriage (*Figure* 4.1) consists of the saddle and apron. It moves by hand or power along the bed, carrying the cross slide, compound rest, and toolpost. Its function is to support the cutting tool rigidly and move it along the bed for different operations. It clamps into place by tightening the carriage lock.

• *Compound rest.* Mounted on the cross slide, the compound rest (*Figure* 4.2) swivels to any angle horizontal with the lathe axis to produce bevels and tapers. Cutting tools fasten to a toolpost on the compound rest. The calibrations on the front of the base are numbered in degrees from 55° right to 55° left.

• *Cross slide.* The cross slide (*Figure* 4.1) moves crosswise at 90° to the lathe axis by manual turning of the cross-feed screw handle and under power through the feed rod.

• *Feed direction Forward/Reverse lever.* With the lathe turning counterclockwise and this lever (*Figure* 4.1) in the Up position, the leadscrew and feed rod run the carriage toward the tailstock and the cross slide toward the operator. With the lever in the Down position, travel reverses. The middle position is neutral; the feed rod and leadscrew do not turn.

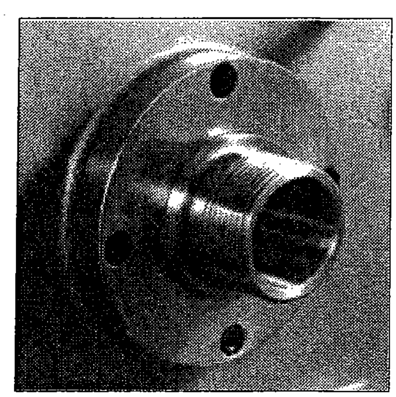
• *Feed rod.* The feed rod (*Figure* 4.1) runs the length of the bed and powers the crossfeed and long feed. It transfers the power to the carriage by means of a wormgear. Use the feed rod for standard lathe turning.

• *Forward/Off/Reverse lever.* This the main switch used to operate the lathe (*Figure* 4.1). It works only when the red kill switch is up (the red light is on).

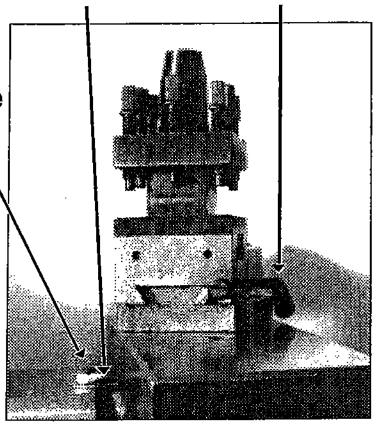
• *Headstock.* The headstock (*Figure* 4.1), which is secured to the bed, houses the gears and belts that drive the lathe spindle.

• *Lathe belt tensioner.* To adjust the lathe belt tensioner (*Figure* 4.1), pull the handle forward to release the tension, back to tighten it.

• *Lathe spindle.* The end of the lathe spindle facing the tailstock is the spindle nose (*Figure* 4.3). The spindle nose, which has an MT5 taper, drives lathe chucks and other workholding devices and rotates the workpiece. It has a 2-1/4" diam, eight-threads-per-inch (tpi) thread.


4.3 Lathe spindle nose has an 8-tpi thread and MT5 taper.

• *Leadscrew.* The leadscrew (*Figure* 4.1) runs the length of the bed, and its external thread is cut with great precision. The leadscrew moves the carriage for thread cutting. The thread pitch of the leadscrew is 8 tpi, 7/8" diameter.



4.4 Locks on the cross slide, carriage, and compound keep them from moving.

• *Leadscrew/feed-rod selector.* This lever (*Figures* 4.1) transmits the power to the leadscrew when moved to the right and to the feed rod when moved to the left.

• *Locks.* Locks on the cross slide (*Figure* 4.4), carriage (*Figure* 4.4), tailstock (two)), and compound (*Figure* 4.4) keep them from moving. During machining, lock all axes except the one you want to move.

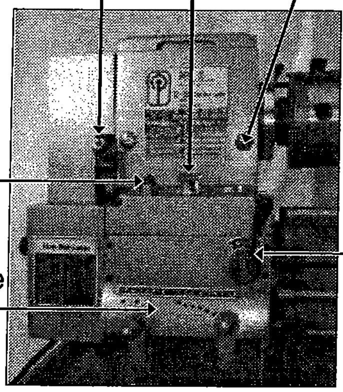
• *Micrometer control and calibration.* Just inside the handles of the tailstock (*Figure* 4.1), crossfeed (*Figure* 4.2), and compound feed (*Figure* 4.2) are collars calibrated in inches and millimeters. The long-feed handwheel (*Figure* 4.2) is calibrated in inches only.

These micrometer dial collars can move independently around the handle shafts. This independent motion is called *float*. The BZ-239 has floating dials on the cross slide, tailstock, and leadscrew. They let you zero the collars at any point and read the feed travel from that point on the dial for increased accuracy.

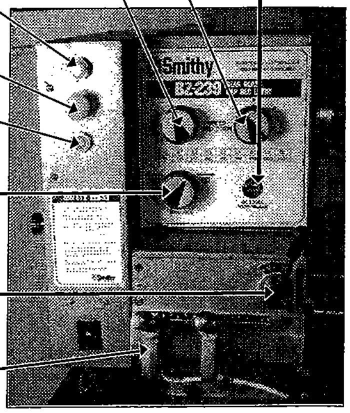
• *Power console, BZ-239 only.* When you turn the red stop button on the power console (*Figure* 4.5) clockwise, it pops up and the red light comes on, indicating power to the lathe. The green button is a temporary positioning switch. You can use it to run the lathe a partial revolution to mesh gears or to position the work at an exact position. It does not remain engaged by itself.

BZ-239 G only. The green button (*Figure* 4.6) is a reset button. To start the lathe, switch the circuit breaker on, turn the red button clockwise until it pops up, and push in the green reset button. You can then operate the lathe normally with the Forward/Off/Reverse lever. Whenever the red button is turned off or the circuit breaker trips, push in the green button so the Forward/Off/Reverse lever will work.

The side cover door has a safety switch that shuts down the lathe when the door is open. To restart the lathe, close the door and reset the green button.

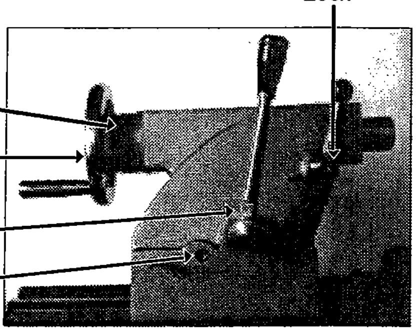


4.5 Power console, BZ-239.



4.6 Power console, BZ-239 G.

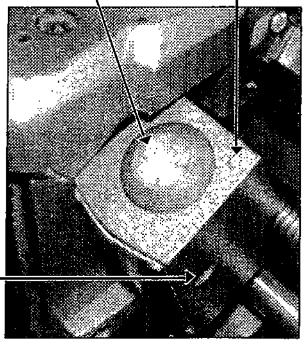
• *Quick-change gearbox.* Select the thread pitch (for threading) or the feed rate (for turning) by adjusting the levers in the quick-change gearbox (*Figure* 4.1). Place the left-hand lever in one of the five lettered holes and the right-hand lever in one of the eight numbered holes according to the feed rate or thread pitch you want.



4.7 The tailstock provides right-hand support for the workpiece.

• *Rack.* Running the length of the bed, the rack (*Figure* 4.1) is geared to the carriage handwheel in front of the apron. The gears that link the carriage handwheel to the rack let you move the carriage lengthwise manually.

• *Saddle.* The saddle (*Figure* 4.1) slides on the carriage ways, supporting the cross slide and compound rest. To move it, turn the handwheel geared to the rack.



4.8 The threading dial is geared to the leadscrew.

• *Tailstock.* The tailstock (*Figure* 4.7), which provides right-end support for the work, moves along the bed and can stop at any point on it. It holds centers, drills, reamers, taps, and other tools. To move the tailstock spindle turn the tailstock handwheel. The scale of offset calibrations on the back of the tailstock is in 20-thousandths.

• *Threading dial.* The threading dial (*Figure* 4.8), which is geared to the leadscrew, allows you to engage the half-nut at the proper time during threading to keep the tool on thread for successive passes.

SECTION FIVE
UNCRATING AND SETTING UP THE BZ-239

5.1 Transporting the machine

Moving a machine tool is a potentially dangerous operation. Improper techniques and methods can cause personal injury and/or damage the machine. To find a professional to move and site your BZ-239, look in your local Yellow Pages under "Machine Tools, Moving and/or Rigging." If there is no such listing or your community does not have a rigging specialist, a local machine shop or machinist may be able to provide a referral.

When you pick up the machine at the shipping terminal, bring a crowbar, tin snips for cutting the metal straps, and a hammer. If there is obvious shipping damage to the crate, you'll be able to inspect the machine before signing for it. Note any damage on the bill of lading (shipping document). Fill out the claims forms and notify both Smithy Co. and the shipping terminal about the damage. Failure to notify both parties can complicate and/or invalidate any claims process.

Trucking company terminals usually have forklifts to assist customers. The most convenient ways to transport the machines are by trucks without canopies and by large vans.

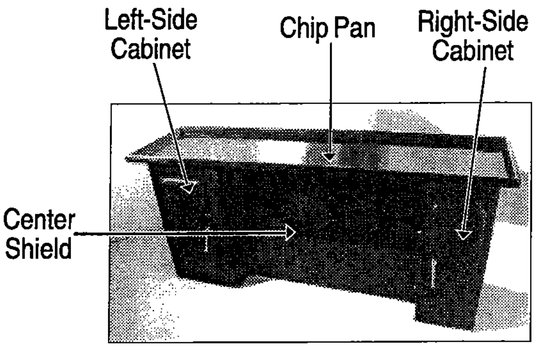
5.2 Uncrating and positioning the machine

The BZ-239 is assembled, inspected, and ready to go on its stand. It's wrapped in a water and greaseproof cover, strongly braced, and crated. A box of accessories is also in the crate.

The metal bands that encircle the crate are under tension. Wearing eye protection and gloves, cut the metal bands with tin snips. Be careful—the cut edges are sharp. The bands secure the crate to the base. After removing the bands, lift off the crate top. From the tailstock end, tip the crate up and over the machine. *Do not damage the crate; you may need it another time to transport the machine.*

Now open the accessories box. Check the items in it against the accessory checklist. After accounting for all parts, you're ready to assemble the stand.

The stand is in two cardboard boxes strapped to the top of the crate. The larger part supports the headstock, the smaller, the tailstock. The chip pan and center shield (the piece of metal that spans the gap between the headstock and tailstock ends of the stand) are nailed to the inside of the shipping crate.

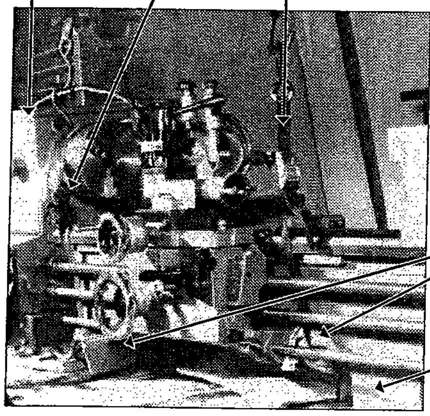


5.1 Assembled BZ-239 stand.

Assemble the right and left parts of the stand and attach the center shield. Put the assembled stand into position (*Figure* 5.1).

If you make your own stand, be sure it is strong and rigid. It should be 64" long x 24" wide x 28 – 33" high.

You're ready now to put the BZ-239 on its stand. Move the tailstock to the end of the lathe bed and the saddle about two-thirds of the way down the lathe (*Figure* 5.2). Remove all boxes from the packing. We recommend using a cherry picker, forklift (*Figure* 5.3), or hoist to raise and move the machine with the help of two sturdy straps rated at 2000 lb. If you are lifting from a single point, use a



5.2 Move the tailstock to the end of the lathe bed and the saddle most of the way down the lathe.

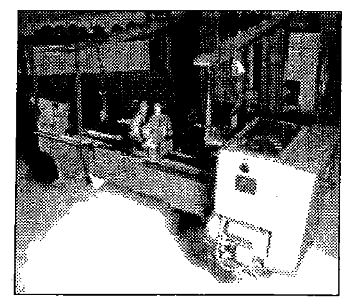
spreader bar to keep the straps vertical.

Strap #1 supports the headstock end of the machine. Pass it under the lathe bed to the right of the headstock, running the belt between the lathe bed and the leadscrew, feed rod, and switch rod. Take great care not to bend any of the shafts. Protect the strap from sharp edges with padding.

Strap #2 supports the tailstock end of the machine. Pass it under the lathe bed to the left of the tailstock pedestal between the leadscrew, feed rod, and switch rod and the lathe bed. Pad it to protect it from the edge of the casting.

Equalize the tension on the straps. Unbolt the machine from the pallet base and remove the packing crate bolts. Replace them with the mounting bolts provided. Use these bolts as guides to position the machine on the stand. Make sure the lathe does not tip toward the headstock; there is a lot of weight outside the strap, and the machine could slip and cause serious damage and/or injury.

Carefully lift the lathe, move it over the stand, and lower it into position. Do not let any part of your body come between the machine and the stand. Bolt the machine to the stand, using one flat washer and one lock washer per bolt.



5.3 Moving the BZ-239 with a forklift.

Before permanently anchoring the BZ-239, be sure the bed is level (*Figures* 5.4 and 5.5). Use a precision level, both along and across the bed. Shim up any low points with sheet metal or other noncompressible material. After tightening the anchor bolts, check the bed again.

5.3 Selecting a location

There are several major considerations for selecting a location for your BZ-239:

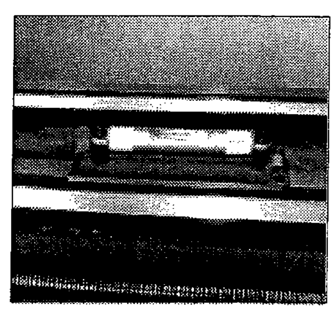
- Operation is from the apron side, so allow at least 40–48" operator clearance in front of the machine.

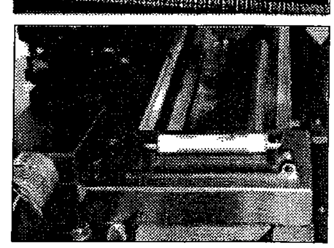
- The machine should be on a 30-amp circuit, positioned as close as possible to the power supply. It's better not to use an extension cord. If you must use one, check with an electrician about the proper size.

- Provide ample working light over the operator's shoulder.

- Place the machine on a solid foundation—concrete, if possible. If you put it on a wood floor, make sure the floor is adequate. Brace it if necessary to prevent sagging or settling. Place the BZ-239 solidly and squarely on the bed, and make sure it is level.

- Make allowances at the back of the machine tool, at the end, and





5.4 Check along (top) and across (bottom) the bed to make sure it is level.

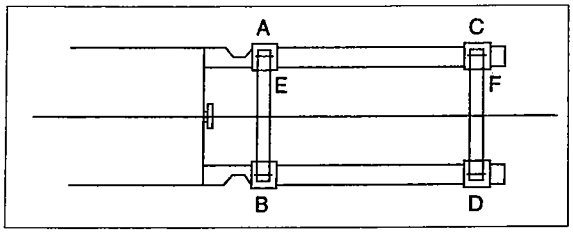
above it for later additions, attachments, and/or accessories. Provide clearance on the left end for feeding bar stock through the spindle. If you are considering placing more than one machine in an area, allow enough floor space to feed long bar stock to each machine.

- Mount the machine on a heavy, rigid stand.

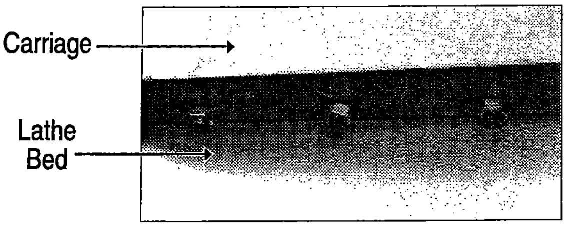
5.4 Cleaning and lubricating the machine

BZ-239s are shipped with a protective grease coating. Use noncorrosive kerosene or white mineral spirits to remove it.

Once you've set up and cleaned your BZ-239, it is ready for lubricating. Lubricate it carefully and thoroughly before starting the machine. Use a pressure oilcan and a supply of good-quality SAE No. 20 or 30-weight machine oil and any good-quality grease.



5.5 To check bench and bed level accuracies, successively place level at A, B, C, D (longitudinal positions) and E and F (transverse positions). Bedways alignment in the longitudinal plane should be better than 0.0016/40"; alignment in the transverse plane should be better than 0.0024/40".



5.6 Tighten the three adjusting screws under the flat way.

Follow this routine:

Lubricating the BZ-239 headstock

- Raise the headstock lid and fill the two oil cups on the front of the spindle bearings. Fill the sight glass halfway. Too much oil will cause the motor to lug and sling oil out from behind the chuck and inside the belt box.

- Turn the idler pulley until you expose the grease zerk between the second and third sheaves of the pulley. Put grease here and in the zerk in the middle of the backgear. Swing out the gear guard to expose the pick-off gears. Grease the three grease zerks in the hubs of the idler and pick-off gears. Then put a few drops of oil on the teeth of all the gears.

- Oil the quick-change gearbox by putting some oil in each oil port to the left and right of the electrical console. Excess oil will drip into the chip tray. *Do this every time you use the machine.*

Lubricating the BZ-239 G headstock

- The gearbox should be filled until the sight glass is half-full with a good-quality 20 to 30-weight oil. The oil fill hole is under the rubber mat on top of the headstock.

- Open the side cover door and put a few drops of oil on the gears.

- Put some oil in the oil port on top of the quick-change gearbox. Excess oil will drip into the chip tray. *Do this every time you use the machine.*

Oiling the ways

- Run the carriage as far to the left as possible. Put a few drops of oil on the ways. Run the carriage to the extreme right and repeat. You may want to use Waylube, an oil specially formulated for ways.

Oiling the carriage

• Force oil into the oil button directly inside the micrometer-indexing collar of the crossfeed.

• Put a few drops of oil on the cross-feed worm. The oil button is in the middle of the saddle behind the toolpost.

• Lubricate the oil buttons in the cross-feed table. There are four buttons, two each over the front and back ways.

• Put oil in the oil button inside the micrometer-indexing collar of the compound.

• Put a few drops of oil on the compound feedscrew.

• Put a few drops of oil on the compound slides.

Oiling the tailstock

• Oil the three buttons on top of the tailstock.

Oiling the apron

• Put oil into the left-hand oil cap to lubricate the apron's internal gears. Oil the apron only when you are going to use it, because excess oil will spill out the bottom.

• Put oil in the button just behind the long-feed wheel handle.

• Put oil in the button on top of the feed-rod engagement lever, just below the cross-feed wheel handle.

Oiling the leadscrew

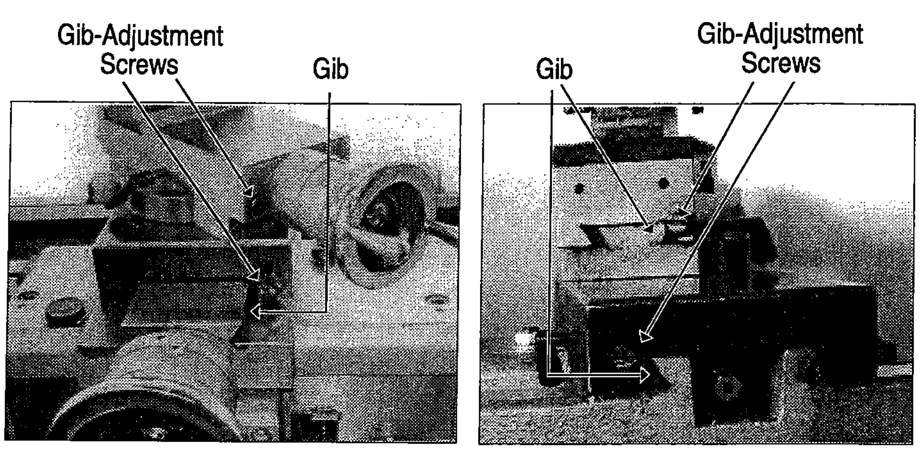
• Put oil in the oil buttons in the support block at the far right end of the leadscrew and feed shaft.

• Put a few drops of oil along the leadscrew and feed shaft.

To keep your machine in peak condition, remove all debris and lubricate it daily.

5.5 Adjusting the gibs

Before using the lathe, tighten the gibs as much as possible while still allowing comfortable movement of the parts. The tighter the gibs, the more accurate the machine. The three adjusting screws for the carriage



5.7 There are tapered gibs on the cross slide and compound slide, with screws at the front (left) and rear (right).

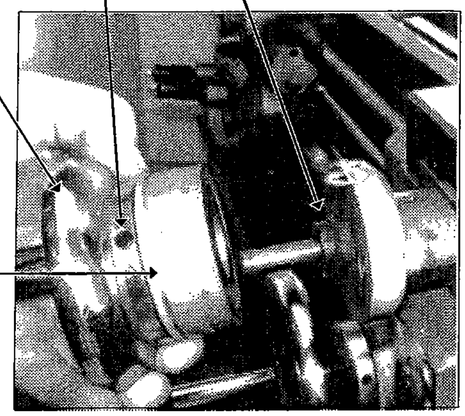
are on the back of the carriage under the flat way (*Figure* 5.6). Be sure to adjust them evenly. To do this, tighten all three and then back them off by the same amount until you can move the carriage comfortably by hand (a matter of individual preference).

The cross slide and compound slide have tapered gibs, each with a screw at the front and rear (*Figure* 5.7). Loosen the rear screw and tighten the front screw. Check the tension by moving the cross slide or compound slide toward the rear. When the "feel" is right, tighten the rear screw to hold the gib in place.

5.6 Adjusting the backlash

To eliminate backlash in the crossfeed and compound-slide screw, make sure the bolt that holds the nut in the center of the cross slide is tight. Then remove the handwheel and dial assembly by removing the setscrew (*Figure* 5.8) and pulling the assembly from the shaft. Tighten the spanner nuts as much as possible while still allowing comfortable movement of the handwheel.

The brass cross-slide nut is a split nut that lets you minimize the play between the screw and nut. Adjust the two screws at the end of the nut. Do not overtighten them, as that would cause excess wear on the nut. You can access them from the back of the machine by moving the cross slide to the back.



5.8 To reduce backlash, remove the setscrew and pull the handwheel and dial assembly off the shaft.

5.7 Electrical system

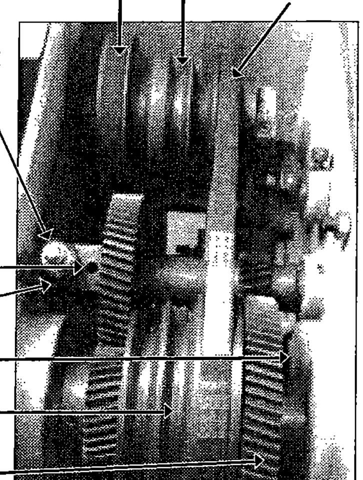
The electrical system is designed to run on 110 or 220 V. The motor supplied with the BZ-239 is a 110-V-only motor (unless you ordered a 220-V motor, in which case it is only 220-V). The switching circuit runs on 110 or 24-V at all times. A transformer converts the power from 110/220 to 110/24. There is also a glass fuse in the electrical panel box that services the switching circuit.

When troubleshooting the switching circuit, the first step is to check the fuse and make sure it is good. When the light is on, there is power to the switches. When it is off, there is no power to the switches, but there is always power to the relays.

Caution: There is power in the electrical panel at all times. Never attempt an electrical repair without first unplugging the machine from the wall outlet.

5.8 Setting the lathe speeds

BZ-239 only. The BZ-239 has 12 speeds, six in the backgear drive and six in the direct drive. To set the speed for 50 rpm, place the motor-to-idler belt in the smallest motor pulley sheave and the largest idler pulley sheave (*Figure* 5.8). Place the idler-to-



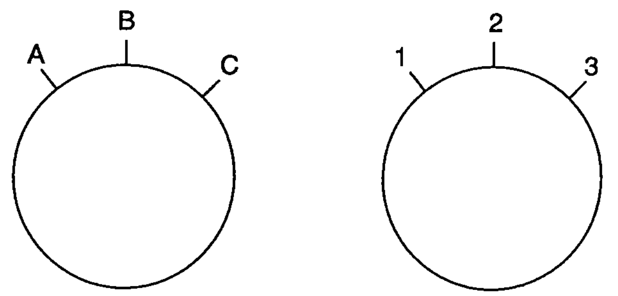
5.9 Setting lathe speeds on the BZ-239 (only).

spindle belt in the smallest idler pulley sheave and the largest spindle pulley sheave. Pull the pin in the right side of the bull gear and turn it 90° to lock it out. Lift up on the backgear handle and pull it forward until it locks into the hole. Check the mesh of the backgear to the spindle gears. If they do not mesh properly, loosen the setscrew in the hole in the supporting plate at the base of the backgear handle with a 4-mm Allen wrench. Pull the gear forward with your hand or tap it lightly with a plastic hammer until the gears mesh properly. Then tighten the setscrew.

To set the speed at 75 rpm, move the idler-to-spindle belt one place to the left, then one place to the left again for 100 rpm. For 120 rpm, set the motor-to-idler belt on the largest motor pulley sheave and the smallest idler pulley sheave. Place the idler-to-spindle belt on the smallest idler pulley sheave and the largest spindle pulley sheave. Then move the belt one place to the left for 165 rpm and one place to the left again for 220 rpm.

For 300 rpm, place the motor-to-idler belt in the smallest motor pulley sheave and the largest idler pulley sheave. Place the idler-to-spindle belt in the smallest idler pulley sheave and the largest spindle pulley sheave. Disengage the backgear, pull the pin in the side of the bull gear, rotate it 90°, and release it. Turn the spindle pulley slowly until the pin drops into the hole to lock the pulley and bull gear together. For successively higher speeds, follow the belt-changing instructions given above.

5.10 Gear-Selection Knobs–BZ-239 G



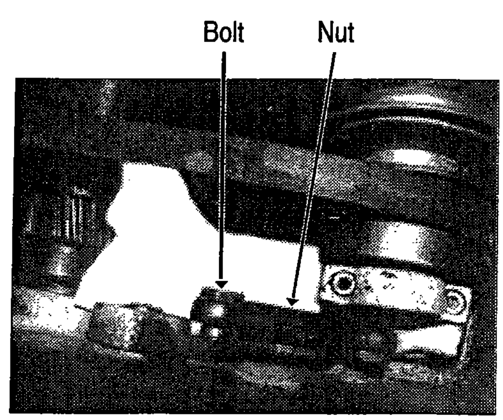
Gears	A3	A1	A2	C3	B3	C1	B1	C2	B2
RPM	64	130	210	380	460	790	940	1300	1500

BZ-239 G. Use the two gear-selection knobs (*Figure* 5.10) to set lathe speeds for the BZ-239 G. The knob on the left has marks labeled A, B, and C. The knob on the right has marks labeled 1, 2, and 3. There are nine speeds ranging from 64 rpm to 1500 rpm.

The knob at the lower left sets leadscrew direction. If you turn it to the right, the carriage will feed toward the tailstock. If you turn it to the left, the carriage will feed toward the headstock.

