



MANUFACTURING SG9A

Automatic Seat and Guide Machine

Serial No.: _____

Company: _____

OPERATIONS AND MAINTENANCE MANUAL



MANUFACTURED BY:

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NOTE: WHEN ORDERING REPLACEMENT PARTS,
PLEASE GIVE THE MODEL AND SERIAL NUMBER.

ORDER BY PART NUMBER.

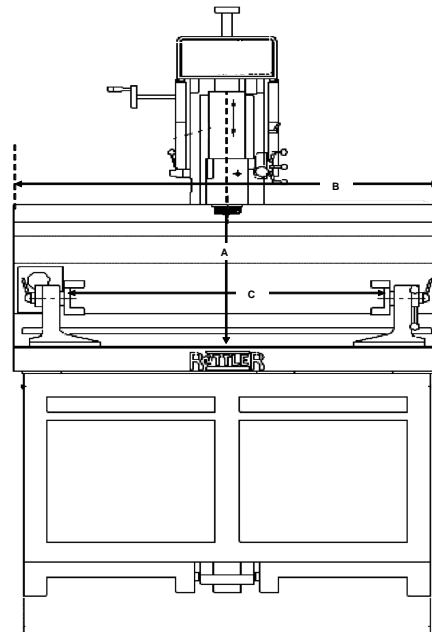
THERE IS A MINIMUM ORDER OF \$25.00

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Chapter 1 SG9A Seat and Guide Machine Specification



Spindle diameter	3.150" 80mm
Maximum Spindle Stroke	8" 203mm
Maximum Tilt (either side of zero)	15 degrees
Distance from Table to Spindle	19.5" 495mm
Maximum Cylinder Head Length (with 360° rolover fixture)	44" 1118mm
Maximum Cylinder Head Length (with diesel fixture)	50" 1270mm
Spindle Speed	40 to 400 rpm
Electrical Requirements	208/220 volt, single phase, 15 amp
Air Requirements	90/100 psi / 6 Bar
Spindle Motor	1 HP/.75 kW
Machine Dimensions	53" Wide x 25" Deep x 80" High 1346mm x 635mm x 2032mm
Working Dimensions	84" wide x 42" deep x 80" high 2134mm x 1067mm x 2032mm
Shipping Dimensions	61" wide x 25" deep x 75" high 1549mm x 635mm x 1905mm
Shipping Weight	2800 Lbs. 1258Kg.

Note: Rottler reserves the rights to change any specifications and over all product design with out any notice

Standard Equipment Shipped with SG9A

- Air float work head and pedal control
- Universal heavy duty 360 degree rolover fixture for cylinder heads
- Flexible compact halogen work light mounted on work head
- Rottler Automatic tightening spindle lock nut system
- 2 piece frame kit allows mounting of overhead camshaft and difficult to mount cylinder heads
- Fine feed for precision spindle movement
- +/-15 degree work head tilt
- Digital display rpm
- Tool Storage Cabinet (3 drawer)
- Digital Electronic Level
- Dial gage for depth control of spindle travel
- Hex key set
- Built in Vacuum Tester

Chapter 2 Introduction / Safety / Installation:

Introduction:

This manual is arranged into sections as listed in the table of contents.

It is required that the new user of the SG9A read this manual, in particular the sections concerning safety, before operating the machine.

The Controls Definition and Operating Instructions chapters should be read very carefully in order to familiarize the user with the actual button pushing sequences required to carry out a job. These chapters in the manual should be considered an introduction.

Limited Warranty:

Rottler Manufacturing Company Model **SG9A** parts and equipment is warranted as to materials and workmanship. This limited warranty remains in effect for one year from the date of delivery, provided the machine is owned and operated by the original purchaser and is operated and maintained as per the instructions in the manual.

Tools proven to be defective within the warranty period will be repaired or replaced at the factory's option.

The products are warranted upon delivery to conform to their published specifications and to be free from defects in material and workmanship under normal use for a period of one year from shipment. Should a product not be as warranted, Rottler sole obligation shall be, at its option, to repair, correct or replace the product or to refund the amounts paid for the Product upon its return to a location designated by Rottler. No warranty shall extend to rapid wear Products (including tooling) or to Products which have been subject to misuse (including any use contrary to Rottler instructions), neglect, accident (including during shipment), improper handling or installation, or subject to any modification, repair or service not certified by Rottler. Rottler shall not be liable for any consequential, direct or indirect damages or for any other injury or loss. Buyer waives any right, beyond the foregoing warranty, to make a claim against Rottler. No warranty is provided for any Products not paid in full.

Merchandise cannot be returned to Rottler without prior approval. Customer must contact the Order Department or representative to get approval and to be issued a Return Goods Authorization number (**RGA #**). Merchandise authorized for return must be returned prepaid. If merchandise is returned with shipping charges collect, the actual amount of these charges may be deducted from any credit which may be due the customer. The RGA # assigned by the Order Department should be written on the shipping label and must appear on a copy of the invoice(s) covering the original shipment. This invoice copy must be included in the box with the parts. Shipment must contain **ONLY** those items on the **RGA** as approved for return. Merchandise must be received within 10 days of the date of **RGA** or the **RGA** will be canceled. All returned merchandise may be subject to a 20% restocking fee on under \$10,000.00 amount or 10% on any items over \$10,000.00. Parts or tooling over 30 days old are considered as customer property and can only be returned with prior written approval from Rottler Corporation Management and/or Shipping Department.

The issuance of a **RGA DOES NOT** guarantee credit - it is only authorization for the return of the goods. Credit for return merchandise is at the sole discretion of Rottler. Credit will be issued only after inspection of returned goods.

Tools proven to be defective within the warranty period will be repaired or replaced at the factory's option.

We accept no responsibility for defects caused by external damage, wear, abuse, or misuse, nor do we accept any obligation to provide compensation for direct or indirect costs in connection with cases covered by the warranty.

Freight charges on warranty items (non-air shipment only) will be paid by Rottler Manufacturing for a period of 60 days only from the date of installation or set-up by a qualified service technician or sales representative.

Freight charges after the 60 day period are the customer's responsibility.

Safety Information :



For Your Own Safety Read This Instruction Manual Before Operating This Machine.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.



DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.



CAUTION used without the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in property damage.



This machine is capable of causing severe bodily injury.

Safety Instructions for Machine Use

KEEP GUARDS IN PLACE and in proper working order.

KEEP WORK AREA CLEAN. Cluttered areas and benches invite accidents.

KEEP CHILDREN AND VISITORS AWAY. All children and visitors should be kept a safe distance from work area.

WEAR THE PROPER APPAREL. DO NOT wear loose clothing, gloves, rings, bracelets, or other jewelry which may get caught in moving parts. Non-Slip foot wear is recommended. Wear protective hair covering to contain long hair.

ALWAYS USE SAFETY GLASSES. Also use face or dust mask if cutting operation is dusty. Everyday eye glasses only have impact resistant lenses, they are NOT safety glasses.

DO NOT OVER-REACH. Keep proper footing and balance at all times.

USE THE RECOMMENDED ACCESSORIES. Consult the manual for recommended accessories. The use of improper accessories may cause risk of injury.

CHECK DAMAGED PARTS. Before further use of the machine, a guard or other part that is damaged should be checked to determine that it will operate properly and perform its intended function. Check for alignment of moving parts, breakage of parts, mounting, and other conditions that may affect its operation. A guard or other part that is damaged should be properly repaired or replaced.

NEVER OPERATE A MACHINE WHEN TIRED, OR UNDER THE INFLUENCE OF DRUGS OR ALCOHOL. Full mental alertness is required at all times when running a machine.

NEVER ALLOW UNSUPERVISED OR UNTRAINED PERSONNEL TO OPERATE THE MACHINE. Make sure any instructions you give in regards to machine operation are approved, correct, safe, and clearly understood.

IF AT ANY TIME YOU ARE EXPERIENCING DIFFICULTIES performing the intended operation, stop using the machine! Then contact our service department or ask a qualified expert how the operation should be performed.

CAUTION No list of safety guidelines can be complete. Every shop environment is different. Always consider safety first, as it applies to your individual working conditions. Use this and other machinery with caution and respect. Failure to follow guidelines could result in serious personal injury, damage to equipment or poor work results.

Electrical Power:



All electrical power should be removed from the machine before opening the rear electrical enclosure. It is recommended that the machine have a electrical LOCK-OUT device installed.

Make sure all electrical equipment has the proper electrical overload protection.

In the event of an electrical short, grounding reduces the risk of electric shock by providing a path of least resistance to disperse electric current.



Electrocution or a fire can result if the machine is not grounded correctly. Make sure the ground is connected in accordance with this manual. **DO NOT** operate the machine if it is not grounded.

CAUTION No single list of electrical guidelines can be comprehensive for all shop environments. Operating this machinery may require additional electrical upgrades specific to your shop environment. It is your responsibility to make sure your electrical system comply with all local codes and ordinances.

CAUTION When you doing any operation on the cylinder head; the machine is capable of throwing metal chips. Eye protection must be worn at all times by the operator and all other personnel in the area of the machine.



The operator and nearby personnel should be familiar with the location and operation of the Emergency Stop Button.

Make sure all electrical equipment has the proper overload protection. The **SG9A** should have **a fully isolated** power supply to prevent damage and uncontrolled movement of the machine. If the SG9A is on the same power lines that are running to other electrical equipment (grinders, welders, and other AC motors) electrical noise can be induced into the SG9A electrical system. Electrical noise can cause the controller to see false signals to move. Not supplying a fully isolated supply to the machine may void factory warranty. Refer to the Power supply section later in this chapter for voltage and amperage requirements of the **SG9A**.

Machine Operator:

The operator of the **SG9A** should be a skilled machinist craftsman who is well versed in the caution, care, and knowledge required to safely operate metal cutting tools.

If the operator is not a skilled machinist he/she must pay strict attention to the Operating Instructions outlined in this manual, and get instruction from a qualified machinist in both production and operation of this machine.

The **SG9A** machines have the following areas of exposed moving parts that you must train yourself to respect and stay away from when they are in motion:



Cutting Tool Area – Any operation involving hands in the tool holder, such as inspection or alignment of the tool holder or tools, changing tool holder or insert holders, tool insertion, and removal, tool holder changes, and size checking etc. requires the machine to be in neutral or on the off position.

CAUTION

Machining – Eye protection must be worn during all operations of the machine. Hands must be kept completely away from the cutter head.

CAUTION

Work Loading and Unloading – Carefully develop handling methods of loading and unloading work pieces so that no injury can result if hoist equipment or lift connection should fail. Periodically check lift components for damage that may cause failure of Cylinder head Handler Assembly.

CAUTION

Machine Maintenance – Any machine adjustment, maintenance or parts replacement absolutely requires a complete power disconnection from the machine, **this is an absolute rule.**

Emergency Procedure:

Assuming one of the following has occurred: tool bit set completely off size, work piece or spindle base not clamped, spindle is not properly centered, and these mistakes will become obvious the minute the cut starts

PRESS THE EMERGENCY STOP BUTTON (on the front control panel) IMMEDIATELY!

Find out what the problem is; return the spindle to its up position without causing more damage. To restart the machine, turn the Emergency Stop Button CW until the button pops out. Make sure the button has been depressed for at least 1 ½ minutes or the drive will not have time to reset and they will not function.

Be alert to quickly stop the machine in the event of a serious disruption of the boring process either at the top or bottom of the bores.

“REMEMBER” metal cutting tools have the speed and torque to severely injure any part of the human body exposed to them.

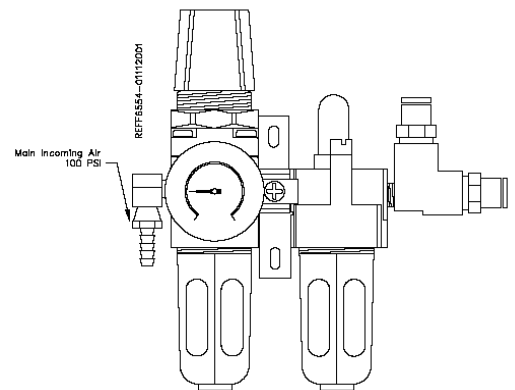
Air Supply:

It is very important the air source for the SG9A machine be moisture free. Water and oil in the line will result in early cylinder and valve failure. The factory recommends installing a water trap at the machine.

Attach a 100 P.S.I. air source to the appropriate intake in the small enclosure located on the left rear of the machine near the bottom.

Bellow you will se the Air regulator panel for the different settings on the flouting planes on the machine.

And cabinet cooler air regulator.



Air Adjustments:

Float:

The float regulator is located at the rear of the spindle base on the bottom of the interconnect box. If the machine is not floating properly, it could be from too much or too little air from the regulator. Turn the regulator all the way off (full counter clockwise).

Start turning the regulator slowly clockwise while continually checking the Work Head for proper floatation. Once the correct float is established, lock the regulator into place by pushing in on the blue adjusting knob.

CAUTION: Use as little air as possible to achieve correct floatation. Using too much air will could cause the spindle base to move slightly to the right when going into tilt. This will cause a scratch up the side of the cylinder.

Power Supply:

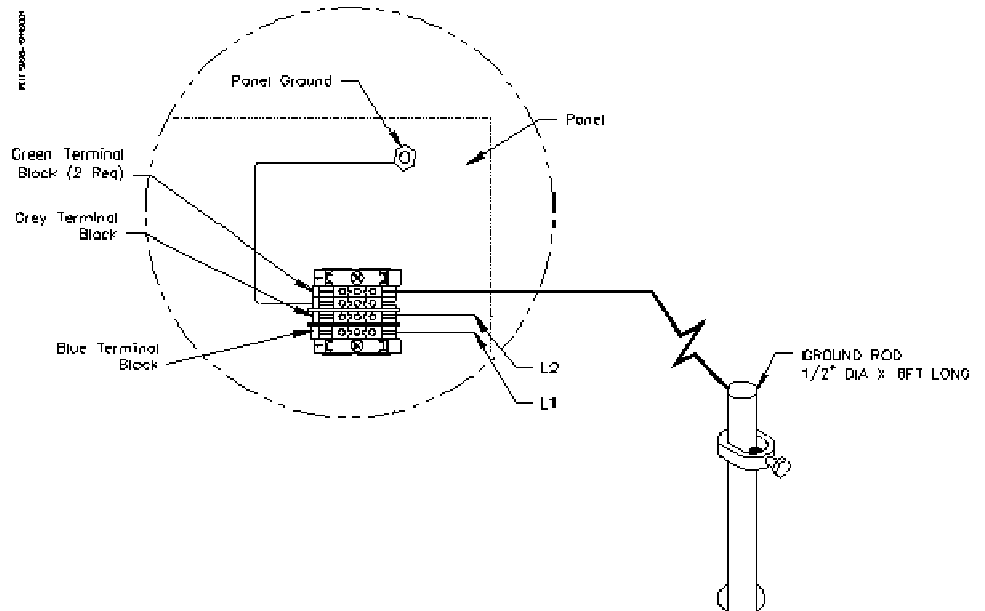
This machine has the following power requirements:
 208 to 240 VAC it shut not exceed 240 Volts
 Single Phase
 50 or 60 Hertz
 30 amps

See illustration below for correct connection of “measured” incoming power. connect single phase wiring to the main rear enclosure, located on the right rear of machine base. The connection point for power is located inside the enclosure. The connection termination point is located on the left hand side of the electrical panel about half way up. Connect L1 to the grey terminal block, L2 (neutral) to the blue terminal block. Attach wire from the grounding rod to the second green and yellow terminal.

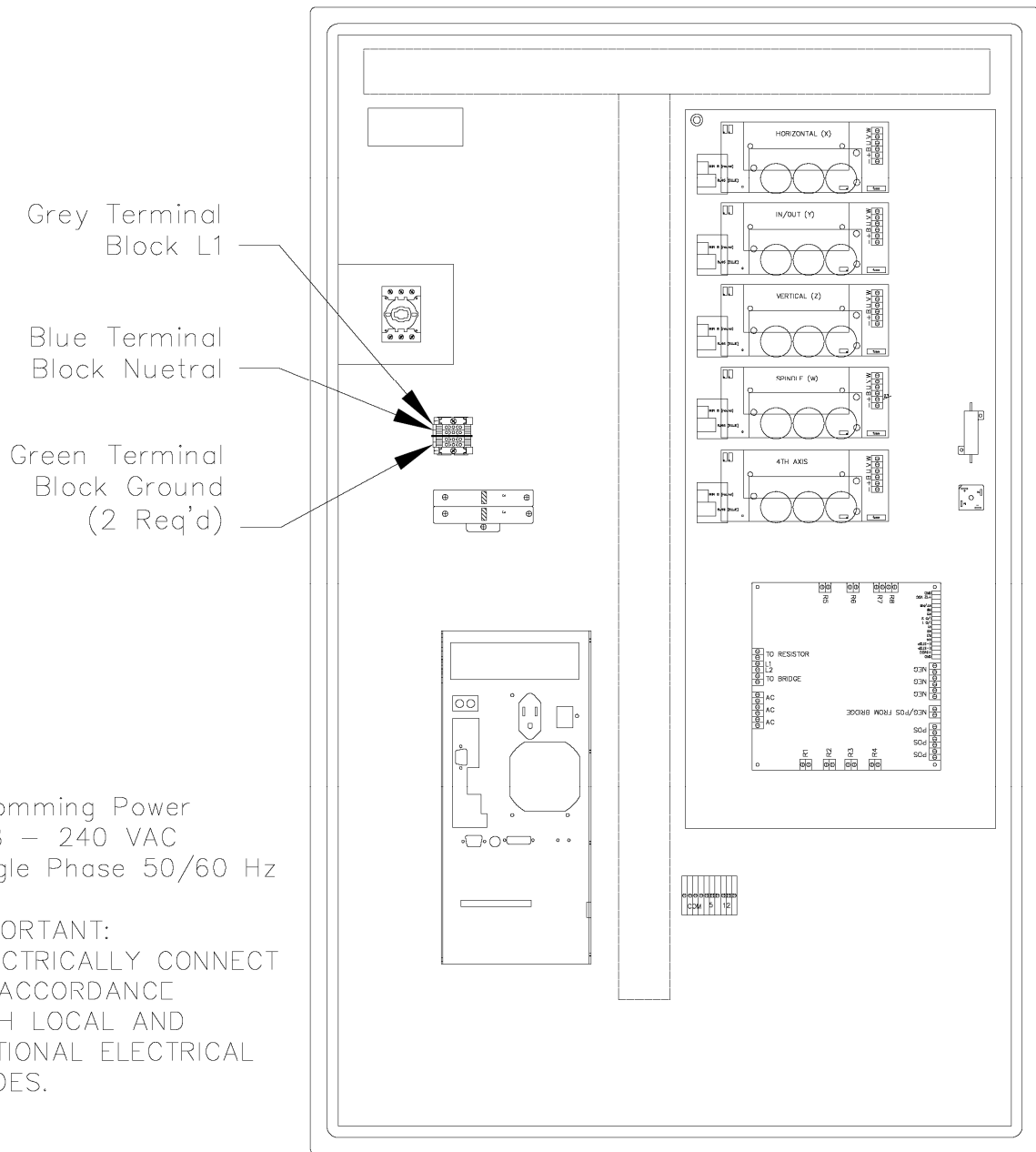
Important: Electrically connect in accordance with national and local electrical codes.

