Bridgeport J-Head Series I Mill Rebuild

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Prepared By:	Hoffman Mechatronics 496 Albrough Blvd. Colonial Beach, Va 22443 mike_hoffman@verizon.net

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1.0 Document Information

1.1 Disclaimer

Milling machines are industrial pieces of equipment meant to be operated by trained personnel. The maintenance and rebuild procedures for these machines are also meant to be carried out by trained personnel. This manual is provided merely to provide information to authorized persons, and the author assumes no liability for any damage or injury from the information and procedures that are documented within. These machines are **heavy**, **powerful**, and **dangerous** to those not trained in their operation or maintenance. I want to emphasize that you should exercise EXTREME CAUTION when working on or with these machines to minimize or eliminate the possibility of personal injury.

1.2 Notes from the Author

This document was created during the rebuild of my personal 1963 Bridgeport Series I J-Head, Stepped Pulley Mill. Much of the information presented in this document is from my own personal experiences, and all of the images that are located throughout the document were taken by me using a Nikon Coolpix 4300 and a Nikon D70s. For those images where I have included drawings, they were created using either TurboCADCAM or SolidWorks.

So why would I take the time to try and document this? First of all, because I could not find the information I needed to complete this rebuild and I thought that others may want some of the same information. Secondly, I wanted to give something back to the home machining community that has provided so much useful information to me. Where possible I have included acknowledgements/references for the assistance I have received. If I have missed anyone, please feel free to let me know. I certainly could not have compiled and reviewed all of this information by myself, nor do I want people to think that I have. There are many trained personnel out there willing to devote their time and machines and I want to make sure that have I given everyone their fair share of credit.

Where possible I have taken pictures of every phase of the assembly and tuning of this wonderful machine. Most of the information I have is from doing, not from being taught, so if you find something in error, I beg of you … please let me know. This document can only improve if people like you are willing to say “Mike is full of crap, I better let him know!”

What is the benefit for telling me that I am full of crap? Well, not only the personal pleasure of doing so, but I will place your name in the acknowledgements section, and send you a revised copy of the manual.

1.3 Copyright

1.4 Document Organization

You will quickly note that I have tried to organize this document to the corresponding parts of the Bridgeport Mill. I believe it will make this document easier to follow should someone be trying to solve a specific problem. It also tends to follow the order of disassembly if someone is starting to completely disassemble their mill for the first time. One of the last sections of the document deals with troubleshooting. Although this portion is rather small now, I am hoping that I can add to this as more and more people provide questions, and solutions to common and not so common problems.

NOTES: are included in the document where I think something bears bringing attention to.
CAUTIONS: are highlighted where someone may be injured if proper safety precautions are not taken.

1.5 Change History

Revision	Date	Changed By	Change Description
Draft	8/29/2005	M. Hoffman	Initial draft
Draft 0.01	10/15/2005	M. Hoffman	More images, callouts, and tense corrections.
1.0.00	8/22/2006	M. Hoffman	More images, more text, and review of all figures

1.6 Dedications and Acknowledgements

First and foremost I want to dedicate this manual to my wife who has put up with my insane hobbies and business ideas for some 21 years. She is the one who carries me to the hospital when I do stupid things, and then cares for me at home until I am once again able to do more stupid things.

Secondly I want to thank my brother for showing me this amazing machine, and putting the idea in my head that I could rebuild it and make it new again.

I also wanted to send out a special thanks to the Chesapeake Area Metalworking Society (CAMS). From the very beginning they have supported my efforts and offered to help with everything. Sorry guys, I won't be bringing the finished mill in for "Show n Tell", but I will bring pictures!

The following people have helped me considerably along the way, and this document would be so much less without their inspiration and guidance.

Kirk Burns & Machinist Preston	(Burns Machine Shop, King George, Va)
Gary Gelts	(Hardinge/Bridgeport)
Jonathan Gavel	(CAMS)
Eric Hoffmeyer	(CAMS)
Leigh Basset	(CAMS)

2.0 Mill Overview

I decided to write this section to provide you with an idea of the condition of the mill as I was evaluating it for purchase and refurbishment. I also wanted to provide a description of the amount of work that went into the mill to make it operational again.