5.9 Adjusting belt tension

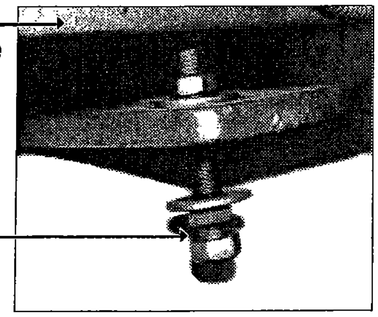
To adjust the tension on the lathe belt, pull the tensioner handle toward you. Remove the bolt (*Figure* 5.11) and turn the nut as needed. Then reattach it and push the handle all the way back. To adjust motor-belt tension, adjust the bolt between the motor mount plate and the chip tray on the back of the lathe (*Figure* 5.12).



5.11 Remove the bolt and turn the nut as needed.

5.10 Running in

Though all BZ-239s are run at the factory and again before shipping, it is wise to put your new machine through a breaking-in run before putting it to work. After oiling the machine, check the belts to make sure the tension is adjusted correctly. *Do not plug in the machine yet.*



5.12 To adjust motor-belt tension, adjust the bolt between the motor mount plate and chip tray.

Follow these steps:

- Set the lathe to 50 rpm.

- Loosen the binding screw at the top of the thread-chasing dial (*Figure* 4.8), swing the actuating gear out of engagement with the leadscrew, and retighten the screw. Keeping the thread-dial indicator in constant engagement (except when cutting threads) causes unnecessary wear on the leadscrew.

- On the apron, put the powerfeed (the lever in the middle, *Figure* 4.1) in neutral so neither the longitudinal nor the power crossfeed engages.

- Depress the red stop button (*Figures* 4.5 and 4.6).

- Plug your machine into a grounded 30-amp circuit.

- *BZ-239 only*. Release the mushroom kill switch by turning it clockwise one-quarter turn. The red light to the left of the kill switch will come on, indicating the BZ-239 is ready to run.

- Depress and release the green button to the right of the red stop button (*Figure* 4.4). Power will flow to the motor only while the button is depressed. The button will not stay down on its own. This is a good way to test your setup, check gear mesh, and make sure everything is in order before starting to work.

- *BZ-239 G*. Turn the circuit breaker switch on and release the red stop button (mushroom kill switch) by turning it clockwise one-quarter turn. Depress and release the green button below the mushroom kill swith.

- Start the motor by selecting Forward or Reverse on the Forward/Off/Reverse switch. Let the lathe run for 15 minutes.

- During the run-in, try the controls on the apron (reversing lever, change gears, etc.). Get the feel of your lathe.

Caution: Never engage or disengage gears while the machine is running.

SECTION SIX
TURNING

In turning, the lathe rotates a workpiece against a cutting edge. With its versatility and nearly numberless attachments, accessories, and cutting tools, it can do almost any machining operation.

The modern lathe offers the following:

- The strength to cut hard, tough materials
- The means to apply power
- The means to hold the cutting point tight
- The means to regulate operating speed
- The means to feed the tool into or across, or into *and* across, the work, either manually or by engine power, under precise control, and
- The means to maintain a predetermined ratio between the rates of rotating works and the travel of the cutting point or points.

6.1 Turning speeds

When metal cuts metal at too high a speed, the tool burns up. You can machine soft metals like aluminum at fast speeds without danger or trouble, but you must cut hard steels and other metals slowly.

You must also consider the diameter of the workpiece (*Figure* 6.1). A point on a 3"-diameter shaft will pass the cutting tool three times as fast as a point on a 1"-diameter shaft rotating at the same speed. This is because the point travels a tripled circumference. For work in any given material, the larger the diameter, the slower the speed in spindle revolutions needed to get the desired feet-per-minute (fpm) cutting speed.

Lathes cut screws or threads in various numbers per inch of material threaded, according to the operator's needs. The BZ-239 cuts threads to metric and inch standards.

In thread cutting, the carriage carries the thread-cutting tool and moves by engaging the half-nut on the rotating leadscrew (*Figure* 4.1). The basic principle is that the revolving leadscrew pulls the carriage in the desired direction at the desired speed. The carriage transports the toolrest and the threading tool, which cuts the screw thread into the metal piece being machined.

The faster the leadscrew revolves in relation to the spindle, the coarser the thread. This is because the threading tool moves farther across the revolving metal with each workpiece revolution.

The lathe spindle holding the workpiece revolves at a selected speed (revolutions per minute, or rpm) according to the type and size of the workpiece. The leadscrew, which runs the length of the lathe bed, also revolves at the desired rpm. There is a definite and changeable ratio between spindle and leadscrew speeds. *Figure* 6.2 shows belt positions for various speeds on the belt-driven BZ-239. Gear positions for various speeds on the BZ-239 G are shown in *Figure* 6.3.

6.1 Cutting Speeds for Various Diameters

FPM	50	60	70	80	90	100	110	120	130	140	150	200	300
DIAM						RPM							
1/16"	3056	3667	4278	4889	5500	6111	6722	7334	7945	8556	9167	12229	18344
1/8"	1528	1833	2139	2445	2751	3056	3361	3667	3973	4278	4584	6115	9172
3/16"	1019	1222	1426	1630	1833	2037	2241	2445	2648	2852	3056	4076	6115
1/4"	764	917	1070	1222	1375	1538	1681	1833	1986	2139	2292	3057	4586
5/16"	611	733	856	978	1100	1222	1345	1467	1589	1711	1833	2446	3669
3/8"	509	611	713	815	917	1019	1120	1222	1324	1426	1528	2038	3057
7/16"	437	524	611	698	786	873	960	1048	1135	1222	1310	1747	2621
1/2"	382	458	535	611	688	764	840	917	993	1070	1146	1529	2293
5/8"	306	367	428	489	550	611	672	733	794	856	917	1223	1834
3/4"	255	306	357	407	458	509	560	611	662	713	764	1019	1529
7/8"	218	262	306	349	393	426	480	524	568	611	655	874	1310
1"	191	229	267	306	366	372	420	458	497	535	573	764	1146
1-1/8"	170	204	238	272	306	340	373	407	441	475	509	679	1019
1-1/4"	153	183	216	244	275	306	336	367	397	428	458	612	918
1-3/8"	139	167	194	222	250	278	306	333	361	389	417	556	834
1-1/2"	127	153	178	204	229	255	280	306	331	357	382	510	765
1-5/8"	117	141	165	188	212	235	259	282	306	329	353	470	705
1-7/8"	102	122	143	163	183	204	224	244	265	285	306	408	612
2"	95	115	134	153	172	191	210	229	248	267	287	382	573
2-1/4"	85	102	119	136	153	170	187	204	221	238	255	340	510
2-1/2"	76	91	107	122	137	153	168	183	199	214	229	306	459
2-3/4"	69	82	97	111	125	139	153	167	181	194	208	278	417
3"	64	76	89	102	115	127	140	153	166	178	191	254	371

Table provides exact speeds (rpm). It does not take machine speed limitations into account. The BZ-239 has 12 spindle speeds (50–1200 rpm). Determine the desired rate of speed and find the closest speed available on your machine.

6.2 Gear ratios

The lathe lets you use various indicated gear combinations to cut the desired number of threads per inch (tpi) or the metric equivalent, or to advance the tool a specified amount each revolution (feed rate expressed as inches per revolution [ipr]). The BZ-239 has a quick-change gearbox (*Figure* 4.4).

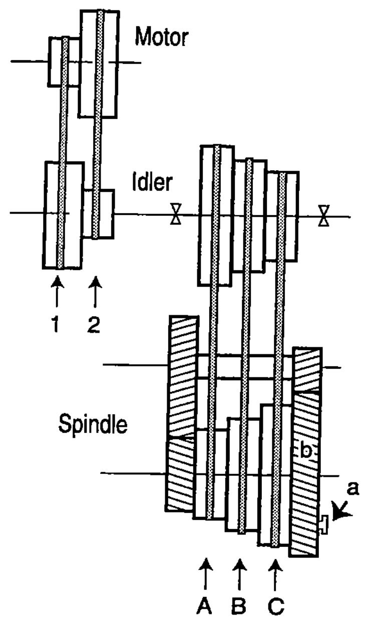
The gearbox mechanism determines the leadscrew's rotation rate in relation to the spindle's for threading, turning, and facing. To change the thread pitch (tpi) and feed rate (ipr), select the desired tpi or ipr (*Figure* 6.3) and set the handles accordingly. The handle on the left goes in one of the five lettered holes, the handle on the right in one of the eight numbered holes.

The gears in the BZ-239 are for cutting standard inch threads. For metric threading or different inch threads, install the change gears according to *Figure* 6.3. Then set the tumbler levers.

You can reverse the gears to get the right alignment. For example, if you want to mesh the 40-tooth gear with the 127-tooth gear, face the hub of the 40-tooth gear out. If you want to mesh the 40-tooth gear with the 120-tooth gear, install the 40-tooth gear hub first.

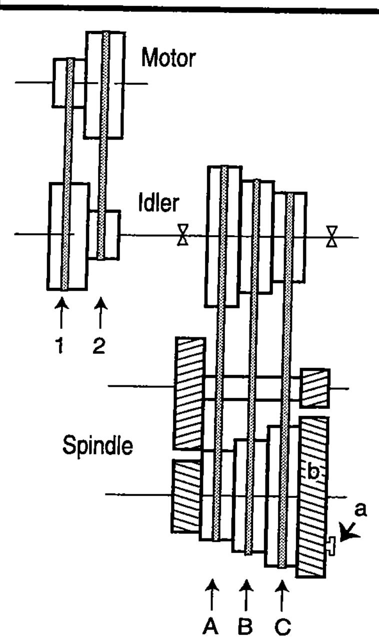
6.2 Lathe Belt Positions for Various Speeds (rpm)—BZ-239

Backgear Drive



Belts	A	B	C
1	100	75	50
2	220	165	120

Direct Drive

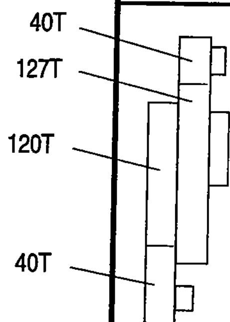


Belts	A	B	C
1	550	410	300
2	1200	900	655

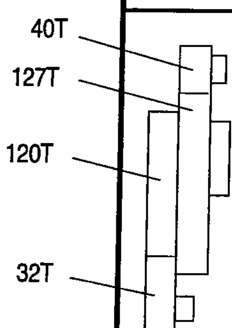
Lathe belt positions for backgear and direct drives. A, B, and C are positions for the idler-to-spindle pulley belt; 1 and 2 are positions for the motor-to-idler belt. The transmission pin is represented by a, the bullgear by b.

6.3 Gear Positions for Various Speeds (rpm)—BZ-239 G

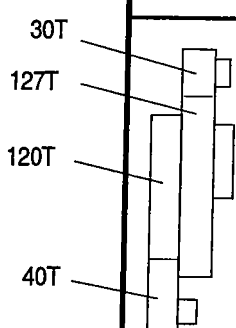
Threads per Millimeter



Gear Setup	Tumbler Lever Positions	1	2	3	4	5	6	7	8
	A	6			4.80		5		
	B	3			2.40		2		
	C	1.50			1.20		1		
	D	0.75			0.60		0.50		
	E				0.30		0.25		



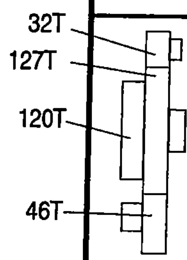
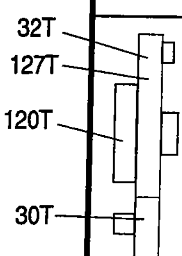
Gear Setup	Tumbler Lever Positions	1	2	3	4	5	6	7	8
	A	7.50			6		5		
	B	3.75			3		2.50		
	C	1.50			1.50		1.25		
	D				0.75				
	E								

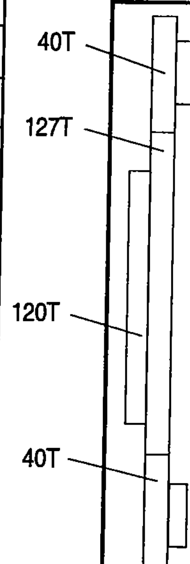


Gear Setup	Tumbler Lever Positions	1	2	3	4	5	6	7	8
	A	4.50	4				3		
	B	2.25	2		1.80		1.50		
	C		1		0.90		0.75		
	D		0.50		0.45				
	E		0.25						

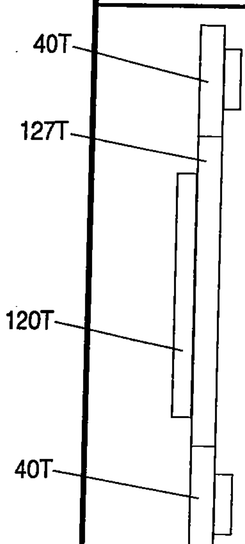
6.3 Gear Positions for Various Speeds (rpm)—BZ-239 G, cont.

Threads per Inch

Gear Setup	Tumbler Lever Positions	1
	A	5.75
	B	11.5
	C	23
	D	46
	E	92
	A	3.75
	B	7.5
	C	15
	D	30
	E	60

Gear Setup	Tumbler Lever Positions	1	2	3	4	5	6	7	8
	A	4	4.50	4.75	5	5.50	6	6.50	7
	B	8	9	9.50	10	11	12	13	14
	C	16	18	19	20	22	24	26	28
	D	32	36	38	40	44	48	52	56
	E	64	72	76	80	88	96	104	112

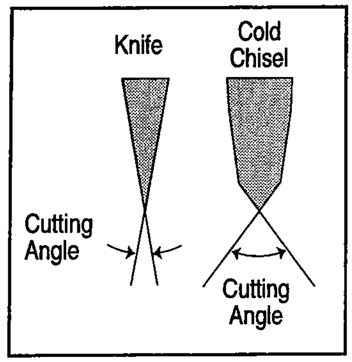
Inches per Revolution

Gear Setup	Tumbler Lever Positions	1	2	3	4	5	6	7	8
	A	0.1320	0.1173	0.1111	0.1055	0.0960	0.0880	0.0812	0.0754
	B	0.0660	0.0585	0.0555	0.0527	0.0480	0.0440	0.0406	0.0377
	C	0.0330	0.0293	0.0277	0.0263	0.0240	0.0220	0.0203	0.0188
	D	0.0165	0.0146	0.0138	0.0131	0.0120	0.0110	0.0101	0.0094
	E	0.0082	0.0073	0.0069	0.0065	0.0060	0.0055	0.0050	0.0047

SECTION SEVEN
METALCUTTING THEORY

A machine tool is no more efficient than its cutting edge. Because lathe operations require continuous regrinding and resharpening of the machine's cutting tools, operators should know some metalcutting theory.

All cutting with a sharp edge, whether with the thin blade of a knife or the almost square edge of a closely supported carbide tool, is basically a wedging-apart action. The first essential of any wedging tool is a penetrating edge. The narrower the blade, the less force or power is required to wedge it through the material to be cut. Therefore, when cutting comparatively soft materials with a cutting tool made from a much harder, stronger substance, the blade can be very thin and sharpened to a long, thin edge.

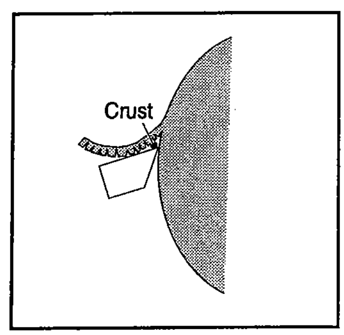


7.1 The knife edge breaks off almost upon contact with the metal because its cutting edge is not as strong as that of a cold chisel.

As the material hardness (or resistance to separation) increases, the strength of the cutting edge must also increase. A knife whose edge is too thin dulls quickly, even when cutting comparatively soft materials. This explains why, in *Figure* 7.1, the knife edge breaks off almost upon contact with the metal while the more obtuse cutting edge of a cold chisel stands up to continuous pounding.

The primary requirements of the cutting edge of any metalcutting tool are that it must be (A) strong and (B) closely supported. This is understandable when we realize how much downward pressure is exerted against the cutting edge. Pressure against cutting tools as great as 250,000 pounds per square inch (psi) have been measured on large metalcutting lathes.

While the workpiece revolves, a strong, rigidly held cutting edge is forced under its surface. As it presses down against the cutting edge, small chips or a continuous ribbon of metal wedges away (*Figure* 7.2). Only in soft, ductile materials is this wedging action continuous.



7.2 Wedging-off action in cutting hard steel. Note the false edge or crust that builds up on the cutting edge.

On harder substances, the wedging force compresses, rises to the shearing point, and shears. Then it builds up and shears again, repeatedly. You can see this in the distortion of chips when cuts are heavy and materials hard.

When the shearing vibration synchronizes with the natural vibration period of any part of the tool, toolholder, or workpiece, *chatter* occurs. You eliminate chatter by changing one of the harmonizing factors: making the tool more rigid, holding the cutter closer up in the toolholder, backing the toolholder farther into the toolpost, or altering the feed of the tool, operating speed of the lathe, or angle of the cutter bit to the workpiece.

7.1 Tool sharpness

Instead of being the all-important factor in determining tool performance, keenness of the cutting edge is just one of many factors. On rough or heavy cuts, it is far less important than strength, because a false cutting edge or crust usually builds up on the tool edge, and though the edge dulls, its angle often increases the cutting tool's efficiency by increasing its wedging action. Cutter shape is more important than edges, which generally are rough-ground and usually must be honed for fine finishing cuts or work in soft, ductile materials like brass or aluminum.

Lack of clearance, which lets a tool drag on the work below the cutting edge, is a brake on the lathe, greatly reducing pressure on the cutting point and interfering with tool performance more than edge dullness. At the same time, excessive clearance weakens a tool because of insufficient support to the cutting edge. Such an edge will break off if you use the tool on hard materials.

Clearance requirements change with almost every operation, but there are certain standards for all aspects of the cutting tool. You must not only provide clearance from the cutting edge; there must also be end and side clearance. To help the chip pass with minimum resistance across the top of the tool, it should often have top rake as well. You determine the shapes and rakes to which you'll grind your tools by the toolholder you use. The BZ-239 has a four-sided turret toolpost that accommodates high-speed-steel (HSS), carbide-tipped, or indexable carbide turning tools.

7.2 Heat

The energy expended at the lathe's cutting point converts largely into heat, and because the energy expended is great, the heat is intense. Before today's high-speed-steel, carbide, and ceramic tools existed, this heat created a serious machining problem. Machining could be done only under a steady flow of coolant, which kept the tool from heating up to its annealing point, softening, and breaking down.

With HSS, you can usually cut dry unless you're using a small lathe at extremely high speeds on continuous, heavy-duty production work. HSS tools are self-hardening even when red hot (950°F). They do not dissipate the heat, however, or in any way prevent the workpiece from heating up. Because steel expands when heated, it is a good idea, especially when working on long shafts, to check the tightness of the lathe centers frequently and make sure workpiece expansion does not cause centers to bind.

In everyday lathe operations like thread cutting or knurling, always use a cutting oil or other lubricant. On such work, especially if the cut is light and lathe speed low, dipping a brush in oil occasionally and holding it against the workpiece will provide sufficient lubrication. For continuous, high-speed, heavy-duty production work, however, especially on tough alloy steels, using cutting oil or coolant will increase cutting efficiency. It's essential if you're using a non-HSS cutting tool. When

7.3 Cutting Speeds and Feeds for High-Speed-Steel Tools

	Low-Carbon Steel	High-Carbon Steel Annealed	Alloy Steel Normalized	Aluminum Alloys	Cast Iron	Bronze
Speed (sfm)						
Roughing	90	50	45	200	70	100
Finishing	120	65	60	300	80	130
Feed (ipr)						
Roughing	0.010–0.202	0.101–0.020	0.010–0.020	0.015–0.030	0.010–0.020	0.010–0.020
Finishing	0.003–0.005	0.003–0.005	0.003–0.005	0.005–0.010	0.003–0.010	0.003–0.010

you use coolant, direct it against the cutting point and cutter. If you don't have one, consider installing a coolant system.

Figure 7.3 lists cutting speeds and feeds for HSS cutters so you can set up safe rpm rates. The formula is as follows:

rpm = CS x 4/D"

where CS = cutting speed in surface feet per minute (sfm) and D" = diameter of the workpiece in inches.

To use this formula, find the cutting speed you need on the chart and plug that number into the CS portion of the formula. After calculating the rpm, use the nearest or next-lower speed on the lathe and set the speed.

If you were to make a finish cut on a piece of aluminum 1" in diameter, for example, you would see the desired sfm per *Figure* 7.3 is 300. Then

rpm = 300 sfm x 4/1

rpm = 1200/1

rpm = 1200 or next slower speed.

For high-carbon steel, also 1" in diameter,

rpm = 50 sfm x 4/1

rpm = 200/1

rpm = 200 or next slower speed.

The BZ-239's four-turret toolpost lets you mount up to four different tools at the same time. You can install all standard-shaped turning and facing tools with 1" or smaller shanks. The centerline is approximately 5/8" above the bottom of the turret. Smithy also offers quick-change tool sets that greatly speed up lathe operations. Contact a Smithy technician for details.

SECTION EIGHT
GRINDING CUTTER BITS FOR LATHE TOOLS

8.1 High-speed-steel cutters

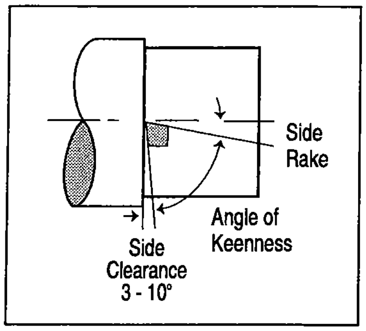
The advantage of HSS cutter bits is you can shape them to exact specifications through grinding. This lets you grind a stock shape into any form. Stock shapes come in an assortment of types, including squares, flats, and bevels. Many shops buy their cutters as ready-ground or ready-to-grind bits or blades.

Ready-to-grind bits and blades are of specially selected HSS, cut to length and properly heat-treated. They are fine tools in the rough and generally superior to HSS shapes sold by the pound.

In grinding HSS cutter bits, you have five major goals:

- A strong, keen cutting edge or point
- The proper cutting form (the correct or most convenient shape for a specific operation)
- Front clearance away from the toolpoint
- Clearance away from the side of the tool (side rake)
- Free chip movement over the tool and away from the cutting edge.

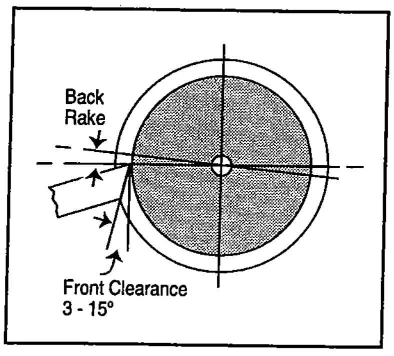
Keenness angles can vary from 60° for mild softness to 90° for hard steels and castings (*Figure* 8.1).



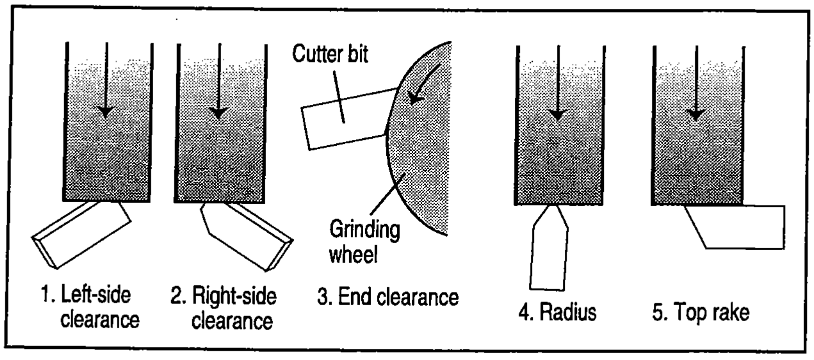
8.1 Keenness angles vary from 60° to 90°.

Front clearance must always be sufficient to clear the work. If it is too great, however, the edge weakens and breaks off (*Figure* 8.2). Side and back-rake requirements vary with the material used and operation performed. Back rake is important to smooth chip flow, which is needed for a uniform chip and good finish, especially in soft materials. Side rake directs the chip flow away from the point of cut.

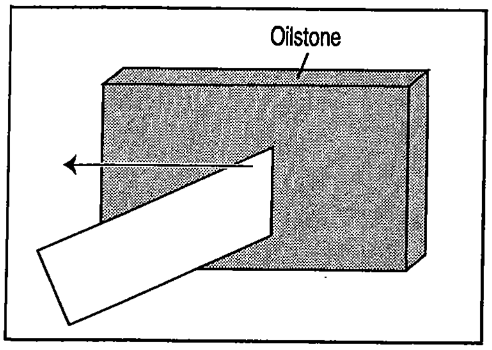
Grind cutters on a true-surfaced, good-quality, medium-grit grinding wheel (preferably an 8", 46–60A or 68A-grit Carborundum wheel) at 6000 or 6500 rpm. When starting with an unground cutter bit, the procedure (*Figure* 8.3) is usually to (1) grind the left-side clearance, (2) grind the right-side clearance, (3) grind the end form or radius, (4) grind the end clearance, and (5) grind the top rake,



8.2 The edge weakens if front clearance is too great.



8.3 Grinding sequence for an unground cutter bit.

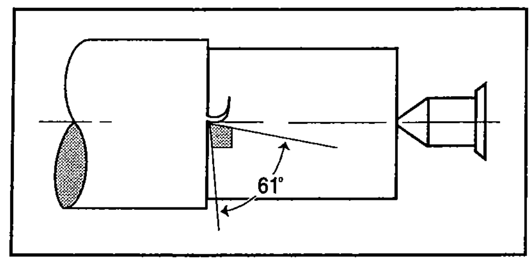


8.4 When honing, draw the cutter away from the cutting edge across the oilstone.

touching in a chipbreaker. If you are honing the cutting edge (for fine finishing or machining soft materials), draw the cutter away from the cutting edge across the oilstone (*Figure* 8.4).

8.2 Materials other than steel

As pointed out earlier, when grinding HSS cutters, we determine cutting angles primarily by strength requirements, not keenness requirements. Angles and rakes for general industrial shop use are established. In machining steel, the softer the steel, the keener the angle of the cutting edge. For soft steels, angles as acute as 61° are possible (*Figure* 8.5).

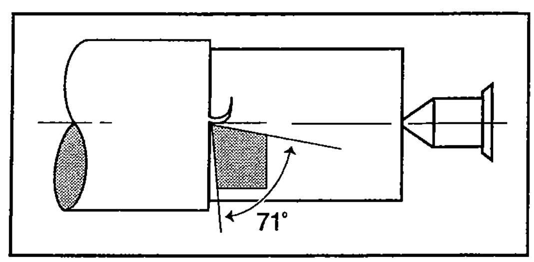


8.5 With soft steels, 61° angles are possible.

The same general rule applies to cast iron. Chilled or very hard cast iron requires tools with cutting-edge angles as great as 85°. For ordinary cast iron, you obtain greatest efficiency with a more acute cutting edge—approximately 71° (*Figure* 8.6).

