Mill-Drill Accessory
For the SC4 Lathe

User's Guide and Installation Manual
Version date: 02-22-11

Please Read This Manual Carefully Before Operating this Machine.

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IMPORTANT SAFETY INSTRUCTIONS

Common sense and caution are factors which cannot be built into any product. These factors must be supplied by the operator.

PLEASE REMEMBER:

1. When using electric tools, machines or equipment, basic safety precautions should always be followed to reduce the risk of fire, electric shock, and personal injury.
2. Keep work area clean. Cluttered areas invite injuries.
3. Consider work area conditions. Do not use machines or power tools in damp, wet or poorly lit locations. Don not expose equipment to rain, keep work areas well lit. do not use tools in the presence of flammable gases or liquid.
4. Keep children away; all children should be kept away from the work area.
5. Guard against electric shock. Prevent body contact with grounded surfaces such as pipes, radiators, ranges and refrigerator enclosures.
6. Stay alert. Never operate a power tool if you are tired.
7. Do not operate the product if under the influence of alcohol or drugs. Read warning labels on prescriptions to determine if your judgment or reflexes might be impaired.
8. Do not wear loose clothing or jewelry as they can be caught in moving parts.
9. Wear restrictive hair covering to contain long hair.
10. Use eye and ear protection. Always wear.
11. Keep proper footing and balance at all times.
12. Do not reach over or across running machines.

Before operations

1. Be sure the power switch is OFF when not in use and before plugging in.
2. Do not attempt to use inappropriate attachments in an attempt to exceed the tool's capacity.
3. Check for damaged parts before using the machine. Any part that appears damaged should be carefully checked to determine that it will operate properly and perform its intended function.
4. Check for alignment and binding of all moving parts, broken parts or mounting fixtures and any other condition that may affect proper operation. Any part that is damaged should be properly repaired or replaced by a qualified technician.
5. Do not use the machine if any switch does not turn off properly.

Operation

1. Never force the machine or attachment to do the work of a larger industrial machine. It is designed to do the job better and more safely at the rate for which it was intended.
2. Always unplug the cord by the plug. Never yank the cord out of the wall.
3. Always turn off the machine before unplugging.

Capabilities of the Mill Drill Accessory

While a lathe, such as the SC4, is one of the most versatile machines in a machine shop, the lathe has only limited abilities to deal with workpieces that are not basically cylindrical in shape. Similarly, the lathe excels at drilling precision holes along the central axis of a cylindrical workpiece, but is not well suited to drilling a series of holes across the surface of a flat workpiece. For these types of operations, the Mill-Drill supplements and extends the capabilities of the lathe.

The milling head accessory for the SC4 lathe is specifically designed to safely and precisely perform drilling as well as light milling operations. The spindle bearings are designed to handle milling forces and the tapered tooling is held securely in the spindle by means of a drawbar. Combined with the X-Y positioning control of the lathe, the mill-drill accessory enables precision placement of drilled holes and milled features.

Should you have any questions regarding the operation of your lathe, please contact ***Travers Technical Support*** for assistance.

Technical Support
(1-**800-234-9985**, press **4**)
Fax: 718-661-5637
Email: tech@travers.com

User Manual

The purpose of this manual is to familiarize the operator with the installation and controls of the mill-drill and basic milling and drilling procedures. To become proficient in using the mill-drill, the operator should seek in-depth training using reference books, resources available on the Internet, training courses at community technical schools or from an operator already skilled in the use of a similar machine tool.

Electrical Requirements

The mill-drill mounts directly to the back of the SC4 lathe bed. It plugs into and is powered by a 120V AC electrical socket located on the rear of the power supply cabinet of the SC4 lathe. Therefore, the electrical requirements are those of the SC4.

The SC4 lathe should be located in a well-lighted and well-ventilated area free from excessive humidity or moisture that could cause rusting of the precision metal surfaces or tooling.

The SC4 lathe configured for U.S. operation uses standard 120V AC 60-cycle single-phase power and has a peak current demand of 12 amps. While a 15-amp circuit may be sufficient for powering the lathe, a 20-amp circuit is recommended. The circuit must not be shared with other high-current devices, such as an air compressor, window air conditioner or coffee pot, that may be operating, or switch on, while the lathe is in use. Low current devices, such as a work lamp, may share the same circuit as the lathe.

A plug-in power failure emergency light that will automatically turn on in the event of a power failure or tripping of an overloaded circuit breaker is recommended for safety. In the event that power to the lathe, or workspace lighting, should be interrupted while the lathe is in use, the emergency light will enable the operator to safely turn off the power switch to the lathe and move away from the lathe until power is restored. Suitable lights are available at most hardware and home-supply stores.

Care should be taken to ensure a safe work area with electrical wiring and grounding approved by local electrical codes. The lathe uses a three-prong electrical plug to protect the operator from risk of shock or electrocution. The lathe must be plugged into a properly grounded outlet to ensure safe operation. Do not attempt to modify the plug to fit a 2-prong outlet or extension cord by removing the ground conductor or by using an adaptor. Doing so may result in shock or electrocution.

If it is necessary to plug the lathe into an extension cord, the extension cord must have a properly functioning 3-prong electrical ground plug and outlet, plugged into a properly grounded 3-prong wall outlet. The extension cord must have at least 15 Amps of current-carrying capacity to avoid overheating the cord, which could cause a risk of fire. A cord rated for 20 Amps or more is recommended. In no case should the length of the extension cord exceed 20 feet.

