



# MANUFACTURING SG9

## **Automatic Seat and Guide Machine**

Serial No.: \_\_\_\_\_

Company: \_\_\_\_\_

### **OPERATIONS AND MAINTENANCE MANUAL**



#### **MANUFACTURED BY:**

#### **ROTTLER MANUFACTURING COMPANY**

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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**


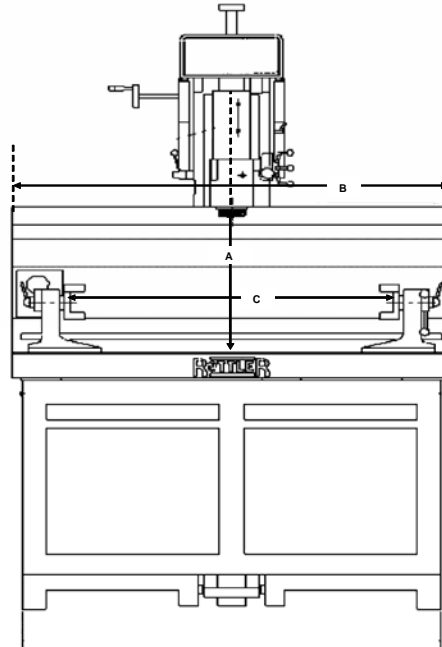
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## Machine Specifications



<b>Quill diameter</b>	3.150" 80mm
<b>Maximum Spindle Stroke</b>	8" 203mm
<b>Maximum Tilt</b> (either side of zero)	15 degrees
<b>Distance from Table to Spindle</b>	19.5" 495mm
<b>Maximum Cylinder Head Length</b> (with 360° rollover fixture)	44" 1118mm
<b>Maximum Cylinder Head Length</b> (with diesel fixture)	50" 1270mm
<b>Spindle Speed</b>	0 to 400 rpm
<b>Electrical Requirements</b>	208/220 volt, single phase, 15 amp
<b>Air Requirements</b>	90/100 psi
<b>Spindle Motor</b>	1 HP/.75 kW
<b>Machine Dimensions</b>	53" Wide x 25" Deep x 80" High 1346mm x 635mm x 2032mm
<b>Working Dimensions</b>	84" wide x 42" deep x 80" high 2134mm x 1067mm x 2032mm
<b>Shipping Dimensions</b>	61" wide x 25" deep x 75" high 1549mm x 635mm x 1905mm
<b>Shipping Weight</b>	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 SG9

- Air float work head and pedal control
- Universal heavy duty 360 degree rollover 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 1 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 **SG9** 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 **SG9** 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.



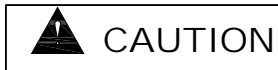
This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.



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.

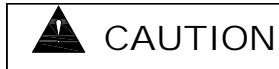
**USE THE RECOMMENDED ACCESSORIES.** Consult the manual for recommended accessories. The use of improper accessories may cause risk of injury.

**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.



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:



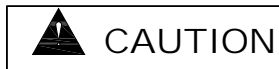
All electrical power should be removed from the machine before opening the rear electrical enclosure. It is recommended that the machine have a electrical LOCK-OUT device installed.

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

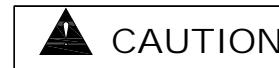
In the event of an electrical short, grounding reduces the risk of electric shock by providing a path of least resistance to disperse electric current.



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.



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.



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 SG9 should have **a fully isolated** power supply to prevent damage and uncontrolled movement of the machine.

If the SG9 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 SG9 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 SG9.

**Machine Operator:**

The operator of the SG9 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 SG9 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.



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



**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.



**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 SG8A 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. Below you will see 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.

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**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.

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### 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

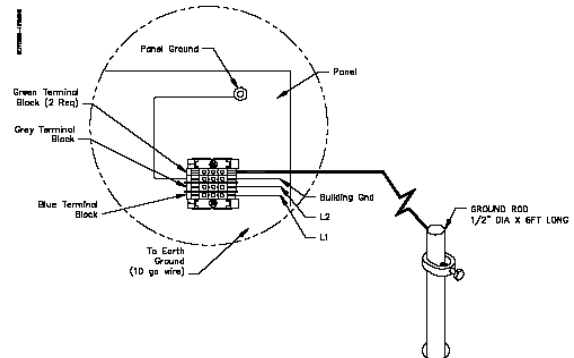
See illustration below for correct connection of “measured” incoming power. connect single phase wiring to the main rear enclosure, located on the right rear of machine base. The connection point for power is located inside the enclosure. The connection termination point is located on the left hand side of the electrical panel about half way up. Connect L1 to the grey terminal block, L2 (neutral) to the blue terminal block and shop ground to the green and yellow 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, ½” 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 2 Machine Installation:

### Location:

The productivity of the SG9 will depend a great deal on the proper initial installation. Pay particular attention to the means by which work pieces are lifted into and out of the machine as well as the material handling to and from other operations in your shop. The proper loading arrangements and work location for your SG9 is extremely important.

For shops where large production runs are anticipated, the work pieces should be loaded and unloaded directly from a conveyer. If this is not the case, we suggest you pay considerable attention to the crane so that it covers an adequate area to allow the operator to back up and remove work pieces without creating a cluttered, dangerous work area.

### Unpacking and Lifting:

Use care when removing the crate materials from the machine. Be careful not to use force on any part of the machine.

Remove the shipping screws (4) from the skid; the shipping brackets will be painted red for easy identification. These screws are located at the four bottom corners of the Main Base.

### 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

- 1- 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.
- 2- 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.
- 3- 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.
- 4- 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.
- 5- 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 foot Pedal is depressed, allowing Head to float on Rails apply (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).

### 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.

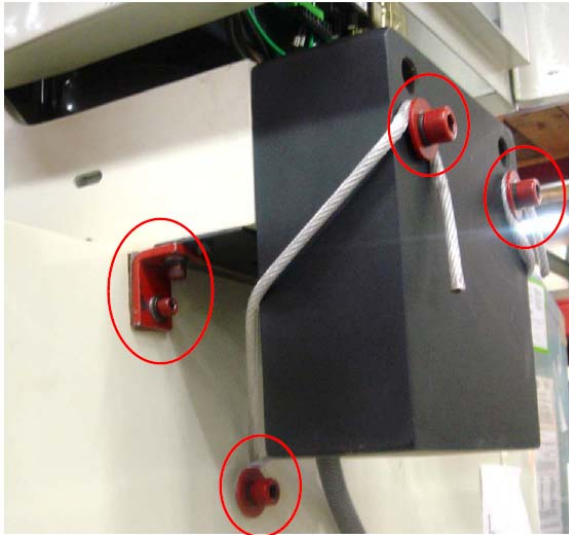


FIGURE - 1

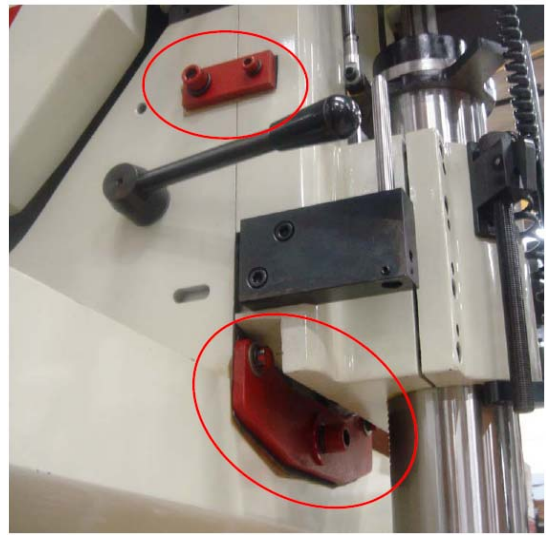
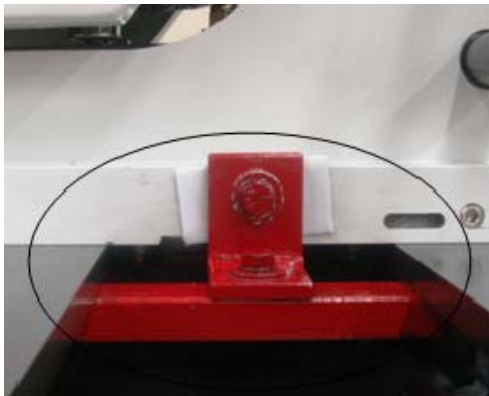


FIGURE - 2

**Figure 3****Figure 4**

Required machinist level. (Starret 98 or better).

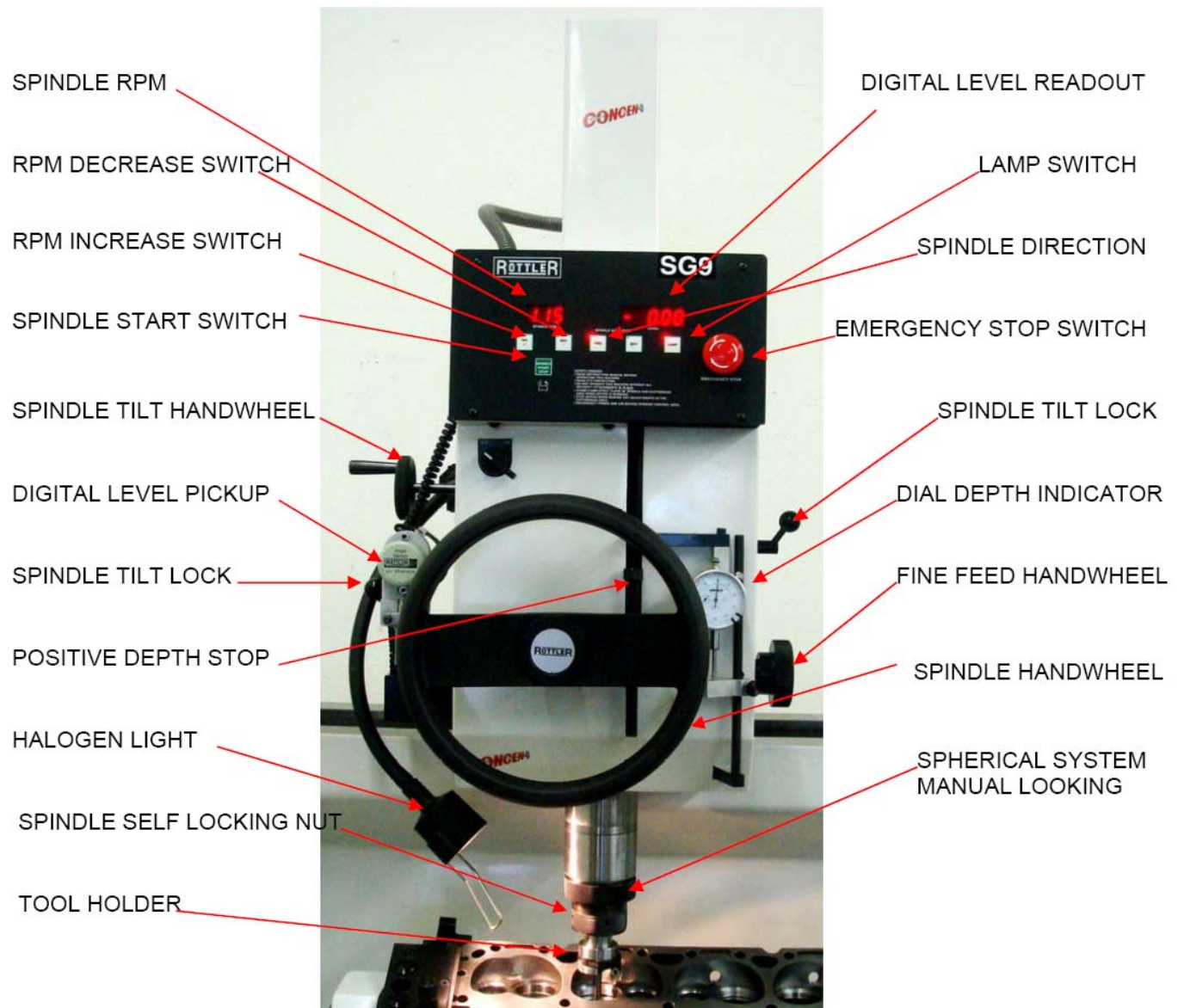
NOTE: Rotate Level 180° to check that Level is properly adjusted. If Level does not read same in both directions, recalibrate level.