8.3 Bits for turning and machining brass

Brass tends to pull or drag when machined. It's best to machine it on dead center with the top rake in the horizontal plane of the lathe centers. Softer than steel, brass needs less support for the cutting edge. Brass cutters require an almost flat top angle and can gain greater angle keenness only in increased side and end rakes. It is often advisable to hone the cutting edges of cutters used to machine brass.

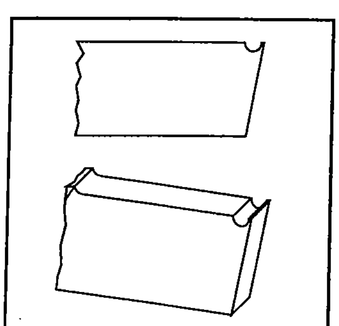


8.6 With cast iron, a 71° angle is most efficient.

Note: All roundnose cutters are ground with flat tops and equal side rakes because they are fed across the work, to both right and left.

8.4 Special chip craters and chipbreakers

When grinding cut-off blades, and occasionally on other cutter bits where the material's extreme hardness or toughness makes it difficult to control the chip leaving the work, it sometimes helps to grind a smooth, round crater just behind the cutting edge. This serves as a chip guide and starts the chip curling smoothly (*Figure* 8.7).

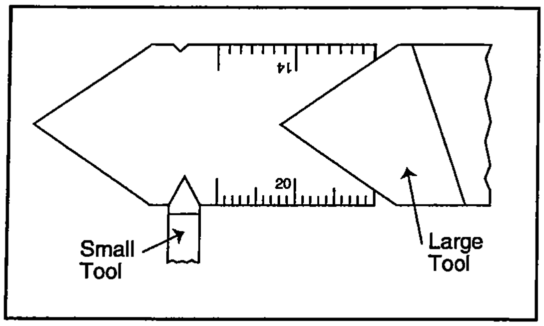


8.7 A crater starts the chip curling smoothly.

8.5 Using a center gauge to check V-thread forms

It may be convenient to grind a standard cutter bit for thread cutting, especially for cutting standard 60° V-threads. When grinding an ordinary square cutter into a thread-cutting tool, take care to ensure a true thread form. The easiest way is to use an ordinary center gauge for a standard V-thread tool or a special thread gauge for special thread forms.

To grind a cutter for an ordinary V-thread, grind first the left side of the tool, then the right side, to 30°. Be careful to grind equally from both sides to center the toolpoint. Then test for true form by inserting the newly ground point into the closest-sized V in a standard center gauge (*Figure* 8.8). Examine the gauge and cutter before a light. When the cutter is ground perfectly, no light streak will show between tool and gauge. Use a grinding chart for other rakes.



8.8 Insert the point into the nearest-sized V in the center gauge.

8.6 Acme or other special threads

Thread gauges are available for all standard threads. Before grinding such cutters, ascertain the correct pitch angle of the particular thread profile. For example, the pitch of an acme thread is 29° to a side, and the toolpoint is ground back square to an exact thread profile that requires a different end width for each thread size.

Thread forms must be accurate if threads are to fit snugly and smoothly. Every resharpening of this type of cutter requires regrinding the entire form. It is far better, when doing any amount of threading, to use a threading tool with a special form cutter. Sharpening such cutters requires only flat, top grinding, which does not alter the cutting profile.

8.7 Carbide-tipped cutters and cutter forms

Carbide is a compound of carbon and a metal. In cutting tools, it is usually carbon and tungsten. The hardness of carbide cutting materials approaches that of diamond. While carbides permit easy machining of chilled cast iron, hard and tough steels, hard rubber, Bakelite, glass, and other difficult or "unmachinable" materials, its primary use in industry is for long production runs on ordinary steels. On such work, carbide-tipped tools permit higher running speeds and much longer runs between resharpenings. The cutting edge of carbide tools stands up 10–200 times as long as the edge of HSS tools (*Figure* 8.9).

The advantage of carbide is that is it tolerates much higher heat than high-speed-steel or other alloys so you can run at higher speeds. The disadvantage is that it is more brittle than HSS and must have adequate support in the toolpost to prevent vibration and breakage.

8.9 Carbide Types and Cutting Tool Applications

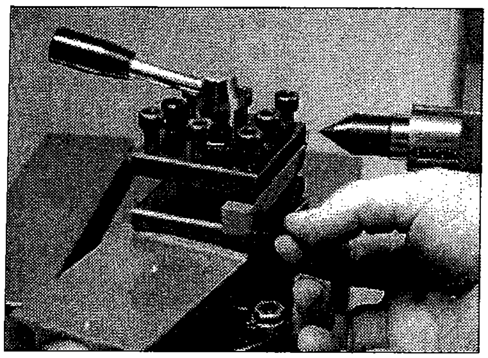
Application	Use	Grade
Cast irons	Roughing cuts	C-1
Nonferrous, nonmetallic, high-temperature alloys	General purpose	C-2*
200 and 300-series stainless steels	Light finishing Precision boring Roughing cuts General purpose	C-3 C-4 C-5 C-6*
Alloy steels	Finishing cuts	C-7
400-series stainless, high-velocity	Precision boring	C-8

*C-2 and C-6 are the most commonly used carbides.

SECTION NINE
SETTING UP LATHE TOOLS

After selecting a cutter, insert it in the toolholder. Allow the cutter bit to project just enough to provide the necessary clearance for the cutting point. The closer the cutter is to the toolpost, the more rigid the cutting edge.

Allen-head capscrews hold the tool in the toolpost. To assure maximum rigidity, don't let the tool extend too far beyond the end of the toolpost turret.



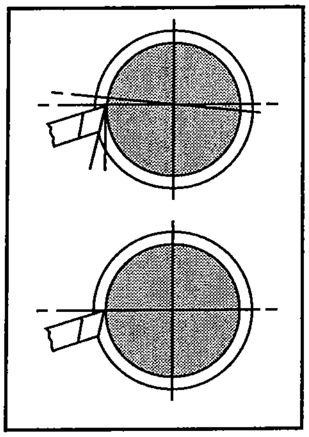
9.1 Placing shims under the tool can correct cutting-tool height.

9.1 Cutting-tool height

After inserting the cutting tool into the toolpost, adjust the height of the cutting edge in relation to the lathe center. Insert a center in the tailstock. Then run the tool and center together. The cutting edge on the tool should meet the point on the center. It may be necessary to use shims, which can be of various thicknesses and materials (*Figure* 9.1). Many seasoned machinists use pieces of old hacksaw blades as shims. If the toolbit is too high, shim the back of the toolbit. If it's too low, shim the entire tool.

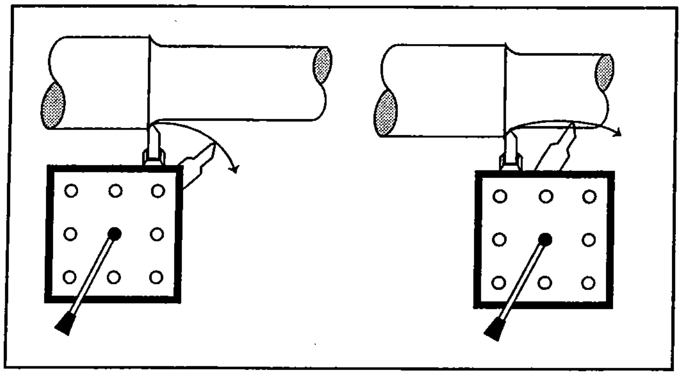
9.2 Turning tools

For general turning operations, set the point of the cutter bit slightly above the centerline of the work. In steel, the harder the material, the less above center (*Figure* 9.2, top). Exceptions are soft brass, aluminum, and materials that tend to pull or tear. When machining these materials, set the cutter on dead center (*Figure* 9.2, bottom).



9.2 The harder the steel (top), the less above center you set the cutter point. For soft brass and aluminum (bottom), set the cutter on dead center.

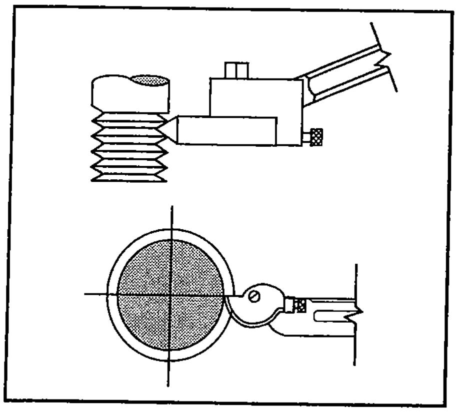
When cutting toward the headstock in most turning and threading operations, swing the compound rest to hold the shank of the toolholder at an angle. The angle should be approximately 29-1/2° left of perpendicular to the line of centers, except for extremely heavy, rough, forcing cuts close to the limits. For such work, use a straight-shanked tool held perpendicular to the line of lathe centers in the right side of the toolpost. The tool will tend to swing out of the cut rather than hog into the work if you reach a stalling point (*Figure* 9.3).



9.3 The tool will swing out of the cut (left) rather than hog into the work (right) if you reach a stalling point. Note the tool is in the right-hand side of the toolpost.

9.3 Threading tools

Threading tools should always engage the workpiece on dead center. Any deviation above or below will affect the thread profile (*Figure* 9.4).



9.4 Threading tools engage the work on dead center.

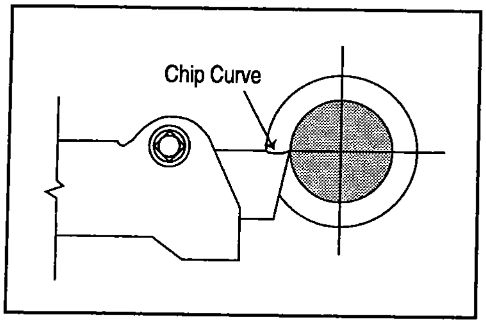
9.4 Cut-off, thread-cutting, and facing tools

For cutoff, thread cutting, and facing, feed the cutter to the work on dead center (*Figure* 9.5). For the beginner, the average feed should not exceed 0.002 ipr.

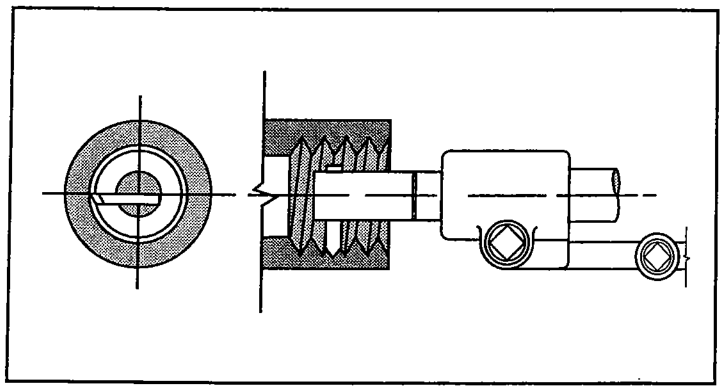
9.5 Boring and inside-threading tools

For boring and inside threading, the cutter point engages the work on dead center (*Figure* 9.6). For greater cutting efficiency, position the bar while parallel to the line of lathe centers sufficiently below center to give the cutter a 14-1/2° approach angle. For internal threading, grind the top face of the cutter to compensate for this angle, giving a flat, true-form top face.

Some machinists prefer to position the tool slightly above center when boring. With the bit above center, if a tool chatters it deflects down into empty space instead of into the workpiece.



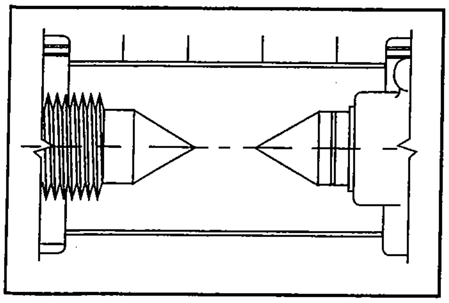
9.5 Feed the cutter on dead center for cutoff, thread cutting, and facing.



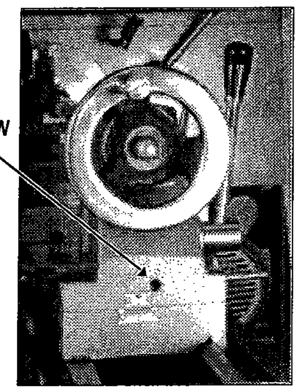
9.6 For boring and inside threading, the cutter point is at dead center.

SECTION TEN

SETTING UP WITH CENTERS, COLLETS, AND CHUCKS


10.1 When aligning spindle and tailstock centers, move the tailstock toward the headstock until the centers touch.

Before setting work up on centers, make sure the spindle and tailstock centers align accurately. Do this by inserting a center into the nose spindle and inserting the tailstock center into the tailstock ram. Then move the tailstock toward the headstock until the centers touch (*Figure* 10.1). You can correct any lateral alignment error by adjusting the side and rear tailstock set-over screws (*Figure* 10.2).



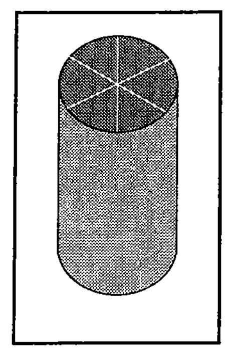
10.2 Adjusting the tailstock set-over screws corrects lateral misalignments.

To adjust the alignment, loosen the setscrew at the rear of the tailstock. To adjust to the right, loosen the left adjusting bolt and tighten the right. To adjust to the left, loosen the right adjusting bolt and tighten the left.

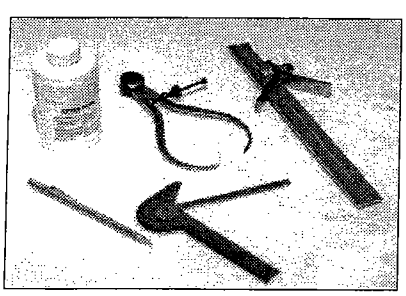
For most turning operations, work is held in the lathe between the lathe centers by means of holes drilled in the ends of the stock to be machined. Your machining accuracy depends primarily on how precisely you locate these holes at the center of the bar or block. Locating these holes is called *centering*.

10.1 Centering

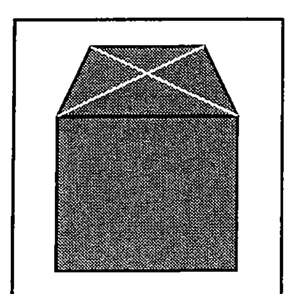
You can improve centering greatly by first squaring the ends of the workpiece (see *Section* 12.1). This gives you a true cross section in which to locate the centering holes.


10.3 Centering on round stock.

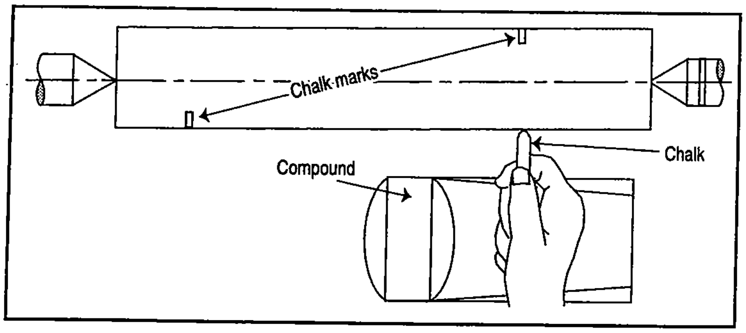
You can center on round stock (*Figure* 10.3) with calipers, dividers, or special centering instruments (*Figure* 10.4). Centering square or rectangular stock is done by scribing lines from opposite corners. The intersection of these lines is the center (*Figure* 10.5).


10.4 Centering instruments.

After locating the center of each end, drive a starting depression for the drill into the stock with a center punch. Check centering accuracy by placing the workpiece between the spindle and tailstock centers. Revolve the headstock slowly against the tip of a tool or a piece of rigidly held chalk. The chalk should touch just the high spots (*Figure* 10.6). If the center proves inaccurate (0.002" or more off), correct the position of the center by repunching at an angle.


10.5 Centering on square or rectangular stock.

Next, drill and countersink the centers to conform to the profile of the lathe centers. This is best done with a combination center drill/countersink held in the tailstock arbor chuck. The centers now will take the lathe centers



10.6 When you revolve the headstock against a piece of chalk, the chalk should just touch the high spots.

without play or chatter.

If a combination drill is not available, you can drill centers with a small drill and countersink them with a drill of sufficient diameter ground to a 60° point. A 60° taper is standard for lathe center points. Correct center depth is given in *Figure* 10.7. Take care to get an accurate 60° countersink in the center (*Figure* 10.8).

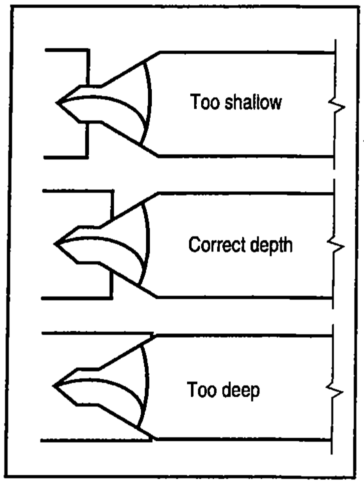
10.2 Mounting work between centers

Remove the chuck from the spindle by loosening the setscrews that lock the backplate to the spindle. Then lock the spindle by engaging the backgear and direct drive. You can unscrew the chuck counterclockwise by putting an adjustable wrench on one of the jaws and giving it a quick jerk (*Figure* 10.9). Be sure to place a piece of wood on the ways to protect them in case the chuck falls.

Run the carriage to the far left. Make sure the tapers are clean in the headstock and tailstock spindles and insert the centers in both. Push the tailstock up to the headstock (*Figure* 10.1). The points of the centers should meet. You may have to adjust the tailstock.

Next, fasten a lathe dog to one end of the workpiece. For ease of operation, use a live or rotating center in the tailstock end so you won't need lubrication. Mount the workpiece as shown in *Figure* 10.10. Before starting the lathe, make sure the centers don't hold the workpiece too tightly. Heat may cause the workpiece to expand, so watch for binding. Adjust the tailstock center so the workpiece turns freely but without end play.

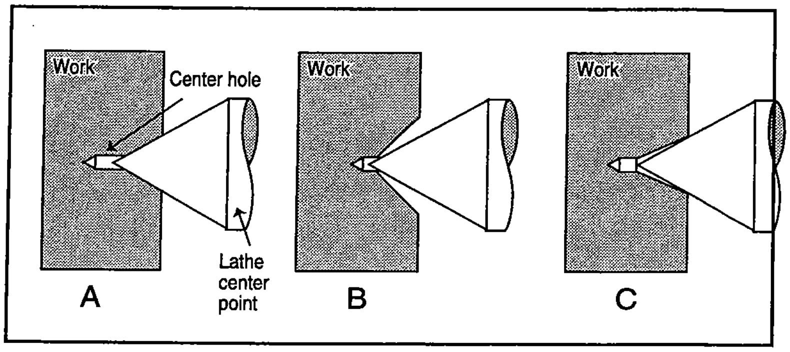
If, after partially machining the workpiece, you find you must machine the stock under the lathe dog, remove the workpiece from the lathe and place the lathe dog on the machined end. Then turn this new tailstock center end of the shaft down to the desired diameter or form.



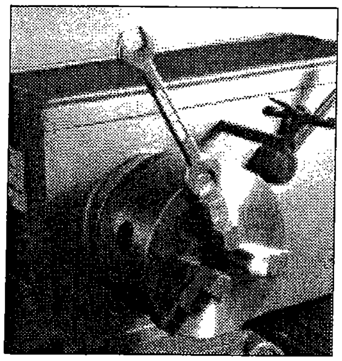
10.7 The correct depth of center is illustrated above. If it's too deep (bottom), only sharp outer edges will contact the center.

10.3 Using a clamp dog

Standard lathe dogs drive round or near-round shapes. Rectangular or near-rectangular stock requires clamp dogs. In a properly made clamp dog, the underface of the heads of tightening screws are convex and fit into concave seats, while the holes in the upper bar are elongated. This design permits a firm grip of off-square shapes without bending the screws. Top and bottom bars should also have V-notches to give a firm grip on triangular or other odd-shaped stock.



10.8 Counterbore centers with a drill to a 60° point so they fit lathe centers (A). Too obtuse (B) or too acute (C) a counterbore will give insufficient bearing, prevent accuracy, and destroy lathe centers.

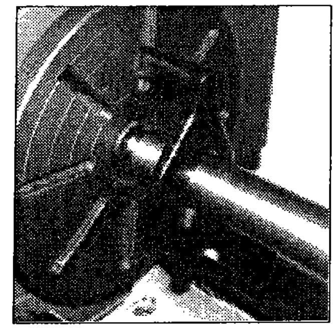


10.9 To loosen the chuck, give the wrench a quick jerk.

You can use clamp dogs or special V-jaw dogs to hold highly polished round bars.

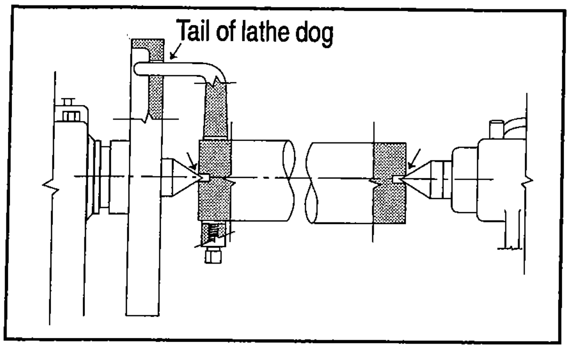
10.4 Using faceplates

For work setup, faceplates serve two purposes. First, they drive workpieces held between centers. Second, they hold workpieces shaped so you can't chuck them or mount them on centers.



10.10 Notched and slotted faceplates, used for driving work on centers, receive driving tools like the tail of a lathe dog.

Faceplates for driving workpieces on centers are generally small. They're notched and slotted to receive the tail of the lathe or clamp dog, bolt drive, or other driving tool (*Figure* 10.10). Faceplates for holding workpieces (irregularly shaped casting, machine, or die parts, for example) are usually larger and of varied design. They may be T-slotted, drilled all over, or slotted and drilled. Workpieces mount on such faceplates with T-slot or standard bolts, strap clamps, angle plates, or other standard setup tools.

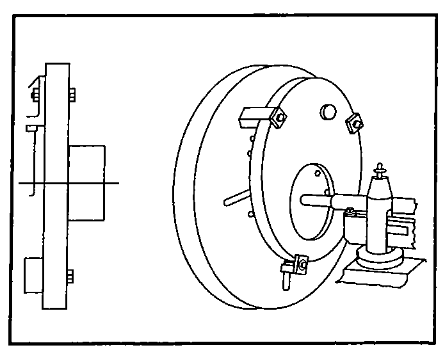


10.11 Make sure the lathe dog tail is free in the faceplate slot so it won't lift off the true line of centers.

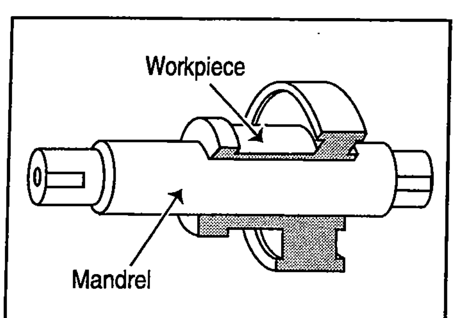
Note: Before starting to machine work set up on centers, check to see the lathe dog tail is free in the faceplate slot so it won't lift stock off its true line of centers, as in Figure *10.11. Also, be sure lathe centers fit closely into the center holes to eliminate side play but not so tightly they bind. If you're working on a long workpiece, check it frequently to be sure the center does not bind. Also, balance unbalanced setups with counterweights to overcome any "throw" as the work revolves* (Figure *10.12).*

10.5 Setting up work on a mandrel

You can machine cylindrical or bored pipe or cored castings too long to fit in a chuck by mounting them first on a mandrel. Then mount them between centers (*Figure* 10.13). The solid mandrels, which are driven into the hole of the workpiece, must be tight enough to turn the workpiece against the tool without slippage. Oil them lightly before driving them into the workpiece. Otherwise, the workpiece may freeze to the mandrel, making it impossible to remove the mandrel without damaging both the workpiece and the mandrel.



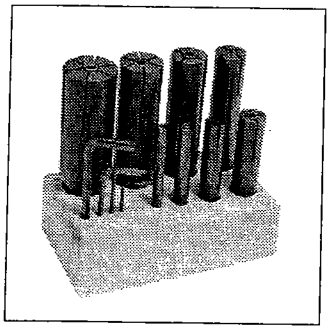
10.12 Counterweights can help with unbalanced setups.



10.13 Mount workpieces too long for a chuck on a mandrel.

When removing a mandrel, drive it back out of, instead of through, the hole. Drive it out in the opposite direction from the way you drove it in.

You can purchase hardened-steel mandrels, which have a slight (0.003") ground taper and an expanding collar, to facilitate mounting and demounting (*Figure* 10.14). Mandrels with compressible ends for holding single or ganged pieces are also

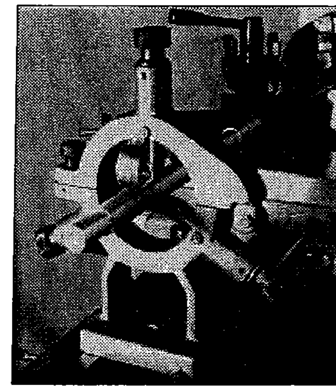


10.14 Hardened steel mandrels have a slight ground taper and expanding collar.

available. Once you've mounted the workpiece on a mandrel, machine it as you would a solid shaft. You can drill eccentric centers in mandrel ends to permit eccentric turning.

10.6 Steady rests and follow rests

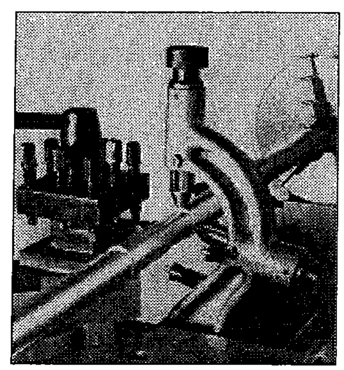
Rests are used for setting up (1) work that is relatively long in proportion to diameter or (2) work whose dead end must be left free for boring or other operations. You can also use rests to machine slender shafts that are apt to spring out of alignment from the thrust of the tool. The purpose of a rest is to support the workpiece and maintain it in accurate alignment for machining. Rests are classed as steady rests and follow rests.



10.15 Steady rests mount on the lathe bed.

Steady rests. Steady rests mount on the lathe bed. Clamped over the ways, they provide three bearing surfaces. These surfaces bear down lightly but rigidly against the surface of the shaft and keep it from moving out of the line of the lathe centers. You can place a steady rest anywhere along the bed where it will best support and steady the workpiece without interfering with the operation (*Figure* 10.15).

To set up a steady rest, first center the work in the chuck and true it up. Then slip the rest into position and tighten it to the bed. With the bearing jaws clearing the work, close the top of the rest and tighten the locking screw. Now, with the lathe running, adjust the three bearing jaws to touch, but not push, the workpiece. Finally, test again for alignment, making sure the axis of the workpiece coincides with the axis of the lathe. Otherwise, the end will not be square and the surfaces and boring will be untrue. The tips of the jaws are bronze and require lubrication.