2.1 Mill Description

The mill that I am rebuilding throughout this document is a 1963 Bridgeport Series I J-Head Mill. The mill was identified by a brass plate in Figure 1 below that was installed by the US Navy. This plate identifies this mill as Model# J60526, Serial# BR69063. If you don't have the nice Navy placard on your mill you can also find the model number of the older mills on the door to the pedestal, the face of the J-Head, and on the knee.

Figure 1 - Mill ID Plate

This mill came equipped with a 9" x 36" Table, 9" knee and a Geared Power Feed unit. I paid $300 for the machine after it was purchased from a Government Surplus by my brother for $400. That's right; my brother gave it to me for less than his cost. Yes, I have a great brother!!!

2.2 Repair Estimates

After my initial look at the mill I estimated that it would cost about $1000 to get the mill operational again, and based on the articles I have read in the forums I estimated that it would be another $1200 to $1300 to convert this machine to Computer Numeric Controlled (CNC).

What follows is a quick summary of the visible items that helped me to make this estimation: the spindle bearings were stuck, the table was stuck, the knee was stuck, the turret in/out axis was stuck, and the entire machine was covered in rust and metal shavings. The spindle bearing felt protector was missing and metal shavings were covering the upper spindle bearing. From this I assumed that the bearings were not merely just stuck, but would be unsalvageable. Some of the components from the J-Head had already been removed and put in boxes, and many items looked as though they were broken and/or bent from the mill being dropped or mishandled. There were also a great many parts that were not damaged at all, just stuck because of years of dried up grease, or the friction from surface rust. Based on the age of the machine and the condition of the spindle bearings, I decided all bearings would most likely need to be replaced. As you can see from Figures 2 and 3 below it barely looked like a mill at all. You can see in the figures that the Y-Axis handle is bent, the Reverse Feed Knob has been sheered off, and many of the 1” Balls that were on the selector shafts have been sheared off as well.

Figure 2 - J Head

Figure 3 - Table and Knee

2.3 Why would I do this?

So why would I tackle such a huge undertaking? There are several reasons, but the most compelling reason for me was that I needed a mill, and why should I buy a mill that is advertised as a Bridgeport Clone, when I could have a Bridgeport? My decision to rebuild this mill was quickly justified after a 5pm telephone call one evening from a technician at Hardinge Tools.

I had called Hardinge Tools to see if I might get more information about disassembling part of the mill. I was working to disassemble the J-Head and ran into a stumbling block removing the reverse feed gear assembly. Since I did not want to break any additional parts, I called Hardinge, fully expecting them to brush me off because I am a home user with a 42 year old machine. I left a voicemail message and went about trying to find the information I needed elsewhere. Imagine my surprise when I received a phone call from Gary Gelts, a Hardinge Bridgeport Service Technician, on his way to a trouble call. He said he had heard my voicemail and wanted to help me out. After we had talked for a couple minutes, he pulled off the road, extracted his manuals, and talked me through the procedure of removing the reverse feed gear assembly. After removing the assembly and thanking Gary for his time, I sat there thinking about the entire phone call, the level of professionalism, the enthusiasm, and the willingness to help someone without the least expectation of payment. Yes, a Bridgeport was definitely the way to go.

2.4 Isn’t it too old?

Not really. As you can expect, many of the older machines were designed to very strict tolerances for accuracy, ease of maintenance, and durability. The machines were so popular and so durable that many of them are still in operation today, and more and more of these mills are finding their way into the home market. They are showing up on Online Auctions and

Government Auctions all of the time, and parts are still readily available from several vendors. To this date I have been able to purchase every single replacement part I have needed for this mill.

The only real downside to the machine for home use (besides the size and weight), is that the motors on the machines are designed for 3-phase AC Power. While this is not an insurmountable challenge, it does require that the user start to thinking about Electronic Phase Converters, Rotary Phase Converters or Variable Frequency Drives (VFD) which I will not cover in this manual. There are already reams of information out there on those. As far as power for my mill is concerned, I started by sharing a VFD between my mill and my South Bend Lathe. Since my ultimate goal was to convert this machine for CNC use, I purchased a very nice 1 ½ HP DC Motor, a DC Motor control and have since converted my mill to use this very nice motor. The controller that I am using allows changing direction by flipping a toggle switch, and speed is controlled through the use of a 5KOhm potentiometer. A perfect addition of the mill as my next goal is to convert this mill for CNC use.