Use the level on both 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 3 Control Definitions:

### SG9 Control Definitions



## Chapter 4 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.





## Chapter 5 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 6 Mounting cylinder Head:

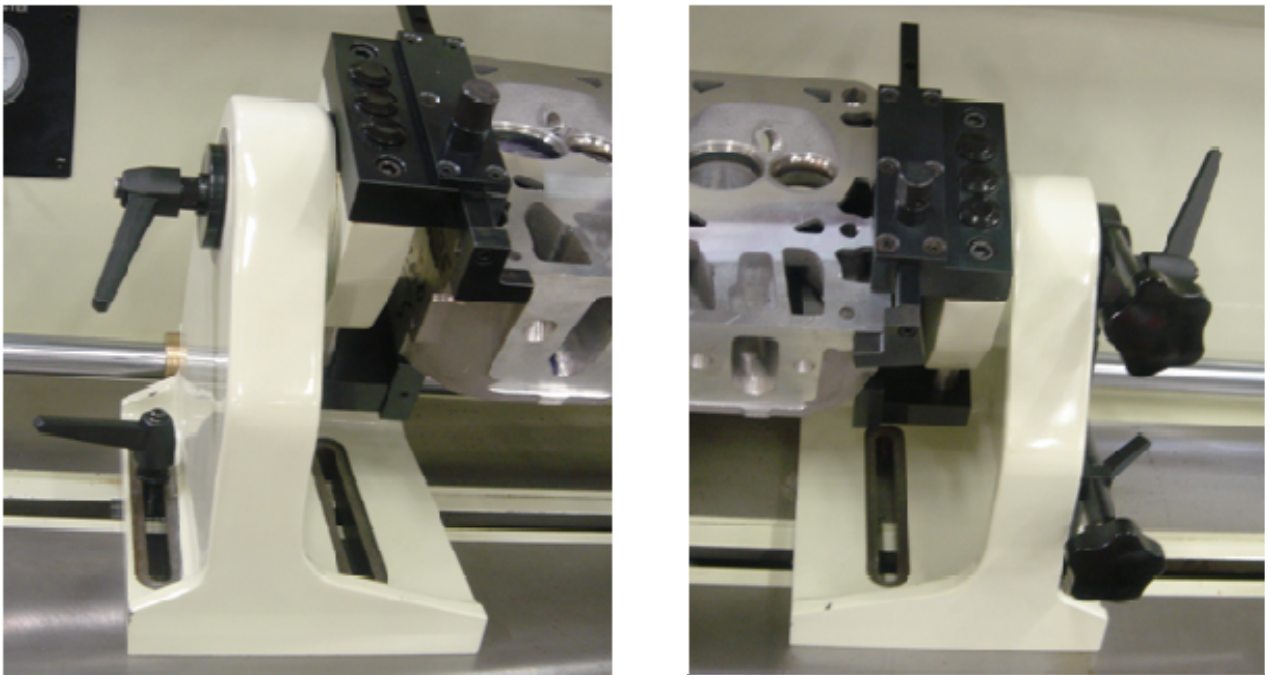
### Using the Air Flow Rollover Fixture:

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. Press right foot pedal and flow cradle 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.

### CYLINDER HEAD ALIGNMENT

To align Cylinder Heads which have Canted Valve Guides, refer to Cylinder Head & Workhead Alignment (Canted) It will be easy to align the cylinder when you use the Canted alignment Fixture.

To align Heads with Standard Valve Guides, proceed as follows:

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.

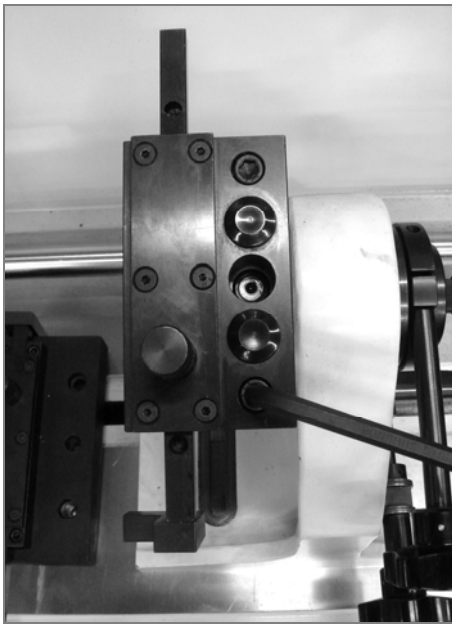
Each support has an adjustable stop, located to the front. The stops have indents, allowing a number of different settings. Position of the stops must be checked for each cylinder head put on the supports. In most cases we will install the cylinder head deck side down with the exhaust side of the head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

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

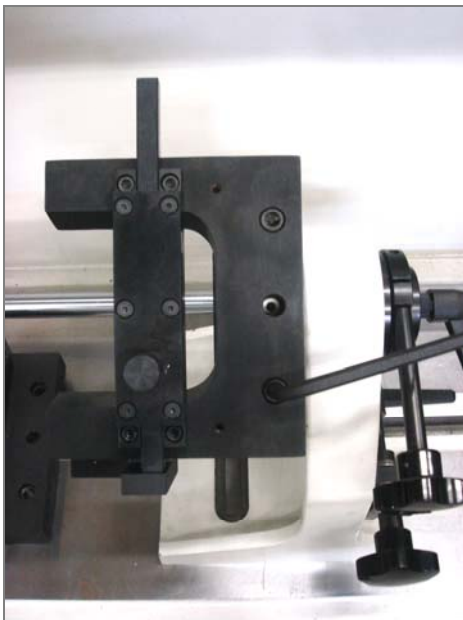
The Quick-Clamp head mounting fixture is provided to accommodate cylinder heads that are difficult to mount directly into the trunions. Some machine operators prefer to use the Quick-Clamp fixture for the majority of heads they do as the mounting is very quick.

## Chapter 7 Overhead Cam U Clamp System

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



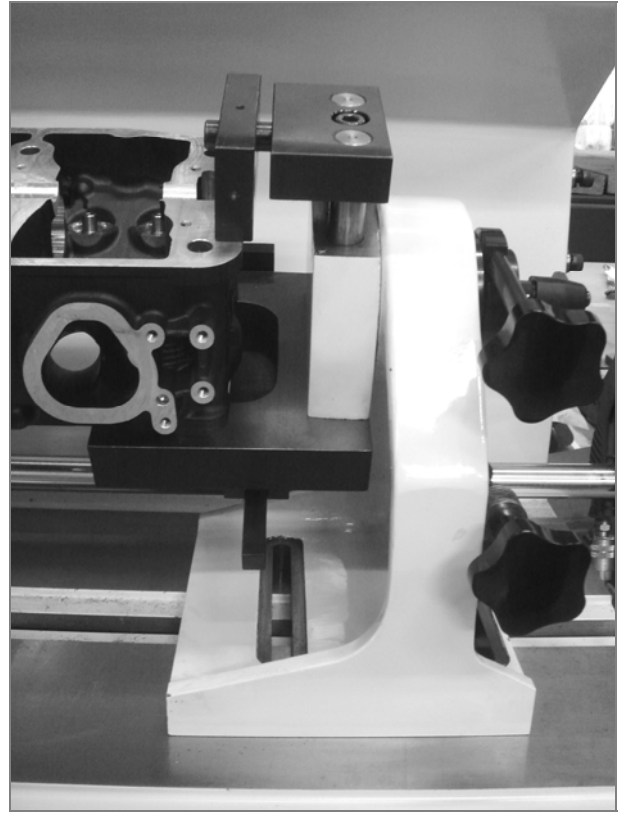
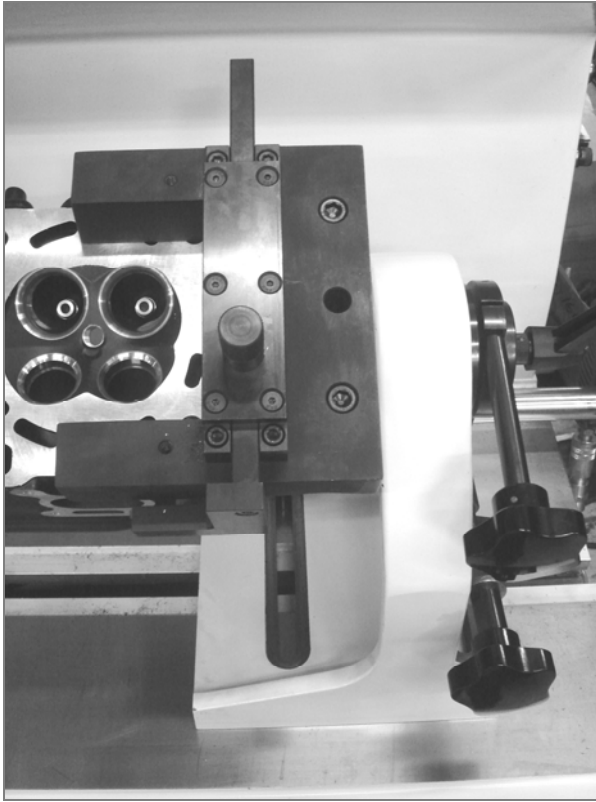
Install the U Clamp, you must use the two bolts included with the fixture and make sure is good and tight