Grounding:

This machine must be connected to a good earth ground rod. A 6 foot, 1/2” diameter, 15 OHM, Copper grounding rod driven into the earth next to the machines is preferred. Not providing a grounding rod could void factory warranty.



Chapter 3 Electrical Enclosure:



Incomming Power
 208 – 240 VAC
 Single Phase 50/60 Hz

IMPORTANT:
 ELECTRICALLY CONNECT
 IN ACCORDANCE
 WITH LOCAL AND
 NATIONAL ELECTRICAL
 CODES.

REF67A01—01062005

Machine Capacity:

Do not attempt to use the machine beyond its stated capacity or operations. This type use will reduce the productive life of the machine and could cause the breakage of parts, which could result in personal injury.

Avoid Accidental Starting:

Make certain the main switch is in the **OFF** position before connecting power to the machine.

Careless Acts:

Give the work you are doing your undivided attention. Looking around, carrying on a conversation and horseplay are careless acts that can result in serious injury.

Job Completion:

If the operation is complete, the machine should be emptied and the work area cleaned.

Replacement Parts:

Use only Rottler replacement parts and accessories; otherwise, warranty will be null and void.

Misuse:

Do not use the machine for other than its intended use. If used for other purposes, Rottler Manufacturing disclaims any real or implied warranty and holds itself harmless for any injury or loss that may result from such use.

Placement:

Air supply is connected at the right, rear of the machine, at base of upper casting. Connection can either be a quick disconnect or permanent threaded connection. Be certain to use an adequately sized air line, permitting proper operation of float. Air pressure should never drop below 90 PSI at any time. Failure to provide adequate air supply may cause improper floating and clamping.

At this time, some customers will install a T fitting or manifold at the regulator, allowing another air hose to be connected, providing a connection point for air tools. The auxiliary hose, if fitted, should be of sufficient length to easily reach the entire front of the machine.

This machine comes pre-wired and ready to be connected to the power source. The power source should meet all local and national electrical codes. This service should connect to its own circuit breaker or fuse. In most cases the machine will require **220 VAC, 15 amp**, single-phase service but you should verify voltage requirements by inspecting the electrical tag located on the rear of the machine.

Chapter 4 Machine Installation

Location:

The productivity of this machine will depend a great deal on its proper initial installation, particularly the means by which cylinder heads are lifted into the machine as well as the material handling to and from other operations in your shop.

The proper loading arrangement and location for your SG9A machine is extremely important.

A slow travel (6 to 10 feet / min.) power hoist operated from either a bridge crane or a jib crane arrangement works very well.

Unpacking and Lifting:

Carefully uncrate the machine. Remove all tooling from storage compartments and unpack. Locate the leveling bolts and leveling pads. Clean all surfaces with solvent and rags to remove protective shipping coatings.

CAUTION

THIS MACHINE IS TOP-HEAVY. Use care when lifting and moving Machine. Approximate shipping Weight of Machine is 2800 lbs. (1258 kg).

Positioning the Machine:

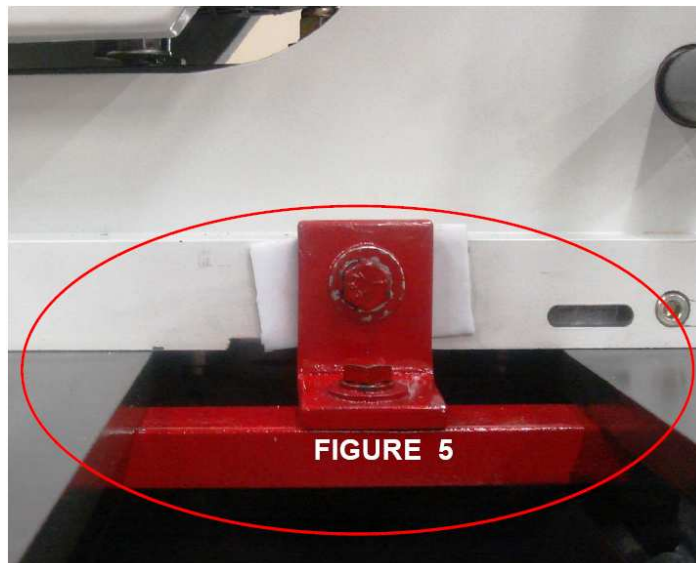
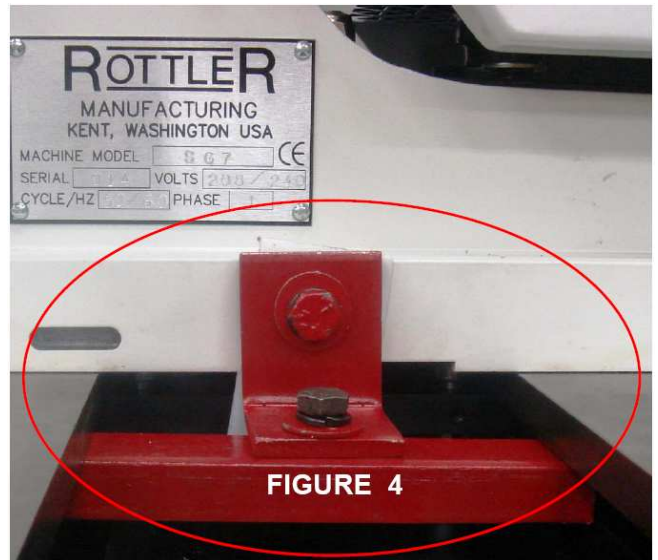
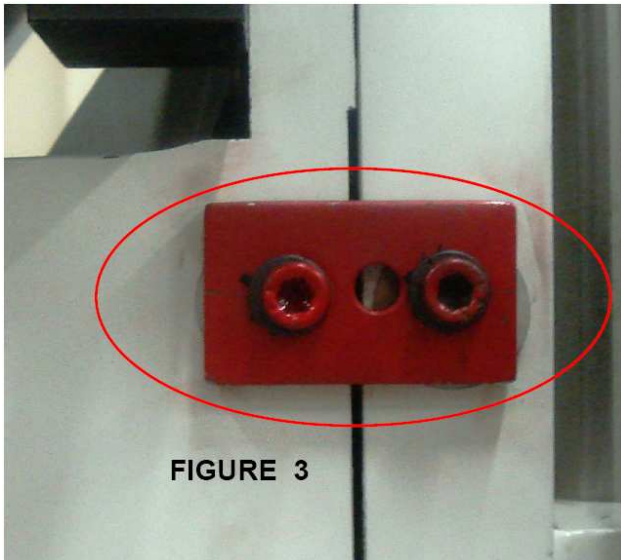
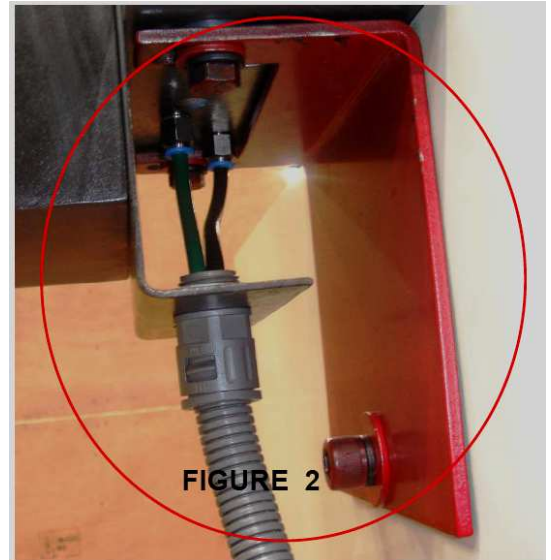
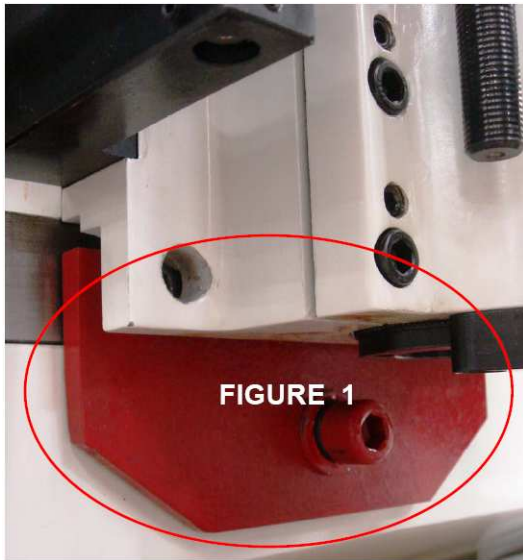
WARNING

- Lift Machine using a fork lift. Move fork lift to front of Machine and separate forks so they are visually centered.
- Insert forks under front-center of Machine, using care not to damage Foot Pedals Valve or Air Lines. Tilt forks slightly upward so Machine will lean toward fork lift and lift Machine.
- While Machine is on fork lift, install five (6) Leveling Screws and Jam Nuts in holes provided in bottom of Machine Base. Two (2) Screws installed in rear-corners and one (2) Screw installed in front and rear - center of Machine Base will serve as Leveling Screws; while two (2) Screws installed in front-corners of Machine Base will serve only as Support Screws.
- Move Machine to desired location and placed leveling bolts over the center hole of the Leveling Pad. Be certain to allow sufficient clearance to allow access for leveling and also for connecting air and electrical lines.
- Lower machine onto leveling pads making certain that the leveling bolts align into counterbore on leveling pads.
- Be certain nothing interferes with air or electrical lines running from the floating head assembly to the cabinet.
- Determine there is no possibility of air or electrical lines dragging on wall surfaces or adjacent machinery.
- Wipe top Rails with a clean, dry cloth to remove protective shipping oil.

CAUTION

Do not attempt to move the Work Head unless Air Supply is connected, and air valve is turned on and power has been turn on (make sure the EMERGENCY STOP Button is off). From the touch screen, float the workhead, spray, and clean surface with (WD40) or similar degreaser and flow the work Head side by side to remove all the shipping oil from under the work head. (Top Upper surfaces rails should be clean and free of oil).

Location of the Shipping Brackets:



Leveling the Machine:

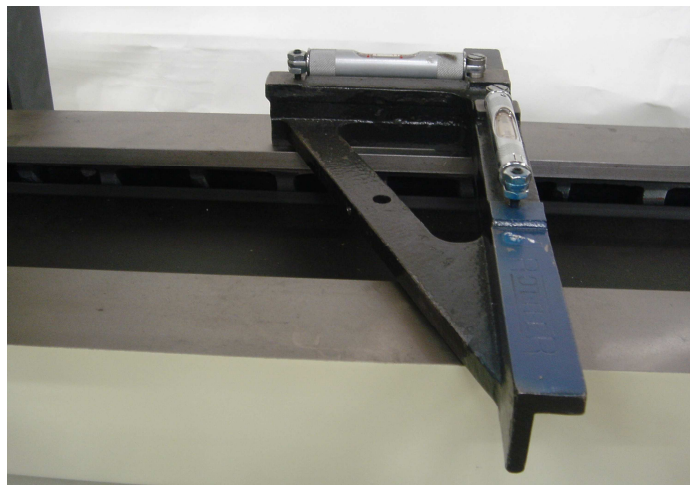
Before leveling the machine, loosen and remove the shipping brackets securing the air float Workhead. (Figures 1 & 2). The air float clamp plate bolts may need to be loosened also. Access to these bolts is gained by tilting the spindle assembly to the left and loosening the bolts on that side approximately 1 turn. Access to the right side bolts is obtained by tilting the spindle to the right.

CAUTION

Do not loosen more than necessary to allow the head to float. Clamp assembly will not clamp tight if bolts are loosened too much. It is best to hold nylock locking nut secure on top side and loosen bolt with wrench from underside of clamp plate.

Required machinist level. (Starret 98 or better).

NOTE: Rotate Level 180° to check that Level is properly adjusted. If Level does not read same in both directions, recalibrate level.



Use the level on the upper float surface, level the machine as precisely as possible, front to back and side to side. Level is obtained fastest when using a three point leveling method.

To utilize a three point leveling method, use only the front outside leveling bolts and the middle bolt in the rear. Use a socket wrench to turn the leveling bolts. After the machine is leveled, bring in the other leveling bolts. Be certain all leveling bolts are effectively supporting the machine. Tighten jam nuts on leveling bolts and recheck level.

Chapter 5 Mounting Tool Sharpener:

Mount tool sharpener on right hand side of machine using the cap screw provided with machine.

Rottler Tool Bit Sharpener

When you sharpen the Rottler form Carbide bits, consists in restoring the tool cutting angle by grinding the face.

To sharp the carbide bit must be fitted on the bit holder also fitted on the tool holder.

The tool holder will be placed on the adjustable 3/8 fixture of the tool sharpener.

Slide the tool holder on the fixture, and release the adjusting knob.

Adjust the fixture to bring the carbide bit flat against the grinding wheel.

Make sure the carbide tip face is perfectly parallel to the wheel face by pushing it with the thumb.

Once a good setting is achieved, lock the adjusting knob.

Before to start the grinding motor, move the carbide bit away from the wheel by rotating the tool holder.

The motor should then be started and the carbide tip face will just be cleaned.

There is no need to remove a lot of stock from the carbide bit. Sharpening only consists in providing a new cutting face.



Built In Venturi Vacuum Tester:

Designed to test valve seat and seat surface seal, and particularly to measure the valve seat surface quality after machining. Including a set of 7 pads and connecting extension to fit most common ports.



Chapter 6 Maintenance:

Lubrication:

.Every 40 Hours the outer spindle surface should be cleaned with kerosene or WD40. Occasionally with a light weight #10 oil. should be wiped onto the outer spindle to prevent excessive dryness.

CAUTION

All floating surfaces should be dry and clean do not oil the surfaces, oil will cause the work heat not to float properly.

Air Adjustments:

Float:

The float regulator is located at the right rear of the main base on the bottom.

If the machine is not floating properly, it could be from too much or too little air from the regulator. Turn the regulator all the way off (full counter clockwise). Start turning the regulator slowly clockwise while continually checking the spindle base for proper floatation. Once the correct float is established, lock the regulator into place by pushing in on the black adjusting knob.

CAUTION

Use as little air as possible to achieve correct floatation. Using too much air will could cause the spindle base to vibrate and not center properly on the on the pilot.

Calibrating the Digital Level:

NOTE: Even though the level has been carefully calibrated at the factory, it is a good idea to recheck calibration before putting the machine into service. In the event that the level is dropped or handled roughly then the following recalibration methods should be implemented.

The level assembly is referenced to the spindle via the level pin. It is there for important to check alignment of pin in reference to the spindle. This is accomplished by mounting a magnetic base dial indicator to the machine spindle and sweeping the pin vertically by raising or lowering spindle to check alignment. Pin alignment should be checked in two positions at 90 degrees to each other. If the pin alignment needs correcting, do so with the set screws located at base of pin block.

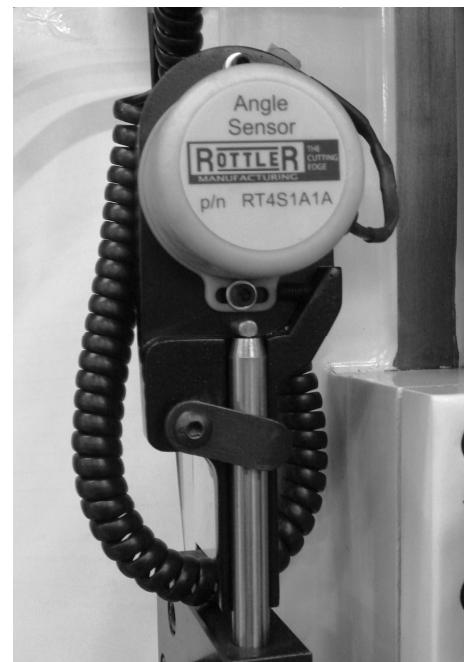
Install level on pin. Orient level to read left to right. Tilt head left or right until level reads 0.00. Now rotate level 180 degrees. The reading should be 0.00, if not then it will be necessary to calibrate the inclinometer to the level body. This is accomplished by loosening the inclinometer's two retaining screws and pivoting the inclinometer until it repeats when level is rotated 180 degrees.

Example: level reads 0.04 to the left, when rotated 180 degrees to the right it should read minus 0.04.

Check the level reading with the pickup oriented front to back. It should read 0.00 if the machine has been properly leveled with a machinist level.

If the LED does not read 0.00 then chances are the machine's leveling procedures have not been properly followed or there are internal problems with the level's electronics.

The sensitivity of the level is so great that it may not zero totally, even while the machine is not being touched. The alignment tolerance for installing guides is plus or minus .04 degrees, and for forming three angle seats is plus or minus .08 degrees.



Chapter 7 Operating Instructions:

Mounting Cylinder Heads:

360 Degree Rollover Fixtures

Initial clamp height adjustments to the head trunions can be accomplished by measuring the head thickness then raising the turning clamping block assembly to the appropriate height using the clamping block acme screws. A 5/16" t-handle allen wrench works well.