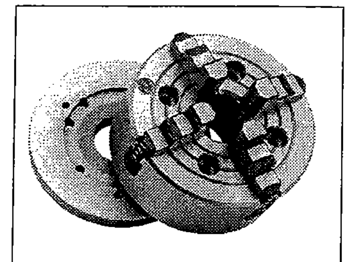


10.16 Follow rests mount on the lathe carriage.

Follow rests. Long or slender shafts that are apt to spring out of alignment by the thrust of the cutting tool often require follow rests (*Figure* 10.16). Follow rests mount on the carriage of the lathe and move with the tool, backing up the workpiece opposite the point of the tool thrust. They have two adjustable supporting jaws, one holding the work down to keep it from climbing up on the tool and the other behind the work to counter the thrust of the tool.

Note: Take great care in adjusting the jaws of rests, as they must form a true axial bearing for the work and let it turn freely but without play.

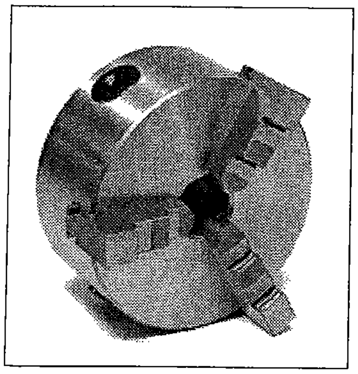
10.7 Setting up work in a chuck



10.17 Four-jaw independent lathe chucks hold round, square, eccentric, or odd-shaped workpieces.

Chucks usually hold work that is too short to be held conveniently between centers or work requiring machining at, into (boring or inside threading), or across its end. While it is possible to set up such work on a faceplate, the convenience of chucks has made them part of every complete lathe. Lathe chucks come in many types and sizes that hold work of diameters approaching the swing of the lathe.

For ordinary use, there are two standard types of headstock chucks.

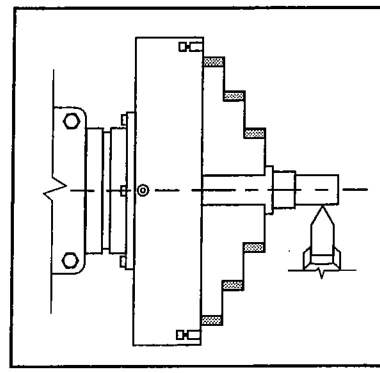


10.18 Three-jaw universal geared scroll chucks hold round or near-round work.

The four-jaw independent lathe chuck has four holding jaws that can operate independently and adjust to hold round, square, eccentric, or odd-shaped work (*Figure* 10.17). The three-jaw universal geared scroll chuck holds only round or near-round work with three, six, nine, 12, or other multiple-numbered sides. It always holds work concentrically. The three-jaw chuck has the advantage of being self-centering—all jaws move in or out together (*Figure* 10.18).

10.8 Mounting work in a four-jaw independent lathe chuck

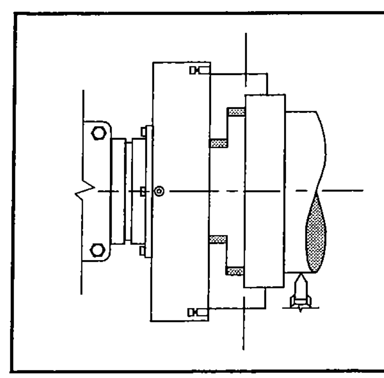
For small-diameter, short workpieces, insert jaws in the chuck with high ends to the center. This gives the maximum gripping and tool clearance (*Figure* 10.19). For large-diameter work, insert the jaws in the chuck slots with the high steps of the jaws to the outside of the chuck (*Figure* 10.20).



10.19 Mount short, small-diameter workpieces with high ends to center.

To place work in a chuck, follow these steps:

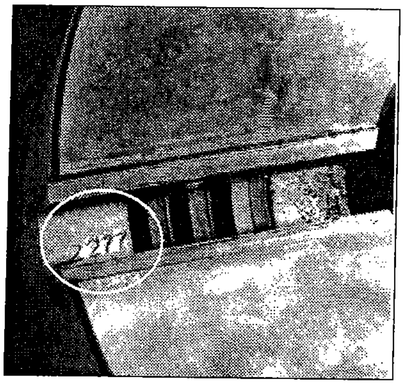
- Adjust the chuck jaws to the approximate opening to receive the work. Roughly center them by matching the nearest concentric ring on the chuck face with the corresponding mark on the jaws.
- Place the work in the chuck and grip it. Turn up the opposing jaws a uniform number of turns with the key provided. This will hold the work in position. Then bring in the other pair of opposing jaws the same way.
- Revolve the spindle slowly with your left hand while holding a piece of chalk until the chalk touches the high point (the nearest surface) of the workpiece (*Figure* 10.6).
- Guided by the chalk marks, readjust the jaws until a chalk line will carry completely around the work. Then tighten all the jaws securely. For greater accuracy, use a dial indicator instead of chalk. When making several identical workpieces, after finished each piece release only two adjoining jaws, leaving the others to hold the center. The jaws of the four-jaw independent chuck are reversible. You can insert them with high steps to the inside or outside.



10.20 Mount large-diameter workpieces with high steps of the jaws to the outside.

Never leave the chuck key (wrench) in the chuck while the chuck is on the spindle. Any movement of the spindle can crash the key into the ways, seriously damaging the ways, spindle, and chuck. Turning on the lathe with the key in the chuck can seriously damage your lathe. The key can also be thrown when the lathe starts, causing damage and/or injury. Never let your hand leave the chuck key unless you are picking it up or storing it.

Never remove a chuck or heavy faceplate without first laying a board across the ways to protect them in case the chuck falls when it comes off the spindle nose. Or use a chuck cradle to ease chuck removal and installation.



10.21 A serial number is stamped in the #1 slot of the three-jaw chuck.

10.9 Mounting work in a three-jaw universal chuck

Work is set up in a three-jaw universal chuck as in the four-jaw independent chuck, with the following exceptions:

- On three-jaw chucks, the key moves all the jaws at once.

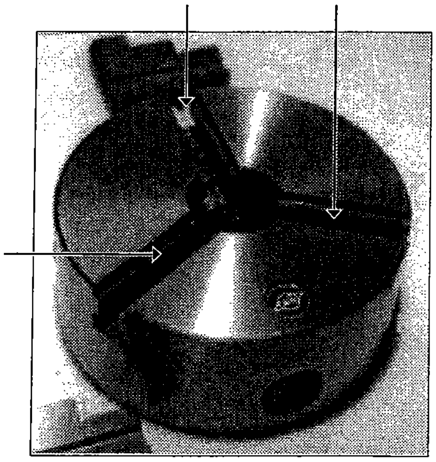
- You need not center or check for concentricity because these chucks center automatically.

- Jaws are not reversible. Each chuck comes with two sets of jaws. One set is for setups with high steps toward the inside (inside jaws), the other for mounting in the chuck with high steps to the outside (outside jaws).

- When installing the chuck jaws on a three-jaw chuck, install them in numerical order and counterclockwise rotation.

Each jaw is stamped with a serial number and jaw number (#1, #2, or #3), *Figure* 10.21. The slots in the chuck are not numbered, but a serial number is stamped at the #1 slot. With the #1 slot in the 12:00 position, the #2 slot is at 8:00 and the #3 slot at 4:00 (*Figure* 10.22).

To install the jaws, first insert the #1 jaw into the #1 slot and turn the key until it engages. Then put in the #2 jaw and engage it, then the #3 jaw.



10.22 With the slot for the #1 jaw in the 12:00 position, the slot for the #2 jaw is at 8:00 and the slot for the #3 jaw is at 4:00.

10.10 Collets and collet attachments

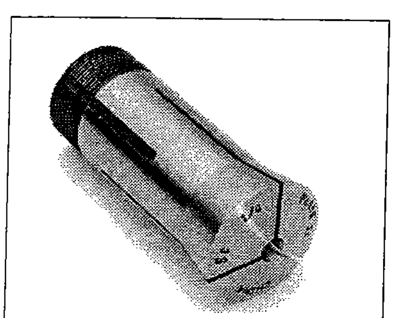
To hold small-diameter work, whether bar stock fed through the hole in the spindle or small pieces of semifinished parts, collet attachments are preferable to standard chucks (*Figure* 10.23) for several reasons:

- They have much faster release and grip actions.

- They center the work automatically and accurately.

- They grip firmly even small pieces and pieces with only a short hold.

- They are housed within the spindle nose for maximum tool clearance, making it possible to machine, thread, or cut off close to the spindle.



10.23 Collet attachments are best for small-diameter work.

While chucks are universal tools that hold a range of stock sizes and shapes, collets are special tools. There is a collet for every size and shape of workpiece.

Made with extreme accuracy, hardened, and ground, standard

split collets are slotted so their jaw ends compress inwardly to grip the workpiece. This is done by pulling the collet jaw's externally tapered shoulder into a matching taper-bored adapter sleeve. The adapter sleeve connects the lathe
spindle's MT5 taper to the collet's MT3 taper. A drawbar holds the collet in place.

10.11 Toolpost grinders

A fully equipped lathe has a toolpost grinder, a small, independently operated grinding head with an integral electric motor that mounts as a unit in the toolpost T-slot of the compound rest. (For lighter work, some are held in the toolpost.) You can maneuver it as you would any other cutting tool.

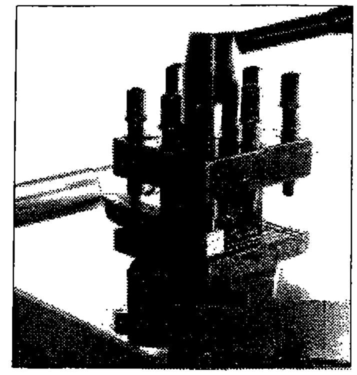
Toolpost grinders come with wheels of different shapes, sizes, and grits for grinding different materials and surfaces. They also come with arbors and mounted wheels for grinding internal surfaces. You can use them to grind or polish surfaces; to grind lathe centers, arbors, taper sockets, leader pins, gauges, valve seats, and other close-fitting parts; and to sharpen tools.

SECTION ELEVEN
LATHE TURNING

11.1 Rough turning

In turning a shaft to size and shape where you have to cut away a lot of stock, take heavy, rough cuts to get the work done in the least time. Use a transverse powerfeed for heavy cuts—from right to left toward the headstock so the thrust is against the headstock or chuck. Use a right-hand turning or roundnose cutter.

After selecting a cutter, place it into the left side of the turret (*Figure* 11.1). The cutter's point should be just above or on the line of the centers. The greater the diameter of the work, the higher the cutter can be. Adjust the height by placing shims under the cutter and raising or lowering it (*Figure* 9.1).



11.1 Place a cutter into the left side of the turret.

With the tool properly positioned, tighten the Allen capscrews. Next, run the carriage to the right end of the workpiece with the handwheel on the apron. Make sure the lathe is set to feed toward the headstock. Now determine the depth of the cut. Move the tool to the desired depth till it just touches the stock and zero the cross-feed dial.

Start the lathe. Run the crossfeed in by hand to take as heavy a cut as is consistent with the power of the drive or the amount of metal to remove.

Say, for example, you need to reduce a diameter by a known number of thousandths of an inch. If you zero the collar and watch the movement of the dial, you'll know the depth of the feed from the zeroing point. *Note: The dial gives you a good approximation, but for exact measurement, use a measuring instrument.*

To reduce the diameter, advance the tool only half as many thousandths on the dial. This is because the tool takes off an equal amount from both sides as it cuts a continuous strip around the work. For example, to reduce the diameter of a shaft 0.005", you advance the tool only 0.0025", or 2-1/2 calibrations. This cuts 0.0025" off each side (0.0025" + 0.0025" = 0.005" off the diameter of the shaft).

Engage the tool before setting the floating dial. The tool must be moving in the direction you want to go before you set the dial to zero.

For a screw to move, there must be some play in the thread. When backing the cutting tool away from the cut, move the feedscrew enough to take up the backlash, or lost motion in the screw, before setting the collar or when drawing the tool from the cut. Normal backlash is 0.008–0.015".

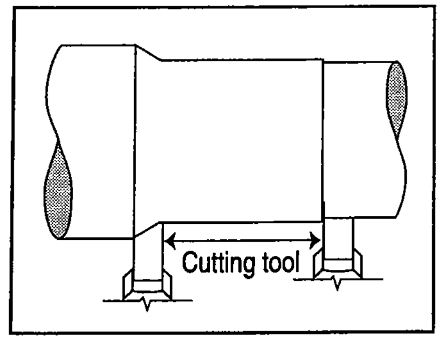
Engage the longitudinal feed by pushing down gently on the half-nut lever. *Do not force it.* Press the handle until the threads in the nut and screw line up and the lever drops into place. Always cut deeply enough to reach below the scale on oxidized bars or iron castings. Hard, oxidized surfaces dull tools rapidly.

11.2 Finish turning

After you've rough-turned the workpiece to within 1/32" of finished size, replace your cutter bit with a freshly ground, keen-edged cutter. Make one or more light finishing cuts across the machined surface.

Check the diameters carefully with a caliper or micrometer to be sure you are working to proper dimensions. Remember: the diameter will reduce twice the thickness of the cut.

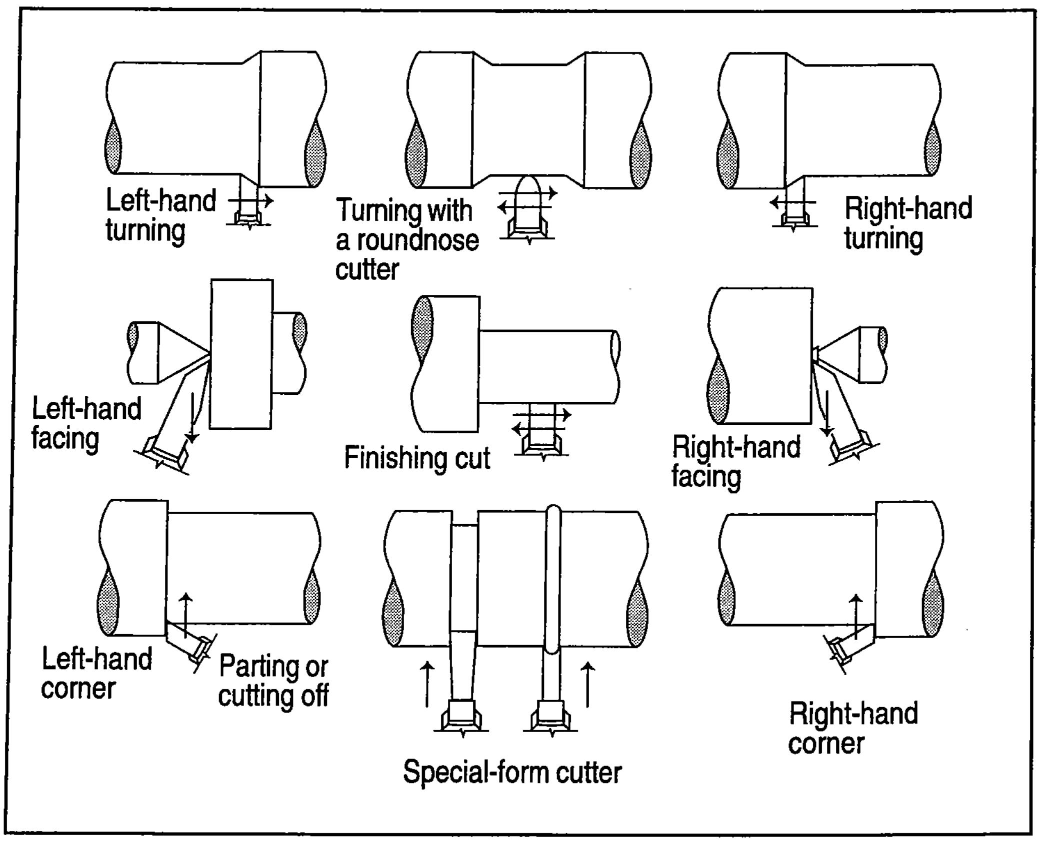
For rough turning, most machinists prefer a deep cut and a comparatively fine feed, but the reverse is true for finishing cuts. They usually use a very light crossfeed and a coarse transverse feed with a cutting edge wider than the feed per revolution. In *Figure* 11.2, the left-hand tool illustrates the first roughing cut and the right-hand tool shows the following finishing cut.



11.2 Roughing (left) and finishing (right) cuts.

11.3 Turning to shapes

Other turning cuts, machining shapes, corners, fillets, etc., are done the same way. The main difference is in selecting cutter bits and maneuvering the cutting point by means of various cutting tools (*Figure* 11.3).



11.3 You can do other turning cuts with different cutter bits and cutting tools.

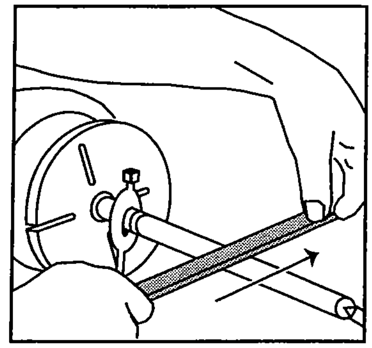
11.4 Machining square corners

To machine an accurate corner, follow these steps:

- Set the compound rest perpendicular to the line of the centers and insert a right or left-hand corner tool.

• Using the longitudinal feed, turn a small diameter to finish up to the shoulder.

• With the compound rest, feed the tool the amount needed to finish the work to the length, taking the last facing cut across the shoulder away from the center.

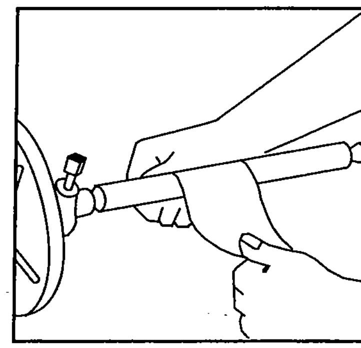


11.4 With a file, take full strokes at an oblique angle; never hold the file still.

11.5 Finishing and polishing

After machining, you'll want a smooth, polished surface free of machine marks. You'll obtain the best results with a toolpost grinder. If you don't have one, use a file.

With a file, take full, biting strokes across the revolving workpiece at a slightly oblique angle (*Figure* 11.4). Do not drag the file back across the workpiece; instead, lift it clear for each return stroke. Use a clean, dry file and keep the workpiece clean, as well. Wipe the workpiece dry and clean if you've used coolant or cutting oil. Never hold the file stationary while the workpiece is revolving.



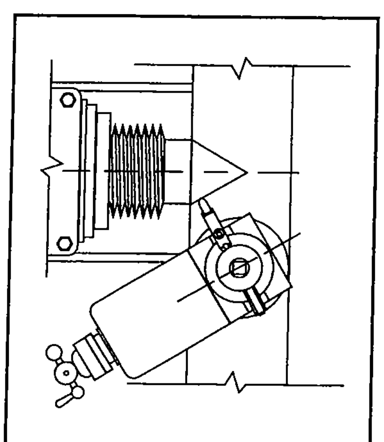
11.5 You can polish a workpiece with an abrasive cloth and oil.

For an even finer file finish, rub railroad chalk into its teeth. This provides additional lubrication and absorbs filings. Do *not* use blackboard chalk.

After filing off the machining marks, polish the workpiece with emery or other abrasive cloth. Keep the lathe turning at high speed and spread a few drops of oil on the workpiece. Don't stop moving the cloth (*Figure* 11.5).

11.6 Taper turning

There are three ways to turn a taper on the lathe: with the compound rest, by setting over the tailstock, and with a taper attachment. In all methods, the cutter must engage the work on dead center if the taper is to be accurate.



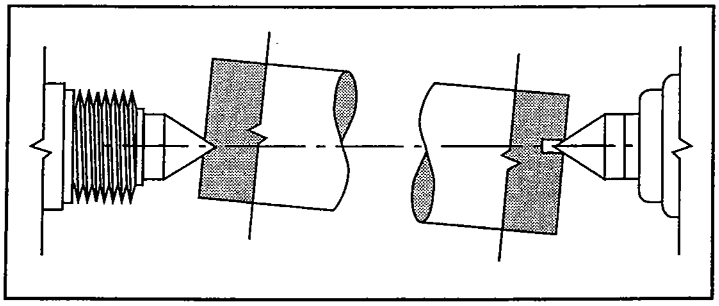
11.6 Tapers cut with the compound rest are usually short, abrupt angles.

Compound rest. Tapers cut with a compound rest are usually short, abrupt angles such as centers, bevel gear blanks, and die parts (*Figure* 11.6). In general, these are not considered taper turning, which applies to machining longer, more gradual tapers.

Setting over the tailstock. Cutting tapers by setting over the lathe tailstock involves misaligning the lathe centers. The lathe centers move from their position parallel to the tool's transverse travel, giving the desired degree of taper (*Figure* 11.7). The tailstock of the BZ-239 has a set-over scale, calibrated both forward and backward from the straight turning or zeroing point, to measure set-over distances.

To offset the tailstock, loosen the setscrew at the rear of the tailstock (*Figure* 10.2). To offset to the right, loosen the left adjusting bolt and tighten the right. To offset to the left, loosen the right adjusting bolt and tighten the left.

You can turn long, gradual tapers by setting over the tailstock, but take care. Your computations must be nearly perfect, because an error will spoil your work.



11.7 In setting over the tailstock, the lathe centers move from their parallel position with the tool's transverse travel.

The distance of tailstock setover needed to machine a given taper depends on three factors:

• The differential between the finished diameters of the extreme ends of the taper

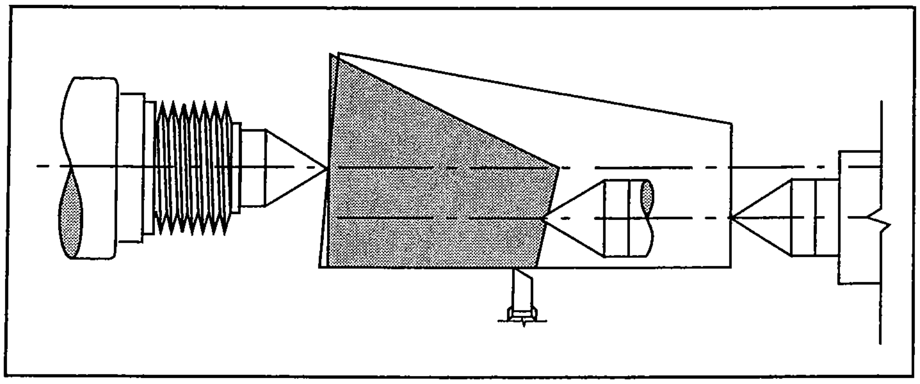
• The length of the taper in relation to its extreme diameters, if the entire shaft is to be tapered

• The ratio between the length of the tapered portion to the length of the entire shaft (or work between centers when you're tapering only part of the shaft).

When the taper extends the entire length of the workpiece, tailstock setover should equal half the difference between the finished diameters of the ends (*Figure* 11.8). When a taper extends only part of the length of the shaft, divide the total shaft length by the length of the portion to be tapered. Then multiply the resulting quotient by half the difference between the extreme diameters of the finished taper.

Notes: (A) Because most drawings give the taper in inches per foot of length, it may be easier to convert all dimensions to inches.

(B) Zero the tailstock before resuming straight turning.



11.8 Tailstock setover should be half the difference between the finished diameters of the ends.

Taper attachment. There are two types of taper attachments, plain and telescoping. Both simplify turning tapers, boring tapered holes, and cutting external or internal threads on tapered surfaces. Both permit greater degrees of taper than you can get by offsetting the tailstock. Permanently attached to the lathe, they do not interfere with straight turning or other operations when not in use.

A taper attachment lets you machine tapers of any length and follow with other operations on the same shaft without changing the setup or losing centers. You can also machine duplicate tapers, even on stock of varied lengths, and turn tapered shafts and identically matched taper-bored holes from the same setup.

Both types of taper attachments consist of the following:

• A backward extension of the cross slide that you bolt onto machined pads ready-tapped to receive it

- A supporting bracket bolted to the back of the carriage saddle

- A compound slide with swiveling top (calibrations on the right end indicate angularity in inches per foot; calibrations on the left indicate angularity in degrees)

- A sliding shoe that moves transversely along the swivel side and attaches to the cross-slide extension

- A clamp bracket that locks the taper attachment at any position along the lathe bed when in use (when not in use, the taper attachment slides freely along the lathe bed with movement of the lathe carriage)

- A locking nut or handle that locks the cross-stud extension to the sliding sleeve, bringing the tool to the correct position as determined by the workpiece diameter.

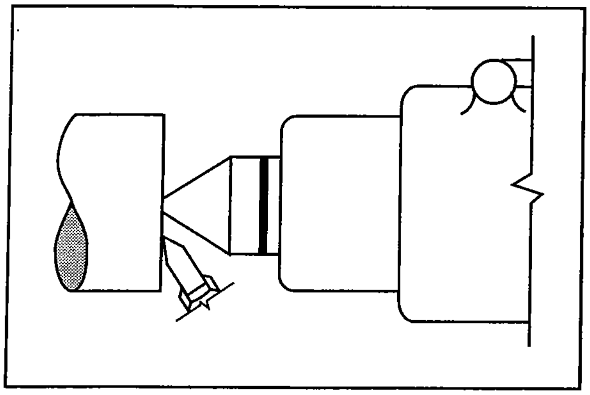
11.7 Boring a tapered hole

Boring a tapered hole involves setting the compound at the desired degree of taper and feeding the tool with the compound rest. Make sure the compound rest is set at half the degrees of the angle of the completed taper hole. You can also use a taper attachment to bore a tapered hole.

SECTION TWELVE

LATHE FACING AND KNURLING

Before removing your work from the centers, face or square up the ends. On accurate work, especially where shoulders, bevels, and the like must be an accurate distance from the ends, do the facing before turning the shank. This also cleans the ends and machines the workpiece to accurate length.



12.1 With a facing cutter, feed the tool from the center outward.

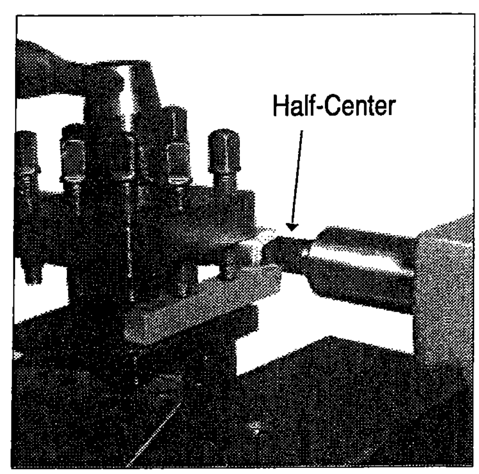
When diameters are large, it's best to face with a special side tool that has a long, thin blade with a wide cutting edge. If you don't have one, use a right or left-hand facing cutter. Feed the tool from the center outward to avoid marring the lathe center (*Figure* 12.1).

12.1 Facing across the chuck

When facing a stub-end workpiece held in the headstock chuck, the same rules apply. Chuck the stock, letting it protrude about an inch. Place a right-hand side tool (or a straight turning tool with a facing cutter) in the toolpost. Carefully adjust the cutting edge so it is exactly on center, then tighten it into the toolpost. If you don't do this, a small tit or projection will remain in the center of the stock, later causing the center drill to run off center.

Start your lathe on the slowest speed. Bring the tool into the cutting position against the center of the workpiece. Feed the tool from the center of the stock outward, toward yourself, using the hand crossfeed. Do not start with a heavy feed because the sfm increases rapidly as the cutter moves through increasing peripheries. One or two light cuts is usually enough to true up an end roughened by the hacksaw. After facing one end, reverse the workpiece and face the opposite end.