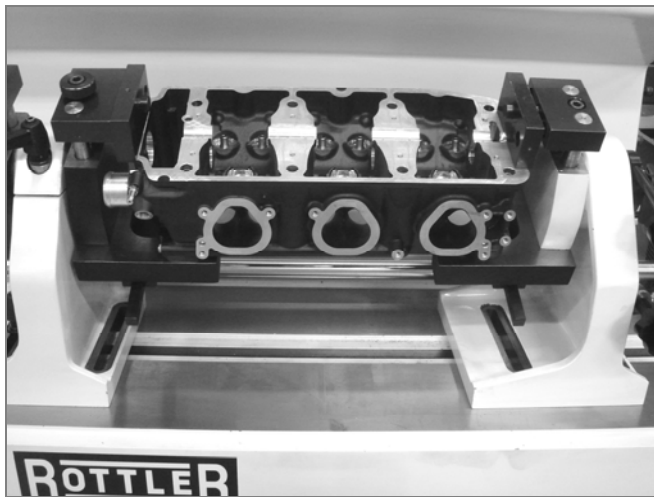


The cylinder head gasket surface must be against the machined surface of the U Clamp Fixture; Slide the stopper rod equally and push the cylinder heads against the stopper rods

**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 they 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 perfectly align the spindle centerline to the 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.**

### 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.

**See below for a guide how to select the proper pilot for the application.**

**Rottler Live and 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.

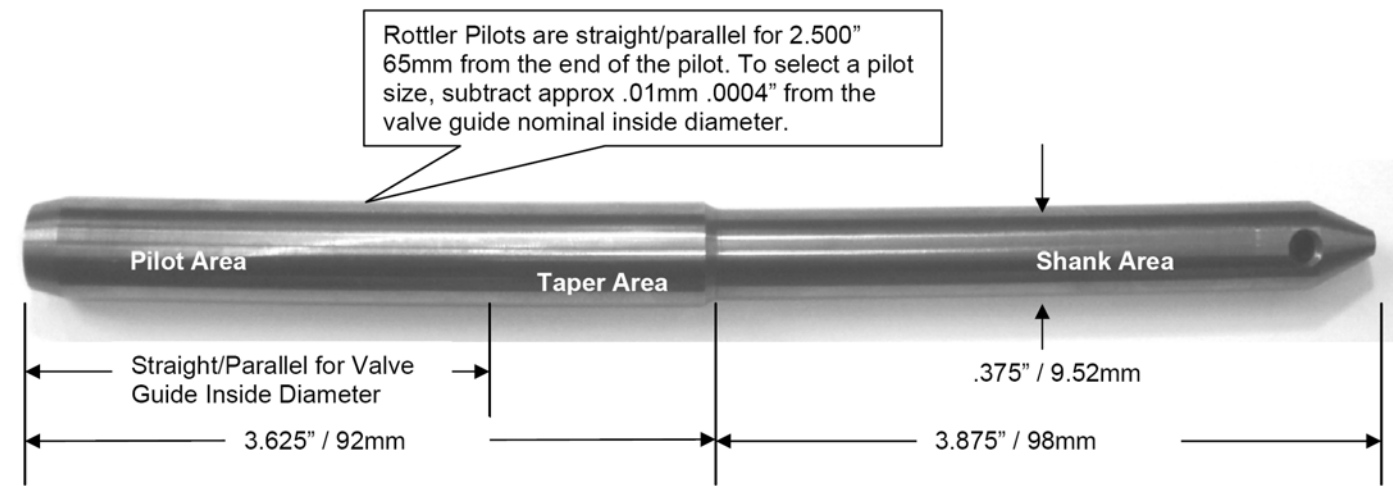
Most new valve guides are manufactured to a **nominal size** such as 7mm or 11/32" and the valve stem diameters are manufactured to be smaller than the nominal size to allow clearance for heat expansion of the valve stem when the engine is operating. For example: a 7mm valve guide has an internal diameter 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.

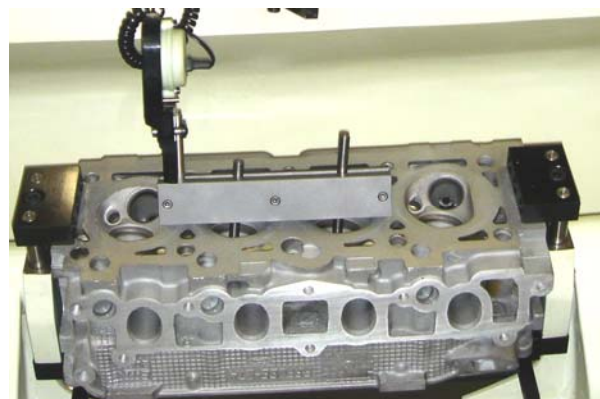
### Canted Valve Cylinder heads

#### 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):



### Fine Feed Engagement:

To engage the fine feed mechanism it is necessary to push inward on the spindle feed handwheel while rotating the fine feed handwheel until engagement is achieved. To disengage the fine feed simply pull outward on the spindle feed handwheel



**ROTTLER FINE FEED SYSTEM**  
BY PUSHING, THE MAIN  
HANDWHEEL (Steering Wheel)  
WILL ENGAGE THE FINE FEED  
SYSTEM. TO DISENGAGE,  
BACK OFF THE FINE FEED AND  
PULL OUT THE HAND WHEEL.

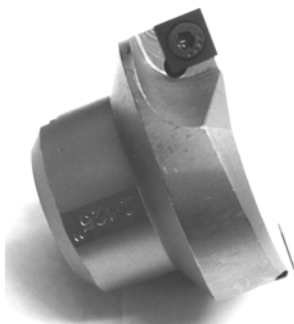
**RECOMMENDED WHEN USING  
THE FIXED PILOT SYSTEM**

### Cutting Counter Bores for Seat Rings:

Align the work piece as explained previously. Cylinder head deck surface must be up.  
Install the seat cutter driver in spindle, Insert correct pilot into the valve guide. Mount cutter adapter sleeve.  
Place the correct counterbore cutter on the adapter sleeve. Float the Workhead while feeding the quill down, until the spindle adapter rests on the cutter. Release the foot pedal to lock the floating head.  
Applying light pressure to the driver, set the positive stop with the seat ring between the stop rod and the quill clamp. This will ensure that quill travel will be limited to the correct amount.  
...or use the following alternative method:  
Set dial indicator for feed depth to zero, being certain the indicator has sufficient travel to allow the proper depth of cut.

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

**FMH**



**Rottler** Fixed Double Replaceable Insert Milling Heads  
- Bore diameter available in increments of 1/16"  
(Required Milling Head driver) specify size

**RS105**



**Rottler** Live Milling Head Driver for Fixed and adjustable replaceable milling head cutters for .625" ID milling head body.

Push the green button to start the spindle rotation. Turn the spindle at approximately 80 RPM - larger seats may require a slower speed; smaller seats may be run faster. Observe dial indicator or positive stop. Cut to proper depth. Swing the indicator out of the way after completing the procedure.



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 degree bits (RCA512) or the square 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.

### Machining valve seats and Counter Boring:

The capacity of the Rottler SG7 / SG8 / SG8A 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)

**Aligning Spindle to Work:**

Most machining operations require the spindle to be directly centered over the work to be performed. This is usually accomplished by air floating the work head above the area to be machined then manually lowering the spindle to engage the tooling that's going to be used. Most of the tooling used with the SG9 has been engineered with this centering feature incorporated into the design.

**CAUTION** If the pedal is released too quickly, the floating head may bounce. True centering may not be achieved, if this happens. Slowly releasing the air float pedal gives the best results. Removing your hands completely from the work head during the final seconds of centering will insure that you do not negatively influence centering accuracy.

**Chapter 8 Three Angle Seat Cutting Setting:**

Place the Toolholder adapter in the spindle.

Align spindle to valve guide.

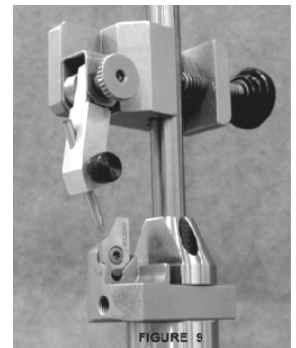
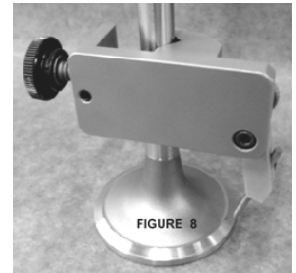
Place a valve in the setting fixture. Position the pointer on the valve where you wish to place the top of the seat.

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 tool holder.

Place Tool Holder with carbide pilot on the V- Type setting Fixture (Pointer). 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 tool holder assembly from setting fixture.



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



## Chapter 9 Machining Valve Seat

### Rottler SG9 Control Panel



#### 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"	24	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

**To Machine the Valve seat follow the proceed below.**

Seat Pocket and valve guide must be clean to ensure proper fit of the carbide pilot.

Select the correct Carbide pilot for the valve guide I.D. Diameter

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

Fit the Rottler Tool Holder and pilot assembly into the spindle cone; make sure to align the locator pins before you fit it into the spindle adapter and push it until you feel that is lock.

The SG9 spindle has been engineered to allow ultra fast tooling changes.

Make sure the that spindle Self 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.

**CAUTION****Spherical Pneumatic Looking System**

Be sure to turn the Spherical pneumatic switch is on the **ON** position; this will allow you to align the pilot on the same axis that the valve guide is set. It will be easy to go into the valve guide.

Most machining operations require the spindle to be directly centered over the work to be performed. This is usually accomplished by air floating the work head by depressing the left foot pedal above the area to be machined; then manually lowering the pilot to the valve guide, once that you have the carbide Pilot about ½" (12.70mm) in to the valve guide

At this point release the Spherical pneumatic switch to the **OFF** position and bring the pilot into the valve guide manually until reach the proper height or until the carbide tip is a few thousands from the valve seat face. Let Workhead flow for few seconds to achieve maximum alignment over the pilot.