2.5 Disassembly/Reassembly Suggestions

Whenever I take something apart I take lots of pictures. I am only 47 years old, but knowing the exact location of every screw is well beyond my instant memory recall. I also tend to use a lot of the cheap zipper sandwich bags, and boxes from the local super market. I find that I can throw a note or drawing inside the bag with the parts, and it will keep things together until I am ready to assemble them. You will see me refer to “baggies” throughout this document, and it is these zipper bags that I am talking about. It is also helpful to come up with a numbering scheme if you intend to disassemble something. Fortunately, Bridgeport has already provided this for us.

I also tend to make notes and draw pictures of things that I find “very interesting”. With regards to the Bridgeport, one of the items that I marked as “very interesting” was the type of grub screws they used for securing parts, then securing the grubs. I had never quite seen an arrangement like this, so I noted it with pictures and notes. In fact, I found this one feature of the Bridgeport so compelling to talk about, that I started the discussion here before you have even started to read the disassembly instructions. The reason for this is two fold, one for information, and also so that you do not break anything during the disassembly.

The grub screw and its hollow locking screw are shown below in Figure 4. What makes these parts interesting is that since the locking grub is hollow, you can actually insert your allen wrench through the locking screw into the grub that is locked, and this will prevent you from being able to break it loose. In some cases I placed masking tape around the allen wrench to keep the allen wrench from going too deep through the hollow locking screw and into the main grub screw.

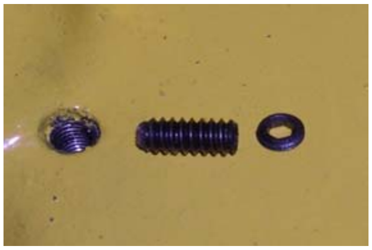

Figure 4 - Grub Screws, note the hollow locking screw.

Whenever you take something apart, whether it be something you intend to repair or not, you should think about how you would reassemble it, and figure out how it worked. I have learned so much by paying attention to the engineers who traveled before me. Something that was innovative 50 or even 100 years ago might still be considered innovative today.

When I disassembled this machine I worked in sections, and I compared everything to the manuals and drawings that I had been able to acquire both from other people and on the web. I looked for missing parts, broken parts, and places where the manuals had not been updated to reflect the machine. As I continued through the disassembly, I started documenting the items I would need to complete the rebuild. This list of parts helped me tremendously, because during the teardown I began to see Bridgeport parts that I needed on the online auctions. I would venture to say that I have saved about $200 on the rebuild of this machine by finding items online for much less than the replacement costs.

I also made a note of the broken parts that I thought I myself could fabricate. Many of the gearshift plungers that were broken could be easily built on my small Craftsman Lathe, so I was able to save money by fabricating the parts myself. In some cases it is cheaper to purchase the replacement parts than to expend the labor to build them. I will leave this decision to you. I prefer to make what I can and hone my skills.

Where parts can get away from you, or be easily overlooked, I have tried to make notes throughout the document to warn the reader. There are some springs in this machine, and if care is not taken when removing some parts, you may find yourself on your hands and knees scouring the garage floor for a 3/16 ball bearing that flew out unexpectedly. By the way, hardware stores sell individual 3/16 ball bearings in their rack sections for 10 cents (Thank goodness!).

3.0 Motor and Drive Section

The motor on this old style Series I J-Head mill is a "Pancake Style" 3-Phase motor capable of operating at 220VAC, or 440VAC at a speed of 1750 RPMs. Power to the spindle is supplied through a "Stepped" pulley arrangement that provides for four different spindle speeds. This mill is also equipped with a back gear arrangement that doubles the number of spindle speeds to 8. For most home users this motor is more than sufficient. Larger motors are available for the mill from various vendors, but unless you are turning some extremely large tools (flycutters, etc), have about $600 to spend, or looking for some extreme RPMs, the ½ HP motor will do just fine. Since I had to disassemble most of my motor for cleaning and painting, I have detailed many aspects of the motor, from the wiring to the sheet metal.