Lifting the Mill-Drill Accessory

The mill-drill accessory weighs approximately 92 lbs. Two individuals, in good physical condition, should lift the machine together.

Proper lifting techniques (e.g. bend at the knees, not at the back) should be used to minimize any risk of personal injury. Consult the Internet for information on proper lifting techniques.

Bench Mounting

For stability and safe operation the lathe must be bolted to a sturdy machine stand or workbench. With the mill-drill attached to the lathe, the bench must capable of safely supporting at least 450 lbs.

A carpenters or machinists level should be used to verify that the lathe bed is level. Large diameter metal fender washers or shims may be used under the mounting feet to level the lathe. Sufficient clearance must be provided on the left side of the lathe to allow the access door to swing open and provide working room to adjust the gears

Machine Cleanup.

The mill-drill head is protected from rust during shipping by a waxy red grease that must be removed before putting the machine to use. This is best done using disposable shop rags

and paint brushes together with a solvent such as kerosene or WD-40™. Avoid solvents such as paint thinner that may damage the painted surfaces of the lathe, and highly volatile solvents such as acetone that present a fire and inhalation hazard.

Good ventilation must be provided when solvents are used and care must be taken to avoid open flames, smoking materials or electrical sparks that could ignite solvent fumes. Care should be taken to clean the shipping grease from all moving parts, including parts that may be hidden from view, such as leadscrews under the cross-slide and compound slide.

Installing the Mill-Drill

Removing the Compound Assembly

When using the mill-drill, the lathe compound assembly is removed from the cross-slide. The flat surface of the top of the cross-slide is then used as a small milling table to hold a vise or to clamp a workpiece directly to the surface of the table.

1. If any lathe bits are protruding from the tool holder, remove them or carefully remove the tool holder so that the sharp tips will not create a hazard in the next steps.

2. Loosen and remove the four nuts and washers that hold the lathe compound to the cross slide. It may be necessary to unlock and rotate the compound to gain access to all four nuts.

3. Remove the compound assembly from the lathe and set it aside where it will be out of the way.

Removing the Drill Chuck

Before installing the mill-drill, any tooling, such as a drill chuck or collet and end mill, must be removed from the spindle.

1. Insert the tip of the spindle retaining tool into the hole in the side of the spindle.

Spindle Retaining Tool

2. Slide an 8 mm wrench over the square section of the drawbar extending above the head.

3. Holding the retaining tool to prevent the spindle from rotating, use the 8 mm wrench to loosen the drawbar by about 1 full turn.

***Caution**: To avoid damaging the drawbar threads in the next step, the drawbar should not be loosened more than 2 turns.*

4. Use a small hammer with a brass or shot-filled head to tap the top of the drawbar. This will break the grip of the tapered tool holder from the spindle.

***Caution**: If a milling cutter is installed in the spindle, use gloves or a shop rag to avoid being cut by the sharp edges of the cutting tool.*

5. Keeping one hand under the tooling to prevent it from dropping onto the lathe, loosen the drawbar the rest of the way until the tool holder drops out of the spindle.

Removing the Chip Shield

Before installing the mill-drill, remove the black sheet-metal chip shield from the back of the lathe.

1. Loosen the two cap head screws that retain the chip shield to the headstock.
2. While supporting the tailstock end of the chip shield with one hand, remove the two cap head screws that retain the chip shield near the tailstock.
3. Pull the headstock end of the chip shield free from the screws loosened in step 1.
4. Store the chip shield where it will be out of the way for subsequent installation steps.

Installing the Support Stand

***Note**: In the following procedures, access to the cap head screws is partially blocked by the structure of the mill head and support stand. A set of ball-end metric hex wrenches will allow easier access to the cap screws and speed up the installation process. Alternatively, a socket wrench with hex drive sockets and a flexible elbow can be used.*

Ball-End Metric Hex Wrench Set

Item #: 71-350-550

***Caution**: always wear industrial-quality eye protection with side shields when using compressed air to remove chips and residue.*

1. Use a small brush and/or low-pressure compressed air to clear out any chips or grit that may be lodged in the bolt holes in the back of the lathe bed casting.
2. Position the support stand near the mounting holes and adjust the height of the foot so that the mounting holes in the support stand are at the same height as the corresponding holes in the lathe bed.
3. While holding the support stand in place with one hand, start one of the two lower cap head screws and screw it in far enough to secure the stand to the lathe bed.
4. Insert and hand-tighten the remaining three cap head screws. Leave the screws loose enough to allow the support stand to be leveled.
5. Place a short carpenter's or machinist's level on the flat mounting surface on the top of the support stand. Rotate the foot of the support stand to adjust the height so that the top surface is level front to back.

6. Use an 8 mm hex wrench (with ball-end, if available) to tighten the four cap head screws that secure the support stand to the lathe bed.

Installing the Mill-Drill on the Support Stand

Next, the mill-drill accessory will be mounted onto the support stand. This step involves lifting and holding the mill-drill accessory in place until it can be secured by the mounting screws. This operation is best done by two people working together.

1. Use the carriage handwheel to move the lathe carriage so that it is centered with the support stand.
2. Secure the power cable to the mill-drill so that it does not get in the way.
3. Stack two small pieces of 2x3 or 2x4 scrap lumber on the surface of the lathe cross-slide.
4. Pre-position the mill-drill head near the rear of the lathe so that it may be safely lifted and lowered onto the support stand in the next step.
5. Lift the mill-drill onto the support stand.
6. Holding the mill-drill steady with one hand, position the stack of wood pieces directly below the spindle. Lower the head and/or spindle of the mill-drill until the spindle rests firmly on the top of the wood pieces.
7. With the mill-drill thus stabilized, insert and tighten the four cap head screws to secure the mill-drill to the support stand.
8. Withdraw the spindle and remove the wood support blocks.