Release your hands from Work Head to allow spindle to stabilize and Cutter to center itself on the valve guide. Release Foot Pedal.

**Spherical ON and OFF  
Pneumatic Looking System**



**CAUTION**

Spherical pneumatic switch should be on the OFF position all the time that you be machining the valve seat, this will give you a positive Live centering system

**Note:** Using the left hand on the work head, guide the work head and with the right hand on the main Hand wheel, lower spindle into the valve guide. This will allow you easy positioning the carbide pilot into the valve guide and with the Right hand on the main hand wheel lower the pilot into the valve guide (Left Pedal needs to be depressed all the time when you centering in the valve guide).

**CAUTION**

If the pedal is released too quickly, the float head may bounce. True centering may not be achieved if this happens. Slowly releasing the air float pedal gives the best results. Removing your hands completely from the work head during the final seconds of centering will insure that you do not negatively influence centering accuracy. DO NOT depress Foot Pedal while spindle is on the ON position, as this will change Machine and Cylinder Head alignment

Once that you achieve seat high; set dial indicator for feed depth to zero, being certain the indicator has sufficient travel to allow the proper depth of cut.

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.

**Tapping Operations:**

Place the universal 3-jaw chuck or collet holder with the proper split collet in the spindle as explained previously. Install tap in the chuck, and tighten.

Center over the hole to be tapped

Press green button to start rotation of the spindle and feed down the hole.

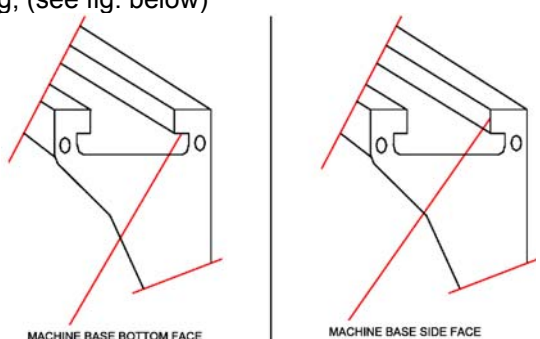
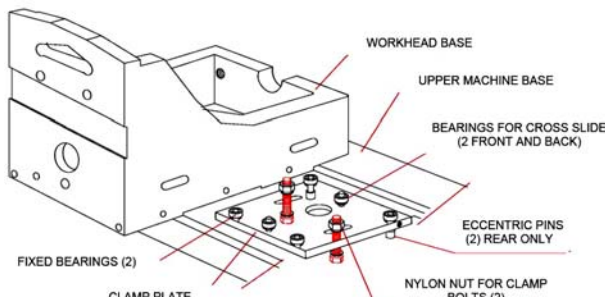
Choose a spindle speed sufficient for the tap (approximately 50 RPM), and allow the tap to feed the spindle as it threads the hole.

When the proper depth is achieved, flip the lever to reverse the spindle and turn the speed control to full speed to clear the hole.

## Chapter 10 Troubleshooting:

### Eccentricity Problems when Cutting Three Angle Seats:

Spindle floated to improper center location.  
Excessive pressure when forming seat.  
Incorrect spindle speed.  
Worn or improperly selected pilot.  
Worn Valve Guide.

<p>Workhead base does not float</p> <p>Concentricity is not within the tolerance</p>	<p>1- Insufficient air pressure</p> <p>2- Clamping plate does not drop when unclamped due to less clearance between upper floating base and ball bearings mounted on clamping plate</p> <p>3- Clamping plate does not drop when unclamped due to the improper adjustment of the four clamping bolts.</p>	<p>1- Set air pressure of supplied line should be minimum 85 PSI ( 6 Bars)</p> <p>2- Take the workhead to one end of the of the upper floating surfaces (Left or Right side) float the workhead and pull it against the front on the T Slatted guide surfaces, then loose the set screws of the eccentric pin to increase clearance by using a feeler gage of 0.008" to 0.010" (0.20mm to 0.25mm) in between the T slotted guide surfaces of the upper base and the eccentric ball bearing; (see fig. below)</p>  <p>Lock the setscrews, remove the feeler gage and inspect if is with the tolerance across the all surfaces. Repeat if it is necessary.</p> <p>3- Adjust nylock nuts to set he correct clearance between the bottom side face of the locking T-Slot of the floating base (Riser) and the top [art of the clampingplate. They are four clamping bolts on the SG8 and two on the SG7. The dropping clearance when is on the floating mode should be 0.015" (0.38mm)on all the four corners of the workhead clamping plate</p> <p><b>SG7 MACHINE</b> <b>ADJUSTMENT OF CLAMPING PLATE BETWEEN UPPER MACHINE BASE AND WORKHEAD BASE</b></p> 
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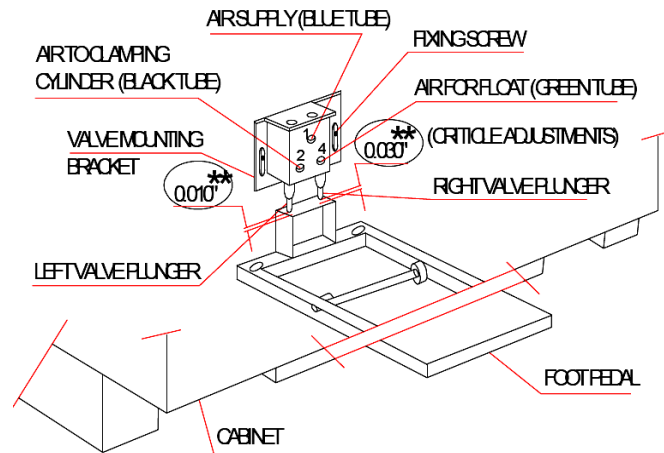
4- Setting of the food pedal operated system actuated valve is misadjust

4- When the food pedal is not pressed, the clearance between the left valve plunger (when looking from the front of the machine) and the food pedal bracket should be 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.



## Chapter 11 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") <b>Req. 2</b>
S250-28-250	BH375WR1 Tip Holder Looking Screw 1/4"-28" X 1/4" <b>Req. 2</b>
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 Rollover Fixture Hold down swivel Handle Zinc Handle 2.000" Long stud (KHF-162)
500-13X1375	SG7- SG8 Rollover Fixture Lock swivel Handle Zinc Handle 1.375" Long stud (KHF-158)
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 12 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 13 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")**

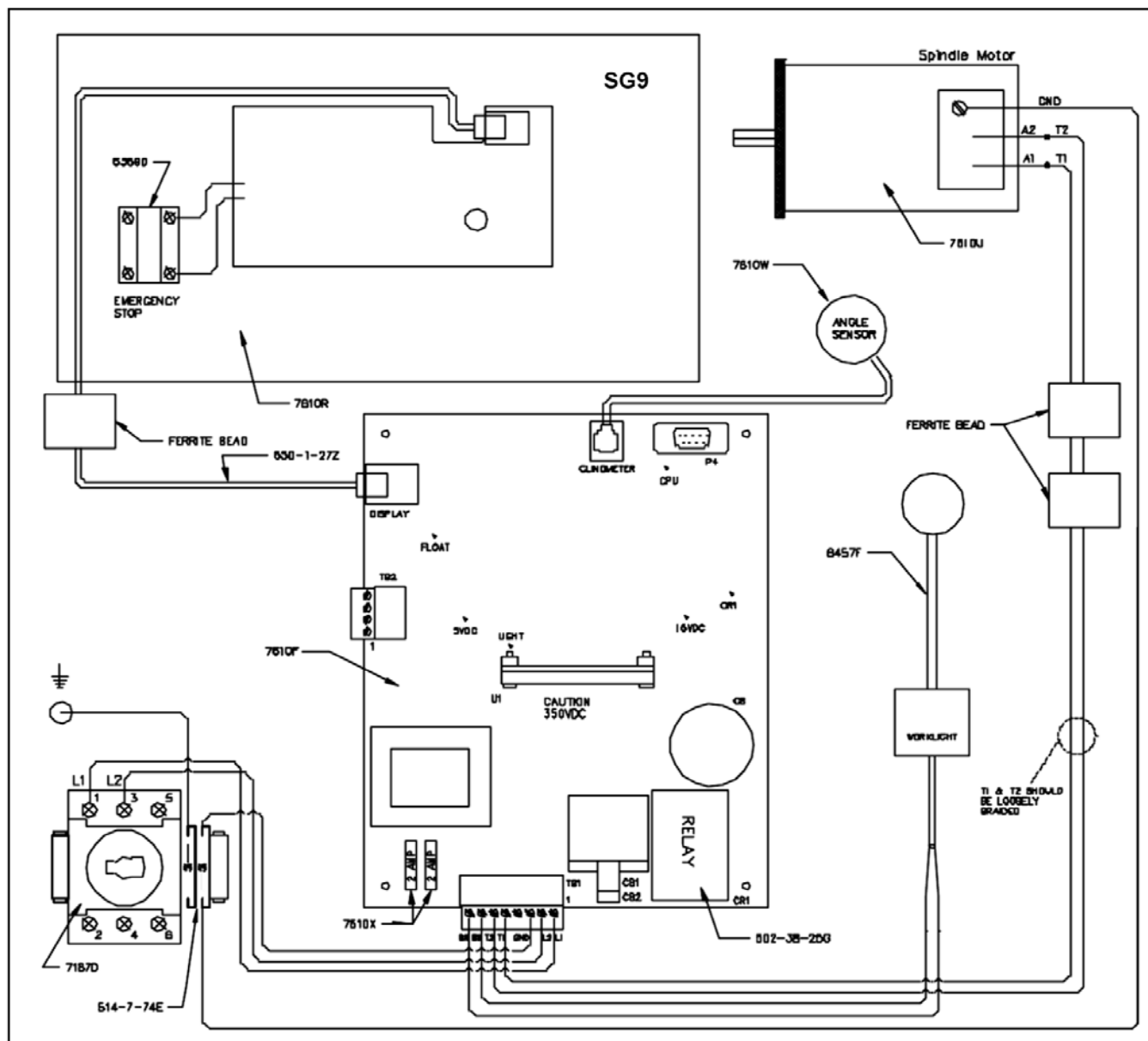
Pilots are available in increments of .01mm (0.0004"). Normally, a small amount of clearance approx .01mm (0.0004") is required between the pilot and the valve guide.