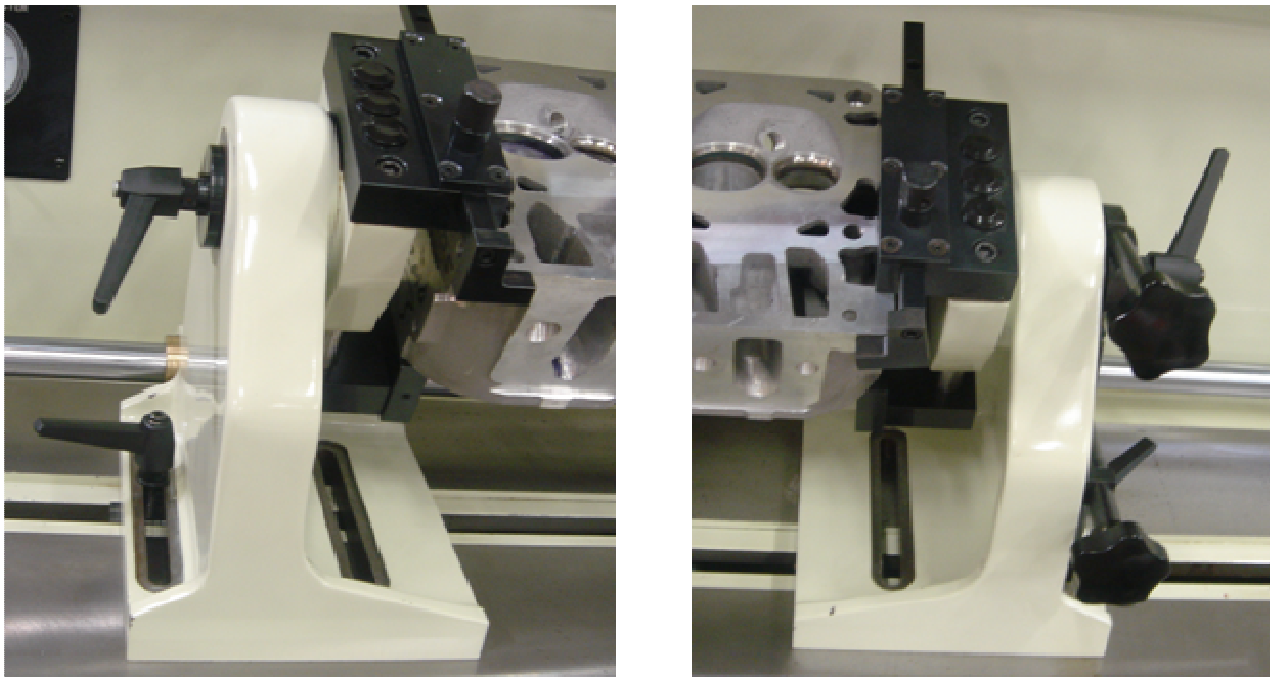
Measure the length of the cylinder head. Spread the trunion assemblies apart from each other so that the cylinder head can be clamped in between the trunions.

Each support has an adjustable stop, located to the front. The stops have indents, allowing a number of different settings. Position of the stops must be checked for each cylinder head put on the supports. In most cases, we will install the cylinder head deck side down with the exhaust side of the head against the adjustable stops.

This is particularly true of wedge style heads. It is necessary for the clamps to thrust the cylinder head against the stops when clamped. When heads are mounted in this fashion, the tallest portion of the combustion chamber will be at the rear of the machine when the head is rotated into the working position.

Try to keep the valve guide center line parallel to the trunion centerline. (Figure 4)

FIGURE 4



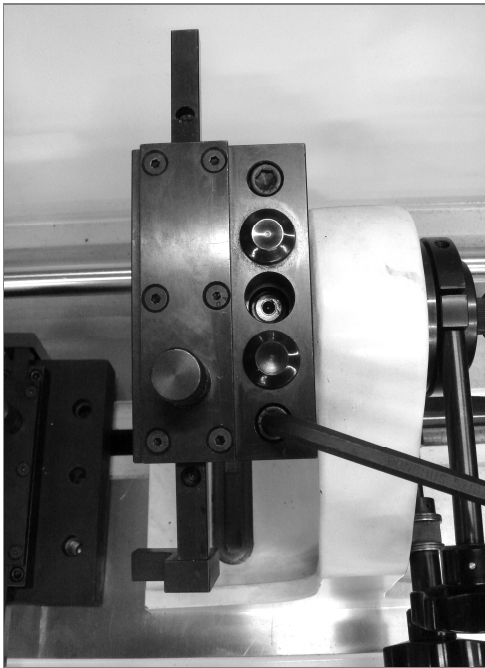
Utilize the grooves in the table to align the trunion supports square to the machine.

The Quick-Clamp head mounting fixture is provided to accommodate cylinder heads that are difficult to mount directly into the trunions. Some machine operators prefer to use the Quick-Clamp fixture for the majority of heads they do as the mounting is very quick.

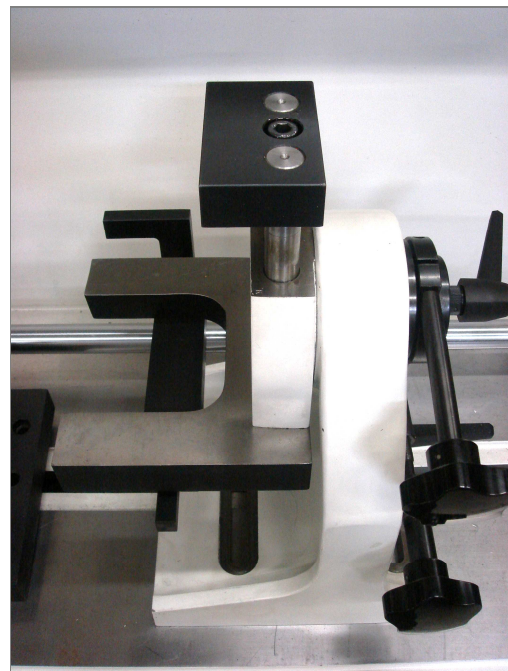
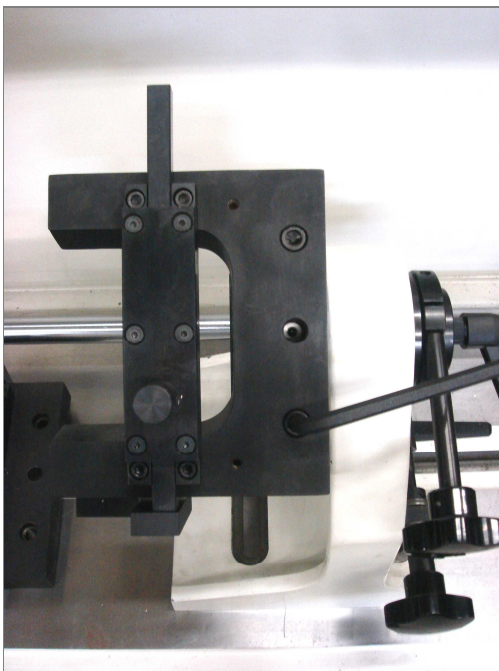
Utilize the grooves in the table to align the trunion supports square to the machine.

Chapter 8 Overhead Cam U Clamp System

Using 5/15" Allen wrench, remove the existing lower fixed plate on the 360 degree fixture (left and right)

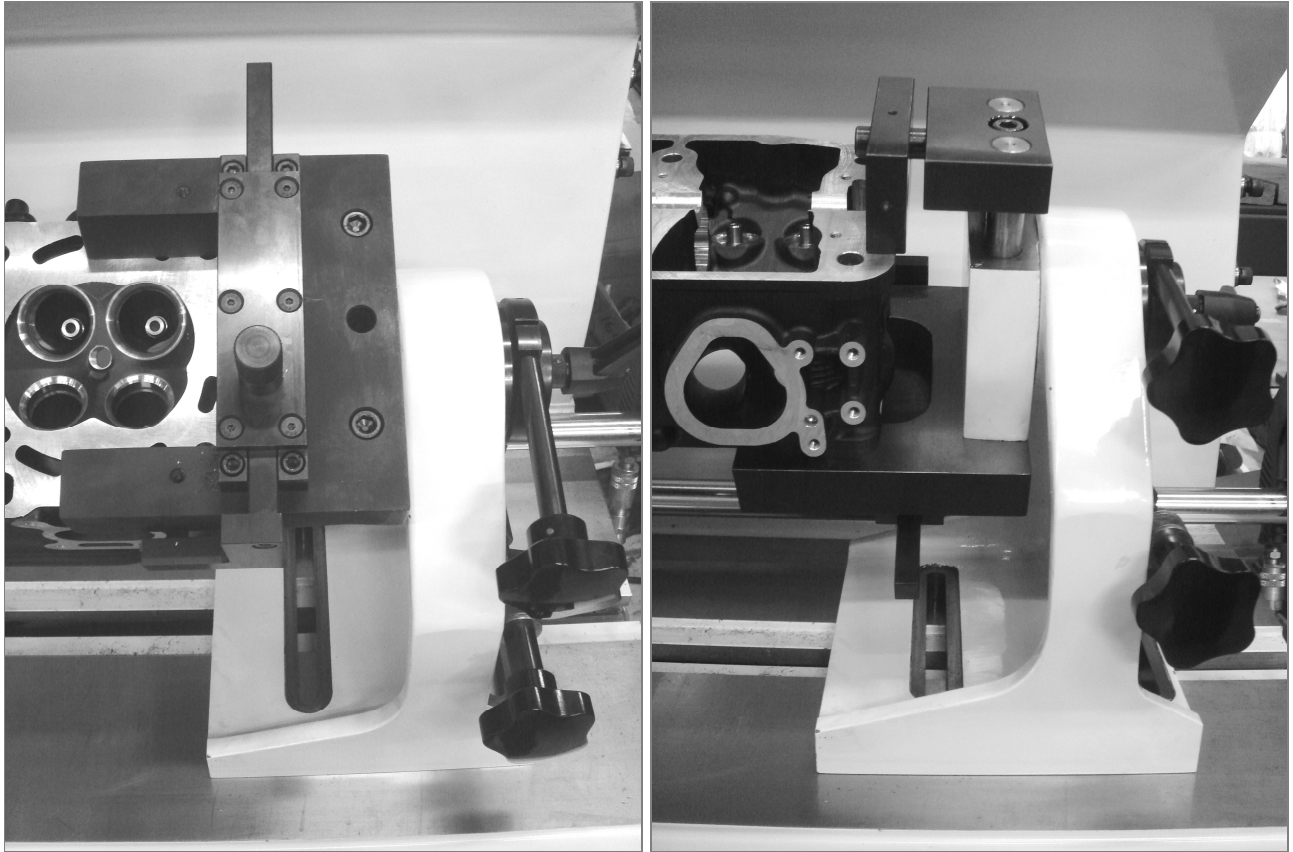


Install the U Clamp, you must use the two bolts included with the fixture and make sure is good and tight

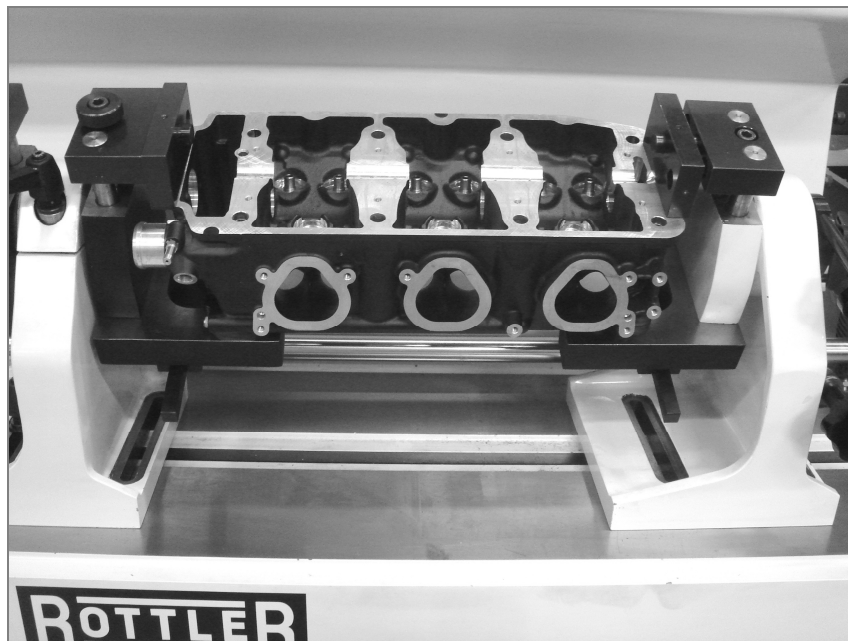


The cylinder head gasket surface must be against the machined surface of the U Clamp Fixture; Slide the stopper rod equally and push the cylinder heads against the stopper rods.

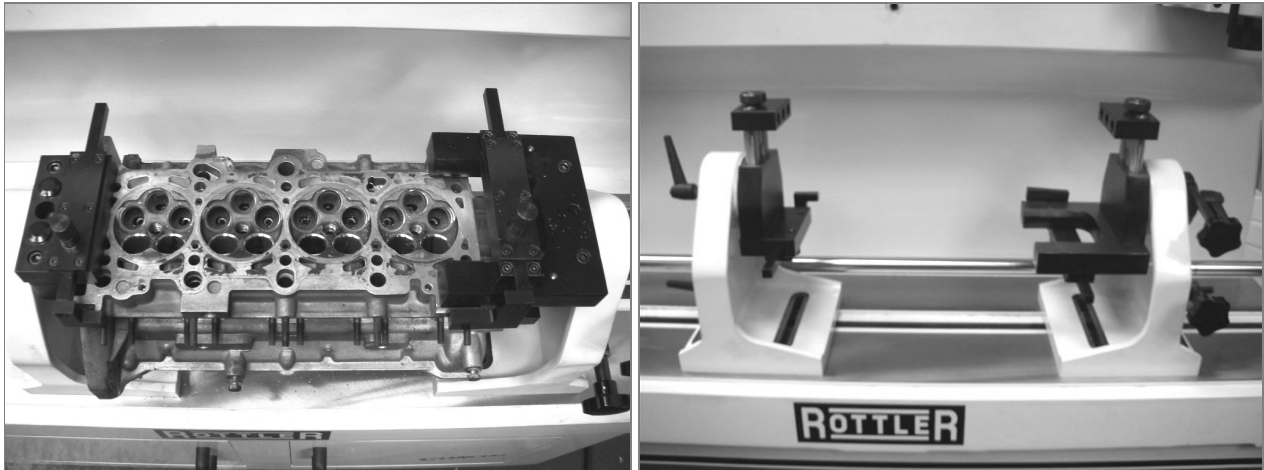
Note: for some cylinder heads, you may need a spacer against between the cylinder head and the stopper rod (not included)



The Quick-Clamp frame is mounted between the trunions and clamped using the clamping plates. (See Pictures) The cylinder head is then held to the frame with the swivel clamp assemblies through the appropriate head bolt holes or used the standard clamp plates.



On This cylinder head we using both style frames.



Alignment and Setup:

Alignment and setup applies to both the cylinder head and the machine's floating head. The goal is to get perfectly align to the spindle centerline of the area of the head to be machined. Most machining operations on cylinder heads use the valve guide centerline as the reference point so we will use that as an example.

IMPORTANT:

Think of the digital electronic level as a comparator. Because the leveling pin is square to the machines spindle, as long as you achieve the same readings front to rear and side to side then the spindle will be in perfect alignment. Rotate Level 180° to check on the display if the Level is properly adjusted. If Level does not read same, adjust the digital Level; See Calibrating the Digital Level section on this manual and follow steps.

Front to Rear Cylinder Head Alignment:

Position the level on level pin to read front to rear and take a reading. Rotate the cylinder head so that the valve seats are facing up. Now place the level on a pilot in the cylinder head and position the level to read front to rear. Loosen the lock levers on the supports. Be certain the fine adjustment lock screw is loosened. Coarse adjustment is made by turning the work piece manually, until the level reading is within a couple of degrees of the reading on the leveling post.

Lightly tighten the lock levers on the supports to remove any play. Now tighten the clamp on the fine adjustment screw. Turn the adjustment knob to achieve the exact reading that was observed on the leveling post. You can now completely tighten both the left and right support locks.

Note:

An optional alignment bar is available that helps establish the front to back alignment on canted valve cylinder heads. The bar is held against two pilots in two adjacent guides. Use the alignment post to adjust the angle.

Left to Right Alignment:

Obtain the left to right reading from a pilot mounted in a guide in the cylinder head. Now place the level on the leveling post. Loosen both of the tilt lock levers on each side of the quill housing. Use the tilt adjusting hand wheel to adjust the reading to be the same as that found on the pilot in the cylinder head. Tighten the tilt lock levers.

Note: Alignment tolerance for core drilling is plus or minus .04 degrees, for forming three angle seats is plus or minus .08 degrees.

Chapter 9 Selection of the Pilots:

Choosing the right pilot will ensure the accuracy of the machining.

The pilot is selected according to the actual guide and not according to the original guide diameter or the valve stem diameter.

Rottler Fixed Carbide Centralizing Pilots are manufactured from fine grain sintered tungsten carbide and are ground to a very high degree of accuracy, straightness and surface finish - designed for a life time of precision machining!

The part number of the pilot represents the actual diameter of the straight/parallel part of the pilot where the pilot fits into the valve guide.

For example:

FCP0700 means that the diameter of the part of the pilot that goes into the valve guide is **7.00mm (0.2756")**

FCP1270 means that the diameter of the part of the pilot that goes into the valve guide is **12.70mm (0.5000")**

The pilot is the only link between the fixed part - the clamped cylinder head and the moving part - the air float machine workhead. The centering and the machining accuracy depend on the use of the correct pilot. The pilot is selected according to the actual valve guide and not according to the original guide diameter or the valve stem diameter, the pilot is ALWAYS larger than the valve stem diameter.

Pilots are available in increments of .01mm (0.0004"). For practical purposes, it is best to select a pilot that is a small amount less than the nominal size of the valve guide, approx .01mm (0.0004") is recommended between the pilot size and the valve guide nominal size. This clearance allows the pilot to enter all the guides in a cylinder head as some valve guides may be smaller than their minimum tolerance.