Electronic Controls

The electronic controls for the mill-drill are located on the left side of the head. AC power for the mill-drill is supplied through the cord that plugs into the back of the SC4 power supply box and is controlled by the red ON-OFF rocker switch on the SC4 front panel.

The controls and indicators are as follows:

For-Rev Switch – Controls the direction of spindle rotation, forward or reverse. In the middle "0" position, power to the motor is turned off.

Fuse Holder – Provides access to check or replace the fuse.

Yellow Lamp – Indicates a controller fault condition.

Green Lamp – Power status; illuminates when power is on.

RPM Knob – Controls the spindle rotational speed.

Forward-Reverse Switch

Most milling and drilling operations are done with the spindle rotating in the clockwise direction as viewed from above the spindle. This is the Forward (**F**) direction. The Reverse (**R**) direction is useful for backing-out drills or taps or when using cutting tools that cut in a counter-clockwise direction.

The "0" position allows power to the mill-drill head to be turned off while power to the lathe is turned on. The switch should be moved to the central "0" position when the mill-drill is not in use or when changing tools in the spindle.

The speed control knob should be rotated fully counterclockwise, until a click is heard, before switching the Forward-Reverse switch to the **F** or **R** position. If this is not done, the yellow fault lamp will illuminate until the speed control has been set to zero. This is a safety feature to prevent the spindle from beginning to rotate (possibly at high speed) if the speed control is not first reset to zero.

Note: The

Fuse Holder

The fuse holder provides acess to a 2 Amp, 250V fuse.

***Caution**: For safety, before removing the fuse, turn off power to the lathe and unplug the lathe from the power outlet or unplug the mill-drill head from the rear of the lathe.*

To inspect or replace the fuse, insert the blade of a small screwdriver into the slot on the face of the holder and twist it counterclockwise about ¼ turn. The fuse holder will then eject from its housing under spring pressure.

A blown fuse usually will be evident by the missing wire, which normally is visible within the glass enclosure, and by discoloration of the inside of the glass. Sometimes a fuse may appear to be normal even though it is not conducting current. Use an ohmmeter or continuity tester when necessary to verify that the fuse is not blown.

***Warning**: when replacing the fuse, always use a fuse of the same size and electrical rating in volts and amps (250V, 2 Amps). Using a fuse with a lower amp rating is likely to cause the*

fuse to blow immediately or prematurely. Using a fuse with a higher amp rating defeats the protective purpose of the fuse and can cause the electrical circuits of the machine to be damaged.

Yellow Lamp – Fault Indicator

The yellow LED lamp indicates that a fault condition has been detected by the motor drive circuitry.

A fault condition occurs if the Forward-Reverse switch is switched to the **F** or **R** position without first resetting the speed control knob fully counterclockwise until a click is heard. This is a safety feature to prevent the spindle from starting unexpectedly.

A fault also occurs when the motor draws excessive current, such as when stalled or taking too deep a cut. When such a condition occurs, the motor controller cuts off power to the motor and illuminates the yellow lamp.

To clear the fault condition, first ensure that the physical cause has been removed by moving the cutting tool clear of the workpiece or any other object, such as a hold-down clamp, that it may have come into contact with.

Next, rotate the speed control all the way counterclockwise until a click is heard. The click indicates that the reset switch has been engaged and should cause the yellow fault lamp to reset.

After the fault lamp is reset, rotate the speed control clockwise until the spindle rotates normally. If the spindle does not rotate, it is possible that the fuse was blown by the overload condition.

Green Lamp – Power Indicator

The green LED lamp indicates that power is present at the mill-drill head and that the Forward-Reverse switch is engaged. When the Forward-Reverse switch is in the central “0” position, the mill-drill is powered off and the green lamp is not illuminated.

***Note**: The power lamp will not illuminate if the Emgergency Stop button on the lathe control panel is locked in the depressed position.*

RPM Knob – Spindle Speed Control

The spindle speed control knob allows continuous adjustment of the spindle speed over two ranges, HI and LO, as set by the HI-LO gear selector to the right of the electrical control panel. In the LO range, speeds are variable from approximately 100 to 1000 RPM, and in the HI range from approximately 100 to 2000 RPM.

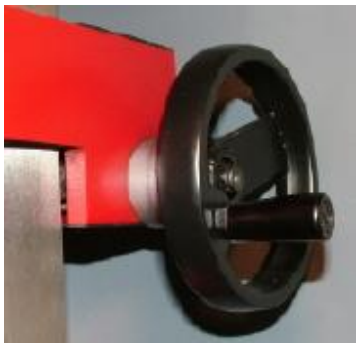
The knob must be turned fully counter-clockwise, until a click is heard, before starting the spindle. This safety feature ensures that the spindle does not immediately start rotating when the Forward-Reverse switch is engaged or in the event that power is restored to the machine after a power failure at the AC outlet.

The spindle speed should be adjusted according to the diameter of the cutting tool in use. Lower speeds should be used for larger diameter cutting tools and higher speeds for smaller diameter cutting tools. Additionally, the spindle speed should take into account the properties of the material being machined, with lower speeds being used for harder materials.