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.

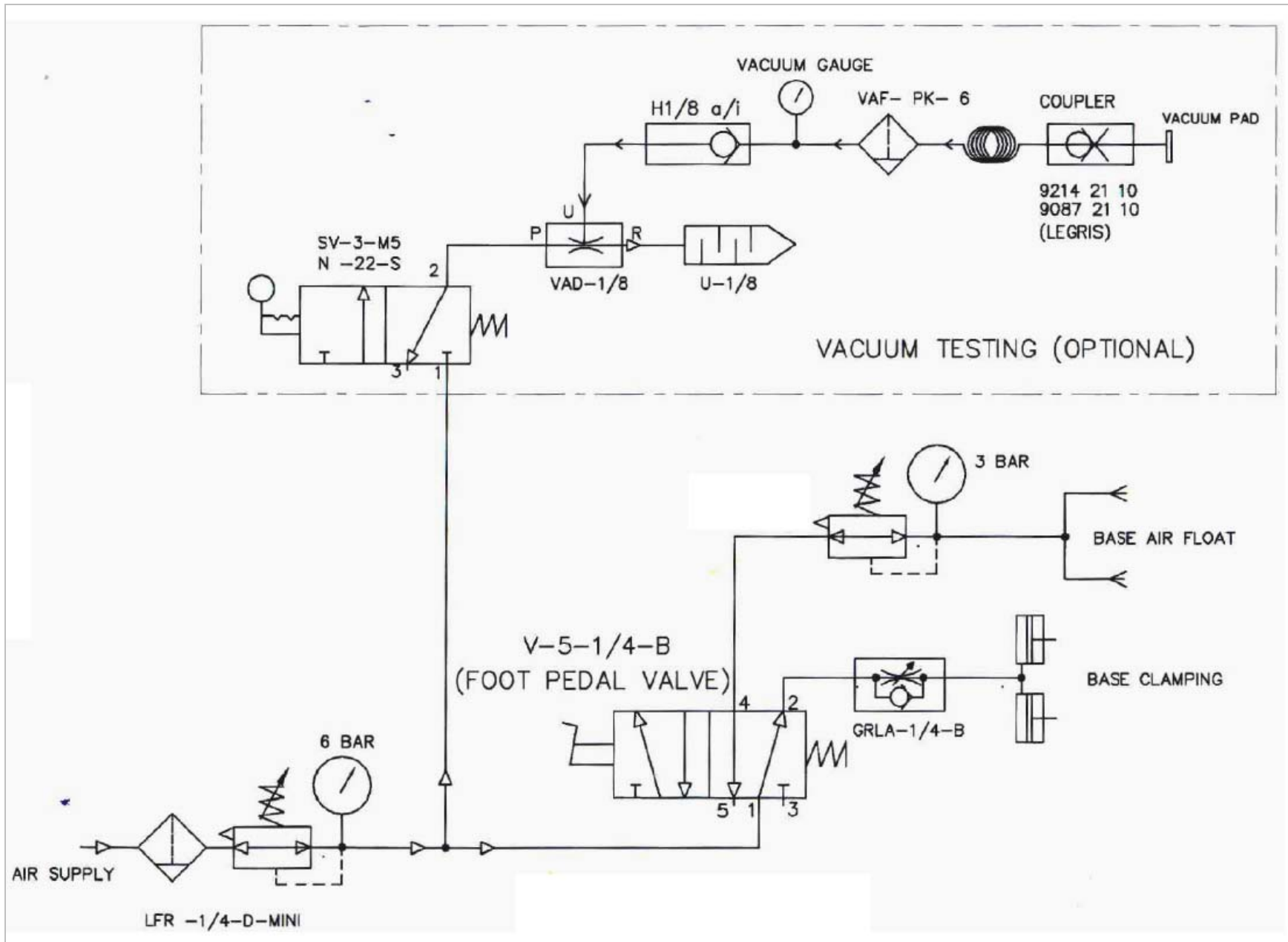
Below is an example of a 9.52mm 0.375" shank diameter pilot:





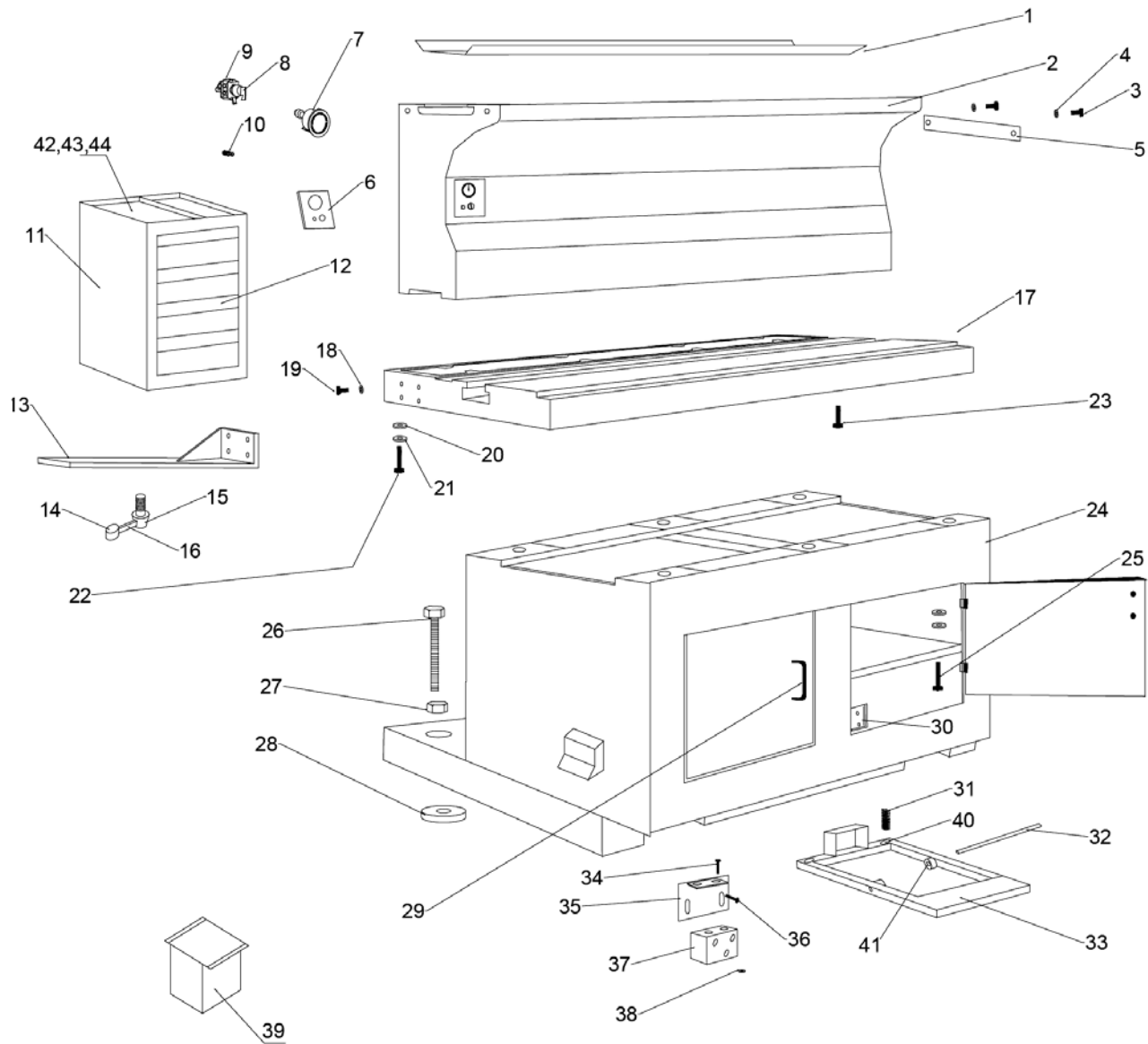
## Chapter 15 Pneumatic Drawings:

### SG9 Pneumatic Drawing



## Chapter 16 Machine Parts

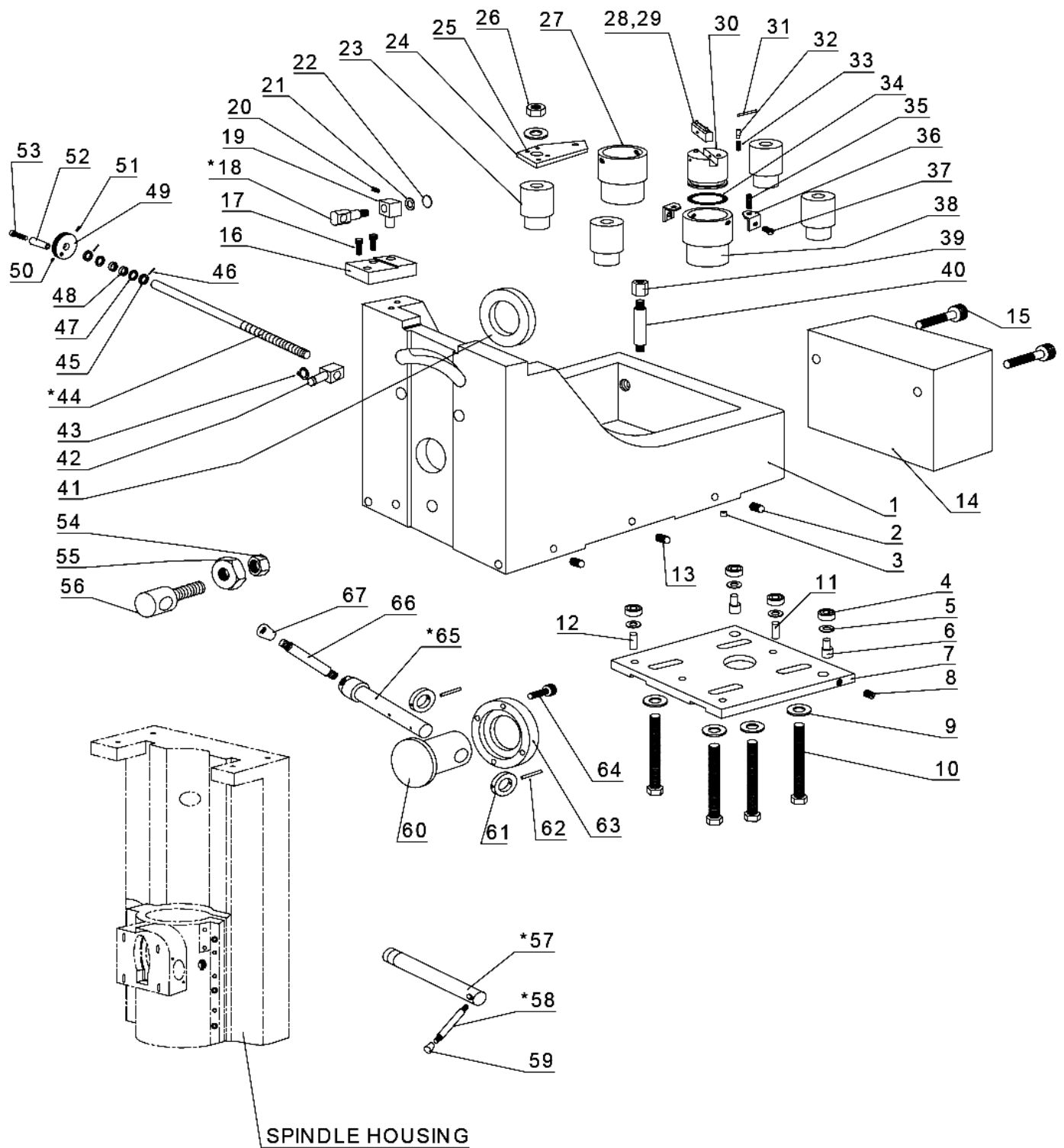
### SKETCH No. 1 Base, Table and Riser Assembly