If you must finish the ends of the shaft, use a half-center (*Figure* 12.2). This lets you extend the tool across the entire face of the work.



12.2 Using a half-center lets you extend the tool across the entire face of the work.

12.2 Knurling

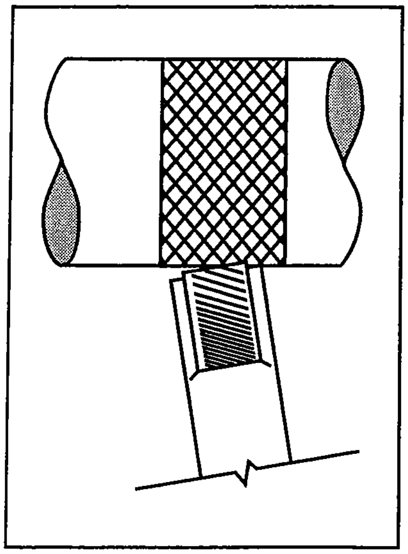
Knurling is not a machining operation because no metal is cut. It is a forming operation in which hard, patterned knurls are pressed into the work, depressing and raising the surface of the metal into a pattern. As with all other forming operations, your work can be no better than the pattern, your knurling no better than the knurls. Be sure the knurls are sharp and clean-cut (preferably hob-cut) and properly hardened.

To make a true knurl, maintain uniform pressure on both knurls. Select a self-centering knurling tool that equalizes pressure on the knurls automatically and is strong enough to withstand end and side thrusts.

In knurling, you use the backgears. Engage them while the lathe is idle—never when it is running, because this will strip the gears. For best results, operate the lathe at the slowest back-geared speed

(50 rpm).

Knurling exerts extreme thrust against centers and bearings. You can lessen this thrust materially by feeding the knurling tool at a slight angle off from perpendicular to the line of the workpiece. This engages the right side of the knurl first (*Figure* 12.3).



12.3 Feed the knurling tool at a slight angle off from perpendicular to the line of the workpiece.

Place a few drops of oil on the workpiece and knurling tool. Start the rolls of the knurling tool from the right-hand scribe line and feed them in until the knurl reaches a depth of 1/64". Then stop the lathe and inspect the work. If the knurl is not clear-cut, adjust the tool in or out as needed.

Use plenty of oil, lubricating both knurl and workpiece. Then start the lathe and engage the automatic feed, moving the knurls across the portion to be knurled. When you reach the left scribe line, force the tool into the work another 1/64", reverse the lathe without removing the tool, and feed it back to the starting point. Feed both ways using the automatic longitudinal feed. Once across, each way, usually makes a good knurl.

SECTION THIRTEEN
CUTTING SCREW THREADS

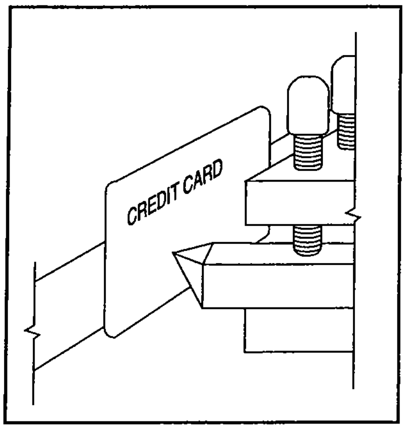
13.1 Threading terms

Before beginning to cut threads, it's useful to learn the major terms used in thread cutting:

• *Pitch.* Metric pitch is the distance from the center of a thread to the center of the next thread. To measure pitch in inches, measure an inch on a bolt and count the threads.

• *Pitch diameter.* This is the diameter of an imaginary cylinder superimposed on a straight screw thread, the surface of which would make an equal width of the thread and the spaces cut by the cylinder.

• *Lead.* The lead is the distance a screw thread advances axially (as through a nut) with one complete revolution. The lead and pitch of a single thread are identical, but they differ on multiple threads (the lead of a double thread is twice its pitch; of a triple thread, three times its pitch).

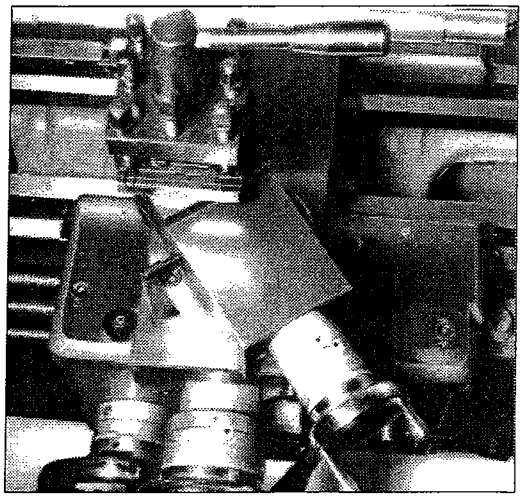


13.1 Checking dead center with a credit card.

Because screw-thread cutting is so much a part of machining, anyone interested in making things of metal should master it. Threading requires a bit of patience and skill. Before attempting to cut a thread on a workpiece, cut a few practice threads on odd bits of steel, iron, and aluminum.

Built for thread cutting, the BZ-239 cuts standard internal and external threads, as well as special threads. You may cut coarse or fine threads in a great range of threads per inch, in V or square shapes, in established profiles like Unified National, acme, and metric. You can cut single or multiple threads, right-handed or left-handed. You determine the type of thread by how you'll use the screw. Each thread form requires a different-shaped tool to cut or chase it.

For most work, the beginner will use the Unified National Standard, which is a V-form thread slightly flat on top and at the root of the thread. Screw threads are usually referred to by pitch numbers, such as 18 or 24, meaning 18 or 24 threads per inch (tpi). The BZ-239 cuts 50 standard threads from 4 to 112 tpi and 24 metric threads from 0.25 to 7.5 mm.


13.2 With the compound perpendicular to the line of centers, rotate it 29-1/2° to the right.

The BZ-239 has a quick-change gearbox, eliminating the need for extra pick-off gears and gear changing for standard SAE threads. All gears remain permanently in the gearbox. You change them mechanically by moving the gearbox lever. Many different threads are available on the machine's index plate.

Because the lathe spindle, which carries the work, connects by gearing to the leadscrew, which moves the cutting tool along the lathe bed, a ratio exists between spindle speed in revolutions per minute and cutting tool movement in inches. When you change the gearing, you change this ratio. For this reason you can cut screw threads of various pitches by changing both the pick-off gears at the head of the lathe and the speed selection lever.

Thread charts on the BZ-239 show both inch and metric measures (*Figure* 6.3). The inch chart on the headstock shows the tpi from 4 to 112. The metric chart on the gearbox shows the distance from thread crest to crest from 0.25 to 7.5 mm.

For right-hand threads, start the threading or chasing tool at the right end of the workpiece and feed it toward the headstock. For left-hand threads, reverse the direction of rotation of the leadscrew, reverse gears, and feed the threading tool from left to right.

With practice, you can grind cutters to almost any profile. It is difficult, however, to sharpen such cutters without altering the cutting form, and almost every resharpening requires a complete regrinding of profile and clearance angles.

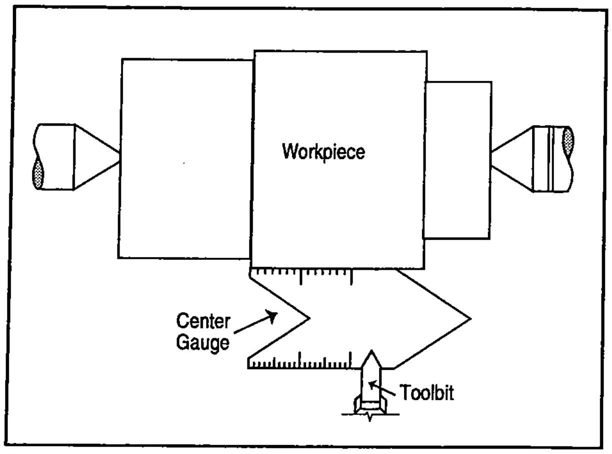
After turning the work to be threaded to the outside diameter of the thread and setting the gears for the desired thread, put a threading tool in the toolpost. Set it exactly on the dead center of the workpiece, using a thread gauge as a guide.

To make sure your cutter is on dead center, place a credit card or shim between the cutter point and workpiece (*Figure* 13.1). When the tool is on dead center, the credit card or shim will remain vertical. With a credit card there is no possibility of chipping the cutter as the workpiece and cutter come together.

Set the compound perpendicular to the line of centers and rotate it 29-1/2° to the right (*Figure* 13.2). Place the thread gauge on the point of the threading tool and feed the tool toward the workpiece (*Figure* 13.3). Adjust the tool so the edge of the gauge is exactly parallel to the workpiece. A slip of white paper held below the gauge will help check the parallel of the gauge to the shaft and the fit of the toolpoint in the V of the gauge. Placing the threading tool perpendicular to the surface of the workpiece assures a true-form thread.

13.2 Using a thread-chasing dial

The leadscrew directly activates a thread-chasing dial (*Figure* 4.8) attached to the lathe carriage. To return the tool to the starting point of the cut, you need not reverse the motor and wait for the tool to return all the way through the cut to the starting point. Instead, after each cut, disengage the split nut and return the carriage to the starting point with the handwheel. The threading dial shows exactly where to reengage the double half-nuts to bring the tool accurately into the groove for the next cut.



13.3 Using a center gauge, set the threading tool at exactly dead center on the workpiece.

The dial is marked with lines numbered 1, 2, 3, 4. Between them are lines with no numbers, called half-lines or unnumbered lines. When the dial engages with the leadscrew, it rotates. A single rivet is marked on the dial housing.

The instruction plate on the dial shows the selection and sequence of matching the revolving lines with the rivet (*Figure* 13.4). For thread cutting, engage the half-nuts at the appropriate numbers shown on the scale columns of the instruction plate.

13.4 Thread-chasing dial instruction plate

TPI	SCALE	TPI	SCALE	TPI	SCALE
4	1-4	12	1-4	38	1-3/2-4
4.50	/	13	1	40	1-8
4.75	/	14	1-3/2-4	44	1-4
5	1	16	1-8	48	1-8
5.50	/	18	1-3/2-4	52	1-4
6	1-3/2-4	19	1	56	1-8
6.50	/	20	1-4	64	1-8
7	1-4	22	1-3/2-4	72	1-8
8	1-8	24	1-8	76	1-4
9	1	26	1-3/2-4	80	1-8
9.50	/	28	1-4	96	1-8
10	1-3/2-4	32	1-8	104	1-8
11	1	36	1-3/2-4	112	1-8

Using a screw-pitch gauge, check the thread pitch. Because you took a light cut, you can correct any mistakes you made.

To take the real cut, apply the appropriate cutting fluid to the work. Feed the compound feed in 0.005–0.020" for the first run, depending on the pitch of the thread you have to cut. If you are cutting a coarse thread, start by taking a few heavy cuts. Reduce the cut depth for each run until it is about 0.002" at the final run. Bring the cross-feed calibration to zero, then make the second cut by engaging the half-nut at the appropriate mark on the threading dial.

If you are cutting metric or odd-size inch threads, you cannot use the threading dial. *Once you engage the half-nut, you cannot disengage it until you are done cutting the thread.*

Make the first pass as described above, but at the end of the pass, do not disengage the half-nut. Turn off the motor and back out the tool. Then reverse the motor to run it back to the start. Set the tool depth for the second pass and turn the motor on again.

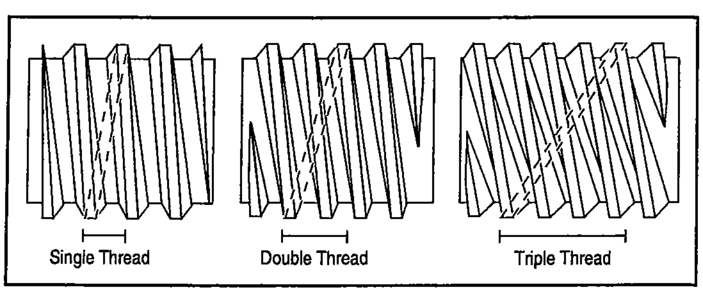
Continue this process, brushing the threads regularly to remove chips. After the second cut, check the thread fit using a ring gauge, a standard nut or mating part, or a screw-thread micrometer (it is best not to remove the piece from the chuck for testing). Continue taking 0.001–0.002" cuts, checking the fit after each cut. When you thread the nut, it should go on easily but without end play.

13.3 Cutting left-hand threads

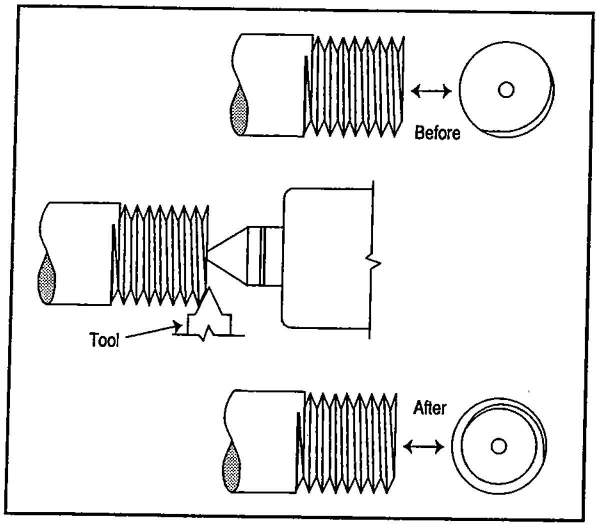
Cut left-hand threads exactly as you cut right-hand threads, except feed the carriage toward the tailstock instead of away from it. Reverse the cutter clearances and grind the cutters back with a clearance angle on the left side. Swing the compound rest to the left rather than to the right.

13.4 Cutting multiple threads

Cut multiple threads (*Figure* 13.5) one at a time exactly as you cut single threads, except increase the lead to make room for succeeding threads (a double lead for a double thread, a triple lead for a triple thread, etc.). After completing the first thread, remove the work from the centers without loosening the lathe dog. Then put it back in the lathe with the tail of the lathe dog in the correct slot to index the work for the next thread. This work requires a face plate with accurately positioned slots, uniformly spaced and equal in number to



13.5 When cutting multiple threads, increase the lead to make room for succeeding threads.

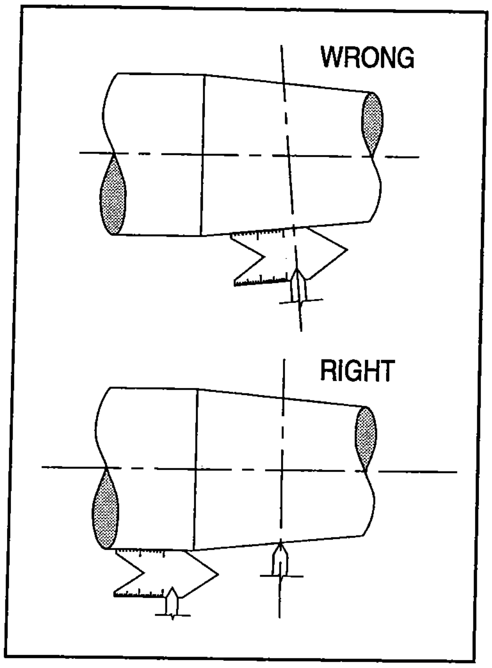


13.6 Chamfer the end of the thread to protect it from damage.

13.5 What *not* to do when cutting threads

Do not disengage the half-nut if cutting metric or nonstandard SAE threads. If you are cutting between centers, don't remove the lathe dog until the thread is finished and tested, and don't disturb the spindle while the work is off the centers.

When you think the thread is finished and ready for testing, and only if absolutely necessary, remove the work from the center, leaving the lathe dog attached. Test the thread. If it does not fit properly and you have to remove another chip or two, place the workpiece back in the centers exactly as it was earlier. Then remove the chips and test again. Repeat until you are finished.



13.7 When cutting a thread on a taper, set the threading tool at 90° to the axis of the taper.

13.6 Finishing off a threaded end

After cutting a thread and before removing the threading tool, chamfer the end (*Figure* 13.6). This improves its appearance and removes sharp corners and burrs. It also aids the screw as it engages a nut or threaded hole.

13.7 Cutting threads on a taper

Cut threads on a taper as on a straight shaft, except in the setup of the tool. Set the threading tool at 90° to the axis of the taper, rather than at 90° to its surface (*Figure* 13.7).

SECTION FOURTEEN
LATHE DRILLING AND BORING

You can lathe drill on the BZ-239 in two ways, holding the drill stationary and revolving the workpiece, or holding the workpiece and revolving the drill. Holding the drill stationary in a tailstock chuck gives a straighter hole (*Figure* 14.1). Without changing setup and recentering, the work is ready for any succeeding operation.

In lathe drilling, keep the drill sharp and properly ground. This is essential for obtaining a straight, accurate hole.

With HSS drills, operating speeds are not as critical as with carbon-steel drills. High speeds can quickly "burn" a carbon-steel drill. The number-of-feet-per-minute rule applies to drills even more than to other cutting edges because there is practically no air cooling of the point after it enters the hole. The larger the drill, the more peripheral feet are cut per revolution. That is why you should use a slower drilling speed. If no drilling speed data are available, it's generally safe to run drills under 1/4" diameter at up to 750 rpm and drills up to 1/2" diameter at 500 rpm, with larger drills at proportionately slower speeds.

14.1 Holding the drill in the tailstock gives a straight hole.

With the workpiece in the headstock and the drill in the tailstock chuck, feed the drill into the workpiece by advancing the tailstock ram. Do this by turning the tailstock handwheel. It is good to make a locating center for the drill point, or even a countersunk center for large diameters, to keep the drill from creeping.

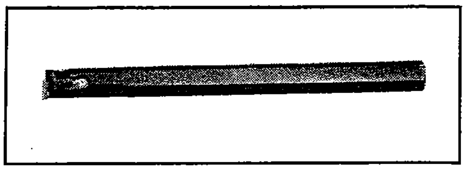
14.1 Reaming

When a hole must be accurate within 0.002" or less, drill it slightly undersized (0.010–1/64" on small diameters and 1/64–1/32" on holes 1–2" in diameter). Then ream it either by hand or in the lathe.

Lathe reaming is usually done with a solid reamer held in a tailstock chuck or with a taper shank that fits the tailstock ram in place of the tailstock center. At low speeds, feed the reamer slowly and evenly into the workpiece. Be sure the reamer teeth are free of burrs and chips.

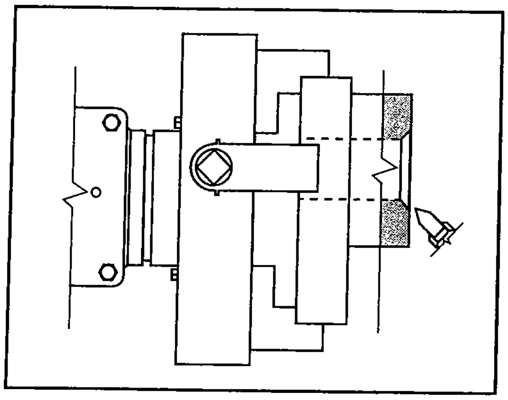
14.2 Boring

Boring is internal turning, or turning from within. The diameter of the opening to be bored is often much smaller than its depth. Boring tools must therefore have relatively small diameters and still support a cutting edge projected at considerable distance from the toolpost or compound rest.



14.2 Tool with smooth-ended bar has no projecting nut or hardened edge.

Boring tools consist of an extremely stiff, strong bar with a formed cutting end or a way to hold an HSS cutter or carbide insert. There are many sizes and types of boring bars. Choose the one that will give the stiffest possible bar at every depth and diameter and the greatest choice of cutters and cutter angles (ask a Smithy technician about the Smithy boring head combo package, #K99-125).

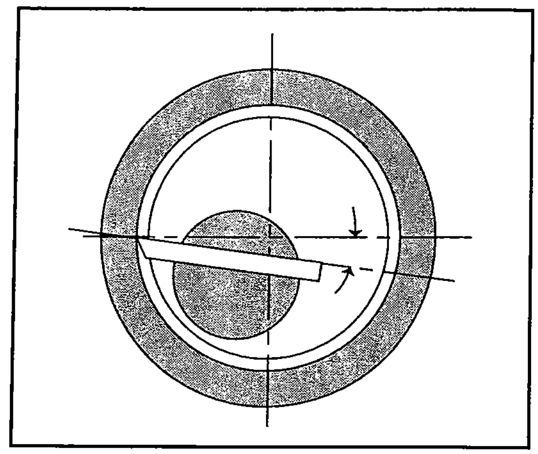


14.3 Chamfer a starting cut in the opening of the hole.

It is also wise to select tools with smooth-ended bars without a projecting nut or hardened edge that might mar the work (*Figure* 14.2). Most boring tools have only one cutting edge. There *are* double-end cutters, however, and they offer advantages in special instances. In grinding cutters, allow sufficient end rake to provide clearance from the internal diameter.

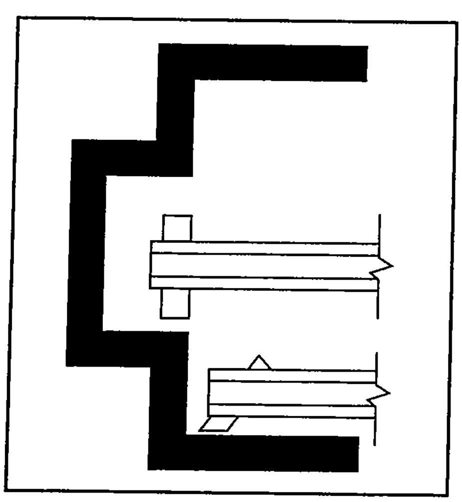
Except with cored castings, pipe, or tubing, begin by drilling a hole large enough to admit the end of the boring bar. Because the holes in cored castings often deflect boring bars from their true axis, you may want to chamfer or turn out a starting cut in the opening of the hole with a turning tool (*Figure* 14.3) before introducing the boring tool.

With the boring toolholder set up in the toolpost or toolpost T-slot, select the largest-diameter boring bar whose cutter the bore will accept. Extend the bar from the holder just enough to reach the full depth to be machined and still allow tool clearance. Except when using the adjustable boring tool (usually for very-large-diameter work), feed the bar into the hole, parallel to the hole's axis. The cutting edge engages the work along a line in the mounted plane of the lathe centers with the bar positioned to give the cutter a top rake of approximately 14° from the radius at the cutting point. This takes into consideration the ground angle (top rake) of the cutter itself (*Figure* 14.4).



14.4 The cutting edge engages the workpiece along a line in the mounted plane of the lathe centers.

For straight longitudinal cuts, you can hold the cutter closer, therefore more rigidly, if it's at a 90° angle to the bar. For machining ends of a bar, however, you need a boring bar that holds the cutter at an angle or angles so the cutter extends beyond the end of the bar (*Figure* 14.5). For maximum visibility, position the cutting edge at the near side, parallel to the centerline.



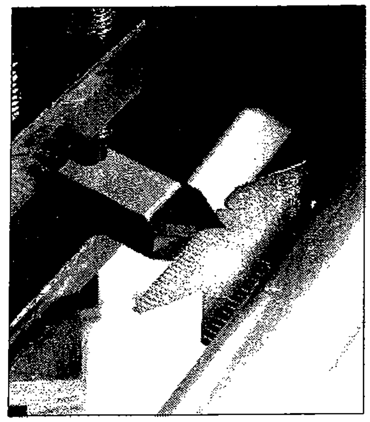
14.5 To machine ends of a bar, use a boring bar that angles the cutter so it extends beyond the bar.

The rules that apply to external turning apply to boring as well, except—as noted earlier—where the rake angles differ. The rake angles are governed by cutter type and bore diameter. Feeds must be lighter to keep the tool from springing. This is especially true for enlarging out-of-round holes, when you take several small cuts rather than one heavy cut.

After the last finish cut, it is common to reverse the feed and take one last, fine cut with the tool coming out of the work. This last cut, taken without movement of the crossfeed, avoids a slightly undersized hole because you compensate for any spring in the bar.

14.3 Cutting internal threads

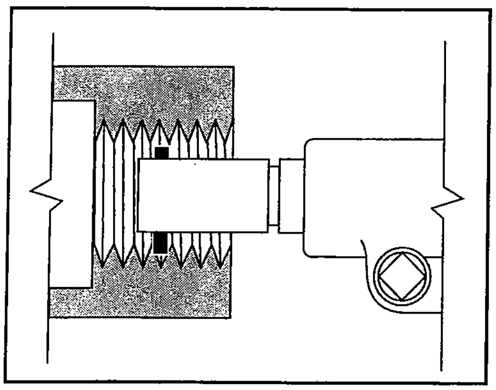
Internal thread cutting is like external thread cutting except you have the clearance restrictions and tool problems of boring. You use the same toolholders, but the cutters have thread forms and are fed at thread-cutting ratios of feed to spindle revolutions.



14.6 Use a center or thread gauge to correct cutter alignment error when squaring the cutter with the workpiece.

Another difference between boring and inside threading is the angle at which the cutter approaches the workpiece. As with external thread cutting, the internal threading tool must engage the work on dead center and be held so the cutter coincides with the workpiece's center radius.

In squaring the cutter with the work, use a center gauge (*Figure* 14.6) or thread gauge. Internal cutters require greater end and side clearance, and cutter length is also restricted because internal thread cutters need enough end clearance that the cutter lifts clear of the thread for removal (*Figure* 14.7). Before cutting an internal thread, bore the workpiece to the exact inside diameter.

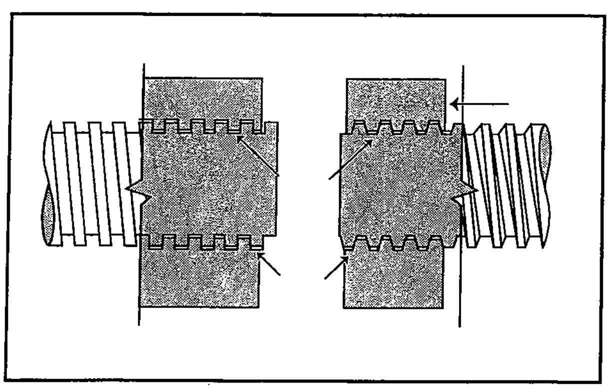


14.7 There must be enough end clearance for the cutter to lift clear of the thread.

Because the feed of successive cuts is toward, not away from, the operator, the thread-cutting set is reversed. Also, you must take lighter cuts because of the cutter's extension from the toolpost. Take an extra finishing cut without changing the setting of the compound rest.

14.4 Cutting special-form internal threads

You can cut internal forms in all thread forms used for external threads. There is only one factor that calls for special attention in cutting special-shaped internal threads: the difference of clearances between the nut and screw recommended for different thread types (*Figure* 14.8). If you don't have recommended clearances, it is safe to cut a nut thread (internal thread) 0.005–0.010" per inch larger in the screw's outside diameter.