A thorough discussion of cutting speeds for various tooling and material combinations is beyond the scope of this manual. Please consult technical reference books or the Internet for information on this subject.

Mechanical Controls

Z-Axis Handwheel



Z-Axis Handwheel

Located near the column on the right side of the machine, the Z-axis handwheel moves the head assembly up or down along the dovetailed column. One full rotation of the handwheel moves the head up or down by 0.050".

***Note**: Always check to make sure that the Head Locking Lever on the left side of the column is loosened before moving the head assembly.*

The dovetailed column ensures that accurate alignment with the workpiece is maintained as the head is moved up or down while the leadscrew drive mechanism provides precise control over the distance moved by the head, down to 0.001" increments. Therefore, the Z-axis handwheel may be used for precise control of the depth of milling cuts.

Head Locking Lever

Head Locking Lever

On the left side of the column, the Head Locking Lever clamps the head securely to the column so that the position of the head assembly does not shift during cutting operations.

The locking lever should always be firmly tightened before any milling operation. While it is not necessary to lock the head for most drilling operations, it will provide extra stability and accuracy when drilling larger sized holes in tough materials.

For convenience, the rotational position of the lever arm may be adjusted. First tighten the locking lever, then pull outwards (away from the column) on the lever and rotate it to the desired position, then release the lever.

Spindle Operating Controls

The smooth metal cylinder visible between the head assembly and the motor drive assembly is the spindle, also known as the quill. The quill can be moved up and down to control the depth of drilling or milling operations independently of moving the head up or down the column.

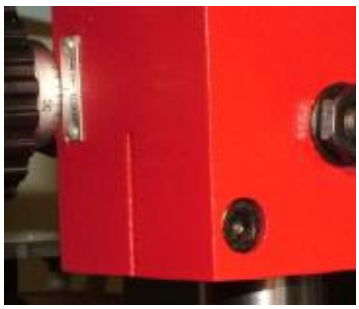
Quill Feed Handle

Quill Feed Handle

As on a drill press, the spindle can be moved up and down by means of the Quill Feed Handle, also known as the downfeed handle or downfeed. This mechanism provides accurate control of feed rates and depths when drilling and allows considerable force to be applied for drilling through steel and other tough materials. The quill feed handle is not normally used for milling operations.

A depth stop calibrated in divisions of 0.050" surrounds the shaft of the handle for drilling multiple holes to the same depth. To set the depth stop, first loosen the locking screw with a 4mm hex wrench. Rotate the quill handle until the drill bit is at the desired depth. Holding the quill handle in position, rotate the depth stop ring until the zero mark aligns with the index mark affixed to the mill head, then tighten the locking screw. Let the quill feed handle rotate back to its starting point.

Quill Lock Screw



Quill Lock Screw

During milling operations, maximum rigidity of the quill must be maintained to ensure a clean and accurate milling cut. Therefore, when milling, it is good practice to extend the quill no more than necessary and to lock it in position before beginning the cut.

Located near the front right corner of the head, the Quill Lock Screw can be tightened using a 6mm hex wrench. This screw should always be locked during milling operations to minimize any vibration or motion of the quill.

Quill Fine Feed Selector

Quill Fine Feed Selector

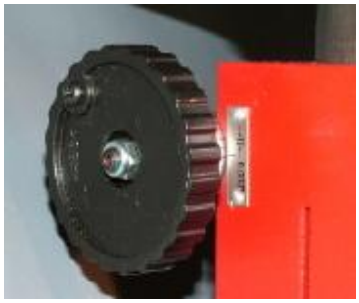
Often it is more convenient to adjust the depth of a milling cut by moving the quill rather than by moving the entire head assembly up or down the column.

Located on the left side of the head, the fine feed selector switches control of the quill movement from the downfeed lever to the quill fine feed knob located on the front of the head.

When the fine feed selector is pulled outwards, quill movement is controlled by the downfeed handle; when pressed inwards quill movement is controlled by the fine feed knob.

When pressing the knob inwards, it may be necessary to simultaneously rotate the quill fine feed knob so that the gears properly mesh. When pulling the knob outwards, first apply light pressure to the quill feed handle to relieve spring pressure. Maintain control of the handle so that it does not snap around.

Quill Fine Feed Knob



Quill Fine Feed Knob

When the fine feed selector is pressed inwards, the quill is moved up or down by turning the fine feed knob on the front of the head.

A calibrated collar on the fine feed knob measures the motion of the quill in units of 0.002" per division. Note that a reading of 10 on the dial represents 10 divisions, or 0.020". One full rotation is 35 divisions, or 0.070".

The collar may be set to zero by holding the fine feed knob steady while rotating the collar until the zero setting lines up with the index mark. If the collar does not turn freely, loosen the feed knob and place a drop of light oil on the shaft. Work the collar back and forth until it rotates without binding, then tighten the screw.

After setting the desired depth, the quill locking screw should be locked to provide maximum rigidity while making the milling cut and to ensure that the depth setting does not change due to vibration and cutting forces.

High-Low Range Selector

High-Low Range Selector

To maintain maximum torque at all cutting speeds, a set of gears inside the head may be shifted between high range (**H**) and low range (**L**). The range selector knob is located on the left side of the head, to the right of the electronic control panel.