## SKETCH No. 1 BASE TABLE &amp; RISER ASSEMBLY DESCRIPTION

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	430-820	COVER PAN	1
2	<b>NCL -99</b>	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	<b>NC - 41</b>	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	<b>430-801-1</b>	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	4
32	<b>430-834-I</b>	ROD	1
33	<b>430-834-II</b>	ROD	1
34	<b>430-835-I</b>	FRAME WELDED SMALL	1
35	<b>430-835-II</b>	FRAME WELDED LARGE	1
36	430-838	SCREW	4
37	430-836	FOOT SWITCH MTG. BKT	2
38	430-814	SCREW	4
39	430-828	FOOT SWITCH ASSY	2
40	430-805	NUT	4
41	430-824	CHIP TRAY	1
42	430-835A	PAD	4
43	<b>430-835B-I</b>	BUSH	4
44	430-826	TOOL BOARD	1
45	430-829	TOOL BOARD (R.H)	1
46	430-839	TOOL BOARD (L.H)	1
47		SUPPORT BRACKET	1
48		SCREW	2
49	<b>NC-42</b>	STOPPER PLATE	1
50		SCREW	2

## SKETCH No. 2 WORKHEAD ASSEMBLY

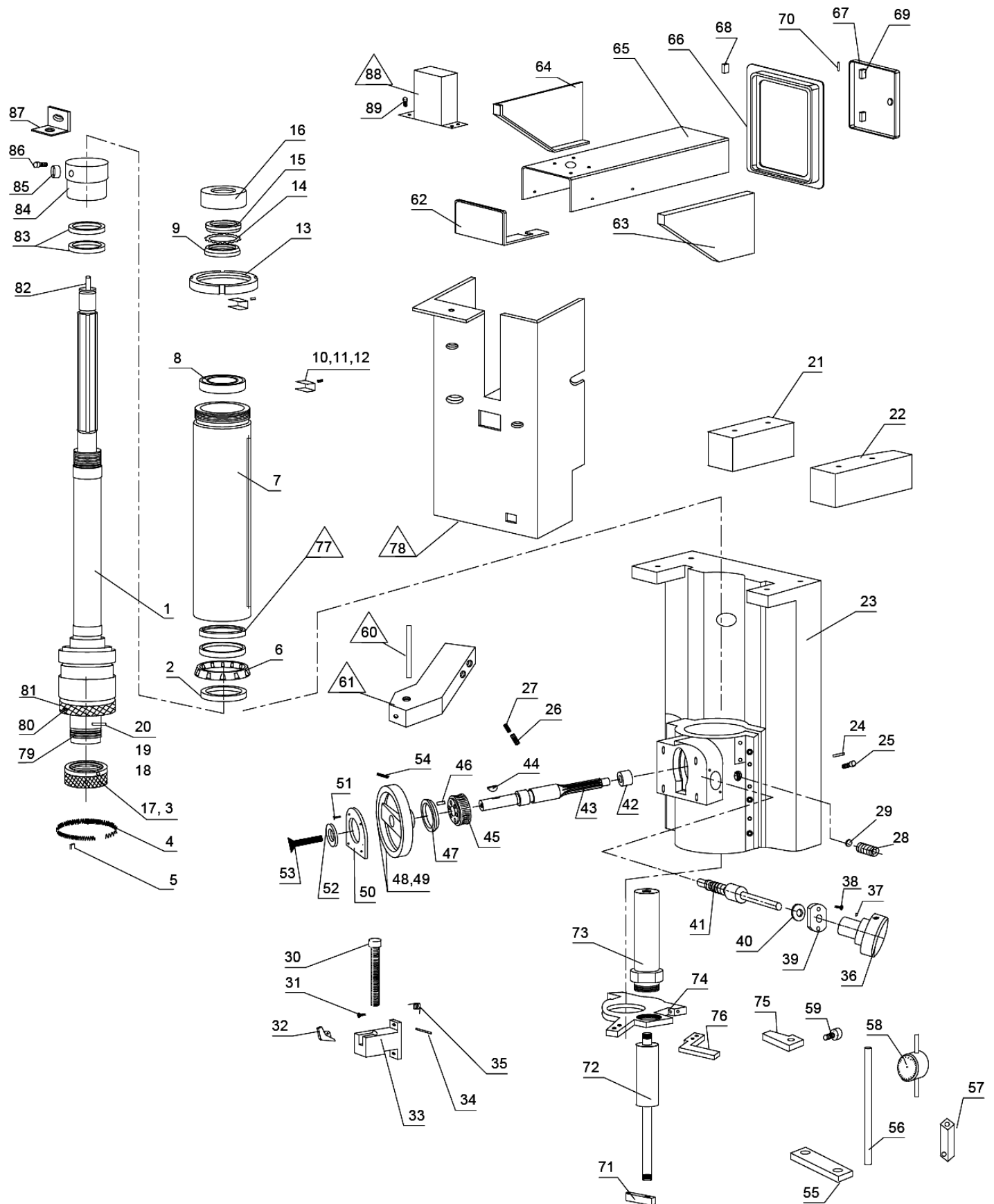


## SKETCH No. 2 WORKHEAD ASSEMBLY - PARTS DESCRIPTION

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	1
56	430-670	EYE BOLT	1
57	<b>NC-35</b>	ECCENTRIC CLAMP	2
58	<b>NC-39</b>	LEVER PIN	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	<b>NC-34</b>	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



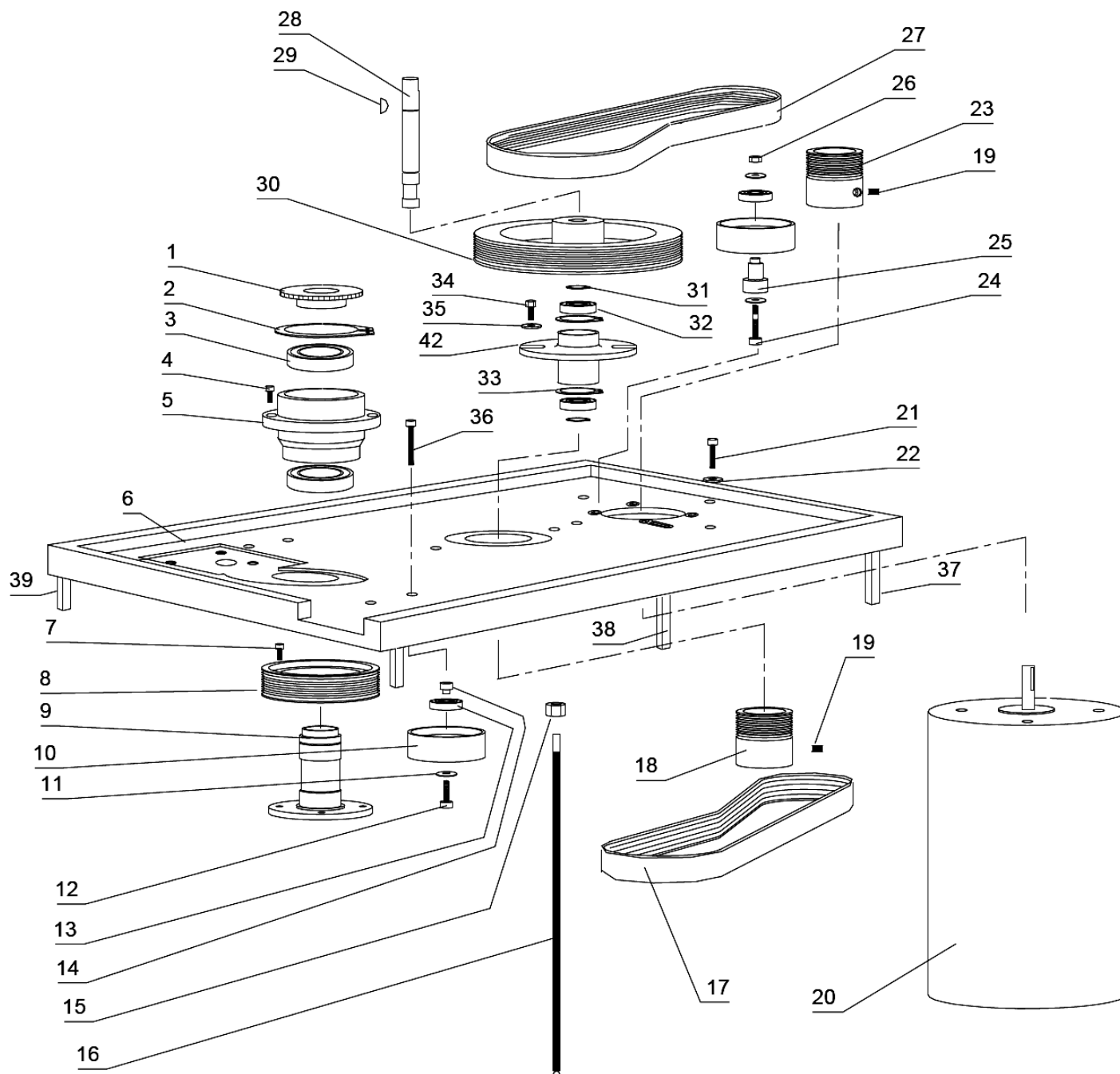
## SKETCH No. 3 SPINDLE ASSEMBLY – PARTS DESCRIPTION