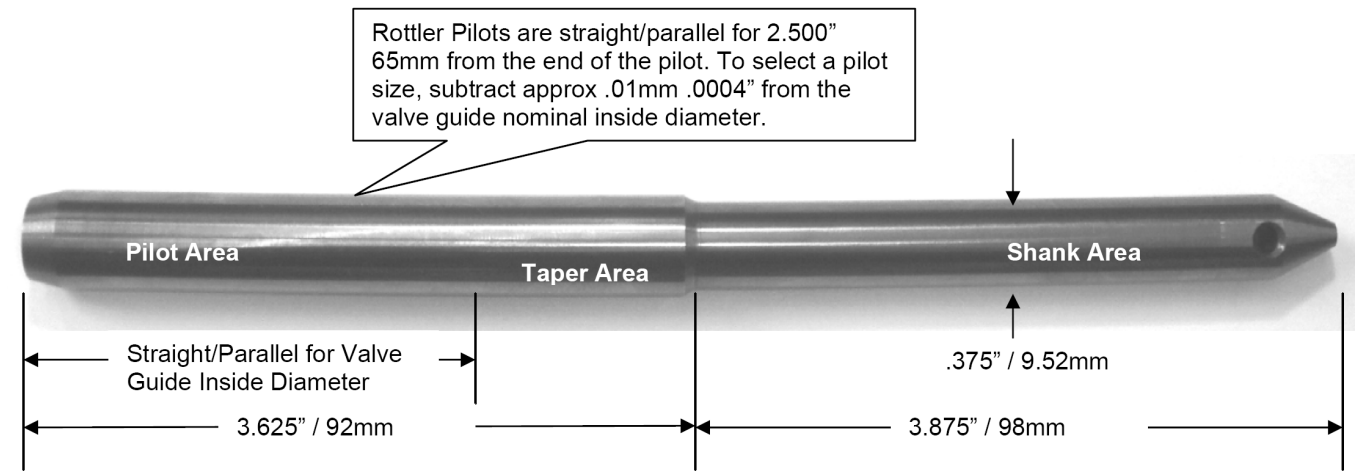
Most new valve guides are manufactured to a **nominal size** such as 7mm or 11/32" and the valve stem diameters are manufactured to be smaller than the nominal size to allow clearance for heat expansion of the valve stem when the engine is operating. For example: a 7mm valve guide has an internal diameter of exactly 7.00mm (.2756") The valve stem diameter of the intake valve is 6.98mm (.2748") and the exhaust is 6.96mm (.2740"). In order for the pilot to fit most all valve guides, the first choice could be FCP0699 to give .01mm (0.0004") clearance. If the valve guide is used and has some wear, then the second choice of pilot could be FCP0700(0.2756").

The pilot can also function as a GO-NO GO gage, in other words, if the pilot does not enter the valve guide, the valve guide may be too small which could result in too little running clearance between the valve stem and valve guide which could result in seizure and major engine failure!

Rottler makes 3 sizes of shanks of pilots:

1. 6.00mm (0.2362") for small valves guides 6mm (0.236") and below. The part number for these pilots is FCPM.
2. 0.375" (9.52mm) for common size valve guides, 6-14mm (.236-.625"). The part number for these pilots is FCP.
3. 20mm (0.7874mm) for large valve guides for SG80A machine. These pilots are made to order specifications.

Below is an example of a 9.52mm 0.375" shank diameter pilot:



IMPORTANT:

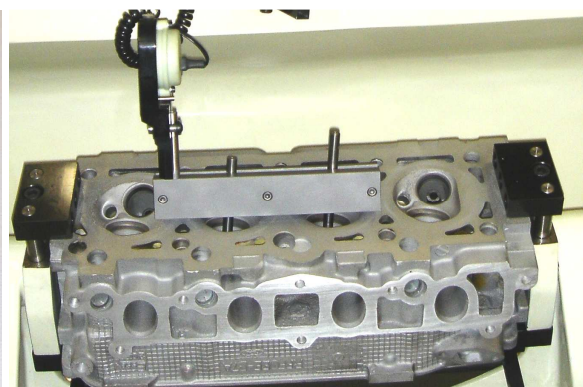
The centering accuracy and the machining accuracy depend on the pilot tolerance. We insist on the necessity of using Rottler Fixed pilots. No other pilots would have the necessary quality for accurate centering.

Aligning Cylinder Heads which have Canted Valve Guides

- 1- Install Cylinder Head.
- 2- Loosen Pivot Locks and rotate Cylinder Head 180°, so combustion chambers are in up position and Valve Guides are approximately vertical.
- 3- Tighten Fine Adjustment Lock. DO NOT tighten Pivot Locks.
- 4- Install two (2) Pilots in exhaust or intake valve guides to be machined. approximately 6.00" to 8.00" (150 to 200 mm) apart. Install largest size Pilots which will fit into valve guides. Pilots should not be more than .001 in. (0,03 mm) smaller than valve guides.
- 5- Install Canted Alignment Fixture (CANTEDFIX) on high side of Pilots. With Locating Pin pointing up, clamp Retaining Spring around left pilot and allow Bar to rest against right Pilot.
- 6- Slide Bar down Pilots so it is resting on cylinder Head.
- 7- Place the digital Level pick up unit on Bar Locating Pin. Rotate Level so it is positioned front to back (see picture bellow).
- 8- Record de tilting of the display panel (upper Right).
- 9- Turn the tilt Adjustment handle CLOCKWISE. (Knob is located on right end of Workhead Assembly.)
- 10- First tighten left Pivot Lock; then tighten right Pivot Lock.
- 11- Recheck Level and readjust as required.
- 12- Remove Level pick up unit from Canted Alignment Fixture and remove Bar.
- 13- Place Adjustable Level on one of the Pilots (see picture bellow) and rotate it so it is parallel with Head (left to right).
- 14- Remove Level pick up unit from Pilot and place on Leveling Post located on left-front of Spindle Housing.
- 15- Rotate Level so it is parallel to Cylinder Head (left to right).
- 16- Pull down on Eccentric Clamps on the workhead(Release Position).
- 17- Turn Column Alignment Handwheel until display unit indicate 0000.
- 18- Push up on (Lock Position) right Upper Eccentric Clamp first, and then lock left Lower Eccentric Clamp.

NOTE: The Workhead is now aligned with Canted Valve Guides.

The alignment fixture will helps to establish the front to back alignment on canted valve cylinder heads.

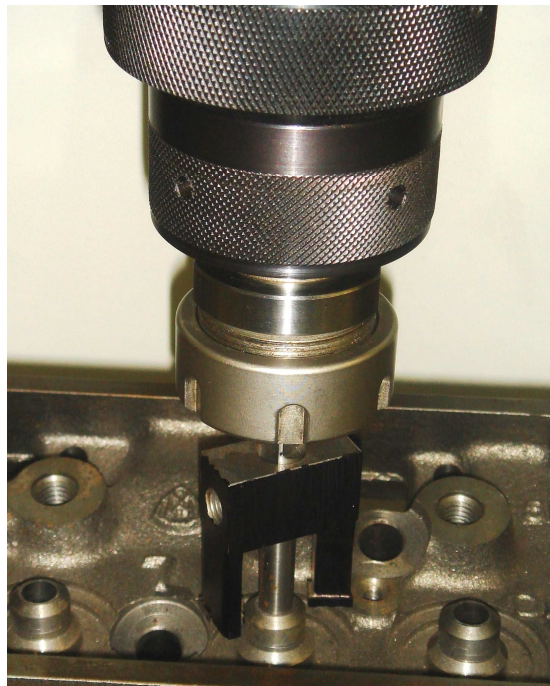


Core Drilling and Reaming Valve Guides:

There is two way to ream the guides on the SG machine with the Cullet holder adapter or with the .375" core drill driver adapter is supplied to accept core drills and reamers.

Align core drill with valve guide by inserting core drill pilot in guide as head of machine is floated and centered Push green button to start the spindle, verify correct rotation. Operate at 240 RPM, feed with moderate pressure until it clears the bottom of the guide.

Raise Quill to bring core drill above upper end of valve guide. Stop spindle by pushing red button. 4. Select and install correct reamer. Repeat step 2 at 150 RPM.

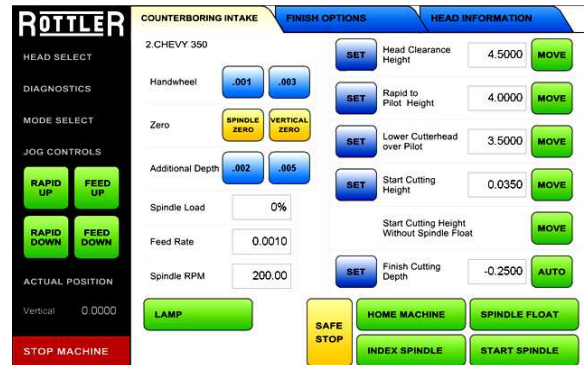
**Using RS500 Rottler Spindle Adapter and Collet Holder .500" (12.7mm):**

Cutting Counter Bores for Seat Rings:

Align the work piece as explained previously. Cylinder head deck surface must be up.

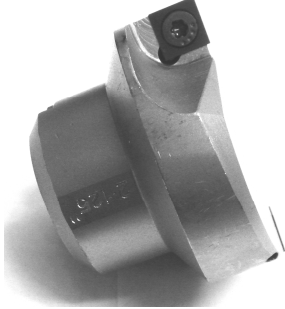
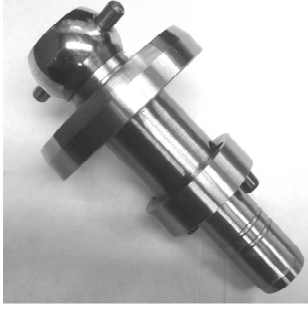
Insert correct pilot into the valve guide. Mount the correct milling head cutter on the milling head Adapter, Install milling head adapter into spindle adapter

Float the Workhead by pressing spindle float, using the handwheel feed the quill down by few thousand from making contact on the Valve Seat insert, press again Spindle float to clamp the workhead.



Turn spindle and feeding using the handwheel on .001 button until you get contact on valve seat, and then set **Vertical Zero**.

Touch inside the Finish Cutting Height box and inner the total depth of the valve seat that you will be installing, remember this value it will be a negative number. ...or use the following alternative method:

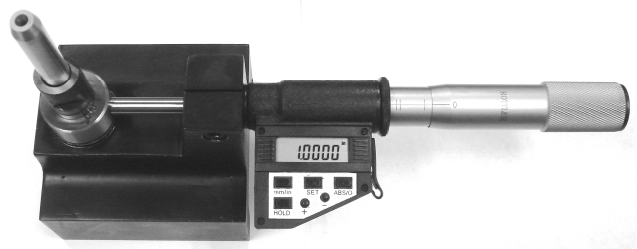
FMH	BD105
	
<p>Rottler Fixed Double Replaceable Insert Milling Heads - Bore diameter available in increments of 1/16" (Required Milling Head driver) specify size</p>	<p>Rottler Spherical Milling Head Driver for Fixed and adjustable replaceable milling head cutters for .625" ID milling head body. (To be used with RBHAR1)</p>

NOTE: See Seat and Guide Catalog for suggesting tools to perform this operation.

Set spindle RPM at approximately 80 - 120 RPM and Feed Rate at .00010 - larger seats may require a slower speed; smaller eats may be run faster.

Adjusting the Square Carbide Inserts:

The micrometer should be used. Set the Digital micrometer (BM) according to the valve seat insert diameter and the required interference. Slide the tool holder without the pilot on the micrometer. With the setting screw, adjust the square tip holder offset.



IMPORTANT: When 90 degreed bits (RCA512) or the Triangle bits are fitted, check that their reference faces are perfectly clean.

The accuracy of the seat angles depends on this.

While rotating the assembly tool holder/carbide tip holder, the carbide bit's cutting edge should just touch the micrometer spindle.

Once in contact with the micrometer spindle, the carbide tip should not be moved at all. If this is not observed, the cutting edge may be damaged and the resulting surface quality, when machining, will be deteriorated.

Tapping Operations:

Place the Jacobs chuck or Collet Holder in the spindle as explained previously. Install tap in the chuck, and tighten.

Center over the hole to be tapped

Set spindle RPM at approximately 50 RPM and Feed Rate at .00010

Choose a spindle speed sufficient for the tap (approximately 50 RPM), and allow the tap to feed the spindle as it threads the hole.

When the proper depth is achieved, press to reverse the spindle rotation and left spindle return the tap off the hole.

Three Angle Seat Cutting:

Place the ball drive adapter in the spindle.
Align spindle to valve guide.

Place a valve in the setting fixture. Position the pointer on the valve where you wish to place the top of the seat.

Remove the valve; replace it with the correct pilot.

Select the proper diameter tool holder. Place the carbide insert in tool holder. Slide tool holder onto ball head.

Place ball head over the pilot in setting fixture. Use radial adjusting screw to set diameter of cutter to correspond to position of pointer on setting fixture.

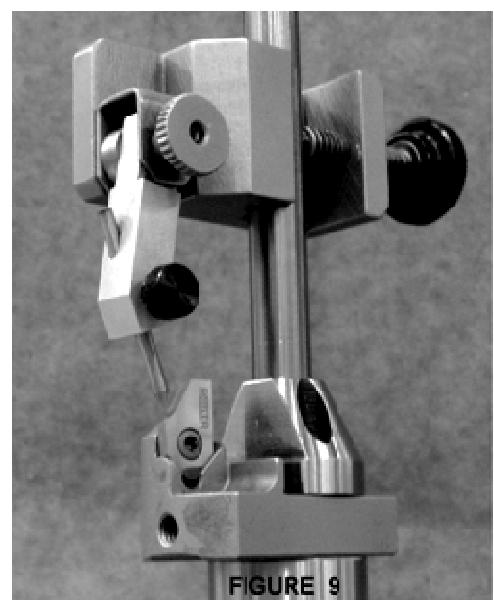
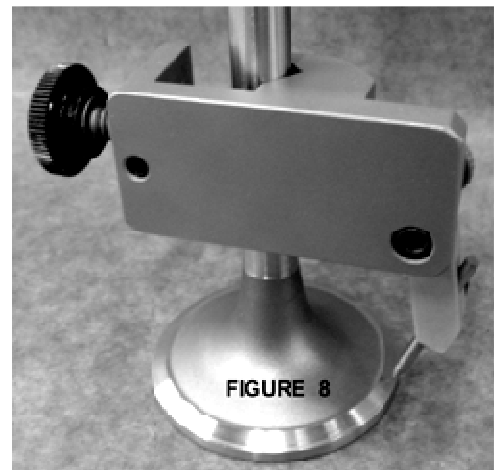
Tighten hex socket screws on bottom of ball head. See figure 9

Remove ball head assembly from setting fixture. Place fixed carbide pilot in cylinder head.
Center the spherical ball head toolholder over the pilot shank.

Required spindle rotation speed will vary, depending on seat hardness. As seat hardness increases, so does the required spindle speed. Some will require full speed.

Special care should be taken in centering the floating head above the valve guide, to achieve a concentric seat.
Cut seat only enough to clean up surface.

Too much cutting will sink the valve too far in the head. Many operators prefer to use the spindle fine feed when machining seats as extreme control of spindle down feed can be accomplished.



The capacity of the Rottler SG7 / SG8 / SG9A / SG9 associated with a complete tooling range allow working on seats of diameters between 14 and 120 millimeters (0.55"- 4.7").

Three tooling ranges are possible:

- ❶ For seats diameters between 14 and 25 mm (0.55"- 1"): tool holder BH600R1 and Mini tip holder TH1999 for seat range .551" - .984" (14mm-25mm) with pilots with 6.00mm shank diameter.
- ❷ For seats diameters between 18 and 60 mm (0.71"- 2.4"): tool holder BH375R1 and tip holder TH2000 for seat range .710" - 1.180" (18mm-30mm) or TH2001 for seat range 1.100" - 1.570" (28mm-42mm) or TH2002 for seat range 1.570" - 2.360" (40mm-60mm), with 9,52 mm (3/8 ") pilots of shank diameter
- ❸ For seats diameters between 40 and 80 mm (1,570"- 3.150"): tool holder BH375WR1 and tip holder S2003N for seat range . 1.570" - 2.360" (40mm - 60mm) or S2004N for seat range 2.280" - 3.150" (58mm - 80mm), with pilots with 9,52 mm (3/8 ") shank diameter.

IMPORTANT: When the form tips, the square tips or the triangle inserts are fitted, check that their reference faces are perfectly clean.

The accuracy of the seat angles depends on this.

While rotating the assembly tool Holder / carbide bit holder, the carbide tip's cutting edge should just touch the micrometer spindle, after the proper diameter has been achieved hand look the locking screws and verify the diameter on the digital micrometer (BM)

Changing the Spindle Adapters:

Once that you have the tool holder setup, fit the ball head tool holder into the spring free spindle adapter.

The SG8A spindle has been engineered to allow ultra fast tooling changes.

Make sure the that spindle spring free locking nut is in the off lock position, line up the two ears of the spindle adapter and insert into the spindle ISO 30 taper. The locking nut automatically will be on the lock position, to remove turn the self-locking nut to the left position, hold the spindle adapter, it may drop on the machine table. Damage will result.

Installing the Spherical self Aligning Toolholder:

Once the spring free adapter is in the spindle, fit the Rottler Spherical Self aligning Toolholder assembly into the spindle adapter; make sure to align the locator pins before you fit it into the spindle adapter and push it until you feel that is lock.

Chapter 10 Spindle to Work:

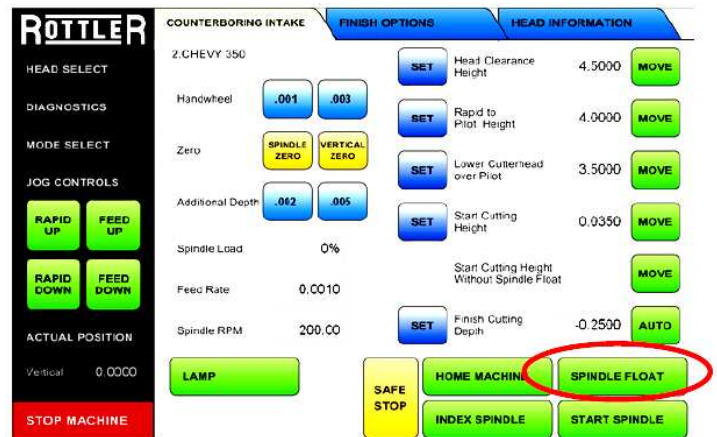


When the cylinder head is clamped properly on the table and adjusted, float the workhead to the first valve guide by pressing spindle float.

At this point, the spindle and workhead should be level according to the position of the cylinder head.

Most machining operations require the spindle to be directly centered over the work to be performed.