***Caution**: The range selector should never be moved while the spindle is rotating. Allow the spindle to come to a complete stop before moving the range selector knob. Moving the knob while the spindle is in motion could damage the internal gears.*

To change gear ranges, from **H** to **L**, twist the knob clockwise until it clicks into a detent position. In order for the internal gears to mesh, it may be necessary to rotate the spindle by hand while maintaining firm pressure on the selector knob. Rotate the knob counterclockwise the shift from **L** to **H**.

Before starting the motor, rotate the spindle a few turns by hand to make sure that it turns smoothly. Turn the motor on to a low speed setting and make sure that no unusual sounds are heard. If any are heard, switch off the speed control knob and rework the H-L selector knob until the gears are properly engaged.

Spindle Disengagement Knob

The large silver knob to the right of the Emergency Stop button on the lathe engages and disengages the lathe spindle from the motor drive while still allowing the leadscrew to turn and move the carriage under power from the gear train.

Spindle Disengagement Knob

When using the mill-drill, the lathe spindle should be disengaged for safety so that the rotating chuck does not pose a hazard.

With the lathe stopped, turn the knob to the right about ¼ turn to disengage the spindle. To re-engage the spindle, rotate the knob to the left while also turning the lathe chuck by hand to allow the gears inside the head to mesh.

***Caution**: The knob should not be moved while the motor is running.*

Tilting Column Feature

For milling or drilling at an angle to the top surface of a workpiece, the column may be rotated up to 45° left or right.

The following steps outline the procedure for tilting the head.

1. Four cap head screws on the back of the column lock the column in position. Use a 6mm hex wrench to loosen the two side screws and the bottom screw.

   ***Caution**: After the screw is loosened in the next step, the column can fall to either side. Maintain firm control of the top of the column so that it does not fall.*

2. While grasping the top of the column securely with one hand, loosen the remaining cap screw.
3. Using the protractor scale attached to the column as a guide, tilt the head to the desired angle.
4. Tighten the top cap screw securely to hold the column at the set angle.
5. Firmly tighten the remaining three cap screws.

After returning the column to a vertical orientation, it is good practice to check the alignment using a machinist's square. A strip of white paper behind the blade of the square makes it easier to see any gaps. A dial indicator will provide even more accurate alignment.

Initial Checkout

Before the mill-drill is used for any machining operations, it should be checked for proper operation.

1. Make sure that the work area around the mill-drill spindle is clear of any tools, rags or other objects that could pose a safety hazard.
2. If the chuck is installed in the spindle, ensure that it is tightly secured by the drawbar and that the chuck key has been removed.
3. Verify that the speed control knob on the mill head is rotated fully counterclockwise until the click of the switch can be heard.
4. Verify that the HI-LO knob is rotated to the **L** position.
5. Turn on the main power switch to the lathe.
6. Turn the Forward-Reverse switch to the **F** position. The green pilot lamp should illuminate.
7. Turn the speed control knob clockwise. Gradually increase the spindle speed from slow to high speed and back to slow speed again to verify that the speed control is functioning properly and that the spindle turns freely.
8. Turn speed control knob to the Off position.
9. Rotate the HI-LO knob to the **H** position.
10. Repeat steps 7 and 8.

If any unusual noises or other unexpected events occur, contact ***Travers Technical Support*** for assistance.

Technical Support
(1-**800-234-9985**, press **4**)
Fax: 718-661-5637
Email: tech@travers.com

Tooling and Accessories

Several basic accessories are recommended for routine operation of the mill-drill.

Securing Work to the Table

When working with the mill-drill, the workpiece may be held in a milling vise, a specialized holder such as a rotary table or may be clamped directly to the surface of the table. Care must be taken that both the workpiece and the holding device(s) are secured by bolts and T-nuts so that they do not move due to the cutting force of the mill.

For convenience in positioning work anywhere on the table surface, slots run the length of the table to be used with T-nuts. T-nuts are special nuts, with a cross-section in the shape of the letter 'T' that can be positioned along the slots.

T-nut

When using T-nuts to secure a workpiece or holding device to the table, the T-nut bolt must not extend past the bottom of the T-nut or it may apply force to the table casting as it is tightened and crack the T-slot.

Avoid using excessive force when tightening T-nuts; use just enough force to securely hold the work in place against the cutting forces of the mill.

Milling Vise

A milling vise provides a quick and convenient means to hold a workpiece for milling and drilling operations. A good-quality milling vise has work-holding surfaces that are parallel and square and that can withstand the horizontal and vertical forces imposed by the milling cutter on the workpiece. The milling vise pictured below is a good fit for the SC4 mill-drill.

Milling Vise

Item # 61-420-000

Depending on the size of the milling vise in use, as well as the method used to clamp the vise to the cross-slide, the fixed jaw of the vise may be aligned either with the X- or Y- axis of the lathe; whichever is most convenient for the configuration of the vise and the milling or drilling operation to be performed.

To ensure that the surfaces of the workpiece will be machined square to each other, the fixed jaw of the milling vise must be aligned with either the X- or Y-axis of the lathe. The alignment usually is done either using a machinist's square or by running the tip of a dial test indicator across the fixed jaw of the vise and adjusting the alignment of the vise until there is no deflection of the indicator as the vise is moved along the X- or Y- axis of the lathe.

After the vise is properly aligned, it must be securely clamped to the cross-slide using the T-slots and T-nuts or T-bolts. While the nuts or bolts should be firmly tightened and secure, over-tightening them with excessive torque could crack the T-slots in the cross-slide table.

Parallels

Parallels are used in matching pairs to support work when clamping it in a milling vise. They serve to raise the top surface of the workpiece above the top edges of the milling vise jaws so

that the milling cutter will not strike the vise jaws.