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	<b>NC-69</b>	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	430-605	SPACER	1
10	<b>NC-32</b>	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	<b>NC-33</b>	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	430-614A	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	<b>430-606-1</b>	STOP ROD BLOCK	1
34	430-617	PIN	1
35	430-618	SPRING	1
36	<b>430-664-1</b>	FEED 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	<b>430-663-I</b>	END COVER	1
40	430-662	WASHER	1
41	<b>430-660-I</b>	WORM SHAFT	1
42	<b>430-631A-I</b>	BUSH	1
43	<b>430-631-I</b>	PINION	1
44	430-632	WOODRUF KEY	1
45	<b>430-661-I</b>	WORM WHEEL	1
46	430-667	PIN	2
47	430-634	SPACER	1
48	<b>430-635-I</b>	HAND WHEEL	1
49	<b>430-635-2</b>	HAND WHEEL EXTENSION	1
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
54	430-639	M4-BALL PLUNGER SCREW	1



S. NO.	PART NO.	DESCRIPTION	QTY/M/C
55	<b>VGS-641-1</b>	INDICATOR MTG. FLAT	1
56	VGS-642	INDICATOR MTG. ROD	1
57	<b>430-643A-1</b>	DIAL CLAMP	1
58	VGS-646	INDICATOR	1
59	430-645A	KNOB	1
60	430-616	LEVELING PIN	1
61	<b>NC-37</b>	PLATE (LEVELING PIN)	1
62	<b>430-650-1</b>	SHROUD	1
63	<b>NC-48-1</b>	RIGHT SIDE COVER	1
64	430-647b	LEFT SIDE COVER	1
65	<b>NC-49-1</b>	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	<b>430-712-1</b>	HOLDER	1
72	430-714-R	GAS SPRING (150N)	1
73	430-717-R	TUBE	1
74	<b>430-625R-1</b>	PLATE	1
75	<b>430-643 B</b>	CLAMP	1
76	<b>430-625R-IV</b>	STOPPER PLATE	1
77	<b>NCL-87</b>	SPACER	1
78	<b>NC-40-1</b>	FRONT COVER	1
79	<b>NCL-76</b>	DRIVE ADAPTOR	1
80	<b>NCL-86</b>	SCREW	2
81	<b>NCL-80</b>	LOCK NUT	1
82	<b>NCL-73</b>	ACTUATING ROD	1
83		BEARING	2
84	<b>NCL-70</b>	BEARING HOUSING	1
85	<b>NC-93</b>	STOPPER	1
86		SCREW	1
87	<b>NCL-97</b>	CABLE BRACKET	1
88	<b>NCL-81</b>	CYLINDER COVER	1
89		SCREW	4

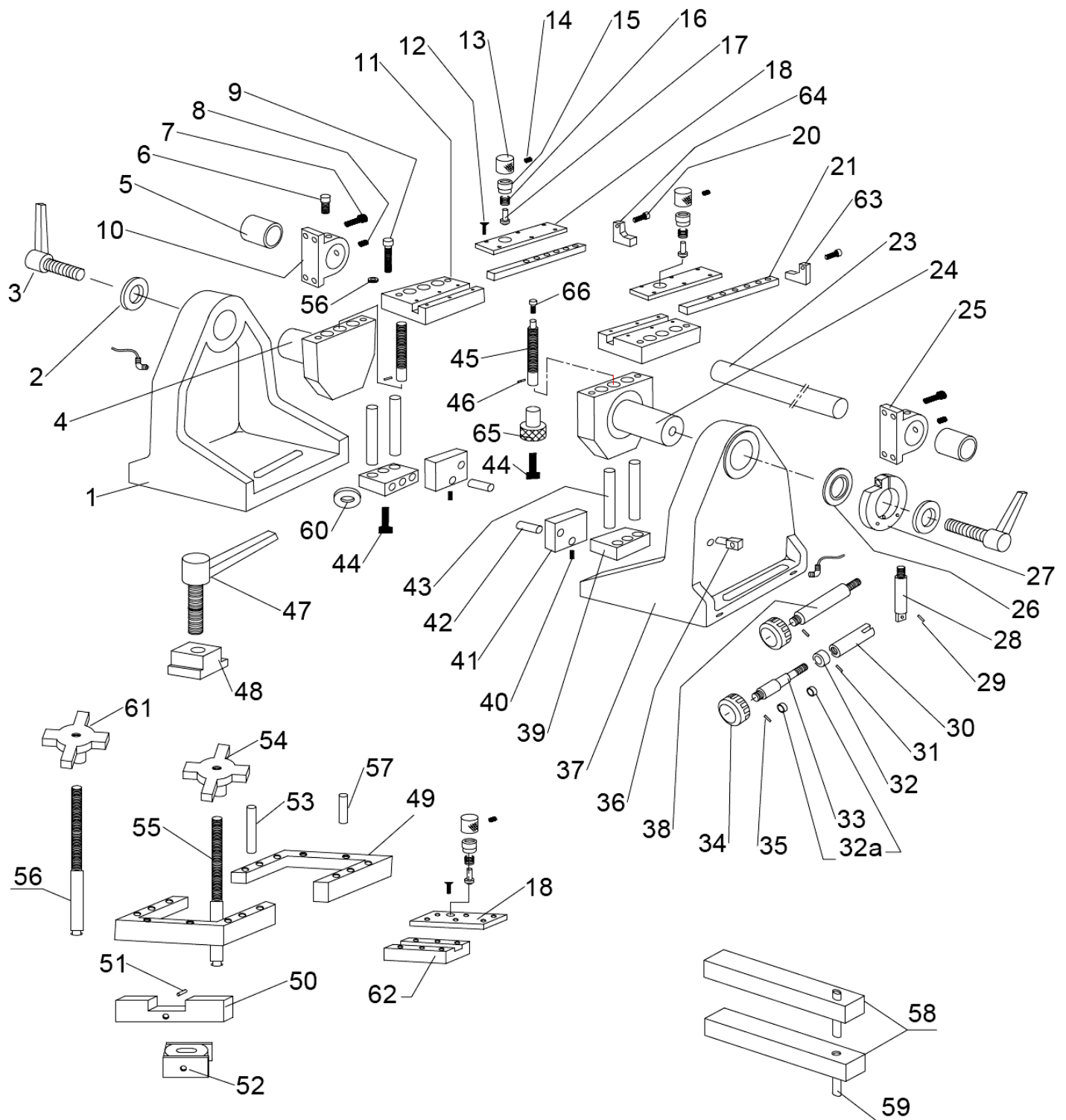
## SKETCH No. 4 TRANSMISSION ASSEMBLY



## 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 HEAD SUPPORT ASSEMBLY



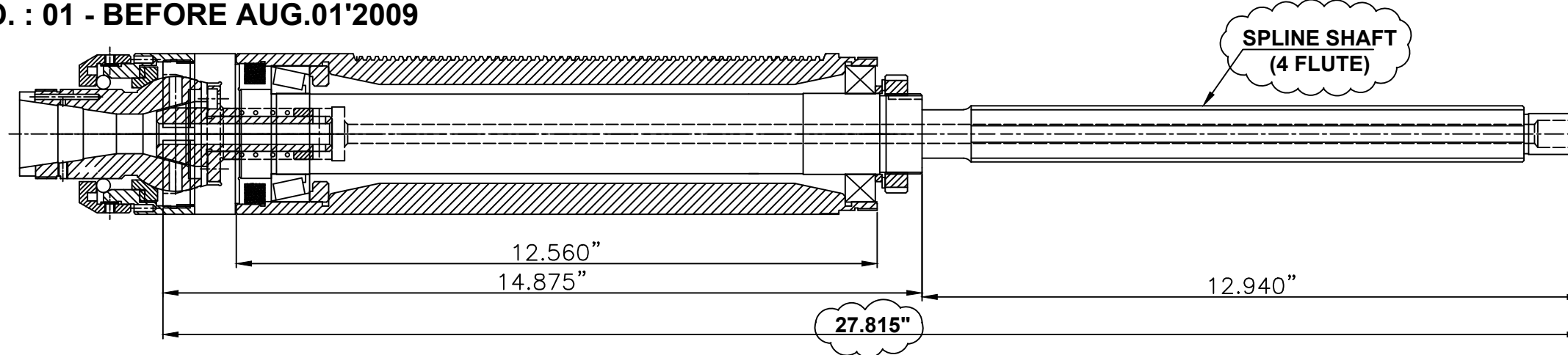
## SKETCH No. 5 HEAD SUPPORT ASSEMBLY Parts description

S. NO.	PART NO.	DESCRIPTION	QTY/M/C
1	<b>430-913-B</b>	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	-----	-----	---
20	430-936	SCREW 1/4"-20 X 3/4" LONG	2
21	430-940	FLAT	2
22	-----	-----	---
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	<b>430-920-B</b>	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
53	430-943	TUBE	2
54	430-942	KNOB	2

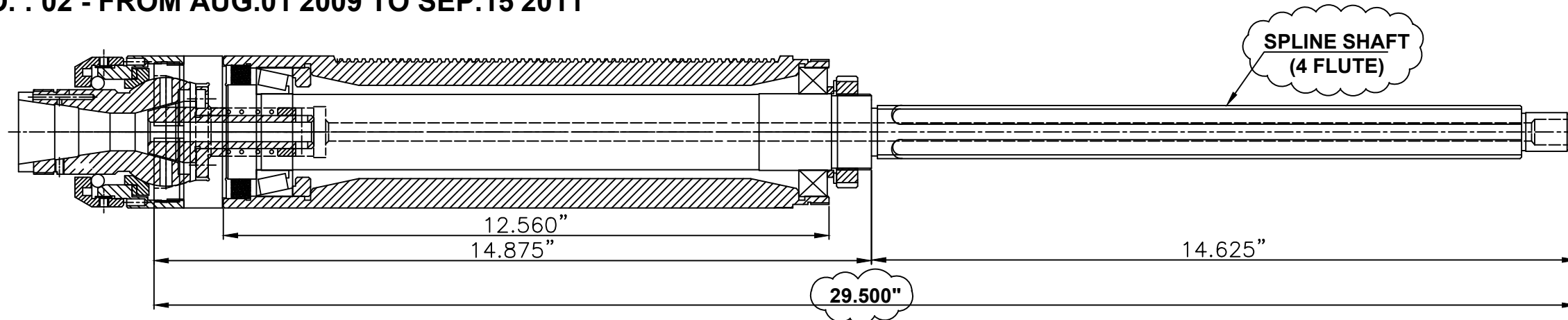
S. NO.	PART NO.	DESCRIPTION	QTY/M/C
55	430-948	TAKE UP ROD	2
56	430-948A	TAKE UP ROD ( 1/4" )	2
57	430-943S	TUBE (SMALL)	2
58	430-944S	PARALLEL FLAT	2
59		DOWEL PIN (1/4" X 1") (PURCHASED)	2
60	VGS-968	WASHER	2
61	430-942-A	KNOB	2
62	430-944-II	LOCATING BLOCK	2
63	430-935-I	STOP PLATE R. H.	1
64	430-937-I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