This is usually accomplished by air floating the workhead above the area to be machined, then manually lowering the spindle to the pilot shank with the spindle adapter sleeve on the down position, once that you have the toolholder about 1/2" in to the pilot shank release the sleeve to the upper position to achieve perfect centering according to the position of the pilot and lower the toolholder into the pilot manually until reach the proper height or until the carbide tip is a few thousands from making contact on the valve seat. Do not make contact with the seat surface, the work head should be floating at all the time for few seconds, do not touch the workhead when is on centering mode.



Special care should be taken in centering the floating Workhead. (keep hands away from flouting Workhead)

Note: when machine the seat, the sleeve should be in upper position. The work head should be in float mode at all times when is on the centering mode.

NOTE: It is important that the operator of the SG9A read the Control Definitions chapter in this manual before proceeding any further.

Chapter 11 Control Definitions:

The purpose of this chapter is to define the function of the buttons throughout the various screens. Certain button functions may not make sense right away in this chapter. As the operator reads through the Operating Instructions chapter of this manual, the function of these buttons will become clear.

Computer and Controller Definition:

The computer and controller are located in the main rear electrical enclosure. This unit is a full computer, running Windows XP Home operating system. Contact the factory if more information on the computer system is required.

Changing or tampering with computer settings without factory authorization will void the factory warranty and may cause the machine to become inoperable.

Master Power On/Off Switch:

This switch is located on the main electrical control enclosure on the right hand side of the machine. The switch must be in the off position before opening the rear enclosure door.

When first applying power to the machine the computer will need to boot up. Be patient, it will take several minutes to complete booting and start the Rottler program.

When turning the main power to the machine off there is a specific procedure to follow so as not to damage the computer. The computer must shut down its internal systems before main power is removed from it.

From any screen press FILE and then EXIT button. This will shut down the Rottler program. The terminal will show the computer desktop screen.

Press the "Start" button in the left-hand side of the Start Bar. This will bring up the "Start Menu". Press the "Shutdown" line at the bottom of the Start Menu. This will bring up a Pop Up menu, make sure that "shut down computer" is selected and press "OK".

This will shut down the computer. It is now OK to turn Main Power off to the machine.

Getting Started:

Once power has been supplied to the machine measure the incoming voltage with a meter to verify proper voltages before turning the Main Power switch on. Failure to measure and record proper voltages to the machine could cause damage and will void factory warranty. Measure L1 to L2 and record on the installation report. Record L1 to ground and L2 to ground and record on the installation report.

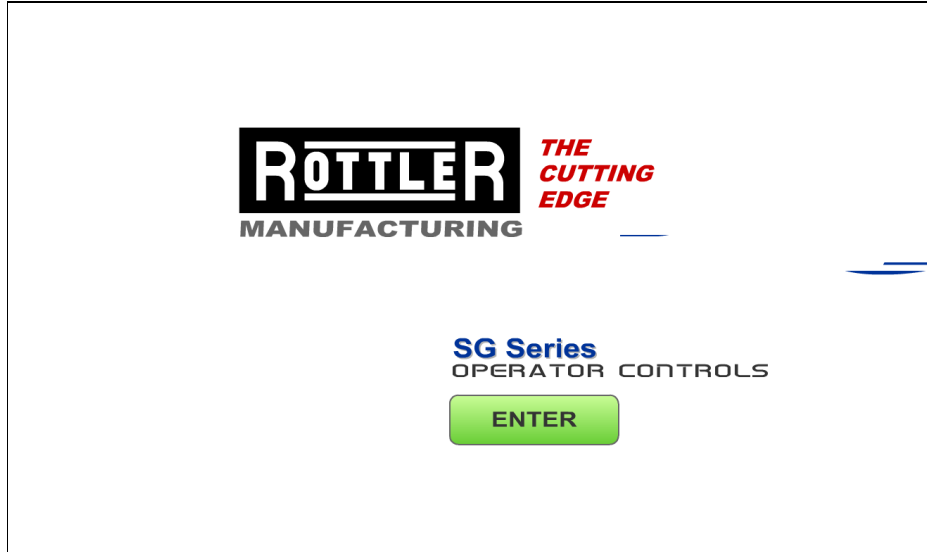
Power Up:

Turn the Main Power switch on. Allow a few minutes for the machine to fully boot up.

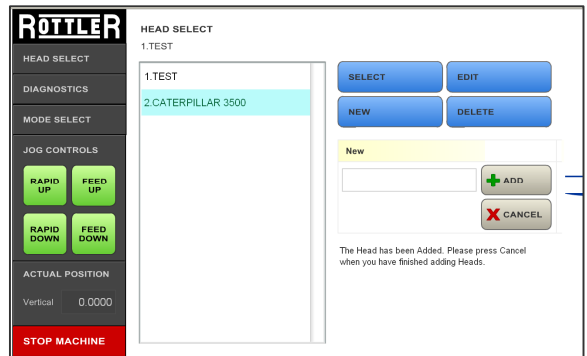
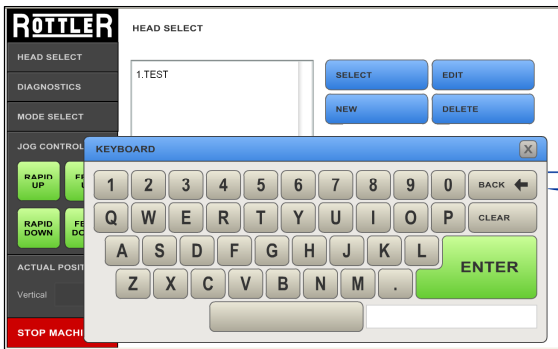
Note: The Rottler SG9A uses a touch screen for control and data transfer to the computer. Be careful not to touch the screen until the machine has fully booted up and a Rottler screen is showing. If the screen is touched prior to full boot –up it may activate a function or interfere with proper boot-up.

Initialization Screen:

The first screen to appear is the Rottler Manufacturing Start Up screen. Press the ENTER button to start the Rottler software.



The next screen to appear is the Cylinder Head Select screen. At this point, select any Head or type Test by pressing **NEW** Button and the Keyboard will appear, type the cylinder head type and press enter, select the head you inner and press **SELECT** to continue to the next screen.



Alter cylinder head model has been select (Caterpillar 3500 or the cylinder head that you have inner, in this case is Caterpillar 3500), press the **ENTER** button to start using the Rottler Program.

General Information:

Once selected, all operations of the **SG9A** can perform are stored in that Cylinder Head model. The following is a more detailed list on the head selecting screen.

Head Select:

This screen allows you to select, create, edit or delete a Cylinder Head model. This will change the screen to the **MODE SELECT** Screen.

New:

Pressing this button will bring up and **ADD** and **DONE** button next to the **NEW CYLINDER HEAD MODEL** entry screen. Using the keyboard, type the desired name for your block. Press **ADD**. This will add the block to the list on the left. When you are finished entering block models press **DONE**.

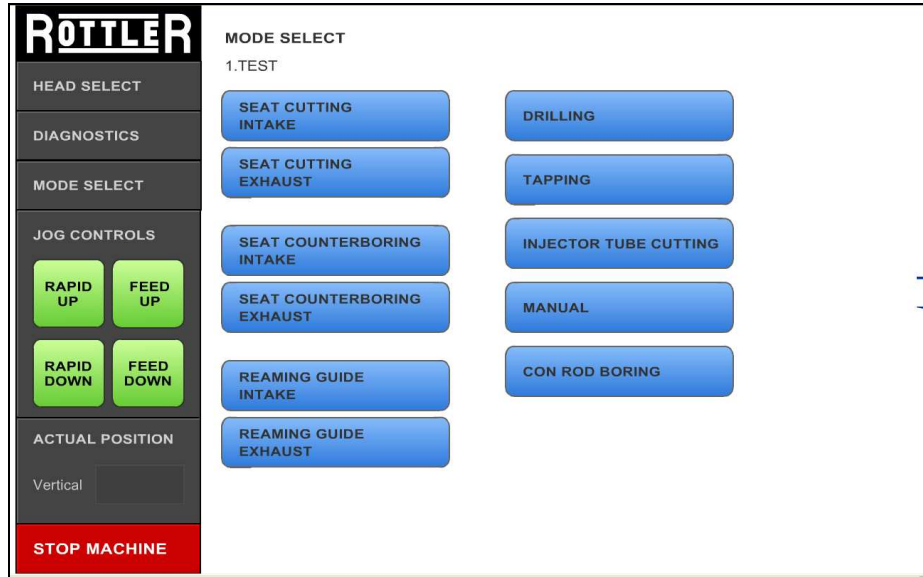
Edit Head Model:

To Edit a Cylinder Head Model name, select a Cylinder Head from the list on the left and then press **EDIT** . This will put the name of the selected block in the **EDIT CYLINDER HEAD MODEL** screen. Use the keyboard to edit the name, press **SAVE** and **DONE**.

Delete Head:

To delete a head, select the head from the list on the left. Press the DELETE CYLINDER HEAD BUTTON. The screen will ask you if you want to delete the Head. Select YES or No and then DONE.

Mode Select:



Once you have selected a block the screen will switch to the MODE SELECT screen. This screen contains all the operations of the SG9A can perform. There are several modes you can select, this manual will describe one operation for each mode, all other operations in that mode are the same.

Programming the vertical stops & Dwell Options

This is an example of what the program would look like on the vertical stops.



Once you select the Head mode and the seat position that you will be working on it, you need to home the machine

Homing:

The **SG9A** ***MUST*** be homed anytime it is turned off. If the machine has not been homed, the reference positions for all programs will be off.

The purpose of Homing the machine is to set reference points in the vertical axis for the machine to operate from. If the machine is not homed, the reference points may be off position. The reference point is set in exactly the same position each time the machine is homed. The machine keeps track of these reference positions internally and the operator will not see them.

Building Programs:

Seat Cutting Mode:

Select Cylinder Head and then the valve seat that you will be machining on the control panel. This will bring up the seat cutting program with the Set Zeros tab shown.

Setting Zeros:

The purpose of setting zero points is to give the operator a specific point to build programs from. The machine also uses these zero points to run the program from. The zero points can be set at any point in the machines' the vertical axis. (except the Spindle rotation) will need to have a zero point set for the machine to operate from.

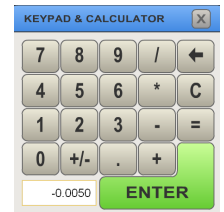
Vertical Zero:

Once that you have set up the tooling for the cylinder head that you will be working and set the insert holder with the right profile insert for the proper seat diameter and by selecting the proper pilot. Float the work head by pressing SPINDLE FLOAT and press the hand wheel bottom .001 and using the Hand wheel located on the right side of the machine; bring the spindle down with the Toolholder on it over the pilot.



NOTE: At this point is better to use the Hand wheel to bring the tool holder over the pilot to avoid crashing the spindle.

Once that you have the Toolholder in the carbide pilot continue floating the Workhead and bring the spindle down close to the seat, about .060" (1.5mm) away from touching the seat. Lock the spindle by pressing Spindle Lock (the bottom will be Red) Turn the spindle to the proper RPM and the FEED RATE (is better to star with low RPM between 150 to 200).

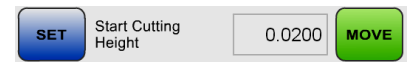


Note. By pressing on RPM bottom next to SPINDLE RPM the Key Pad & Calculator screen will pup up, inner the proper value.

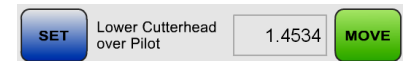
Start the spindle. Press the Handweel .001 button to put the handwheel in .001 per detent. Slowly move the spindle downward until you can hear or see the cutter just touch the valve seat, at this point Press your Vertical Zero button here button and verify the zeros on the left lower corner above the Stop Machine button, The Vertical zero has now been set. From this point on you can star setting the vertical stops.



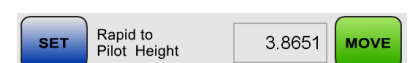
1. After you set the vertical zero, bring the cuter away from the seat with the hand wheel about .030" (0.76mm) and press the SET button on the Starting Cutting Height section, you will see the setting on the display box.



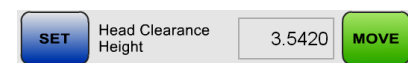
2. Continue going up with the hand wheel until the tool holder is about .500" (12.70mm) from the end of the shank of the pilot (Before the tool holder get off the pilot shank) and press the SET button on the Lower Cutterhead Over Pilot Section.



3. Bring Tool holder out of the pilot about .100" (25.40mm) away from the pilot shack, and press the SET button on the Rapid to Pilot Height Section. (Make sure the pilot height is close or the same on all the valve guides)



4. Move Tool holder to clear pilot enough to clear the fixture if you have to flout the work head out of the working area and press the SET button on the Head Clearance Height Section.



CAUTION

Make sure the Head Clearance Height is sufficient for the Tool holder to clear the Cylinder Head and the fixture when moving the work Head across.

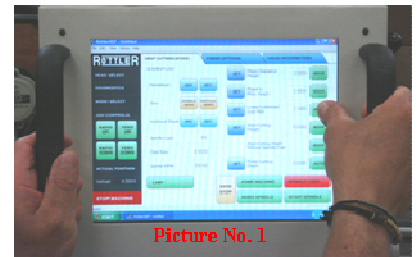
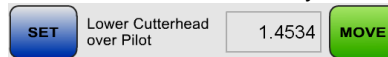
The Vertical stops have now been set. You are finished with the Vertical Stops screen, these steps has to be done on every new cylinder head and it will be save on the Head Selection mode. Is importing to save changes every time you getting out of each mode if you are sure the those changes are correct.

NOTE: Next time you get the same cylinder head all the setting has been storage and all you have to do is bring the tool holder aver the pilot with the Handwheel with work head floating clamp the work head about .060" before touch the seat and using the hand wheel and the spindle on make contact with the valve seat lightly and press zero to set you starting point, now you ready to start machining the seats

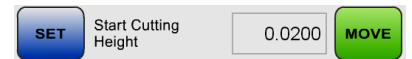
Start Auto Cycle:

1. After you select the right cylinder head, mode and you have all the tooling set to the right specifications for the application that you are working on. Float the work head over the seat that you will be machining and make sure you have enough clarence to go across the pilot.

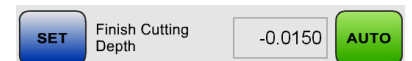
2. By pressing and holding the MOVE (green button) Lower Cutterhead over pilot bring the tool holder into the pilot shank, the work head will automatically be on flouting mode, is very importing to balance the work head with you left Hand so you won't crash the Tool holder into the pilot. See Picture No.1



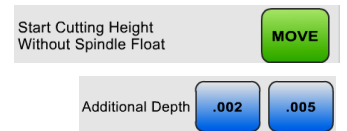
3. Press the MOVE Button Start Cutting Height, the spindle will go davn and float for few seconds to the setting that you inner on the display box. On this sample, the spindle will go down 0.020" before it touching the seat.



4. Press the AUTO Button Finish Cutting Depth, on the simple you will see on the display box -0.0150". The spindle will start at the programmed RPM. The vertical feed will start at the programmed rate in a downward direction until the correct depth is reached.



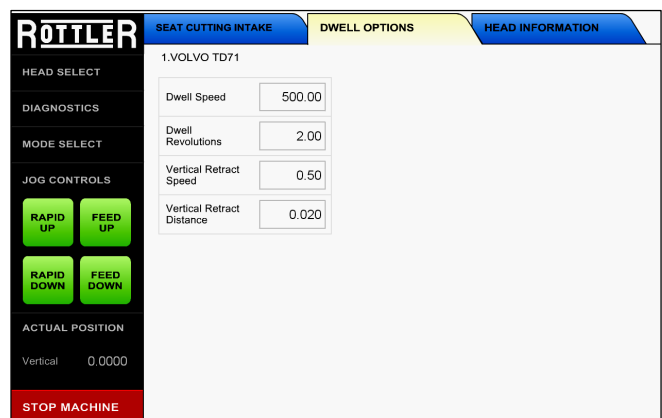
If the seat is not clean completely you can press the MOVE button on the Head Clearance Height and the spindle will retract vertically to the programmed height, you can visually inspect the finish. If you need to cut more to seat, press the MOVE button on the Start Cutting Height Without Spindle Float. You can add more to the Finish Cutting Depth or by adding additional Depth by pressing .002" or .005" button.



5. The cutter will then continue the circular interpolation dwelling to the programmed RPM and then it retracts the cutting tool from the seat. When the cutter is back off the valve seat and all motion will stop, and you satisfy with the finish on the seat. Press the MOVE button on the Head Clearance Height and move the work head to the next seat.

6. Remove the Pilot from the Valve Guide and insert the pilot in to the next Valve Guide; once that you have the spindle on the Head Clearance Height flout the work head to the next seat and you have the pilot in the guide press the MOVE button on the Rapid to Pilot Height and then rapid from Step 2.

The Setting on the Dwell Screen is very import, depending on the seat material you can judge the cutting RPM and the Dwell Speed, in average seat you can start with 200 RPM for cutting and 300 to 400 RPM for Dwell mode



Chapter 12 Safety Tips Before Proceed machining:

- Always wear proper Safety Items (such as safety glasses and other personal safety equipment as necessary or required).
- Never wear loose fitting clothes or jewelry while working on or around Machine.
- Use proper lifting procedures when moving Cylinder Head.
- Use care when installing and/or removing Cylinder Head from Machine. Lock Head Support Assembly before loading or unloading Cylinder Head.
- Keep area around Machine free of paper, oil, water and other debris at all times.
- Keep Machine and area cleaned of excessive lubricant and lubricant spills.
- Keep Machine clear of tools and other foreign objects not needed for the operation.
- Maintain all tools clean and in their proper storage compartments to maintain them in proper working condition and to prolong tool life.
- Before machining always Inspect tooling for cracks, burrs or bent parts that might affect operation. Inspect Carbide Inserts (Seat Pocket Cutter) and Carbide Cutters (Seat Angle Cutter) to ensure they are sharp, firmly attached and are not damaged.
- NEVER force tools when operating. Tools will do a better and safer job when operated at speed rate for which they were designed.
- Always turn OFF electrical power when performing service on your machine, if service does not require power.
- High Voltage exists inside Electrical Control Enclosure – use caution when working on or around Enclosure. Machine must be disconnected from main power supply before any work can be performed inside of Enclosure.
- Machine must ONLY be operated with all Safety Guards in place and locked.

Operation Tips before Machining Valve Seats:

DO NOT depress Foot Pedal once centering is completed, as this will change machine and cylinder Head alignment.

Keep Spindle clean and dry. Never Used Oil.

Clean valve guide with a brush to remove foreign matter.