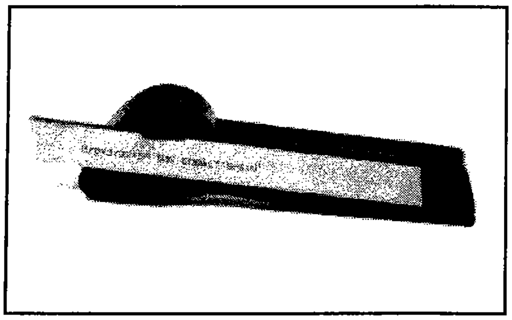


14.8 Use different clearances between nut and screw for different thread types.

CHAPTER FIFTEEN
CUTTING OFF OR PARTING WITH A LATHE

You can cut off in a lathe only when holding one end of the work rigidly, as in a chuck. It is not practical for long workpieces held between centers because the workpieces are not supported closely with a rest and the free section is long enough to sag and pinch the blade. Cutting off requires a tight lathe without excess play in the spindle, compound, carriage, or toolpost. Looseness will almost certainly cause chatter. Cutting off also requires a narrow cutting edge with ample (5–10°) side clearance, fed slowly into the workpiece to prevent hogging in. Once considered a difficult, costly operation, cutting off became much simpler with the development of narrow tools with special cut-off blades (*Figure* 15.1).

The toolpost should hold the cut-off tool as close to the workpiece as possible, with the top of the blade on dead center and exactly perpendicular to the line of centers. Have the blade extend only far enough to pass through the workpiece, just beyond its center. The crossfeed should feed the tool slowly and evenly to the workpiece on exact center. If the tool hogs in and the spindle stops rotating, turn off the motor and reverse the spindle by hand before backing the tool out with the crossfeed.



15.1 Narrow tools with special cut-off blades simplify cutoff.

Always set up the workpiece to cut off as close as possible to the headstock. If you must make a parting cut on a long shaft or on work held between centers, don't complete the cut in the lathe. Finish the parting with a hacksaw and return it to the lathe for facing. Slow the spindle speed until you have a good feel for cutting off. Although lubricants and coolants are not essential on small-diameter workpieces, use them amply on deep cut-off work.

SECTION SIXTEEN
TROUBLESHOOTING

16.1 Powerfeed and thread cutting

Powerfeed does not move carriage

Cause	Solution
• One or more quick-change gear handles not engaged	Engage them
• Leadscrew/feed-rod selecter not engaged	Engage it fully to the right or left
• Half-nut will not engage	Move feed-rod selecter lever to neutral
• Wormgear and spur gears do not mesh well	Tighten wormgear hold-down bolts, replace one or both gears if worn
• Gib too tight	Loosen gib
• Carriage locked	Unlock carriage
• Forward/Reverse gears not engaged	Put powerfeed in Forward or Reverse
• Gears not meshing or teeth missing	Check gears and mesh

Cut is not smooth

Cause	Solution
• Tool dull	Sharpen or replace tool
• Tool not on center	Center tool (shim, if needed)
• Tools not mounted tight in post	Remount tools
• Cross-slide gibs to bed and base loose	Adjust gibs
• Gibs in toolpost loose	Adjust gibs
• Tool turret not tight	Tighten toolpost
• Feed rate too fast	Set quick-change gears at slower rpm
• Gears loose	Tighten gears and posts
• Incorrect tool shape	Regrind tool to correct shape

Thread is not smooth

Cause	Solution
• Tool dull	Sharpen tool
• Tool not centered	Center tool
• Tools not tight in post	Remount tools
• Cross-slide gibs to bed and base loose	Adjust gibs
• Gibs in compound loose	Adjust gibs
• Tool turret not tight	Tighten toolpost

Tool not cutting "on thread"

Cause	Solution
• Half-nut disengaged	Review threading instructions
• Half-nut not fully engaged	Keep half-nut engaged
• Half-nut engaged at wrong time	Review thread dial instructions

16.2 Carriage

Cross slide won't move

Cause	Solution
• Cross-slide locks engaged	Loosen locks
• Gibs too tight	Loosen gibs

Horizontal movement in cross-slide table

Cause	Solution
• Carriage gib improperly adjusted	Adjust carriage gib
• Cross-slide gib improperly adjusted	Adjust cross-slide gib

Vertical movement in cross-slide table

Cause	Solution
• Carriage gib improperly adjusted	Adjust carriage gib
• Cross-slide gib improperly adjusted	Adjust cross-slide gib

Carriage moves smoothly in only one direction

Cause	Solution
• Debris on way or gib	Remove debris
• Burr on gib	Remove burr with fine file
• Gib improperly tensioned	Loosen gib and re-tension
• One or more wipers mounted too low	Reposition wiper(s)

Cross-slide handwheel turns during cutting operations

Cause	Solution
• Cross-slide brass nut worn	Tighten or replace brass nut
• Carriage locks not tight	Tighten carriage locks
• Gibs too loose	Readjust gibs

Too much backlash in cross slide

Cause	Solution
• Loose screw (see *Section* 5.6)	Tighten screw, review how to eliminate backlash
• Brass nut loose	Tighten bolt holding brass nut to cross slide
• Brass nut worn	Replace brass nut or adjust screw at end of nut (see *Section* 5.6)
• Spanner nuts loose on cross-slide screw	Tighten nuts (see *Section* 5.6)

16.3 Lathe turning

Cut is rough

Cause	Solution
• Tool dull	Sharpen or replace tool
• Tool not ground properly	Regrind tool
• Tool at wrong angle	Correct tool position
• Tools not held tightly	Tighten toolholder
• Wrong cutter for material	Use correct cutter
• Cutting speed incorrect	Increase or reduce speed

Work has unwanted taper

Cause	Solution
• Work improperly aligned	Realign centers on work
• Debris in spindle, setup, or tool	Clean and reset setup, work, or tool
• Offset tailstock incorrectly positioned	Correct position of tailstock
• Spindle out of alignment	Tighten taper bearings, replace spindle bearings, realign headstock

Machine vibrates

Cause	Solution
• Work mounted wrong	Remount work
• Speed too high	Reduce speed
• Too much pressure at tailstock	Reduce pressure and increase lubrication

Work stops turning but motor continues to run

Cause	Solution
• Work not mounted securely	Remount work
• Tools forced into work	Reduce force on tools
• Belts slipping	Tension belts, use belt dressing, or replace belts
• Backgear not locked in	Reengage backgear
• Bull gear pin not locked in	Make sure pin is all the way in hole

Diameter of work not consistent

Cause	Solution
• Too much flex in workpiece	Use follow rest
• Too much flex in compound rest, slide, or carriage	Tighten gibs, clean ways

Too much backlash in compound

Cause	Solution
• Loose spanner nuts (see *Section* 5.6)	Tighten spanner nuts
• Worn nut	Replace nut

Slinging oil from behind chuck or in gearbox

Cause	Solution
• Oil reservoir overfilled	Check oil level
• Worn oil seal	Replace felt in seal

16.4 Drilling

Hole off center or bit wanders

Cause	Solution
• Bit dull	Use sharp bits
• Bit not mounted correctly in chuck	Remount tool
• Bit bent	Replace bit
• Debris in tailstock spindle	Clean spindle and arbor and remount tool

Bit turns

Cause	Solution
• Bit feeds into work too fast	Reduce feed rate

Chuck difficult to tighten or loosen

Cause	Solution
• Chuck sticks	Apply lubricant
• Debris in chuck	Clean chuck

Chuck wobbles

Cause	Solution
• Chuck loose on arbor	Clean arbor and remount

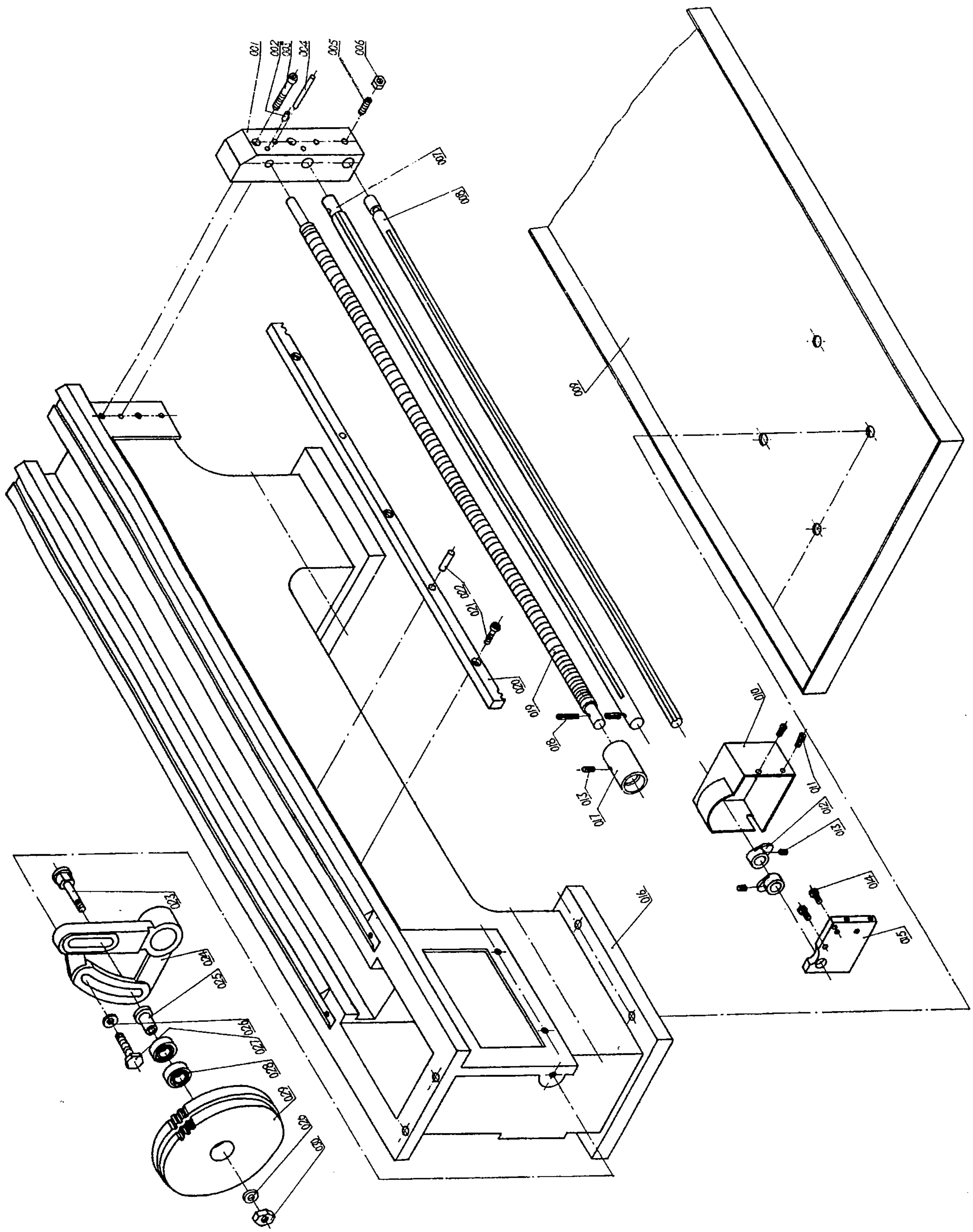
16.5 Drive system

Turn on machine and nothing happens

Cause	Solution
• Machine unplugged	Plug in machine
• Loose electrical connections	Tighten wiring connections
• Red stop switch in Off position	Turn it one-quarter turn to the right (red light indicates power through the switch)
• Fuse blown	Replace fuse

SECTION SEVENTEEN
PARTS LISTS WITH SCHEMATICS

17.1 Lathe Bed



Lathe Bed

1	Z40062		Fixing Block
2	Z40024		Oiler
3	S12361		Socket-Head Capscrew
4	S22280	M8x50	Spring Pin
5	S12291	5x50	Socket-Head Capscrew
6	S18125	M8x20	Nut
7	Z40063	M8	Feed Rod
8	Z40231		Switch Rod
9	Z40068		Chip Pan
10	Z40232		Switch Cover
11	S11955	M6x12	Roundhead Screw
12	Z40233		Eccentric Bracket
13	S11918	M6x6	Headless Setscrew
14	S11951	M6x12	Socket-Head Capscrew
15	Z40234		Switchboard
16	Z40048		Bed
17	Z40059		Leadscrew Sleeve
18	S22250	5x30	Spring Pin
19	Z40061		Leadscrew
20	Z40060		Rack
21	S11991	M6x20	Socket-Head Capscrew
22	S22260	5x30	Spring Pin
23	Z40293		Change-Gear Shaft
24	Z40064		Support
25	Z40066		Bearing Sleeve
26	S18170		Washer
27	S12640	M10x40	Bolt
28	S20140	60103	Bearing
29	Z40065		Change Gear (big)
30	S18155	M10	Nut

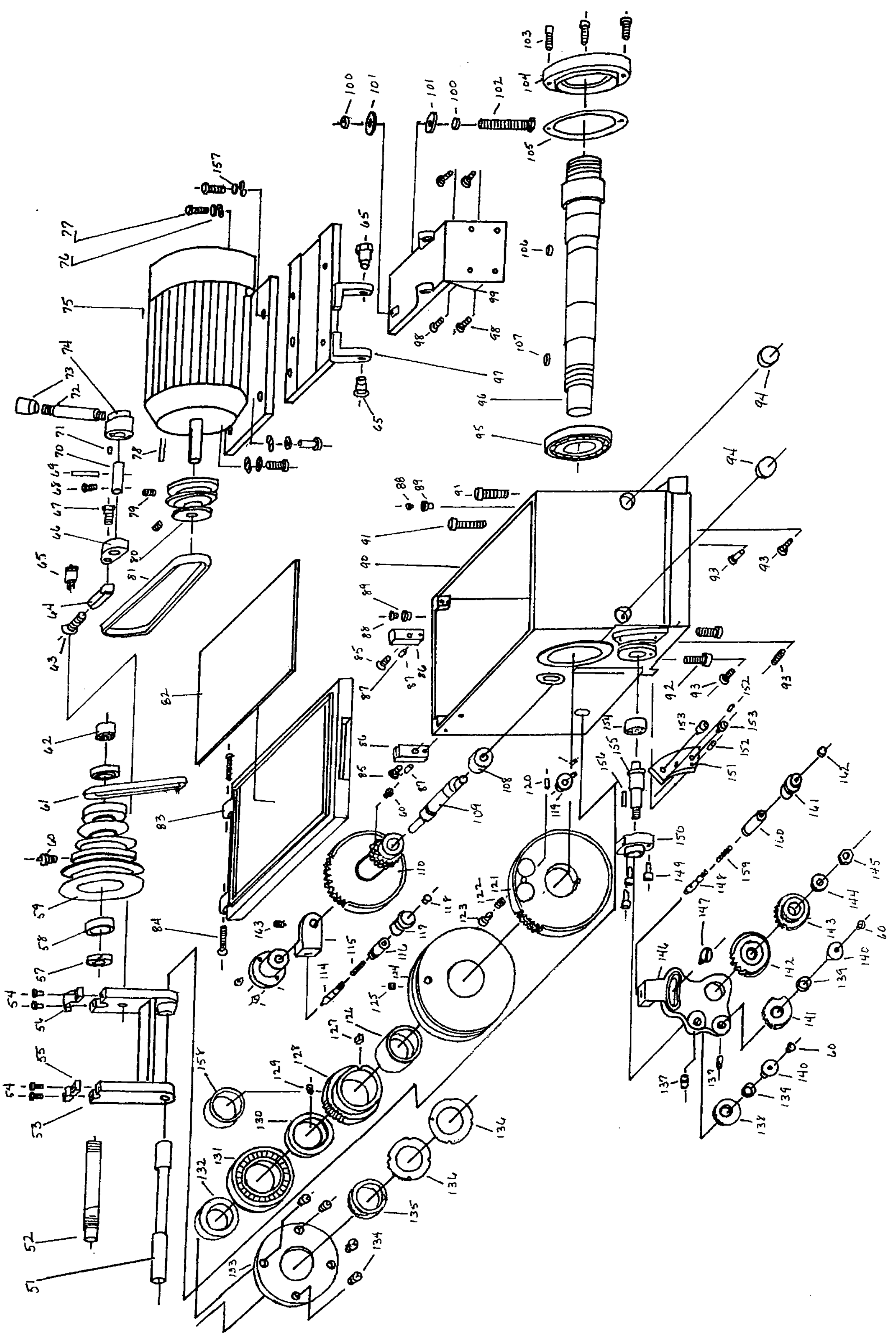


Diagram 2: BZ-239 Headstock

51	Z40032		V-Pulley Supporting Shaft
52	Z40025		V-Pulley Shaft
53	Z40030		Bracket
54	S11651	M5x12	Screw
55	Z40027		Bracket Cover (small)
56	Z40029		Bracket Cover (big)
57	Z40026	M25x1.5	Nut
58	S20350	60105	Bearing
59	Z40026		V-Pulley
60	Z40024	M6x1	Oiler
61	81-103	B-838	V-Belt
62	Z40221		Locking Nut
63	Z40028		Bolt
64	Z40221		Adjustable Nut
65	Z40217		Bolt
66	Z40002		Transmission Bracket
67	Z40217		Hexagon Bolt
68	S12252	M8x12	Screw
69	S22270	5x40	Pin
70	Z40003		Axle
71	S22160	5x14	Pin
72	Z40034		Clamping Lever
73	Z40033	BM10x50	Knob
74	Z40005		Lever Seat
75	Z40040		110-V Motor, 3/4" Shaft
→	Z40277	Gear Drive	110-V Motor, 15/16" Shaft
	Z40193		220-V Motor, 3/4" Shaft
	Z40279		220-V Motor, 15/16" Shaft
76	S18135	8	Spring Washer
77	S16020	M8x25	Bolt
78	S21650	6x32	Key
79	S12278	M8x16	Screw

80	Z40039		Motor Pulley, 3/4" Bore
	Z40278		Motor Pulley, 15/16" Bore
81	81-103	B-813	V-Belt
82	Z40239		Cover Washer
83	Z40031		Cover
84	Z40223	M8x35	Bolt
85	S12291	M8x20	Screw
86	Z40238		Hinge
87	S22240	5x25	Pin
88	Z40237		Plug
89	Z40236		Plug
90	Z40001		Headstock
91	S12631	M10x35	Screw
92	S12621	M10x30	Screw
93	S12321	M8x30	Screw
94	Z40012	16	Oiler
95	S20710	C7211	Bearing
96	Z40008		Main Spindle
97	Z40052		Motor Seat
98	S12321	M8x30	Screw
99	Z40041		Motor Baseplate
100	S18185	M12	Nut
101	S18200	12	Washer
102	S17860	M12x75, M12x80	Bolt
103	S12311	M8x20	Screw
104	Z40007		Main Spindle Front Cover
105	Z40235		Paper Washer
106	S21770	8x14	Key
107	S12710	6x16	Key
108	Z40006		Backgear Sleeve
109	Z40022		Backgear Shaft
110	Z40023		Backgear

Diagram 2: BZ-239 Headstock cont.

111	Z40020		Backgear Change Seat
112	Z40021		Backgear Cover
113	S11941	M6x10	Screw
114	Z40038		Small Locating Shaft
115	Z40036		Compressing Spring
116	Z40037		Positioning Lever Grip
117	Z40035		Positioning Lever
118	S18331	M6	Nut
119	Z40218	M8	Figured Flat Nut
120	S22052	3x16	Pin
121	Z40010		Helical Gear
122	Z40013		Spring
123	Z40014		Transmission Pin
124	Z40011		V-Pulley
125	S11948	M6x10	Screw
126	Z40015		V-Pulley Bush
127	S21800	8x20	Key
128	Z40016		Helical Gear
129	S12218	M8x10	Screw
130	Z40018		Supporting Plate
131	S20650	C7210	Bearing
132	Z40240		Bush
133	Z40042		Main Spindle Back Cover
134	S12271	M8x16	Screw
135	Z40019		Spur Gear
136	Z40219	M45x1.5	Nut
137	S11952	M6x12	Screw
138	Z40043		Spur Gear
139	Z40049		Bush
140	Z40050		Axle
141	Z40044		Spur Gear
142	Z40051		Spur Gear
143	Z40046		Gear
144	S18200		Washer
145	S18185	M12	Nut
146	Z40045		Tumbler
147	Z40224		Screw
148	Z40038		Backgear Locating Shaft
149	S11991	M6x16	Screw
150	Z40217		Bearing Seat
151	Z40241		Change-Gear Seat
152	S22230	5x20	Pin
153	S11671	5x16	Screw
154	S20170	202	Bearing
155	Z40047		Axle
156	S21290	5x25	Key
157	S18140	8	Washer
158	Z40017		Helical Gear Bush
159	Z40036		Spring
160	Z40037		Sleeve
161	Z40035		Lever
162	S18096	M6	Domed-Cap Nut
163	S12298	M8x20	Screw
	Z49001		Idler Bracket Assembly

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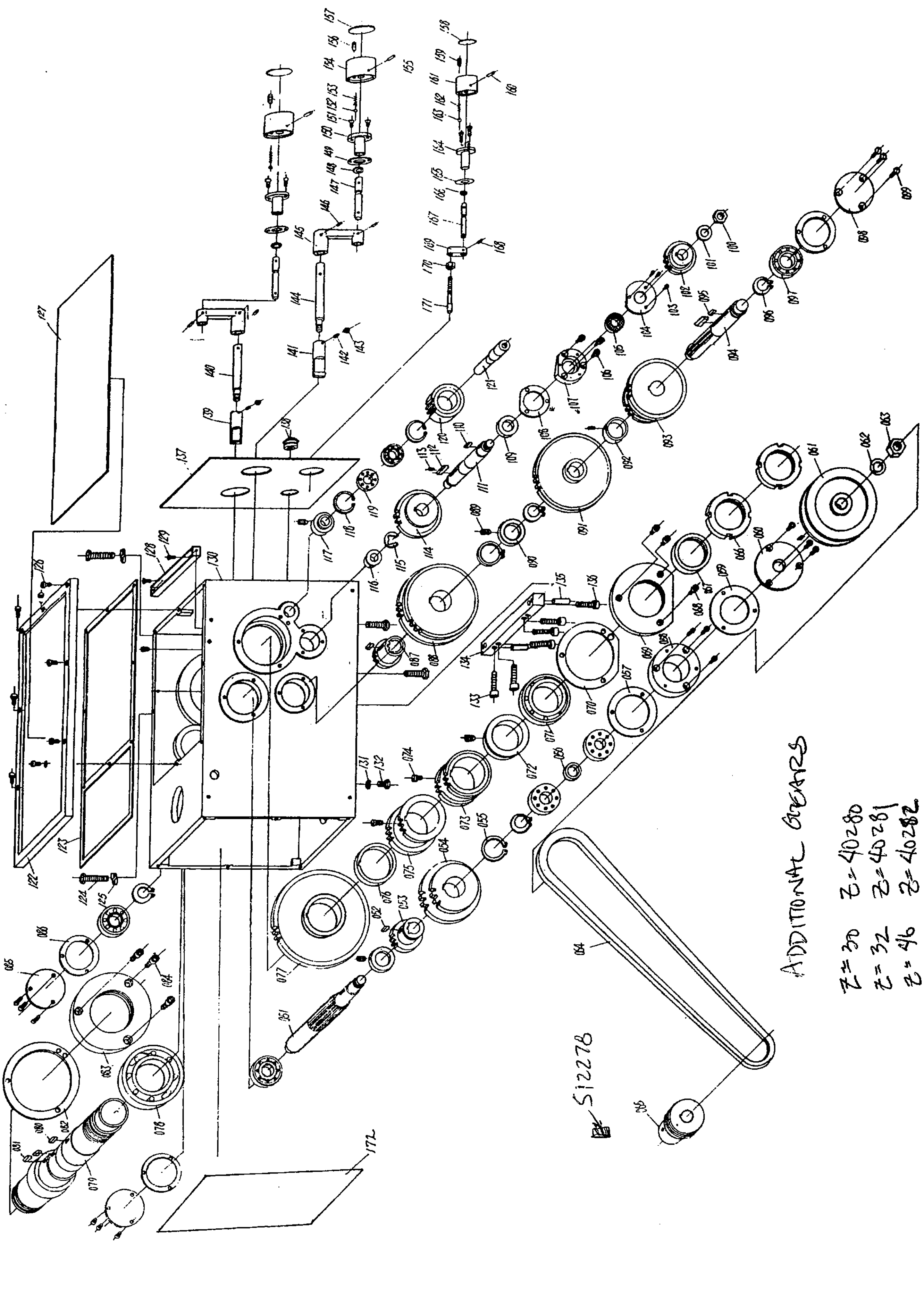
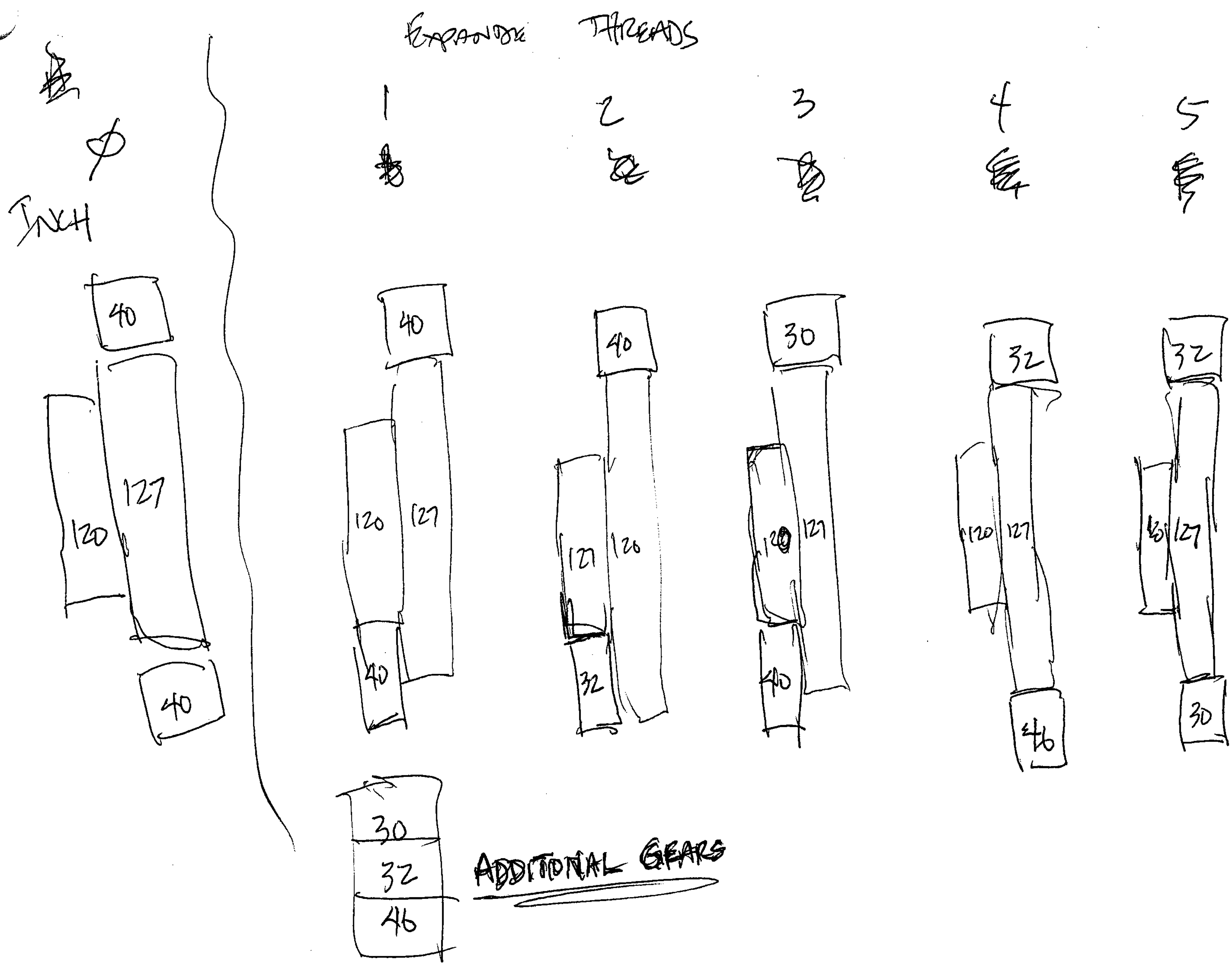
17.3 BZ-239 G (only) Headstock