Set of parallels

Item # 57-101-500

Drill Sets

The mill-drill has a #2 Morse Taper (MT) spindle. A Jacobs-type adjustable drill chuck with a #2 MT arbor is included with the mill-drill. The maximum drill diameter that can be held by the chuck is approximately 3/8" or 10 mm.

Drill sets in inch, metric and number and letter sizes will provide a great range of capabilities when using the mill as a precision drill press.

End Mills

End mills usually are the most commonly used cutting tools for milling operations. End mills are available in a wide range of sizes, configurations and materials specialized for different types of work.

End mills may be held either in properly sized #2 Morse Taper collets or #2 Morse Taper end mill holders. Due to the limited space between the spindle and the milling vise, collets are recommended for holding end mills with the mill-drill.

Collets may be purchased individually in sizes corresponding to the shank sizes of the end mills you will be using, or may be purchased in sets that will accept a range of end mill shank sizes. For the mill-drill, collet sizes from 1/8" up to ½" are useful. A ½" collet can hold a 9/16" end mill that has a ½" shank.

Collets

Collets are used to hold end mills in the tapered spindle. The mill-drill has a #2 Morse Taper spindle and can accommodate up to a ½" diameter collet. A pair of collets with bores of 3/8" and ½" will accommodate end mills with cutting diameters from 3/16" up to 9/16".

#2 MT Collets

Eye Protection

Milling machines produce hot and sharp metal chips that can fly out from the cutting area at high speed to a distance of 24 inches or more. Always wear appropriate industrial-quality safety glasses or face shields when operating the mill. Safety shields attached to the machine or held by a magnetic base may also be used together with eye protection for additional safety.

Safety glasses

Item # 96-085-300

Face shield

Item # 97-000-794

Safety shield

Item # 99-003-525

Basic Drilling and Milling Operations

The following procedures describe typical sequences for setting up a workpiece for basic drilling and milling operations. Before operating the mill, please review the safety checks below.

Safety Checks

Before beginning any cutting operation:

- Check to make sure that the milling vise, or other work-holding clamps, are securely tightened and are supported by a solid area of the cross-slide table.
- Be sure that the work is securely fastened to the table by a vise or clamping devices.
- Verify that the tool and tool holders are secure and tight before starting the spindle.
- Clear the work area of any objects that could cause you trip or slip; also any tools or other objects on or near the mill table that are not required for the current operation.
- Avoid loose sleeves or loosely fitting shirts that could become entangled in rotating parts. Remove or secure necklaces and other jewelry. Tie back long hair to avoid getting it entangled in rotating machinery.
- Be careful when removing work that has just been machined. Both the work and the tool used to cut it may be very hot from the frictional forces of cutting and may have sharp edges.
- Use recommended cutting fluids to reduce the force required by the cutting tool. This will help keep the tool cooler and increase its life, and will make it less likely that chips will weld to the tool or workpiece causing rough surface finishes.

Drilling Operations

1. Turn on the main power switch to the lathe.
2. Verify that the speed control knob on the mill head is rotated fully counterclockwise until the click of the switch can be heard.
3. Verify that the HI-LO knob is rotated to the **H** position.
4. Raise the head to provide enough clearance to set up a vise on the table. Make sure that the head is raised high enough to provide clearance for the drill chuck and drill bit above the top surface of the workpiece.
5. Mount a milling vise on the table. Use a machinist's square or dial test indicator to align the fixed jaw of the vise parallel to the table. Use T-nuts and bolts to secure the vise to the table. Ensure that the bolts are secure but not overly tight.
6. Position the workpiece in the vise. Support the workpiece on parallels, if necessary, to raise the work surface to a convenient height above the vise jaws.
7. Firmly tighten the workpiece in the vise. Check to make sure that the workpiece cannot be moved.
8. If the workpiece will be drilled all the way through, verify that the drill bit will not hit the parallels or the base of the vise below the workpiece. Remove the parallels, if necessary, while keeping the workpiece tightly clamped in the vise.
9. Install a drill chuck in the spindle. Tighten the drawbar firmly, but not overly tight.
10. Insert the drill bit into the chuck and tighten the chuck using the chuck key. It is good practice to tighten the chuck at two or all three chuck key positions to ensure that the drill is tightly secured in the chuck.
11. If necessary, lower the head on the column using the Z-axis handwheel until the tip of the drill bit is about ¼" to ½" above the workpiece. Use the Z-axis lock to lock the head in position on the column.
12. Use the carriage and cross-slide handwheels to position the workpiece below tip of the drill bit at the location where the hole is to be drilled. It is good practice to mark this point on the workpiece in advance using a center punch. The depression formed by the center punch will help to keep the drill tip from wandering when the hole is started.
13. Check to make sure that the spindle lock is unlocked.
14. Rotate the Forward-Reverse knob to the Forward (**F**) position.
15. Rotate the speed control knob clockwise about ½ turn.
16. Use the quill downfeed handle to advance the drill into the workpiece. If the hole will be deeper than 2 to 3 times the diameter of the drill bit, back the drill bit out frequently to clear chips from the hole, then advance the drill to continue drilling until the hole is at the desired depth.
17. When the hole has been drilled to the desired depth, rotate the speed control knob fully counterclockwise until a click is heard or felt. Keep clear of the cutting tool until the spindle has come to a complete stop.