Required spindle rotation speed will vary, depending on seat hardness. As seat hardness increases, so does the spindle speed will change. Some will require full speed

NOTE:

If valve guides are so badly worn that the proper centering will be impossible, it will be necessary to replace that valve guide to achieve the a concentric valve seat.

See suggested machining speed chart below.

Seat machining Suggested RPM Chart

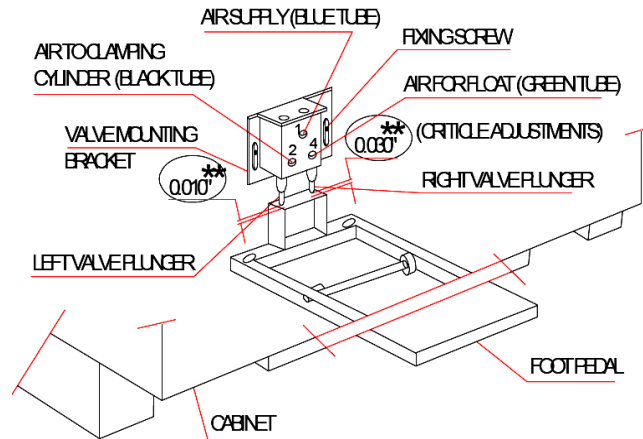
VALVE SEAT DIAMETER		SPINDLE SPEED
INCH	METRIC	RPM
15/16"	24MM	175
1.000"	25.4MM	150
1.125"	29MM	150
1.250"	32MM	125
1.375"	35MM	100
1.500"	38MM	100
1.625"	41MM	100
1.750"	44.5MM	100
1.875"	47.5MM	75
2.000"	51MM	75
2.125"	54MM	75
2.250"	57MM	75
2.375"	60MM	50
2.500"	63.5MM	50

0.010" (0.20mm) whereas the clearance between the right valve plunger and the food pedal bracket should be 0.039" (0.75mm).

This can be achieved by loosening the two fixing screws and adjusting the valve mounting bracket.

Tighten back the bracket (see fig below).

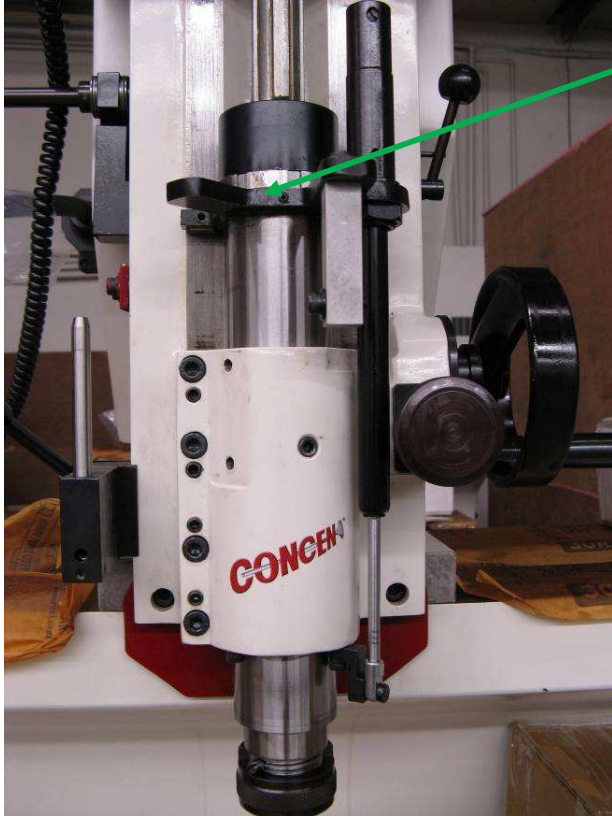
When the food pedal is pressed, remove the black air tube from the left port and it should be a full air flow, whereas when you remove the green air tube from the right port it should not be any air coming out.



Adjusting and aligning the outer spindle on SG models

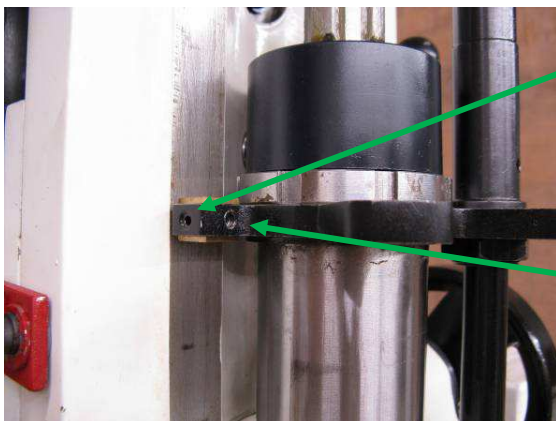
There are 2 brass guide shoes located on the guide plate on top of the spindle that align the rack gear on the back of the spindle with the pinion gear that moves the spindle up and down.

Lower the spindle to the center position of travel.



Check the guide plate at the top of the spindle, tighten if necessary.

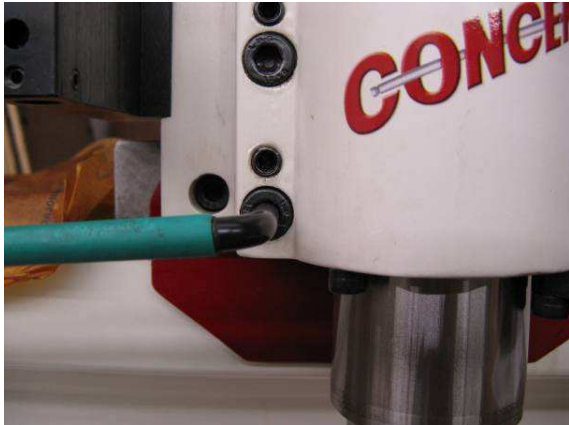
Clean and lightly lubricate sliding guide surfaces with grease. Adjust brass guide shoes on guide plate so that there is no twisting movement. Run the spindle through its full travel to confirm that there is no binding.



Loosen locking screw to adjust brass guide shoe. Tighten after adjusting.

Use adjusting screw to adjust brass guide shoe.

Adjusting outer spindle clearance.



Loosen the 4 lock bolts.



Loosen the 4 adjusting set screws.

Clean outer spindle and lubricate – add a few drops of oil to a clean cloth and wipe outer spindle.

Starting with the bottom set of lock bolt and adjusting set screws, tighten the lock bolt until there is drag on the spindle when it is move through its range of travel.

Then tighten the adjusting set screw until the amount of drag on the spindle is reduced to the point that there is a slight drag on the spindle through its range of travel.

You may have to make further adjustment to the lock bolt and set screw the get the spindle adjusted properly.

Repeat the above procedure the other 3 sets of lock bolts and set screws.

Chapter 14 Consumable Parts

REFERENCE	DESCRIPTION
SLEEVE R1	Spindle adapter replacement sleeve
BSW002	Diamond Wheel Cutting Bit Sharpener replacement Wheel (3.000" Diameter OD by .375" ID)
PRW600PIN	Replaceable Pins for PRW600 Pilot Removable wrench tool
PRW375PIN	Replaceable Pins for PRW375 Pilot Removable wrench tool
PRW20PIN	Replaceable Pins for PRW375 Pilot Removable wrench tool
VT-FP1562	Replacement Foam Pad for Round Vacuum Pad 1.562" diameter
VT-FP1875	Replacement Foam Pad for Round Vacuum Pad 1.875" diameter
VT-FP2125	Replacement Foam Pad for Round Vacuum Pad 2.125" diameter
VT-FP3125	Replacement Foam Pad for Round Vacuum Pad 3.125" diameter
VT-FP25X22	Replacement Foam Pad for Square Vacuum Pad 2.500" x 2.250" square
VT-FP31X20	Replacement Foam Pad for Square Vacuum Pad 3.125" x 2.000" square
VT-FP33X27	Replacement Foam Pad for Square Vacuum Pad 3.375"x 2.750" square
511-29-12F	T7 Torx driver for 1/4" insert (straight angle insert holders only)
511-29-12E	TORX SCREW M2.5 X 0.45 X (straight angle insert holders only)
T8S	T8 Torx Tip Holding Screws
T15S	T15 Torx Tip Holding Screws
MHS-375	Fixed Double Replaceable Insert Milling Head Screws for Large diameter milling Head (3/8" insert)
MHS-250	Fixed Double Replaceable Insert Milling Head Screws for Small diameter milling Head (1/4" insert)
S1032-250	BH375R1 and BH600R1 Tip Holder Looking Screw (10/32" X 1/4") Req. 2
S250-28-250	BH375WR1 Tip Holder Looking Screw 1/4"-28" X 1/4" Req. 2
S1032-437	TH1999 Adjusting Screw (10/32" X 7/16")
S1032-375	TH2000 Adjusting Screw (10/32" X 3/8")
S1032-500	TH2001 Adjusting Screw (10/32" X 1/2")
S1032-625	TH2002 Adjusting Screw (10/32" X 5/8")
S600-1570	TH2003 Adjusting Screw (6.00mm X 15.70mm)
S600-2015	TH2004 Adjusting Screw (6.00mm X 20.15mm)
M10X15X35	SG7 Rollover Fixture Hold down swivel Handle Zinc Handle 35mm (1.375") Long stud (KHF-725)
500-13X2	SG8 – SG9A - SG9 Rollover Fixture Hold down swivel Handle Zinc Handle 2.000" Long stud (KHF-162) (Sketch No. 5 part No. 47 from the Sketch)
500-13X1375	SG7- SG8 – SG9A - SG9 Rollover Fixture Lock swivel Handle Zinc Handle 1.375" Long stud (KHF-158) (Sketch No. 5 part No. 3 from the Sketch)
ICC003	Insert, Indexable carbide, for Fixed milling heads - large size - for 1.562" and larger cutters
ICC002	Insert, Indexable, carbide, for Fixed milling heads - small size - for 1.250" to 1.500" cutters

Chapter 15 Carbide Inserts:

See Carbide Insert Catalog for a complete list of Insert Profiles available from Rottler Manufacturing.

Special Profiles

Special Profile Cutter Inserts can be manufactured to your exact specifications and can include a combination of angles and radius blends.

There is three different style insert blanks.

A - Style Blank insert, **RCA** is a small insert for all standard applications.

B - Style Blank insert, **RCB** in design for long profiles like High Performances profiles with multi angles o Radius or other special applications

C - Style Blank insert, **RCC** is a much thicker insert for Heavy Duty tooling and can be use for hard seat materials (will work only on the Large Inserts holders series 3000 style insert holders, for the 20.00mm tooling)

Special Order - Special Profile Carbide Cutter Bits are generally considered to be "Customer Proprietary". These are uniquely numbered, exclusively for the ordering customer; prices will vary depending on quantities and additional charge for initial run.

Call us for a quote.

RT312 Insert, triangular positive rake, 3/8 1/32" (.787mm) radius, for the TH3000 series insert holder and RT212 Insert, triangular positive rake, 1/4" (6.35mm) 1/32 " radius for the TH2000 series, for hard seat materials applications (Counterboring and straight angles only)

Chapter 16 Carbide Pilots

See Carbide Pilot catalog for a complete list of Pilots available.

Rottler Solid Fixed Carbide Pilots are manufactured from fine grain sintered tungsten carbide and are ground to a very high degree of accuracy, straightness and surface finish - designed for a life time of precision machining!

The part number of the pilot represents the actual diameter in metric of the straight/parallel part of the pilot where the pilot fits into the valve guide.

For example:

FCP0700 means that the diameter of the part of the pilot that goes into the valve guide is **7.00mm (0.2756")**

FCP1270 means that the diameter of the part of the pilot that goes into the valve guide is **12.70mm (0.5000")**

Pilots are available in increments of .01mm (0.0004"). Normally, a small amount of clearance approx .01mm (0.0004") is required between the pilot and the valve guide.

Most new valve guides are manufactured to a **nominal size** and the valve stem diameters are manufactured to be smaller than the nominal size to allow clearance for heat expansion of the valve stem when the engine is operating. For example: a 7mm valve guide has an internal diameter of exactly 7.00mm (.2756") The valve stem diameter of the intake valve is 6.98mm (.2748") and the exhaust is 6.96mm (.2740"). In order for the pilot to fit most all valve guides, the first choice could be FCP0699 to give .01mm (0.0004") clearance. If the valve guide is used and has some wear, then the second choice of pilot could be FCP0700(0.2756").

Rottler makes 3 sizes of shanks of pilots:

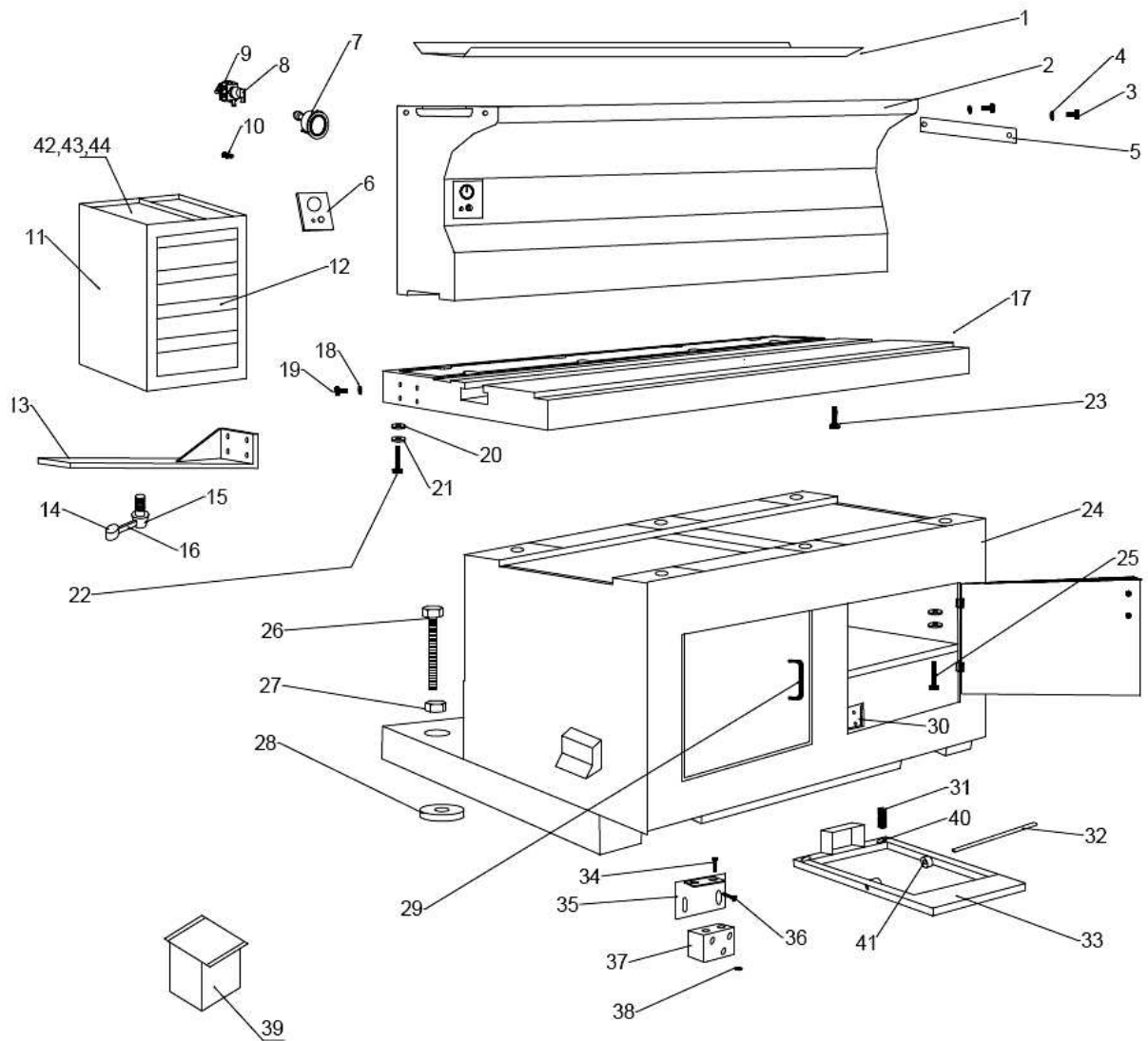
6.00mm (0.2362") for small valves guides 6mm (0.236") and below. The part number for these pilots is FCPM.

0.375" (9.52mm) for common size valve guides, 6-14mm (.236-.625"). The part number for these pilots is FCP.

20mm (0.7874mm) for large valve guides for SG80A machine. These pilots are made to order specifications.