3.1 Motor Removal, Inspection, & Reassembly (RIR)

The motor on my mill is a ½ horsepower 3-phase Pancake Style motor. In 1963 the ½ horsepower motor was considered a powerful motor, and many of the larger surfacing bits were not being used. I would recommend that you attempt to work with the motor that you have before considering a replacement. Many home machinists will simply not use all of the capabilities of the machine. If you are going to be using some large bits, or working some extremely hard metals, you may want to consider a larger more powerful motor.

CAUTION : Before attempting to remove the motor, disconnect the power to the mill.

3.1.1 Motor Removal

The motor on a Bridgeport mill is fairly easy to remove. You need to release the nuts that secure it to the drive housing portion of the mill as shown in Figure 5 below, remove the belt, disconnect any power cables, and lift the motor off the unit. This motor weighs about 30 pounds and was very easy for me to manage.

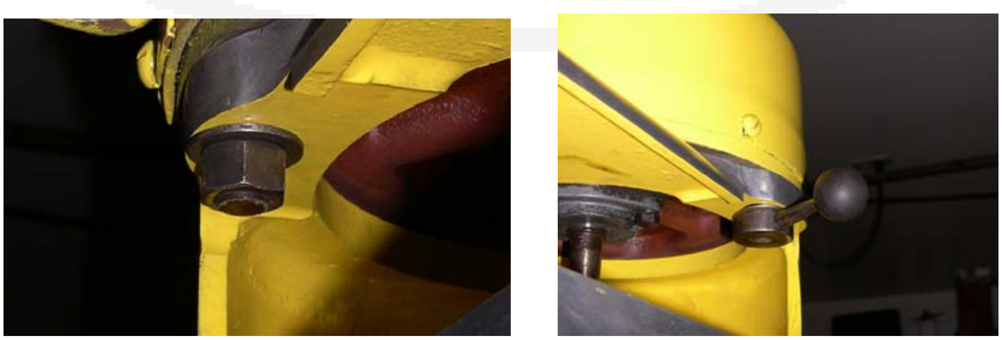

Figure 5 - Motor Nuts

3.1.2 Motor Inspection

These motors are extremely durable. My motor, manufactured in 1963 did not have any problems other than the fact that the outer housing was covered in rust. It ran fine, had plenty of power, and continues to work well for most of my applications. The only real thing that bears inspection on the motor is the motor bearings. Once the motor has been removed from the mill, you should be able to easily turn the motor shaft with your hand. The operation should be smooth and uniform. If you feel any “gritty” or “jerky” motion, then your bearings are most likely bad and will need to be replaced.

Replacement of the bearings starts with the removal of the step pulley. Remove all grub screws securing the step pulley to the motor shaft, and use a gear puller capable of reaching to the bottom of the step pulley to extract it from the shaft. Do not attempt to use a gear puller on the pulley face surfaces as these will break easily.

With the pulley removed, you should have easy access to the bearing retainer bolts. These bolts, once removed, allow the bearing retainer to be removed exposing the bearings for replacement. I found it easiest to remove the motor cover, and to press the motor shaft out through the motor casing. The bearings could then easily be removed from the motor casting. Before pressing the motor shaft out through the casing ensure that the shaft is clean and lubricated. If you feel any resistance stop pushing and find the cause of the binding.

3.1.3 Motor Reassembly

For reassembly, you will start by installing new bearings into the motor casing. In some cases people have told me that this is easier to do with the motor shaft in place. Others have put the new bearings in, put the bearing plate in a press and pressed the motor shaft onto the bearings. Since the motors differ slightly among the models you should do what works best for your motor.

Once the bearings have been installed, and the motor has been reassembled, you can loosely install the step pulley and place the motor back on the mill. The reason for leaving the step pulley loose is so that is may be aligned with the matching step pulley in the motor housing. Failure to align the pulleys will reduce belt life and make for a noisy drive system. Alignment is accomplished simply with the use of a straight edge aligning the faces of the pulleys. Once you have the pulleys aligned, tighten the grub screws for the motor pulley.