Milling Operations

There are many different cutting operations that use an end mill, such as milling a slot, surfacing a workpiece, milling a shoulder or milling a pocket. In this section two basic milling operations: surfacing and cutting a slot will be performed.

Inserting and Removing End Mills

When in use, the tapered end of the collet must be held tightly in the spindle taper by the drawbar provided with the mill-drill.

1. Grip the plastic safety cap on top of the mill-drill head and twist it to remove it.

2. Use a shop rag to clean off any chips or grit from the inside surface of the spindle taper and the taper of the collet.

3. Insert the collet fully into the spindle.

4. While holding the collet in the spindle, screw the drawbar by hand all the way into the top of the collet.

5. Slide the shank of the end mill into the collet. Use a twisting motion if necessary.

   ***Caution**: the shank of the end mill must be of the proper size for the collet. Collets should not be compressed or expanded to attempt to hold an improperly sized tool.*

6. While holding the spindle in place with the spindle retaining tool, tighten the drawbar snugly, but not overly tight, using a wrench. Only a moderate amount of tightening force is needed to secure the drawbar.

To remove a tool from the spindle, hold the spindle with the retaining tool and loosen the drawbar using a wrench, reversing the process used to tighten it.

Keep one hand under the cutting tool to prevent it from dropping onto the lathe. To avoid being cut by the sharp edges of cutting tools, hold the tool in a shop rag or leather glove.

While loosening the drawbar may be enough to cause the tool to drop loose from the collet, typically a light tap on the top of the drawbar from a brass or lead hammer is needed to break the grip that binds the two tapered surfaces together.

Milling a Surface

This exercise demonstrates a surfacing operation. Surfacing forms a flat and even surface on a workpiece which is rough from being cut on a bandsaw or hacksaw.

Since the surface of the workpiece often is several times wider than the diameter of the end mill, a succession of shallow parallel cuts is made until the entire surface is smooth and even. The workpiece is then flipped over and the opposite side is similarly surfaced until, if needed, all six sides have been completed.

Set Up for Surfacing

***Note**: The following exercise assumes that the surface of the workpiece has been cut by a bandsaw or hacksaw and is rough, but with no large projections or other obstacles to the cutting tool.*

The following sequence of steps sets up the mill and the workpiece to begin the surfacing operation.

1. Verify that the Forward-Reverse switch to the mill-drill is in the zero “0” off position.
2. Raise the head to provide enough clearance to set up a vise on the table. Make sure that the head is raised high enough to provide clearance for the milling tool holder and end mill above the top surface of the workpiece.

3. Mount a milling vise on the table. Use a machinist's square or dial test indicator to align the fixed jaw of the vise parallel to the table. Use T-nuts and bolts to secure the vise to the table. Ensure that the bolts are secure but not overly tight.
4. Position the workpiece in the vise so that the part to be milled is about ¼" above the top of the vise jaws. Support the workpiece on parallels if necessary.
5. Firmly tighten the workpiece in the vise. Check to make sure that the workpiece cannot be moved.
6. Select a ½" diameter collet and a ½" diameter end mill to be used for this exercise.
7. Insert the collet into the spindle and engage the drawbar threads into the upper end of the collet. Turn the head of the drawbar several turns but leave the collet open so that the end mill can be inserted.
8. Insert the end mill shank into the collet, then, while holding the spindle in place using the spindle retaining tool, fully tighten the drawbar to secure the end mill.
9. For maximum rigidity during milling operations it is good practice to keep the spindle locked in the fully retracted position and use the Z-axis handwheel to lower the head to control the depth of cut. However, it is sometimes more convenient to lock the head to the column and lower the spindle to control the depth of cut if heavy cuts are not required. For this exercise, we will lock the head and lower the spindle.
10. With the spindle fully retracted, lower the head on the column using the Z-axis handwheel until the tip of the end mill is about ½" above the workpiece. Use the Z-axis locking lever to lock the head in position on the column.
11. Use the carriage and cross-slide handwheels to position the workpiece so that the front left corner is below the tip of the end mill.
12. Check to make sure that the spindle lock is unlocked.
13. Engage the spindle fine-feed selector in the fine-feed position.
14. Rotate the spindle depth handwheel (the black knob on the front of the head) clockwise until the tip of the end mill just touches the surface of the workpiece.
15. Rotate the graduated collar on the spindle depth handwheel to set it to zero. This will be the reference for measuring the depth of the cut.
16. Back off the spindle depth handwheel about ½ turn so that the tip of the end mill is clear of the workpiece.
17. Rotate the cross-slide handwheel until the tip of the end mill is clear of the front side of the workpiece.
18. Rotate the spindle depth handwheel clockwise while observing the graduated collar. Set the cutting depth to 5 divisions (0.010").
19. Rotate the spindle locking screw clockwise until snug to lock the spindle.

Surfacing Operation

With the workpiece and cutting tool now properly positioned, the following steps will perform the surfacing operation.

Surfacing Operation

1. Turn the Forward-Reverse switch to the **F** position.

2. Rotate the speed control knob fully clockwise to set the spindle speed to about 1000 RPM.
3. Rotate the cross-slide handwheel counterclockwise to move the table towards the operator, advancing the front edge of the workpiece towards the cutting tool.
4. Continue rotating the cross-slide handwheel clockwise until the cutting tool moves all the way past the rear edge of the workpiece.
5. Rotate the carriage handwheel counterclockwise to move the table and workpiece to the left, towards the headstock. Position the workpiece so that the start of the next cut (towards the operator) overlaps the previous cut by a small amount.
6. Rotate the cross-slide handwheel clockwise to move the cutting tool away from the operator. Continue until the cutting tool is clear of the workpiece.
7. Repeat the above steps until the entire surface of the workpiece has been surface.
8. Withdraw the cutting tool away from the workpiece.
9. Turn the F-R knob to the center “0” position. Keep clear of the spindle until it has come to a complete stop.