Chapter 17 Machine Parts

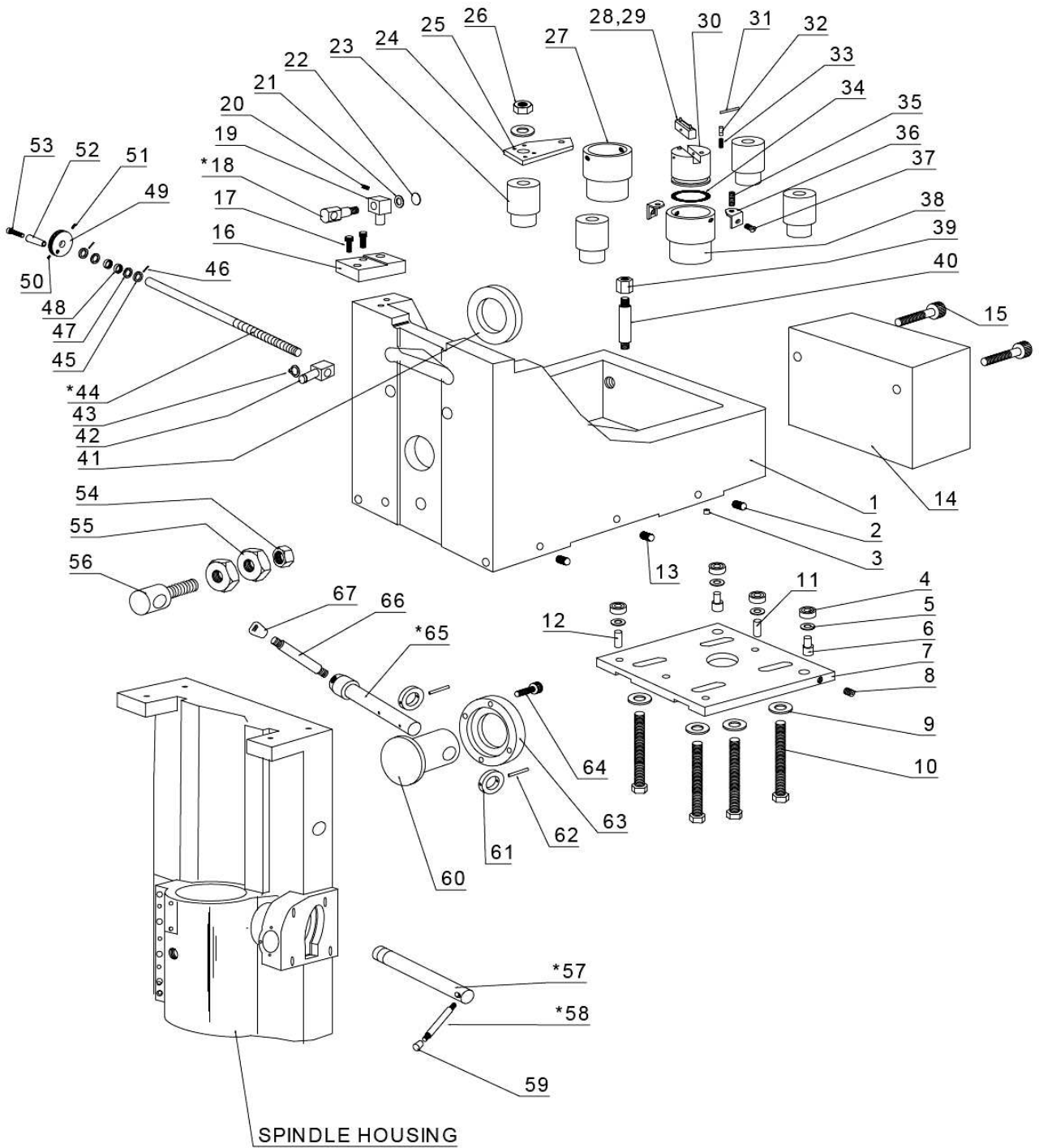
SKETCH No. 1 Base, Table and Riser Assembly



SKETCH No. Base, Table and Riser Assembly - Parts Description:

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	430-820	COVER PAN	1
2	430-815	RISER	1
3	430-822	SCREW	4
4	430-822A	WASHER	4
5	430-821	STOP PLATE	2
6	033-071	PLATE	1
7	430-830	VACCUM GAUGE 2.5" STD-B X ¼ NPT	1
8	430-831	N-22-SW (9301)	1
9	430-832	SV-3-M5 (6817)	1
10	430-837	QSS-6 (153158)	1
11	430-807	TOOL CABINET	1
12	430-816	TOOL TRAY	4
13	430-806	MOUNTING BRACKET	1
14	430-802	KNOB	1
15	430-817	CLAMP PIN	1
16	430-823	CLAMP LEVER	1
17	430-808	TABLE	1
18	VGS-804	WASHER	4
19	VGS-803	SCREW	4
20	430-811	PLAIN WASHER	11
21	430-810	LOCK WASHER	11
22	430-809	HEX. SCREW	3
23	430-812	HEX SCREW	7
24	430-801	CABINET ASSY	1
25	430-813	HEX SCREW	4
26	430-818	LEVELING BOLT	6
27	430-818A	HEX NUT	6
28	430-819	PAD	6
29	430-825	HANDLE	2
30	430-827	MEGNET BLOCK	2
31	430-833	SPRING	2
32	430-834	ROD	1
33	430-835	FRAME WELDED	1
34	430-838	SCREW	2
35	430-836	FOOT SWITCH MTG. BKT	1
36	430-814	SCREW	2
37	430-828	FOOT SWITCH ASSY	1
38	430-805	NUT	2
39	430-824	CHIP TRAY	1
40	430-835A	PAD	2
41	430-835B	BUSH	2
42	430-826	TOOL BOARD	1
43	430-829	TOOL BOARD (R.H)	1
44	430-839	TOOL BOARD (L.H)	1

SKETCH No. 2 Workhead Assembly

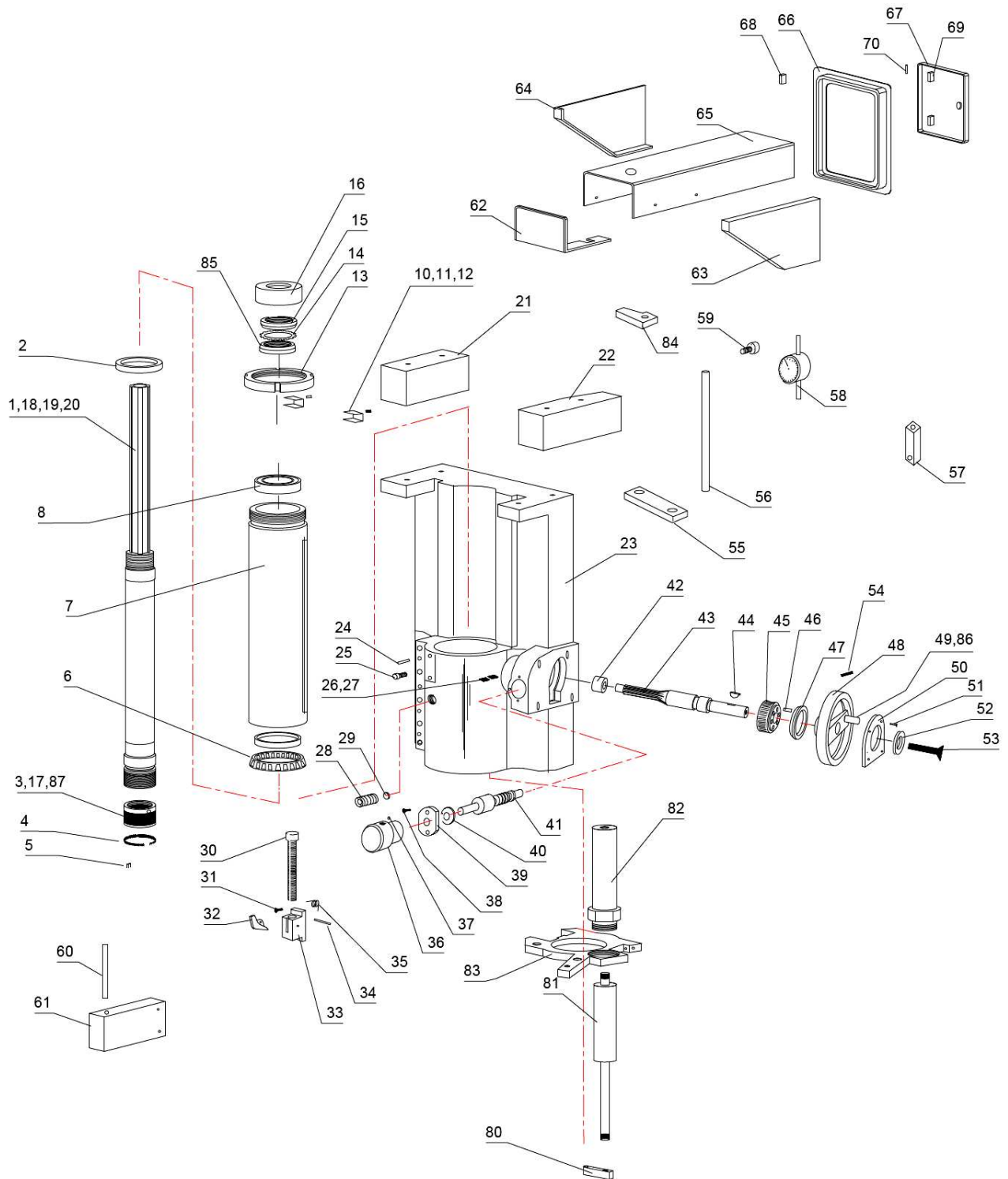


SKETCH No. 2 Workhead Assembly - Parts Description:

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	430-514	BASE	1
2	VGS-512	SET SCREW 5/16" NF X 3/8"	4
3	VGS-513	PLUG (BRASS)	16
4	VGS-505	BALL BEARING	6
5	VGS-503	WASHER OD 0.350", ID 0.203" X 0.05" THK	8
6	VGS-506	ECCENTRIC PIN	2
7	430-501	PLATE	2
8	VGS-507	GRUB SCREW 10-32 X 1/4" DOG PT.	2
9	VGS-508	WASHER 3/8"	8
10	430-509	HEX. BOLT	4
11	VGS-504	PIN	2
12	VGS-502	PIN	2
13	VGS-511	GRUB SCREW 10-32 X 1/4" FLAT PT.	2
14	430-518	WEIGHT	1
15	430-519	ALLEN HD. SCREW (1/2" UNC X 2.5")	2
16	430-521	SWIVALING BLOCK	1
17		ALLEN HD. SCREW	2
18	430-525	SWIVALING PIN	1
19	430-522	PIN HOLDER	1
20		GRUB SCREW 1/4" BSW	1
21	430-527	WASHER	1
22	430-528	NUT 3/8" BSW	1
23	VGS-536	BUSH	4
24	VGS-544	LEVER	4
25	VGS-545	HAMMER RIVET	16
26	VGS-546	NYLOCK NUT 3/8" BSW	4
27	VGS-547	CYLINDER (LH)	1
28	VGS-538	GUIDE PIN	4
29	VGS-539	LEVER	2
30	VGS-540	PISTON	2
31	VGS-540A	PIN	2
32	VGS-540B	PISTON PIN	4
33	VGS-540C	SPRING	4
34	VGS-540D	'O' RING	2
35	VGS-543	GRUB SCR. 8-32 X 20mm F. POINT	4
36	VGS-541	BRACKET	4
37	VGS-542	BUTTON HD SCR 10-32 X 1/4"	4
38	VGS-537	CYLINDER (RH)	1
39	VGS-535	NUT (NEST)	1
40	430-534	STUD	1
41	430-520	SPACER	1
42	430-523	ADJUSTING NUT	1
43	430-524	RETAINING RING	1
44	430-526	INCLINATION ROD	1
45	430-548	RETAINING RING	2
46	430-549	SPRING PIN 1/8" X 3/4"	2
47	430-551	NEEDLE BEARING	1
48	430-550	THRUST BEARING	2
49	430-531	KNOB	1
50	430-530	GRUB SCR. 1/4" BSW X 1/4" FLAT PT.	1
51	430-529	SET SCREW 5/16" BSW X 1/4" F.PT.	1
52	430-532	HANDLE	1

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
53	430-533	ALLEN HD SCREW 5/16" BSW X 2.50'	1
54		NYLOCK NUT 3/8" UNF	1
55	VGS-640	NUT	2
56	430-670	EYE BOLT	1
57	430-669	ECCENTRIC COLLAR	2
58	VGS-521	LEVER	1
59	VGS-522	KNOB	1
60	VGS-629	PIVOT PIN	1
61	430-510	ECCENTRIC COLLAR	2
62	430-552	TAPER PIN	2
63	430-628	RING	1
64	430-630	ALLEN HEAD SCR. 1/4" BSW X 1/2" LONG	4
65	430-515	CLAMP	1
66	430-516	LEVER	1
67	430-517	KNOB	1
68	430-514-S-1	CLAMP PLATE (NOT SHOWN)	1
69	430-514-A	BASE COVER PLATE (NOT SHOWN)	1
70	430-514 S-2	SHIPPING CLAMP (NOT SHOWN)	2

SKETCH No. 3 Spindle Assembly

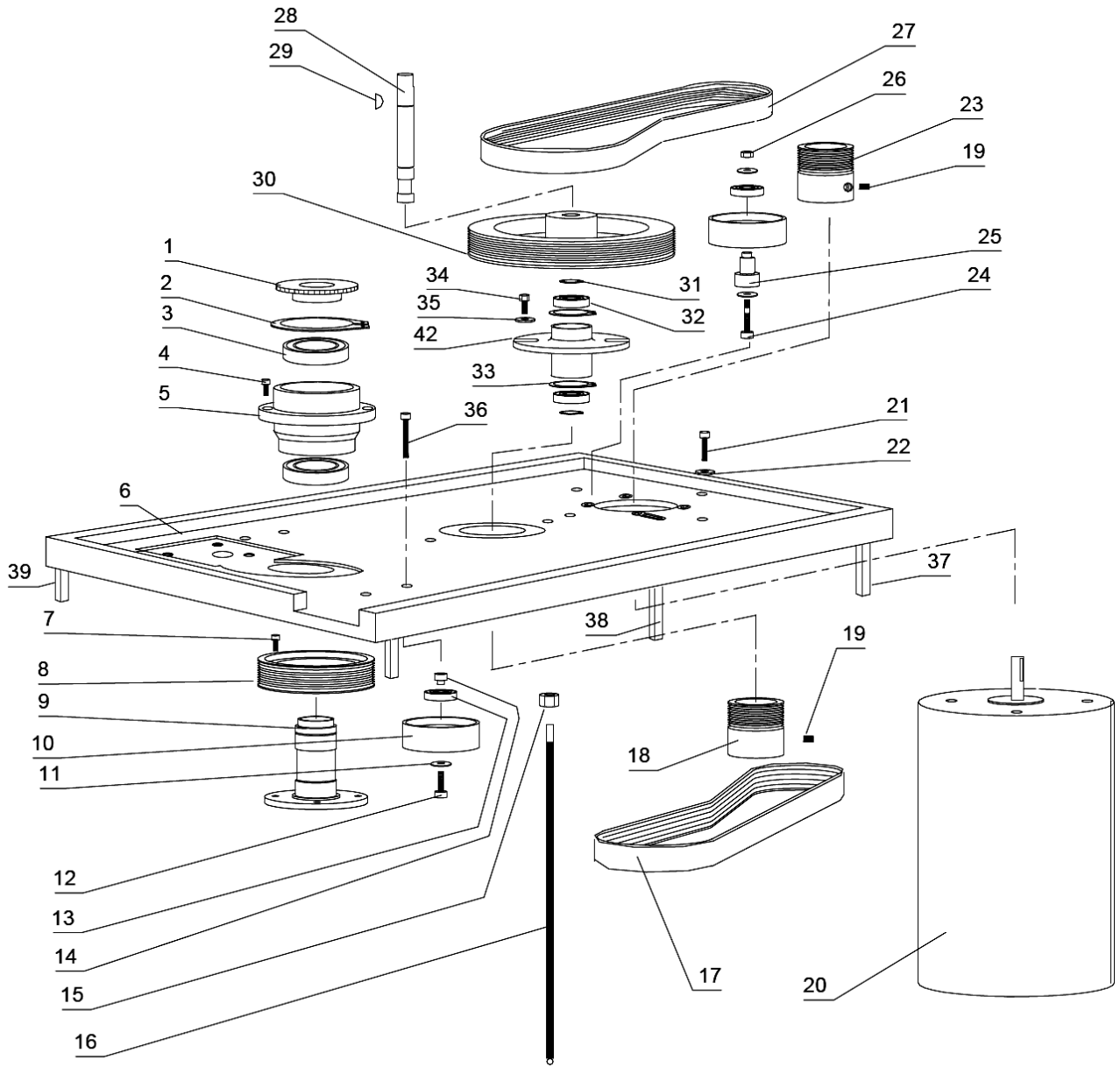


SKETCH No. 3 Spindle Assembly – Parts Description:

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	430-604 R	DRIVE SHAFT	1
2	430-671	RUBBER SEAL	1
3	KS-08-07	QUICK NUT	1
4	KS-08-03	SPRING	2
5	KS-08-02	PAD	2
6	430-659	TAPER ROLLER BEARING	1
7	430-608	COLUMN	1
8	430-648	BALL BEARING	1
9			
10	430-623	BRASS PAD	2
11	430-623A	C.PT. GRUB SCR. 3/16" X 1/2" BSW	2
12	430-623B	F.PT GRUB SCR. 3/16" X 1/2" BSW	1
13	430-622	STOP PLATE LOCK NUT	1
14	430-603A	LOCK WASHER	1
15	430-603	LOCK NUT	2
16	430-601	END STOPPER	1
17	KS-08-06	COVER	1
18	KS-08-05	PIN	1
19	KS-08-04	SPRING	1
20	KS-08-01	STOP PIN	1
21	430-711	EXTENSION BLOCK LEFT	1
22	430-716	EXTENSION BLOCK RIGHT	1
23	430-614	SPINDLE HOUSING	1
23A	430-614S	SHIPPING CLAMP	1
24	430-627	GRUB SCR. D.PT. 5/16" NF X 1.25" LONG	4
25	430-609	ALLEN SCREW 5/16" NF X 1.5" LONG	5
26	430-621	GRUB. SCR. D. PT. 5/16" NF X 1/2" LONG	1
27	430-621a	GRUB SCR. F. PT. 5/16" NF X 0.200" LONG	1
28	430-619	GRUB SCREW 3/8" BSW X 1/2" LONG	1
29	430-619A	BRASS PLUG	1
30	430-615 (A & B)	CONTROL STOP SCREW ASSY.	1 EACH
31	430-607	C'SINK SCR. 1/4" X 1/2" BSW	2
32	430-620	CONTROL STOP LATCH	1
33	430-606	CLAMP	1
34	430-617	PIN	1
35	430-618	SPRING	1
36	430-664	KNOB	1
37	430-665	SET SCR. F. PT. 5/16" NF X 3/8" LONG	1
38		C' SINK SCR. 10-32 X 1/4" LONG	1
39	430-663	END COVER	1
40	430-662	WASHER	1
41	430-660	WORM SHAFT	1
42	430-631A	BUSH	1
43	430-631	PINION	1
44	430-632	WOODRUF KEY	1
45	430-661	WORM WHEEL	1
46	430-667	PIN	2
47	430-634	SPACER	1
48	430-635R	HAND WHEEL	1
49	430-637R	KNOB	
50	430-668	COVER PLATE	1
51	430-666	C' SINK SCREW	4
52	430-636	WASHER	1
53	430-636A	C'SINK SCR. 1/4" X 1/2" BSW	1