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ADDITIONAL GEARS

17.3 BZ-239 G (only) Headstock

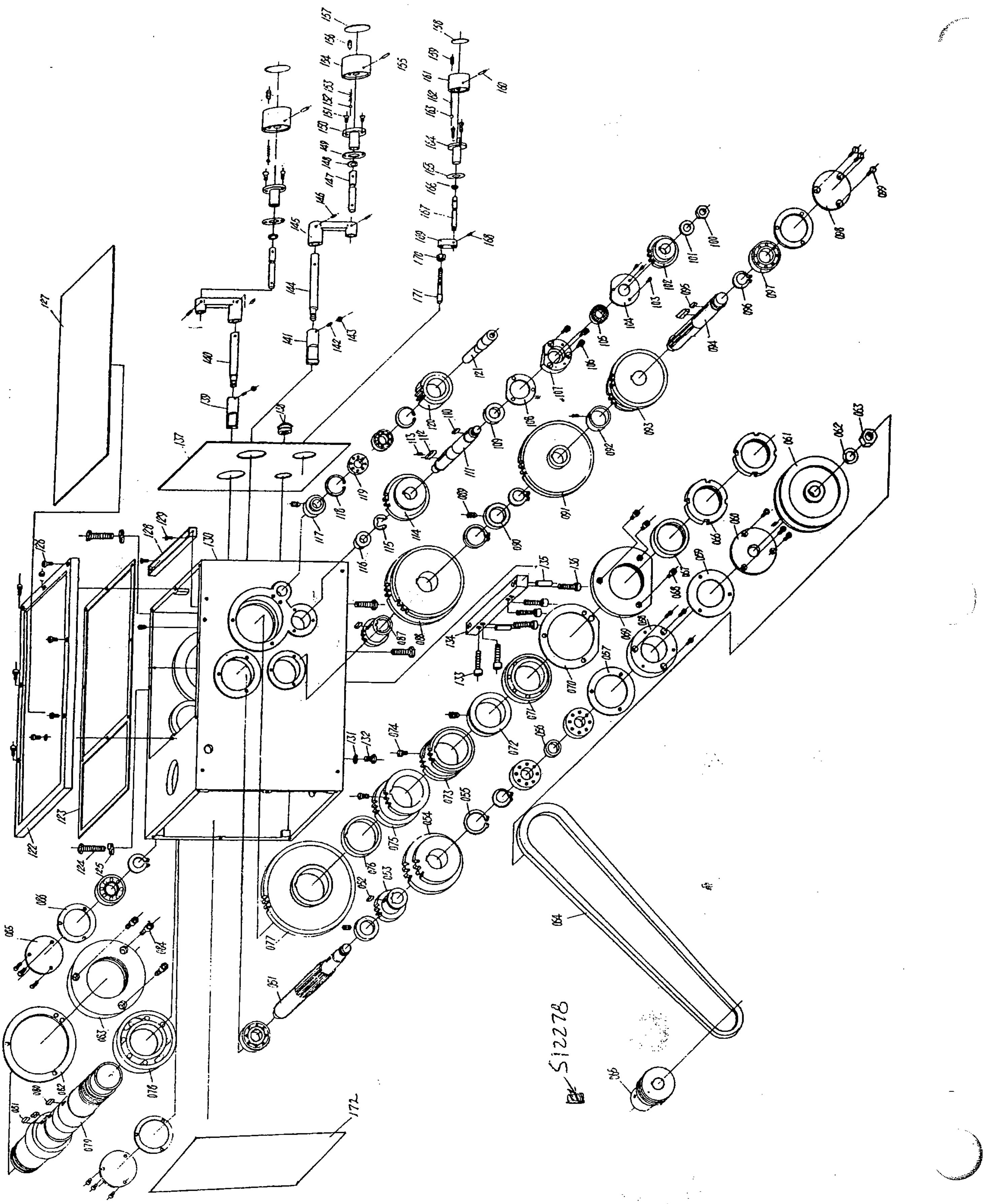

Diagram 3: BZ-239 G Headstock

51	Z40305		Shaft
52	S21805	8x25	Key
53	Z40306		Gear
54	Z40307		Duplex Gear
55	S23285		Snap Ring
56	Z40308		Sleeve
57	Z40309		Sleeve Gasket
58	Z40310		Bearing Seat
59	Z40311		Sleeve Gasket
60	Z40312		Front Cover
61	Z40313		V-Pulley
62	S18232		Washer
63	S18216		Nut
64	Z40314		V-Belt
65	Z40315		Motor Pulley
66	Z40316	M50x1.5	Nut
67	Z40317		Sleeve
68	S11961	M6x14	Socket-Head Capscrew
69	Z40318		Back Cover
70	Z40319		Sleeve Gasket
71	S20660		Bearing
72	Z40320		Washer
73	Z40321		Gear
74	S11631	M5x8	Screw
75	Z40322		Gear
76	Z40323		Sleeve
77	Z40324		Gear
78	S20710	7211D	Bearing
79	Z40325		Main Spindle
80	S21815	8x32	Key
81	S21800	8x20	Key
82	Z40326		Sleeve Gasket
83	Z40327		Front Cover
84	S12311	M8x25	Socket-Head Capscrew
85	Z40328		Cover
86	Z40329		Sleeve Gasket
87	Z40330		Gear
88	Z40331		Duplex Gear
89	S11632	M5x8	Screw
90	Z40332		Supporting Plate
91	Z40333		Gear
92	Z40334		Sleeve
93	Z40335		Duplex Gear
94	Z40336		Shaft
95	S21592	6x18	Key
96	S23230		Snap Ring
97	S20290		Bearing
98	Z40337		Cover
99	S11643	M5x10	Screw
100	S18185	M12	Nut
101	S18200		Washer
102	Z40338		Gear
103	S11033	M3x8	Screw
104	Z40339		Cover
105	Z40340	PD18x30x10	Oil Seal
106	S11671	M5x16	Socket-Head Capscrew
107	Z40341		Cover
108	Z40342		Sleeve Gasket
109	Z40376		Bearing
110	S21220	5x14	Key
111	Z40343		Shaft
112	S21715	6x45	Key
113	S22221	4x10	Spring Pin
114	Z40347		Gear

Diagram 3: BZ-239 G Headstock cont.

115	S23205		E-Clip
116	Z40345		Copper Bush
117	Z40346		Supporting Plate
118	S23275		Snap Ring
119	S20195		Axopetal Bearing
120	Z40347		Gear
121	Z40348		Shaft
122	Z40349		Cover
123	Z40350		Sleeve Gasket
124	S12630	M10x35	Bolt
125	S18165		Spring Washer
126	S11671	M5x16	Socket-Head Capscrew
127	Z40351		Rubber Washer
128	Z40352		Oil Pipe
129	S11954	M6x12	Screw
130	Z40353		Headstock
131	S24175	10x1.8	O-Sleeve Gasket
132	S12571	M10x16	Socket-Head Capscrew
133	S12321	M8x30	Socket
134	Z40354		Adjustable Bracket
135	S22290	A8x26	Pin
136	S12621	M10x30	Socket-Head Capscrew
137	Z40355		Plate
138	Z40356		Oil Indicator
139	Z40357		Steel Block
140	Z40358		Rod
141	Z40359		Steel Block
142	S11952	M6x12	Screw
143	S18095	M6	Nut
144	Z40360		Rod
145	Z40361		Tie Rod
146	S22230	5x22	Spring Pin
147	Z40362		Shaft
148	S24150	8.75x1.8	O-Sleeve Gasket
149	Z40363		Sleeve Gasket
150	Z40364		Fixing Seat
151	S11633	M5x8	Screw
152	C30126		Steel Ball
153	Z40365	1x5x20	Compression Spring
154	Z40366		Hand Lever
155	S22275	5x50	Spring Pin
156	S12208	M8x5	Screw
157	Z40367		Indicator Plate
158	Z40368		Indicator Plate
159	S11908	M6x5	Screw
160	S22224	4x32	Spring Pin
161	Z40369		Hand Lever
162	Z40370	0.6x3.5x15	Compression Spring
163	C30199		Steel Ball
164	Z40371		Fixing Seat
165	Z40372		Sleeve Gasket
166	S24100		O-Sleeve Gasket
167	Z40373		Shaft
168	S22222		Spring Pin
169	Z40374		Tie Rod
170	S18125	M8	Nut
171	Z40375		Rod
172	Z40377		Electric Box Cover
	Z49008		Side Cover Assembly (not shown)

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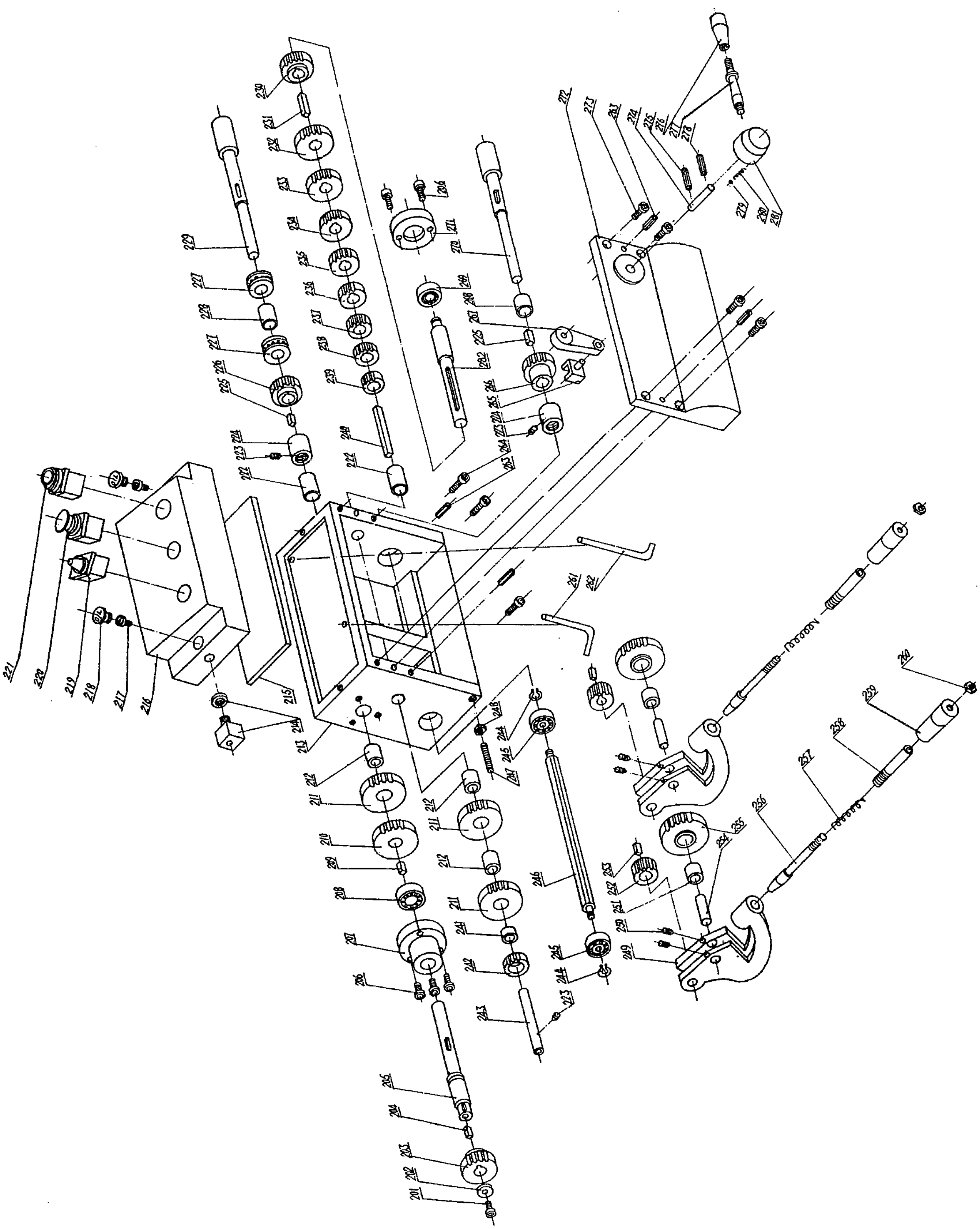

Diagram 4: Quick-Change Gearbox

201	S11951	M6x12	Screw	232	Z40135		Gear
202	S18110		Washer	233	Z40134		Gear
203	Z40119		Gear	234	Z40133		Gear
204	S21530	5x14	Key	235	Z40132		Gear
205	Z40121		Shaft	236	Z40131		Gear
206	S11941	M6x10	Screw	237	Z40130		Gear
207	Z40120		Bearing Cover	238	Z40129		Gear
208	S20140	60103	Bearing	239	Z40128		Gear
209	S21230	5x16	Pin	240	S21410	5x74	Key
210	Z40124		Duplex Gear	241	Z40127		Bushing
211	Z40125		Duplex Gear	242	Z40126		Gear
212	Z40127		Gear Sleeve	243	Z40250		Shaft
213	Z40122		Gear Box	244	S23110		Washer
214	Z40242		Pipe Connection	245	S20110	60201	Bearing
215	Z40102		Carpet	246	Z40109		Shaft
216	Z40244		Knob Seat (BZ-239)	247	S12332	M8x35	Screw
216	Z40101		Cover (BZ-239G)	248	S18125	M8	Nut
217	S11931	M6x8	Screw	249	Z40115		Lever Seat
218	Z40100		Plug	250	S11912	M6x6	Screw
219	Z40246		Indicator	251	Z40251		Bushing
220	Z40203		Stop Switch	252	Z40118		Gear
221	Z40284		Knob	253	S21220	5x14	Key
222	Z40247		Axle Sleeve	254	Z40116		Gearshaft
223	S11972	M6x16	Screw	255	Z40117		Gear
224	Z40248		Nut	256	Z40113		Gripper Axle
225	S21590	6x16	Key	257	Z40114		Spring
226	Z40099		Gear	258	Z40112		Grippper Sleeve
227	S20200	8104	Bearing	259	Z40111		Lever
228	Z40137		Axle Sleeve	260	S18096	M6	Nut
229	Z40294		Axle	261	Z40252		Oil Pipe
230	Z40136		Gear	262	Z40253		Oil Pipe
231	S21650	6x32	Key	263	S22230	5x20	Pin

Diagram 4: Quick-Change Gearbox cont.

264	S12311	M8x25	Screw
265	Z40107		Fork
266	Z40136		Gear
267	Z40105		Connecting Rod
268	Z40254		Bushing
269	S20110	601201	Bearing
270	Z40110		Shaft
271	Z40255		Front Cover
272	Z40106		Gearbox Front Cover
273	S11971	M6x16	Screw
274	Z40103		Shaft
275	S22240	5x26	Pin
276	Z40033	BM10x50	Lever Grip
277	Z40290		Lever
278	S22270	5x40	Pin
279	Z40073		Steel Ball
280	Z40095	IX4.5x16-2	Compressing Spring
281	Z40288		Knob
282	Z40257		Shaft

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17.5 Lathe Apron

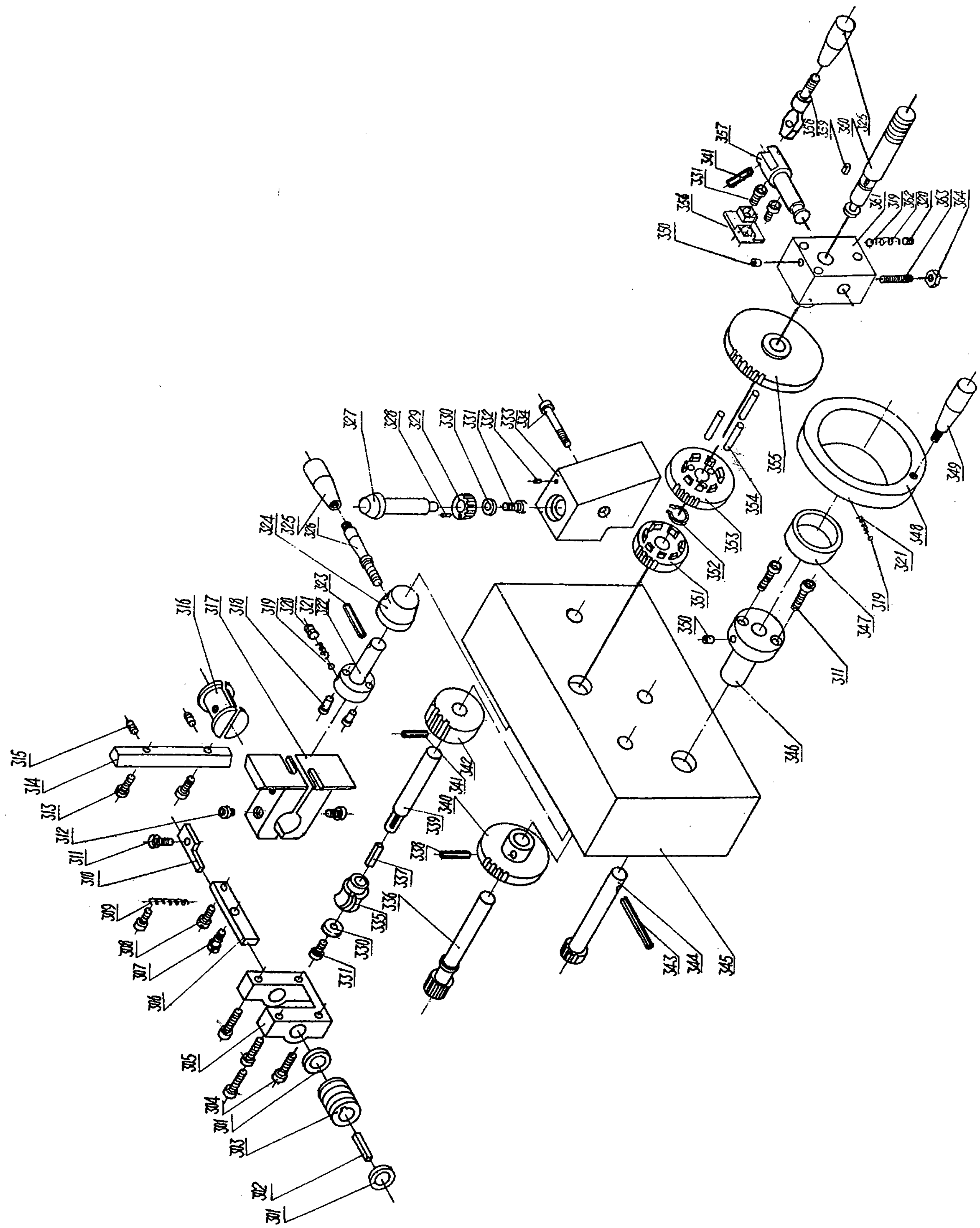

Diagram 5: Lathe Apron

301	Z40258		Washer	333	Z40096		Thread Dial
302	S21315	5x32	Key	334	X12051	M6x45	Screw
303	Z40090		Worm	335	Z40085		Worm
304	S12011	M6x25	Screw	336	Z40078		Transmission Shaft
305	Z40091		Seat Frame	337	S21170	4x20	Key
306	Z40093		Safety Piece	338	S22250	5x30	Pin
307	Z40226	M6x8	Screw	339	Z40086		Axle
308	S11361	M4x14	Screw	340	Z40077		Spur Gear
309	Z40094		Spring	341	S22240	5x25	Pin
310	Z40083		Arm	342	Z40080		Transmission Gear
311	S11971	M6x16	Screw	343	S22270	5x60	Pin
312	S11951	M6x8	Screw	344	Z40076		Handwheel Gear
313	S11671	M5x16	Screw	345	Z40070		Apron Case
314	Z40081		Guideplate	346	Z40075		Handwheel Seat
315	S11952	M6x12	Screw	347	Z40072		Graduation Collar
316	Z40084		Half-Nut	348	Z40071		Handwheel
317	Z40082		Half-Nut Seat	349	Z40079	BM8x63	Handle
318	S22310		Pin	350	Z40291		Oiler
319	Z40073		Steel Ball	351	Z40087		Clutch Gear
320	S11238	M8x8	Screw	352	S23200		Snap Ring
321	Z40074		Spring	353	Z40088		Clutch Gear
322	Z40289		Half-Nut Clutch	354	S22195	6x30	Pin
323	S22270	5x40	Pin	355	Z40089		Clutch Gear
324	Z40288		Knob	356	Z40287		Safety Stopper
325	Z40033	BM12x50	Lever Grip	357	Z40260		Change Rod
326	Z40290		Lever	358	Z40286		Change Lever
327	Z40097		Indicator Shaft	359	S21110	4x8	Key
328	S22040	3x12	Pin	360	Z40092		Change Shaft
329	Z40098		Indicator Gear	361	Z40261		Change Lever Seat
330	S18110		Washer	362	Z40074		Spring
331	S11991	M6x12	Screw	363	S12338	M8x35	Screw
332	S22355	2.5x5	Rivet	364	S18125	M8	Nut

17.6 Carriage Assembly

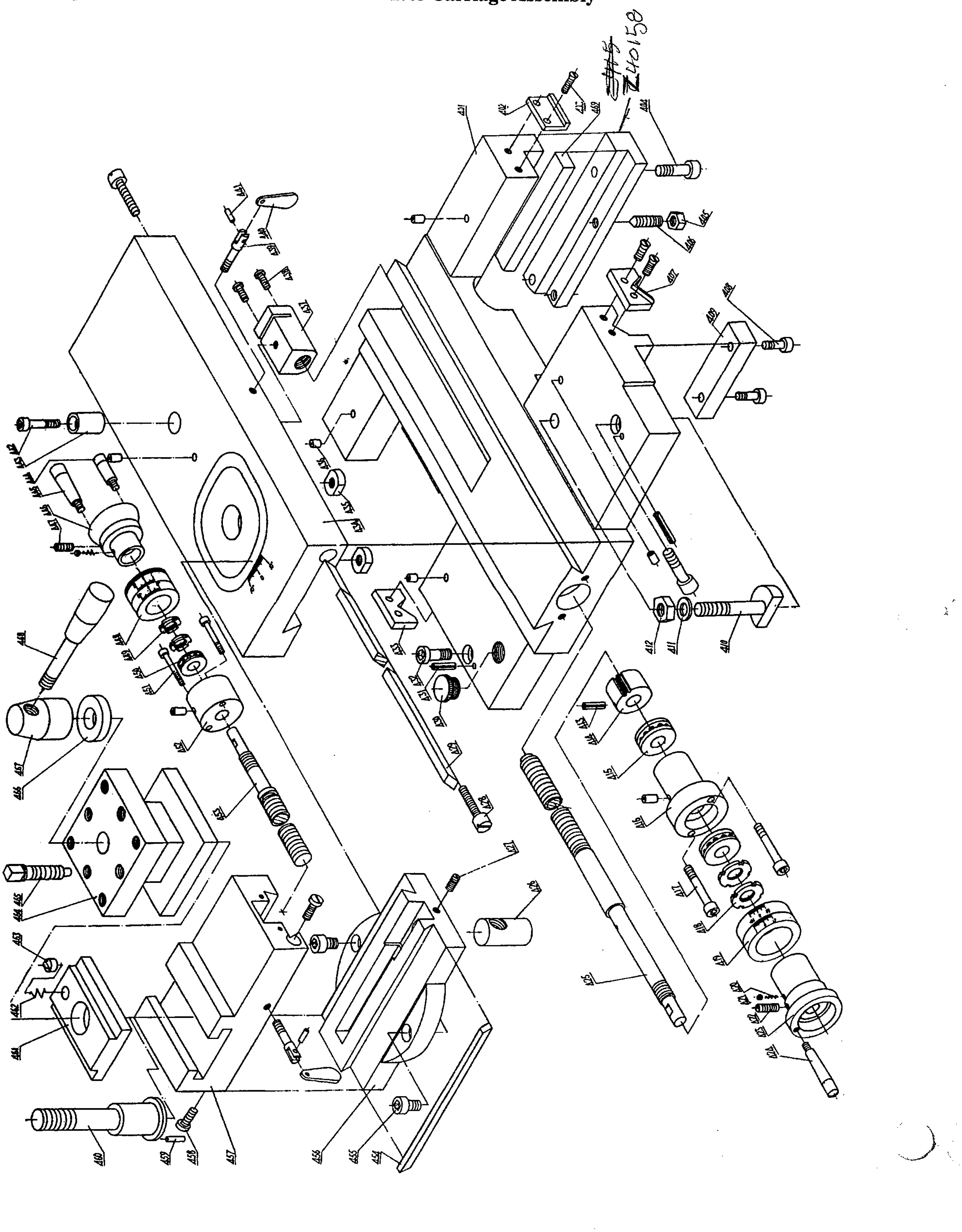

Diagram 6: Carriage Assembly

401	Z40160		Saddle
402	Z40157		Rear Wiper
403	S11675	M5x12	Screw
404	S12311	M8x25	Screw
405	S18125	M8	Nut
406	S12302	M8x22	Screw
407	Z40190		Right Front Wiper
408	S11971	M6x16	Screw
409	Z40189		Block Slide
410	Z40185		Fixing Bolt
411	S18170		Washer
412	S18155	M10	Nut
413	S22230	5x20	Pin
414	Z40188		Gear
415	S20080	8101	Bearing
416	Z40180		Leadscrew Seat
417	S12051	M6x45	Screw
418	Z40229	M12x1.25	Nut
419	Z40186		Graduation Collar
420	Z40074		Compression Spring
421	Z40073		Steel Ball
422	S11972	M6x16	Screw
423	Z40173		Handle Wheel
424	Z40174		Lever
425	Z40159		Saddle Leadscrew
426	Z40178		Nut
427	S11952	M6x12	Screw
428	S12007		Adjusting Screw
429	Z40177		Gib
430	Z40100		Plug
431	S22260	5x35	Pin
432	S12321	M8x30	Screw
433	Z40292		Left Front Wiper
434	Z40156		Cross Slide
435	Z40172		Fixing Block
436	Z40291		Oiler
437	Z40161		Leadscrew Nut
438	S11395	M4x20	Screw
439	Z40192		Clamping Bolt
440	Z40192		Clamping Lever
441	Z40192	2x8	Pin
442	S11991	M6x20	Screw
443	Z40162		Fixing Seat
444	Z40181		Lever
445	Z40183		Lever
446	Z40182		Handwheel
447	S11918	M6x6	Screw
448	Z40184		Graduation Collar
449	Z40230	M10x1	Nut
450	S20080	8100	Bearing
451	S11421	M4x30	Screw
452	Z40191		Bearing Seat
453	Z40179		Compound-Slide Leadscrew
454	Z40169		Gib
455	S12281	M8x18	Screw
456	Z40171		Swivel Base
457	Z40176		Toolpost
458	S12007		Adjusting Screw
459	S22221	4x10	Pin
460	Z40166		Clamping Nut
461	Z40266		T-Key
462	Z40164		Compressing Spring
463	Z40163		Locating Block
464	Z40168		Toolpost

Diagram 6: Carriage Assembly cont.