**SPINDLE ASSEMBLY**  
**MODEL: SG 9, SG9M & SG9MTS**

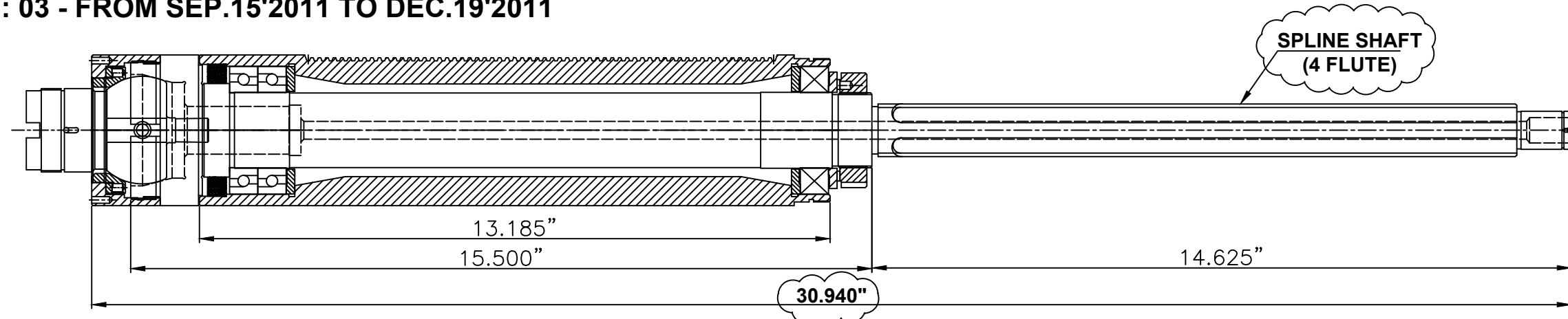
**S.NO. : 01 - BEFORE AUG.01'2009**



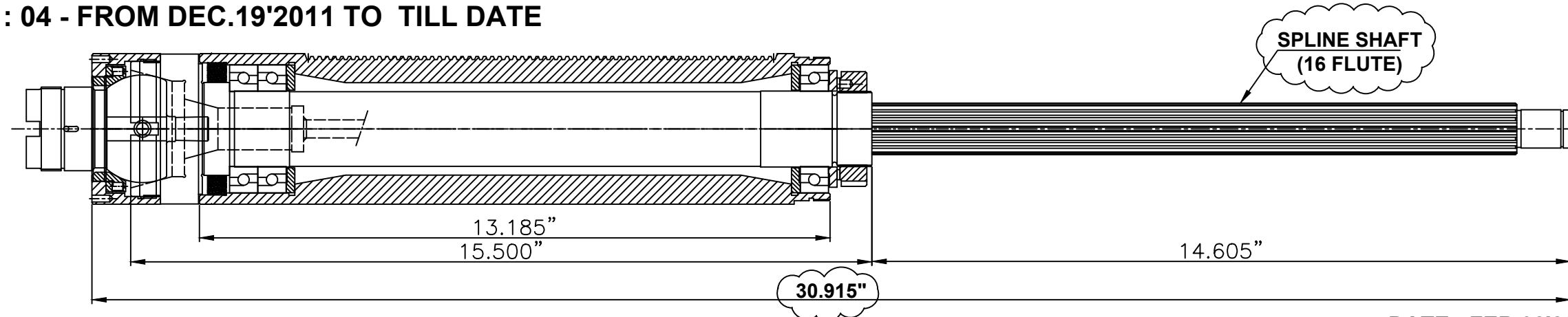
**S.NO. : 02 - FROM AUG.01'2009 TO SEP.15'2011**



**S.NO. : 03 - FROM SEP.15'2011 TO DEC.19'2011**



**S.NO. : 04 - FROM DEC.19'2011 TO TILL DATE**



**DATE : FEB.02'2023**

# Chapter 17 DECIMAL TO METRIC CONVERSION CHART

## UNITS OF LENGTH

TO CONVERT	MULTIPLY BY	TO OBTAIN
MM	0.03937	IN.
CM	0.3937	IN.
METERS	39.37	IN.
METERS	3.281	FT.
METERS	1.0936	YD.
KM	3,281	FT.

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
FT.	0.3048	METERS
FT.	0.0003048	KM
YD.	0.9144	METERS
YD.	0.0009144	KM
MILES	1.609	KM
IN.	25,400	MICRONS

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
<b>1/8</b>	<b>0.1250</b>	<b>3.1750</b>
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
<b>1/4</b>	<b>0.2500</b>	<b>6.3500</b>
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
<b>3/8</b>	<b>0.3750</b>	<b>9.5250</b>
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
<b>1/2</b>	<b>0.5000</b>	<b>12.7000</b>
33/64	0.5156	13.0969
17/32	0.5313	13.4938
35/64	0.5469	13.8906
9/16	0.5625	14.2875
37/64	0.5781	14.6844
19/32	0.5938	15.0813
39/64	0.6094	15.4781

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
<b>1 1/8</b>	<b>1.1250</b>	<b>28.5750</b>
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
<b>1 1/4</b>	<b>1.2500</b>	<b>31.7500</b>
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
<b>1 3/8</b>	<b>1.3750</b>	<b>34.9250</b>
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
<b>1 1/2</b>	<b>1.5000</b>	<b>38.1000</b>
1 33/64	1.5156	38.4969
1 17/32	1.5313	38.8938
1 35/64	1.5469	39.2906
1 9/16	1.5625	39.6875
1 37/64	1.5781	40.0844
1 19/32	1.5938	40.4813
1 39/64	1.6094	40.8781

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
<b>2 1/8</b>	<b>2.1250</b>	<b>53.9750</b>
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
<b>2 1/4</b>	<b>2.2500</b>	<b>57.1500</b>
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
<b>2 3/8</b>	<b>2.3750</b>	<b>60.3250</b>
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
<b>2 1/2</b>	<b>2.5000</b>	<b>63.5000</b>
2 33/64	2.5156	63.8969
2 17/32	2.5313	64.2938
2 35/64	2.5469	64.6906
2 9/16	2.5625	65.0875
2 37/64	2.5781	65.4844
2 19/32	2.5938	65.8813
2 39/64	2.6094	66.2781



<b>5/8</b>	<b>0.6250</b>	<b>15.8750</b>
41/64	0.6406	16.2719
21/32	0.6563	16.6688
43/64	0.6719	17.0656
11/16	0.6875	17.4625
45/64	0.7031	17.8594
23/32	0.7188	18.2563
47/64	0.7344	18.6531
<b>3/4</b>	<b>0.7500</b>	<b>19.0500</b>
49/64	0.7656	19.4469
25/32	0.7813	19.8438
51/64	0.7969	20.2406
13/16	0.8125	20.6375
53/64	0.8281	21.0344
27/32	0.8438	21.4313
55/64	0.8594	21.8281
<b>7/8</b>	<b>0.8750</b>	<b>22.2250</b>
57/64	0.8906	22.6219
29/32	0.9063	23.0188
59/64	0.9219	23.4156
15/16	0.9375	23.8125
61/64	0.9531	24.2094
31/32	0.9688	24.6063
63/64	0.9844	25.0031
<b>1</b>	<b>1.0000</b>	<b>25.4000</b>

<b>1 5/8</b>	<b>1.6250</b>	<b>41.2750</b>
1 41/64	1.6406	41.6719
1 21/32	1.6563	42.0688
1 43/64	1.6719	42.4656
1 11/16	1.6875	42.8625
1 45/64	1.7031	43.2594
1 23/32	1.7188	43.6563
1 47/64	1.7344	44.0531
<b>1 3/4</b>	<b>1.7500</b>	<b>44.4500</b>
1 49/64	1.7656	44.8469
1 25/32	1.7813	45.2438
1 51/64	1.7969	45.6406
1 13/16	1.8125	46.0375
1 53/64	1.8281	46.4344
1 27/32	1.8438	46.8313
1 55/64	1.8594	47.2281
<b>1 7/8</b>	<b>1.8750</b>	<b>47.6250</b>
1 57/64	1.8906	48.0219
1 29/32	1.9063	48.4188
1 59/64	1.9219	48.8156
1 15/16	1.9375	49.2125
1 61/64	1.9531	49.6094
1 31/32	1.9688	50.0063
1 63/64	1.9844	50.4031
<b>2</b>	<b>2.0000</b>	<b>50.8000</b>

<b>2 5/8</b>	<b>2.6250</b>	<b>66.6750</b>
2 41/64	2.6406	67.0719
2 21/32	2.6563	67.4688
2 43/64	2.6719	67.8656
2 11/16	2.6875	68.2625
2 45/64	2.7031	68.6594
2 23/32	2.7188	69.0563
2 47/64	2.7344	69.4531
<b>2 3/4</b>	<b>2.7500</b>	<b>69.8500</b>
2 49/64	2.7656	70.2469
2 25/32	2.7813	70.6438
2 51/64	2.7969	71.0406
2 13/16	2.8125	71.4375
2 53/64	2.8281	71.8344
2 27/32	2.8438	72.2313
2 55/64	2.8594	72.6281
<b>2 7/8</b>	<b>2.8750</b>	<b>73.0250</b>
2 57/64	2.8906	73.4219
2 29/32	2.9063	73.8188
2 59/64	2.9219	74.2156
2 15/16	2.9375	74.6125
2 61/64	2.9531	75.0094
2 31/32	2.9688	75.4063
2 63/64	2.9844	75.8031
<b>3</b>	<b>3.0000</b>	<b>76.2000</b>