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
54	430-639	M4-BALL PLUNGER SCREW	1
55	VGS-641	INDICATOR MTG. FLAT	1
56	VGS-642	INDICATOR MTG. ROD	1
57	430-643A	DIAL CLAMP	1
58	VGS-646	INDICATOR	1
59	430-645A	KNOB	1
60	430-616	LEVELING PIN	1
61	430-644	PLATE (LEVELING PIN)	1
62	430-650	CONTROL PANEL MOUNTING	1
63	430-647a	RIGHT SIDE COVER	1
64	430-647b	LEFT SIDE COVER	1
65	430-647-C	TOP COVER	1
66	430-713	BACK COVER FRAME	1
67	430-715	BACK DOOR	1
68	430-722	FIX BLOCK	2
69	430-723	SWING BLOCK	2
70	430-724	PIN	2
71	30-672	SHAFT (NOT SHOWN)	1
72	30-673	HOLDER (NOT SHOWN)	1
73	30-674	PLATE (NOT SHOWN)	1
74	30-675	THUMB SCREW (NOT SHOWN)	1
75	30-676	COVER (NOT SHOWN)	1
76			
77			
78			
79			
80	430-712-R	HOLDER	1
81	430-714-R	GAS SPRING (150N)	1
82	430-717-R	TUBE	1
83	430-625-R	PLATE	1
84	430-643 B	CLAMP	1
85	430-605	SPACER	1
86	430-638 R	PLUG (LEVER)	1
87	KS-08-07 S P	NUT	1

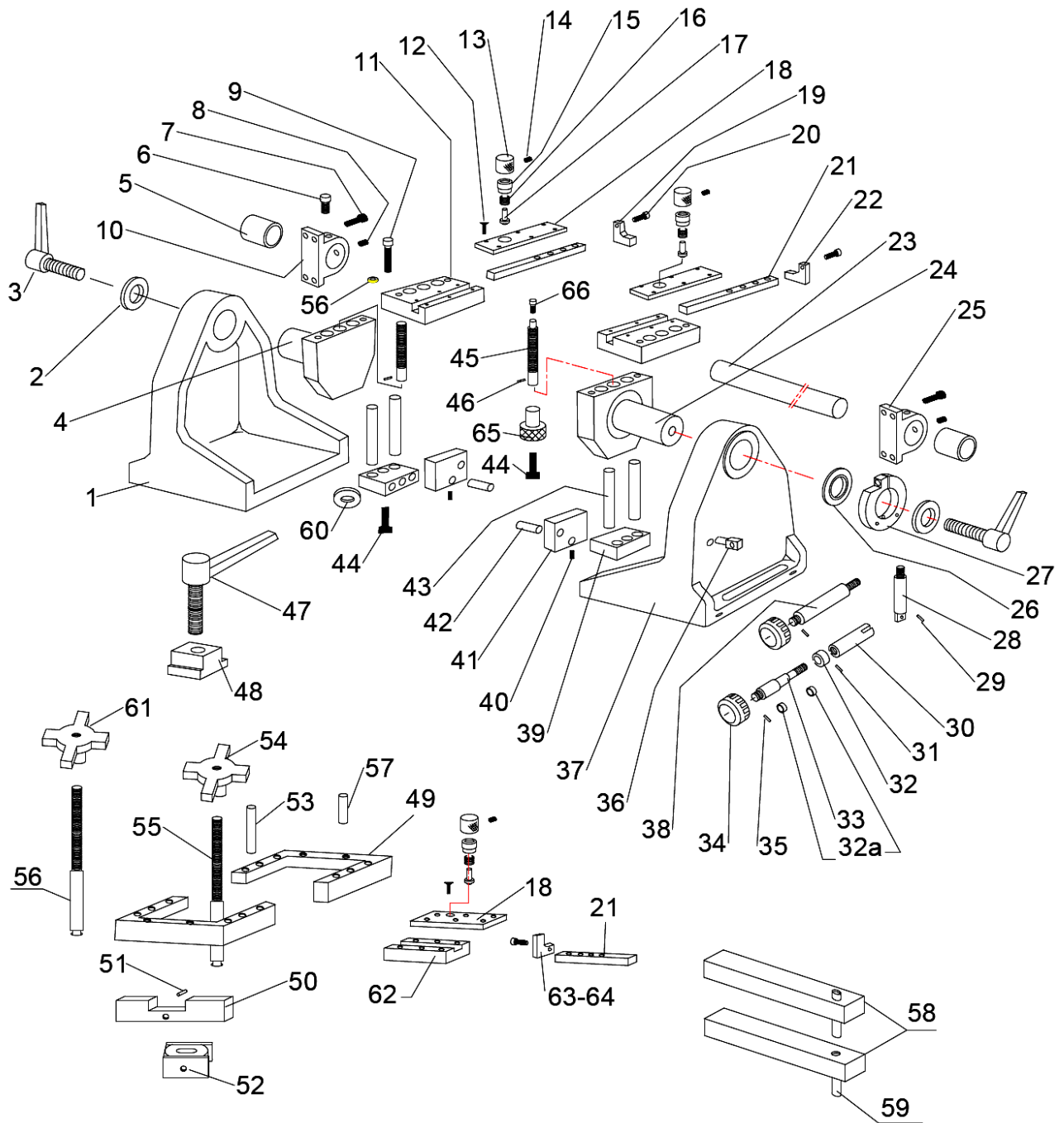
SKETCH No. 4 Transmission Assembly



SKETCH No. 4 Transmission Assembly – Parts Description:

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	430-750	SENSOR WHEEL	1
2	430-705B	EXT. CIRCLIP	1
3	430-648	BALL BEARING	2
4	430-705A	ALLEN SCR. 1/4" BSW X 3/4"	6
5	430-705	BEARING HOUSING	1
6	430-735	PLATE	1
7	VGS-703	ALLEN SCREW 10-32 X 5/8" LONG	4
8	430-702	DRIVE PULLEY	1
9	430-701	FLANGE	1
10	VGS-707	IDLER PULLEY	2
11	VGS-706	ALLEN SCREW 1/4" NF X 1.250"	1
12	VGS-706A	1/4" WASHER	3
13	VGS-708	BEARING	2
14	VGS-709	IDLER HUB	1
15	VGS-725	HEX NUT 1/4"-20	1
16	430-721	MOTOR CONTROL SUPPORT	1
17	VGS-710	V-BELT (COUNTER SHAFT)	1
18	VGS-751	PULLEY	1
19	VGS-753	GRUB SCR. 1/4" -20 X 3/8" CUP PT.	3
20	430-726	MOTOR DC 1HP (CDP 3445)	1
21	VGS-731	ALLEN SCR. 3/8" BSW X 1" LONG	4
22	VGS-732	3/8" WASHER	4
23	430-738	PULLEY	1
24	430-706A	ALLEN SCREW 1/4" X 2" LONG	1
25	430-709A	IDLER HUB	1
26	430-706B	HEX NUT 1/4" -20	1
27	VGS-737	V-BELT (DRIVE)	1
28	430-746	SHAFT	1
29	VGS-742	WOODRUF KEY 3/16" X 3/4" LONG	1
30	430-741	PULLEY	1
31	VGS-745	EXT. CIRCLIP	2
32	VGS-743	BEARING	2
33	VGS-744	INT. CIRCLIP	2
34	VGS-739	HEX SCREW 1/4" BSW X 3/4" LONG	2
35	VGS-740	1/4" WASHER	2
36		ALLEN SCREW	4
37	430-718	COVER SUPPORT	4
38	430-719	COVER SUPPORT	2
39	430-720	COVER SUPPORT	2
40	430-735W	SPACER (NOT SHOWN)	4
41	430-735B	SENSOR SWITCH MTG. BKT. (NOT SHOWN)	1
42	VGS-747	FLANGE	1

SKETCH No. 5 Cradle Assembly



SKETCH No. 5 Cradle Assembly – Parts Description:

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	430-913	HEAD SUPPORT LEFT	1
2	430-912	WASHER	2
3	430-938 A&B	CLAMP BOLT LH & RH	1 EACH
4	430-970	HOLDER LEFT	1
5	430-901	BUSH	2
6	430-911	SCREW	1
7	430-906	SCREW	8
8		GRUB SCREW	2
9	VGS-959	SCREW	4
10	430-902	BEARING BUSH LEFT	1
11	430-957	PLATE	2
12	430-925	C'SINK SCREW	24
13	430-918	KNURLING COLLAR	4
14	430-917	SCREW 1/4"-20	4
15	430-916	PIN HOLDER	4
16	430-921	SPRING (SAME AS #100-057)	4
17	430-919	PLUNGER	4
18	430-915	PLATE	4
19	430-937	STOP PLATE (LH)	1
20	430-936	SCREW 1/4"-20 X 3/4" LONG	4
21	430-940	FLAT	4
22	430-935	STOP PLATE (RH)	1
23	430-914	GUIDE ROD	1
24	VGS-958	HOLDER RIGHT	1
25	430-907	BEARING BUSH RIGHT	1
26	430-934	SPACER	1
27	430-933	COLLAR	1
28	430-929	ARM	1
29	VGS-928	PIN	1
30	430-927	CLAMP	1
31	430-904	PIN	1
32	430-548	RETAINER RING	1
32A	430-550	THRUST BEARING	2
33	430-926	ADJUSTING SCREW	1
34	430-923	KNOB	1
35	430-924	PIN	2
36	430-922	PIVOT BLOCK	1
37	430-920	HEAD SUPPORT RIGHT	1
38	430-931	LOCK COLLAR SCREW	1
39	430-965	CLAMP PLATE	2
40		GRUB SCREW	2
41	430-964	CLAMP	2
42	430-949	PIVOT PIN	2
43	VGS-961	GUIDE PIN	4
44	VGS-967	SCREW	2
45	VGS-962	SCREW	2
46	VGS-963	PIN	2
47	430-941	HANDLE	2
48	430-939	T-NUT	2
49	430-944-1	HEAD SUPPORT	2
50	430-945	BAR	2
51	430-946	ROLL PIN	2
52	430-947	SWIVEL CLAMP	2

S. NO.	PART NO.	DESCRIPTION	Q TY/M/C
53	430-943	TUBE	2
54	430-942	KNOB	2
55	430-948	TAKE UP ROD	2
56	430-948A	TAKE UP ROD (1/4")	2
57	430-943S	TUBE (SMALL)	2
58	430-944S	PARALLEL FLAT	2
59		DOWEL PIN (1/4" X 1") (PURCHASED)	2
60	VGS-968	WASHER	2
61	430-942-A	KNOB	2
62	430-944-II	LOCATING BLOCK	2
63	430-935-I	STOP PLATE R. H.	1
64	430-937-I	STOP PLATE L. H.	1
65	430-962-2	KNOB	2
66	430-903	SCREW 5/16" X 1/2" LONG	2

Chapter 18 Decimal to Metric Conversion Chart UNITS OF LENGTH

TO CONVERT	MULTIPLY BY	TO OBTAIN
KM	1093.6	YD.
KM	0.6214	MILES
MICRONS	0.00003937	IN.
IN.	25.4	MM
IN.	2.54	CM
IN.	0.0254	METERS

TO CONVERT	MULTIPLY BY	TO OBTAIN
KM	1093.6	YD.
KM	0.6214	MILES
MICRONS	0.00003937	IN.
IN.	25.4	MM
IN.	2.54	CM
IN.	0.0254	METERS

TO CONVERT	MULTIPLY BY	TO OBTAIN
KM	1093.6	YD.
KM	0.6214	MILES
MICRONS	0.00003937	IN.
IN.	25.4	MM
IN.	2.54	CM
IN.	0.0254	METERS

FRACTION	DECIMAL	MM
1/64	0.0156	0.3969
1/32	0.0313	0.7938
3/64	0.0469	1.1906
1/16	0.0625	1.5875
5/64	0.0781	1.9844
3/32	0.0938	2.3813
7/64	0.1094	2.7781
1/8	0.1250	3.1750
9/64	0.1406	3.5719
5/32	0.1563	3.9688
11/64	0.1719	4.3656
3/16	0.1875	4.7625
13/64	0.2031	5.1594
7/32	0.2188	5.5563
15/64	0.2344	5.9531
1/4	0.2500	6.3500
17/64	0.2656	6.7469
9/32	0.2813	7.1438
19/64	0.2969	7.5406
5/16	0.3125	7.9375
21/64	0.3281	8.3344
11/32	0.3438	8.7313
23/64	0.3594	9.1281
3/8	0.3750	9.5250
25/64	0.3906	9.9219
13/32	0.4063	10.3188
27/64	0.4219	10.7156
7/16	0.4375	11.1125
29/64	0.4531	11.5094
15/32	0.4688	11.9063
31/64	0.4844	12.3031
1/2	0.5000	12.7000

FRACTION	DECIMAL	MM
1 1/64	1.0156	25.7969
1 1/32	1.0313	26.1938
1 3/64	1.0469	26.5906
1 1/16	1.0625	26.9875
1 5/64	1.0781	27.3844
1 3/32	1.0938	27.7813
1 7/64	1.1094	28.1781
1 1/8	1.1250	28.5750
1 9/64	1.1406	28.9719
1 5/32	1.1563	29.3688
1 11/64	1.1719	29.7656
1 3/16	1.1875	30.1625
1 13/64	1.2031	30.5594
1 7/32	1.2188	30.9563
1 15/64	1.2344	31.3531
1 1/4	1.2500	31.7500
1 17/64	1.2656	32.1469
1 9/32	1.2813	32.5438
1 19/64	1.2969	32.9406
1 5/16	1.3125	33.3375
1 21/64	1.3281	33.7344
1 11/32	1.3438	34.1313
1 23/64	1.3594	34.5281
1 3/8	1.3750	34.9250
1 25/64	1.3906	35.3219
1 13/32	1.4063	35.7188
1 27/64	1.4219	36.1156
1 7/16	1.4375	36.5125
1 29/64	1.4531	36.9094
1 15/32	1.4688	37.3063
1 31/64	1.4844	37.7031
1 1/2	1.5000	38.1000

FRACTION	DECIMAL	MM
2 1/64	2.0156	51.1969
2 1/32	2.0313	51.5938
2 3/64	2.0469	51.9906
2 1/16	2.0625	52.3875
2 5/64	2.0781	52.7844
2 3/32	2.0938	53.1813
2 7/64	2.1094	53.5781
2 1/8	2.1250	53.9750
2 9/64	2.1406	54.3719
2 5/32	2.1563	54.7688
2 11/64	2.1719	55.1656
2 3/16	2.1875	55.5625
2 13/64	2.2031	55.9594
2 7/32	2.2188	56.3563
2 15/64	2.2344	56.7531
2 1/4	2.2500	57.1500
2 17/64	2.2656	57.5469
2 9/32	2.2813	57.9438
2 19/64	2.2969	58.3406
2 5/16	2.3125	58.7375
2 21/64	2.3281	59.1344
2 11/32	2.3438	59.5313
2 23/64	2.3594	59.9281
2 3/8	2.3750	60.3250
2 25/64	2.3906	60.7219
2 13/32	2.4063	61.1188
2 27/64	2.4219	61.5156
2 7/16	2.4375	61.9125
2 29/64	2.4531	62.3094
2 15/32	2.4688	62.7063
2 31/64	2.4844	63.1031
2 1/2	2.5000	63.5000

33/64	0.5156	13.0969	1 33/64	1.5156	38.4969	2 33/64	2.5156	63.8969
17/32	0.5313	13.4938	1 17/32	1.5313	38.8938	2 17/32	2.5313	64.2938
35/64	0.5469	13.8906	1 35/64	1.5469	39.2906	2 35/64	2.5469	64.6906
9/16	0.5625	14.2875	1 9/16	1.5625	39.6875	2 9/16	2.5625	65.0875
37/64	0.5781	14.6844	1 37/64	1.5781	40.0844	2 37/64	2.5781	65.4844
19/32	0.5938	15.0813	1 19/32	1.5938	40.4813	2 19/32	2.5938	65.8813
39/64	0.6094	15.4781	1 39/64	1.6094	40.8781	2 39/64	2.6094	66.2781
5/8	0.6250	15.8750	1 5/8	1.6250	41.2750	2 5/8	2.6250	66.6750
41/64	0.6406	16.2719	1 41/64	1.6406	41.6719	2 41/64	2.6406	67.0719
21/32	0.6563	16.6688	1 21/32	1.6563	42.0688	2 21/32	2.6563	67.4688
43/64	0.6719	17.0656	1 43/64	1.6719	42.4656	2 43/64	2.6719	67.8656
11/16	0.6875	17.4625	1 11/16	1.6875	42.8625	2 11/16	2.6875	68.2625
45/64	0.7031	17.8594	1 45/64	1.7031	43.2594	2 45/64	2.7031	68.6594
23/32	0.7188	18.2563	1 23/32	1.7188	43.6563	2 23/32	2.7188	69.0563
47/64	0.7344	18.6531	1 47/64	1.7344	44.0531	2 47/64	2.7344	69.4531
3/4	0.7500	19.0500	1 3/4	1.7500	44.4500	2 3/4	2.7500	69.8500
49/64	0.7656	19.4469	1 49/64	1.7656	44.8469	2 49/64	2.7656	70.2469
25/32	0.7813	19.8438	1 25/32	1.7813	45.2438	2 25/32	2.7813	70.6438
51/64	0.7969	20.2406	1 51/64	1.7969	45.6406	2 51/64	2.7969	71.0406
13/16	0.8125	20.6375	1 13/16	1.8125	46.0375	2 13/16	2.8125	71.4375
53/64	0.8281	21.0344	1 53/64	1.8281	46.4344	2 53/64	2.8281	71.8344
27/32	0.8438	21.4313	1 27/32	1.8438	46.8313	2 27/32	2.8438	72.2313
55/64	0.8594	21.8281	1 55/64	1.8594	47.2281	2 55/64	2.8594	72.6281
7/8	0.8750	22.2250	1 7/8	1.8750	47.6250	2 7/8	2.8750	73.0250
57/64	0.8906	22.6219	1 57/64	1.8906	48.0219	2 57/64	2.8906	73.4219
29/32	0.9063	23.0188	1 29/32	1.9063	48.4188	2 29/32	2.9063	73.8188
59/64	0.9219	23.4156	1 59/64	1.9219	48.8156	2 59/64	2.9219	74.2156
15/16	0.9375	23.8125	1 15/16	1.9375	49.2125	2 15/16	2.9375	74.6125
61/64	0.9531	24.2094	1 61/64	1.9531	49.6094	2 61/64	2.9531	75.0094
31/32	0.9688	24.6063	1 31/32	1.9688	50.0063	2 31/32	2.9688	75.4063
63/64	0.9844	25.0031	1 63/64	1.9844	50.4031	2 63/64	2.9844	75.8031
1	1.0000	25.4000	2	2.0000	50.8000	3	3.0000	76.2000