***Caution**: After milling, the workpiece will have sharp edges that can cut you.*

Remove the workpiece from the vise and use a file to clean up the sharp edges of the workpiece.

Run a finger gently over the machined surface of the workpiece. If ridges can be seen or felt, the column may not be exactly vertical, resulting in slight “wall” between each successive cutting pass. For best results, the column should be aligned using a dial indicator – a process called tramming. Consult technical reference manuals or the Internet for more information.

Milling a Slot

Setup for Slot Milling

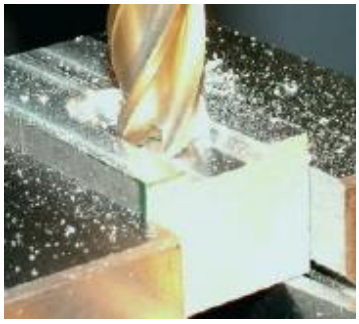
***Note**: The following exercise assumes that the surface of the workpiece has been cut by a bandsaw or hacksaw and is rough, but with no large projections or other obstacles to the cutting tool. If you are continuing from the surfacing exercise, the surface of your workpiece will already be reasonably smooth and even.*

The following sequence of steps sets up the mill and the workpiece to begin the slot milling operation.

1. Verify that the Forward-Reverse switch to the mill-drill is in the zero "0" off position.
2. Raise the head to provide enough clearance to set up a vise on the table. Make sure that the head is raised high enough to provide clearance for the milling tool holder and end mill above the top surface of the workpiece.
3. Mount a milling vise on the table. Use a machinist's square or dial test indicator to align the fixed jaw of the vise parallel to the table. Use T-nuts and bolts to secure the vise to the table. Ensure that the bolts are secure but not overly tight.
4. Position the workpiece in the vise so that the part to be milled is about ¼" above the top of the vise jaws. Support the workpiece on parallels if necessary.
5. Firmly tighten the workpiece in the vise. Check to make sure that the workpiece cannot be moved.
6. Select a ½" diameter collet and a ½" diameter end mill to be used for this exercise.
7. Insert the collet into the spindle and engage the drawbar threads into the upper end of the collet. Turn the head of the drawbar several turns but leave the collet open so that the end mill can be inserted.
8. Insert the end mill shank into the collet, then, while holding the spindle in place using the spindle retaining tool, fully tighten the drawbar to secure the end mill in the collet.
9. For maximum rigidity during milling operations it is good practice to keep the spindle locked in the fully retracted position and use the Z-axis handwheel to lower the head to control the depth of cut. However, it is sometimes more convenient to lock the head to the column and lower the spindle to control the depth of cut if heavy cuts are not required. For this exercise, we will lock the head and lower the spindle.
10. With the spindle fully retracted, lower the head on the column using the Z-axis handwheel until the tip of the end mill is about ½" above the workpiece. Use the Z-axis locking lever to lock the head in position on the column.
11. Use the carriage and cross-slide handwheels to position the workpiece so that the front left corner is below the tip of the end mill.
12. Check to make sure that the spindle lock is unlocked.
13. Engage the spindle fine-feed selector in the fine-feed position.
14. Rotate the spindle depth handwheel (the black knob on the front of the head) clockwise until the tip of the end mill just touches the surface of the workpiece.
15. Rotate the graduated collar on the spindle depth handwheel to set it to zero. This will be the reference for measuring the depth of the cut.
16. Back off the spindle depth handwheel about ½ turn so that the tip of the end mill is clear of the workpiece.

17. Rotate the cross-slide handwheel until the tip of the end mill is clear of the front side of the workpiece.
18. Use the carriage handwheel to position the workpiece so that the end mill is approximately centered on the front edge of the workpiece.

Cutting the Slot



The following steps will mill a slot ½" wide by 0.100" deep using a series of five passes to avoid overloading the cutting capacity of the mill.

1. Rotate the spindle depth handwheel clockwise while observing the graduated collar. Set the cutting depth to 10 divisions (0.020").
2. Rotate the spindle locking screw clockwise until snug to lock the spindle.
3. Rotate the speed control knob fully clockwise to set the spindle speed to about 1000 RPM.
4. Slowly rotate the cross-slide handwheel counterclockwise to move the table towards the operator.
5. Continue rotating the cross-slide handwheel until the slot has been cut to a length of approximately one inch (for this exercise the length of the slot is not important.)
6. Now rotate the cross-slide handwheel in the opposite direction to move the table and workpiece away from the operator, thus retracing the slot that was just cut. Continue until the tip of the cutting tool is completely clear of the workpiece.
7. Unlock the spindle lock, then use the spindle fine-feed handwheel to lower the cutting tool tip by another 10 divisions.
8. Lock the spindle.
9. Repeat steps 4-8, increasing the cutting depth by 0.020 on each successive pass until five passes have been made.
10. Withdraw the cutting tool away from the workpiece.
11. Rotate the spindle speed control knob fully counterclockwise until it clicks into the off position. Keep clear of the cutting tool until the spindle has come to a complete stop.

This concludes the slot cutting exercise.