465	Z40227	Toolpost Screw
466	Z40228	Washer
467	Z40165	Lever
468	Z40167	Handle
469	Z40295	Slide Gib
	Z49005	Compound-Angle Toolpost (complete)

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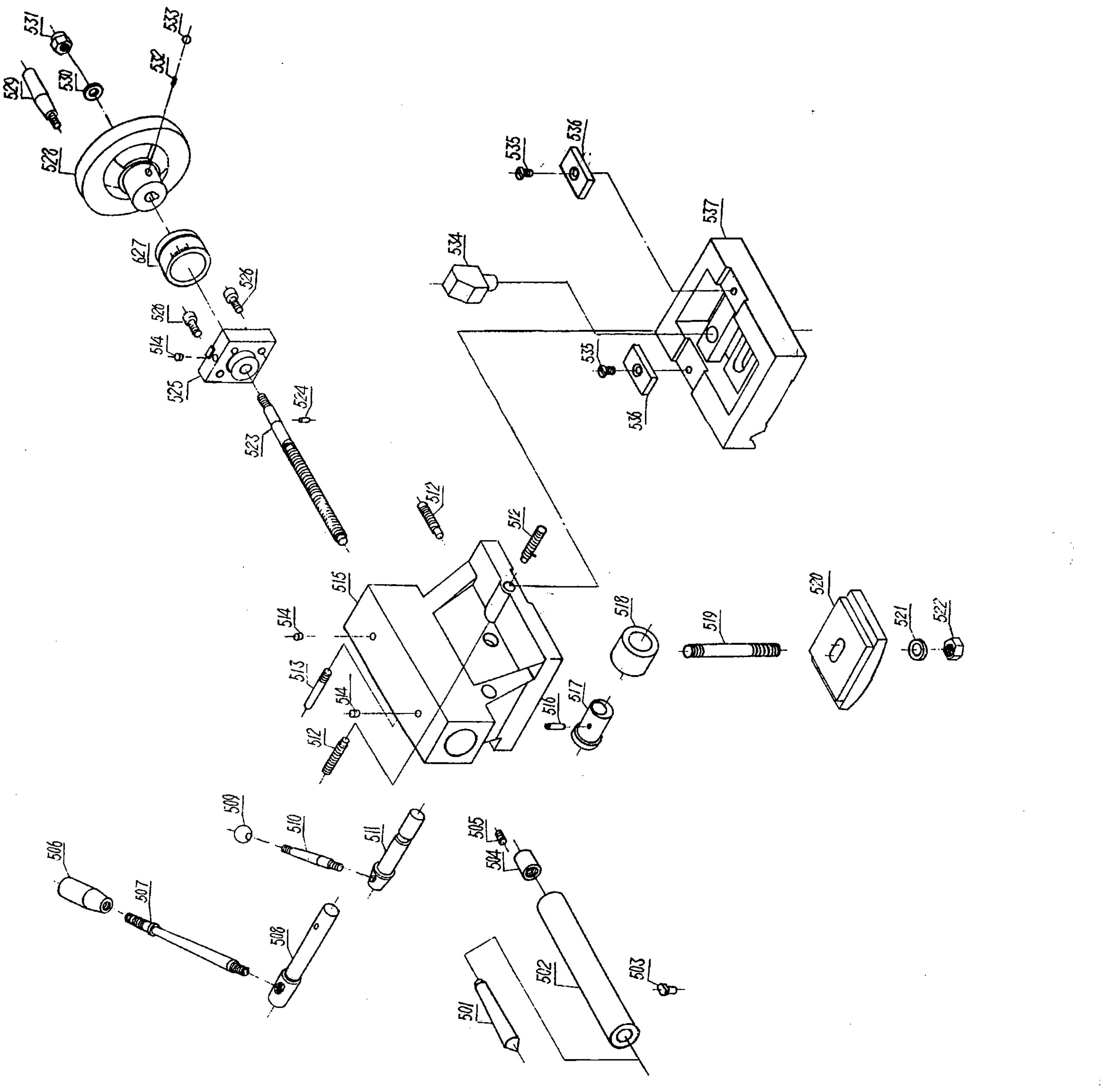
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Diagram 7: Tailstock

501	41-002		MT2 Center
502	Z40147	- Z40147MT3	Tailstock Quill
503	S21501		T-Key
504	Z40149		Tailstock Leadscrew Nut
505	S11942	M6x10	Screw
506	Z40033	BN10x50	Lever Grip
507	Z40034		Lever
508	Z40144		Clamping Shaft
509	Z40153	M6x20	Lever Ball
510	Z40154		Lever
511	Z40146		Eccentric Axle
512	S12648	M10x40	Screw
513	Z40155		Fixing Axle
514	Z40291		Oiler
515	Z40139		Tailstock
516	S22240	5x25	Spring Pin
517	Z40143		Eccentric Axle Sleeve
518	Z40145		Sleeve
519	Z40141		Double Bolt
520	Z40142		Clamping Bolt
521	S18200		Washer
522	S18185		Nut
523	Z40148		Tailstock Leadscrew
524	S22160	5x8	Pin
525	Z40150		Bracket
526	S11971	M6x16	Screw
527	Z40151		Graduation Collar
528	Z40152		Tailstock Handwheel
529	Z40079	BM8x63	Handle
530	S18170		Washer
531	S18155	M10	Nut
532	Z40074		Spring
533	Z40073		Steel Ball
534	Z40205		Fixing Bracket
535	S11953	M6x12	Screw
536	Z40267		Fixing Block
537	Z40140		Baseplate
	Z49004		Tailstock (complete)

17.8 Forward/Off/Reverse Switch

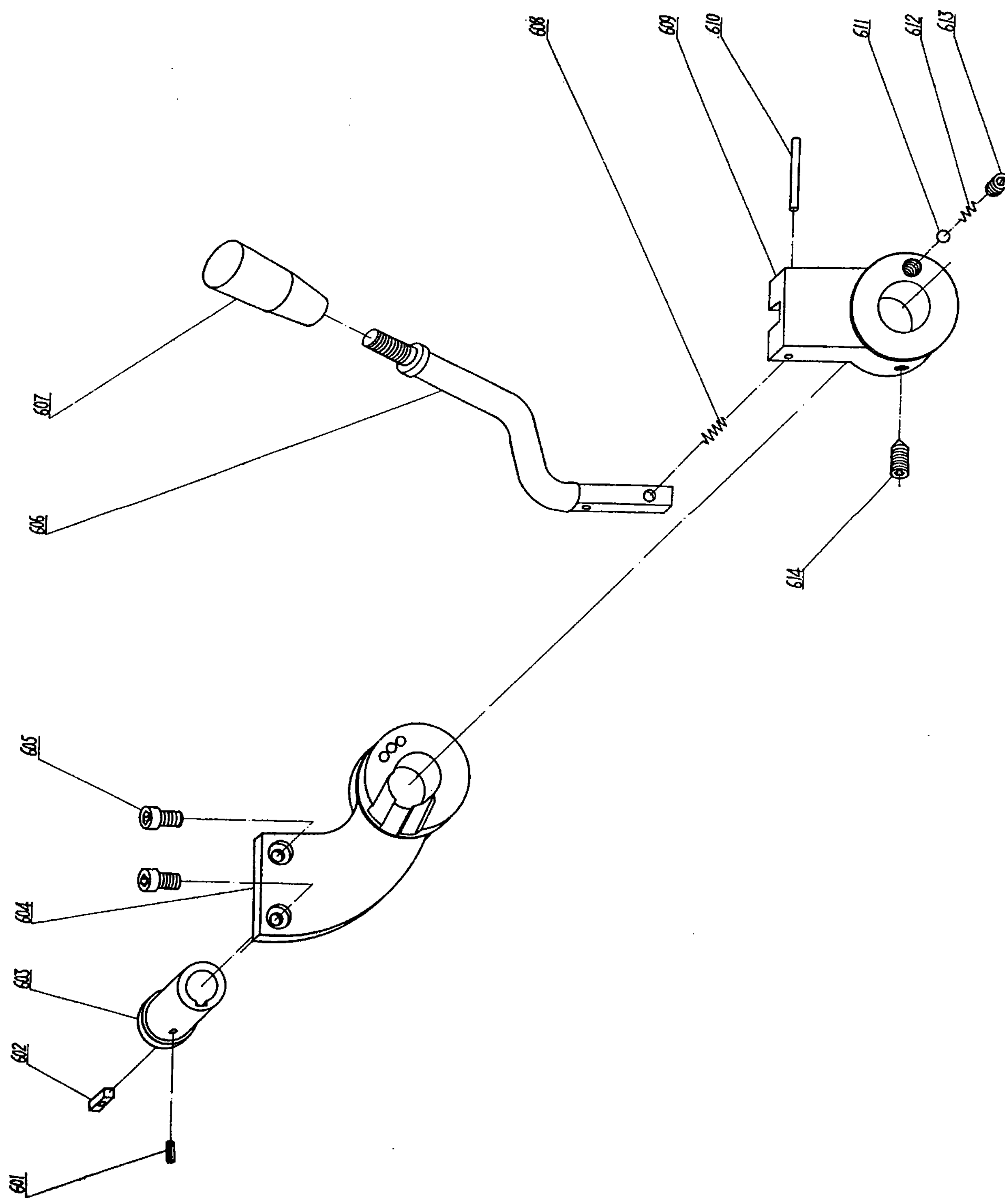

Diagram 8: Forward/Off/Reverse Switch

601	S22205	3x5	Spring Pin
602	S21232	B5x18	Key
603	Z40268		Axle
604	Z40269		Lever Bracket
605	S11951	M6x12	Screw
606	Z40270		Handle
607	Z40033	BM10x50	Lever Grip
608	Z40271	1x6x22	Spring
609	Z40272		Switch Cover
610	S22062	B5x35	Pin
611	Z40073		Steel Ball
612	Z40273	1x6x9	Spring
613	S12248	M8x10	Screw
614	S12252	M8x12	Screw

17.9 BZ-239 (only) Side Cover

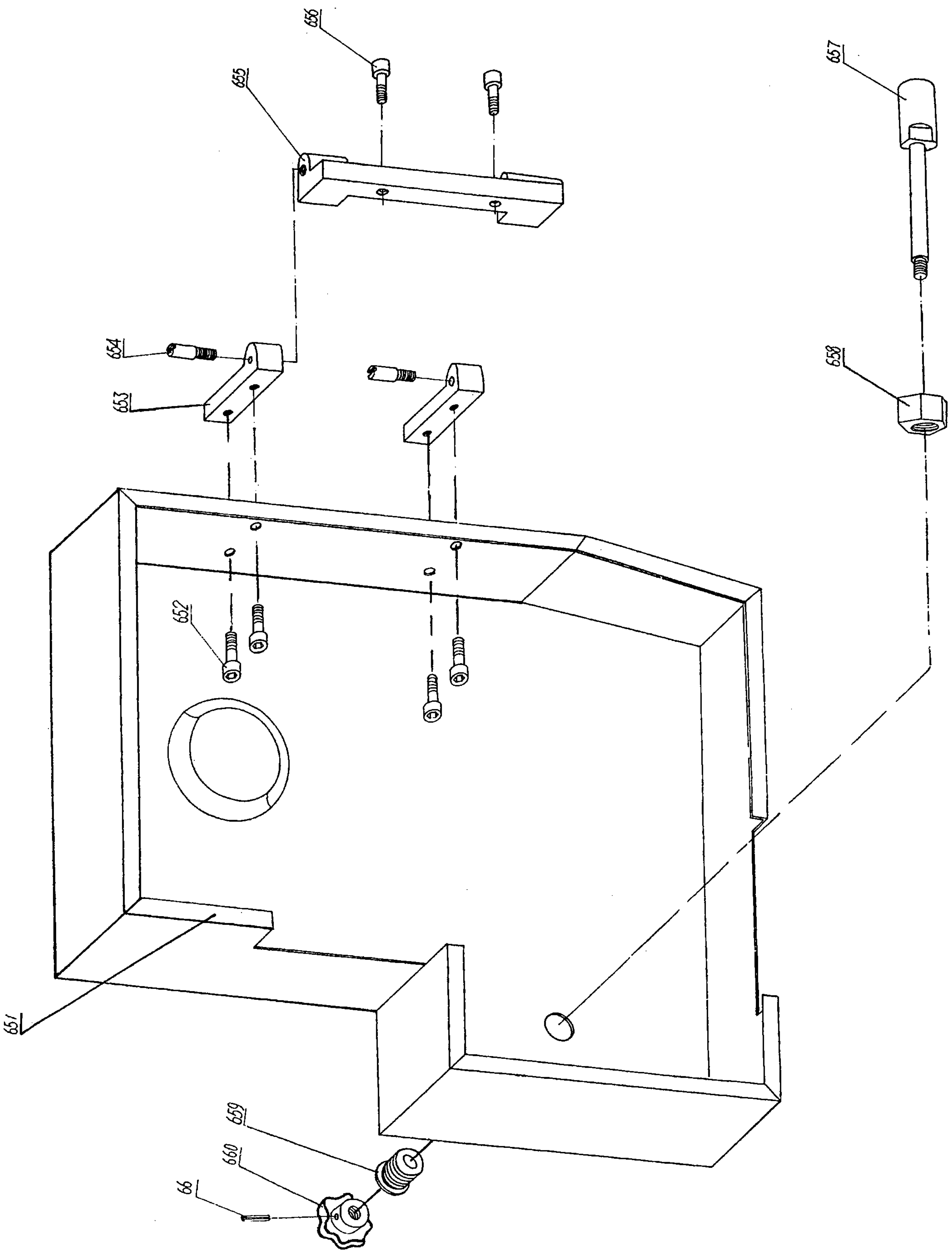

Diagram 9: BZ-239 Side Cover

651	Z40054		Side Cover
652	S11951	M6x12	Socket-Head Capscrew
653	Z40274		Side Cover Seat
654	Z40225		Locating Screw
655	Z40053		Side Cover Support
656	S11971	M6x16	Socket-Head Capscrew
657	Z40058		Locking Rod
658	S18216	M16	Nut
659	Z40057		Locking Rod Sleeve
660	Z40055	BM8x32	Knob
661	S22220	3x16	Spring Pin

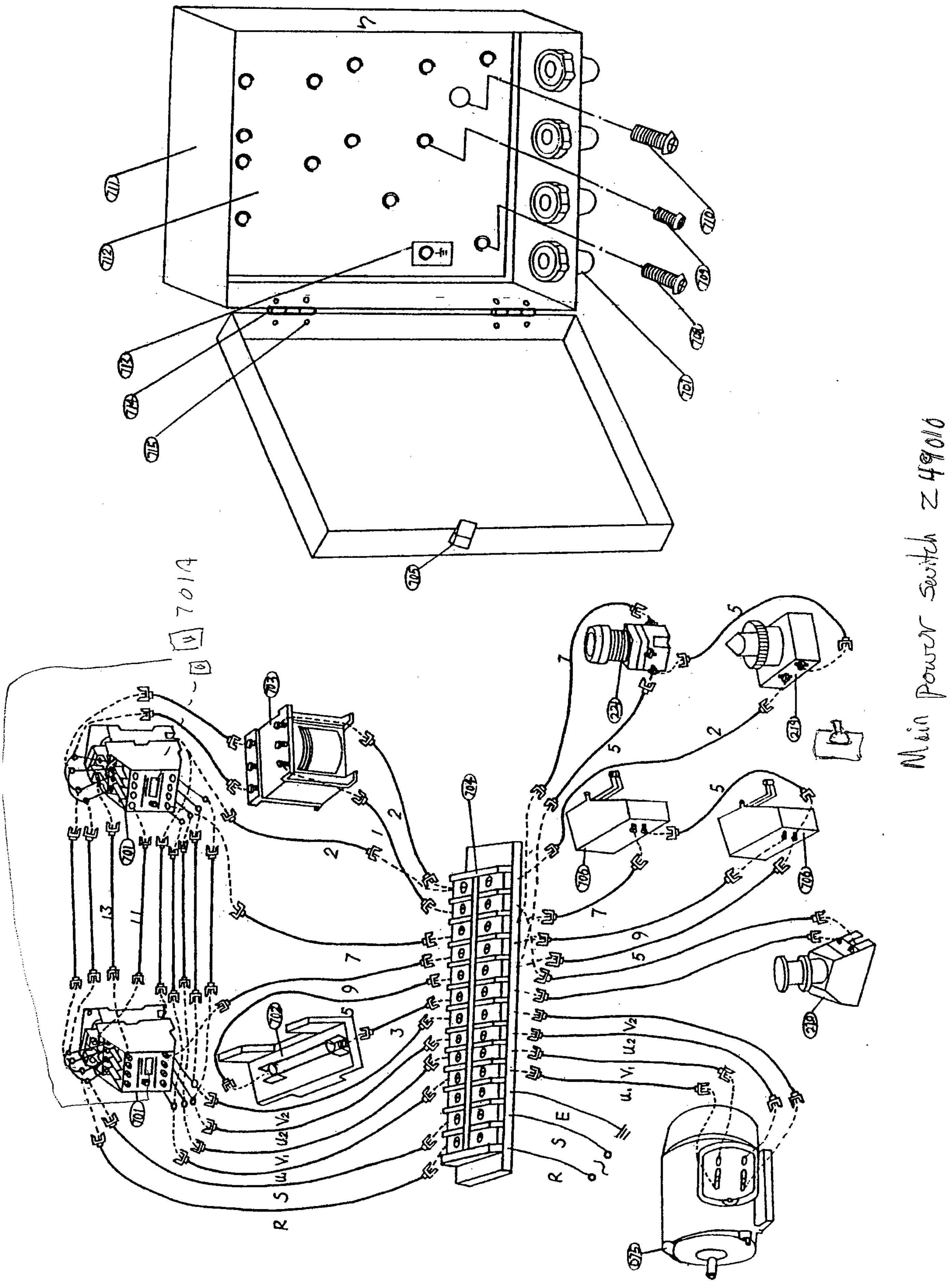
Main power switch Z 49010

Diagram 10: Electrical Panel

219	Z40246	Indicator
220	Z40203	Stop Switch
701	Z40202	Relay Switch
702	Z40204	Fuse
703	Z40296	Converter
704	Z40297	Support Plate
705	Z40298	Knot
706	Z40201	Travel Switch
707	Z40299	Union Joint
708	S11355	Screw
709	S11355	Screw
710	S11655	Screw
711	Z40300	Electrical Control Box
712	Z40301	Electrical Installed Plate
713	Z40302	Grounding Plate
714	Z40303	Hinge
715	Z40304	Rivet
	Z49003	Control Panel (Relays,Transformer, Support Plate)

701A Auxiliary Switch Z40202-1
B2B Relay Z40256
Main Relay Z40249

Gear Drive
24v

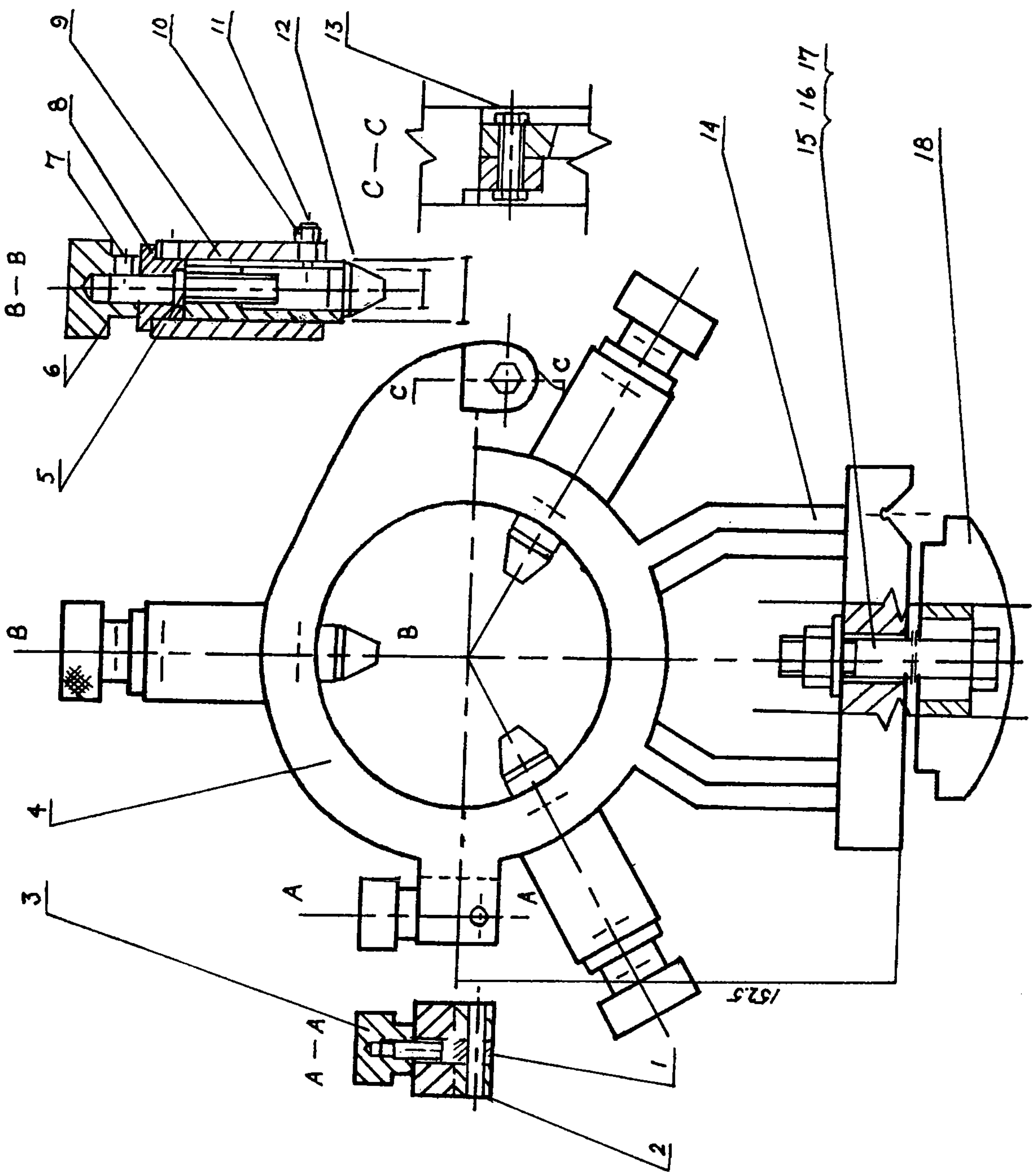
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Diagram 11: Steady Rest

1	Z40206	Locking Piece
2	S22250	Pin
3	Z40207	Knob
4	Z40208	Top Piece
5	Z40209	Adjusting Bolt
6	Z40210	Knob
7	S11932	Screw
8	Z40211	Sleeve Ring
9	Z40212	Sleeve
10	S18095	Nut
11	S11988	Screw
12	Z40213	Brass Center
13	S12010	Screw
14	Z40214	Base Piece
15	S13000	Screw
16	S18185	Nut
17	S18200	Washer
18	Z40142	Clamp
	Z49006	Steady Rest (complete)

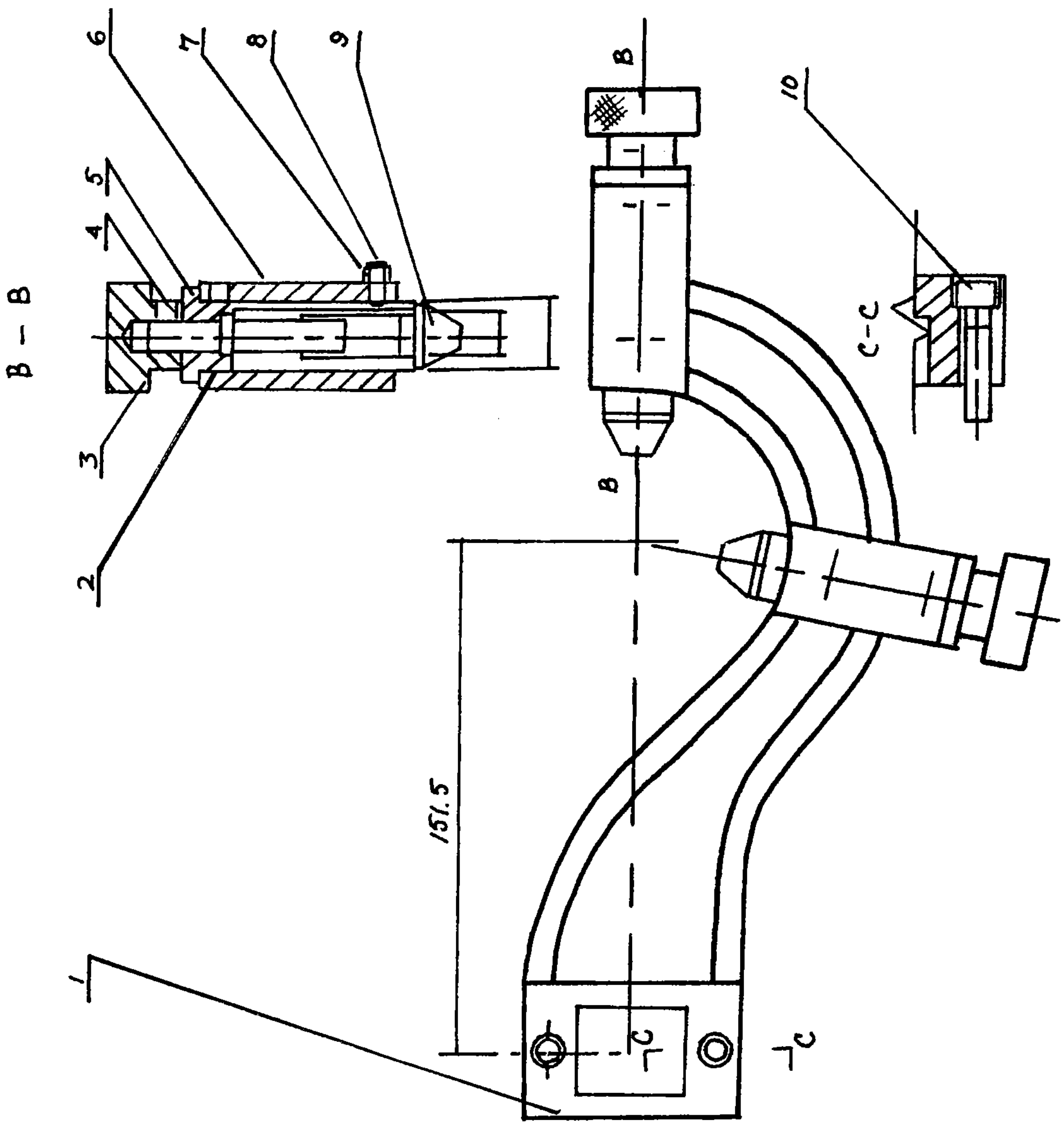
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Diagram 12: Follow Rest

1	Z40216	Frame
2	Z40209	Adjusting Bolt
3	Z40210	Knob
4	S11932	Screw
5	Z40211	Sleeve Ring
6	Z40212	Sleeve
7	S18095	Nut
8	S11978	Screw
9	Z40213	Brass Center
10	S12331	Screw
	Z49007	Follow Rest (complete)