3.2 Motor Replacement

I have had several people ask me why I would consider a motor replacement for my mill, and what I generally tell them is that the reasons for me were that I want to control spindle speed through CNC controls, and that I would like to be able to operate at speeds outside the range of the existing motor.

To that end, I happened to be looking on the online auctions for parts when I happened across a new 1½ hp DC motor with a 5/8” shaft made by Pacific Scientific. I couldn’t resist, so I bought the motor and a controller for it. The controller I purchased allows controlling spindle direction with a toggle switch (or relays with my CNC Controller), and speed is currently controlled with a 5KOhm Potentiometer, or a voltage source 0-9VDC. Being a computer software/hardware person I intend to build a control that contains a small microprocessor that will allow me to set the Spindle Rotations Per Minute (RPMs). By reading an optical reflector that will be connected to the spindle pulley or the motor, the microprocessor will be able to control the Pulse Width

Modulation (PWM) to the motor to maintain the selected RPMs even under load. I have done this before in my line of work at 12 and 24VDC. I am just hoping that I don't kill myself with the 90-110VDC that this motor requires.

The advantage to a system like this is that I no longer require 3-phase, and I will have precise control of spindle speed. Since this motor has a max rated speed of 3800 RPMs, it will also allow me to drive the spindle at slightly higher speeds which may be required for some CNC operations.

3.3 Drive Housing Section

The Drive Housing Section, shown in figure 6 below, houses the stepped pulley assembly, spindle brake assembly, and all of the spindle drive components for the mill including the back gear. Within this assembly, the power from the motor is transmitted to the spindle through a stepped pulley and v-belt system, and a timing belt arrangement. Power to the spindle may also be directed through the back gear which provides a gear reduction unit that will allow spindle speeds as low as 80 rotations per minute (RPMs).

Figure 6 - Drive Housing Assembly

3.3.1 Drive Housing Removal

You should first follow the steps for removing the motor. Once the motor has been removed, you can remove the Drive Housing Assembly by removing the 3 bolts sown in Figure 7 below that secure it to the J-Head and slide the assembly up and over the spindle.

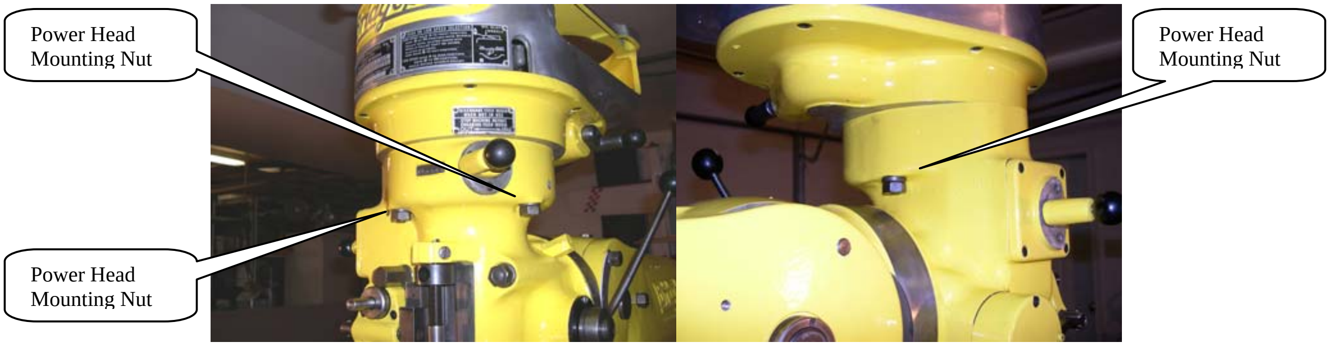

Figure 7 - Power Head Mounting

I found it easier to separate the drive housing cases by removing the timing belt from the larger timing belt pulley first. There may be several ways of doing this, but the most effective for me was to remove the 4 flat head screws from the timing pulley that secure the top portion of the timing pulley as shown in Figure 8 below. You can then slide the timing belt up and over the top of the pulley. You will not be able to remove the belt at this time, but at least it will be out of the way.

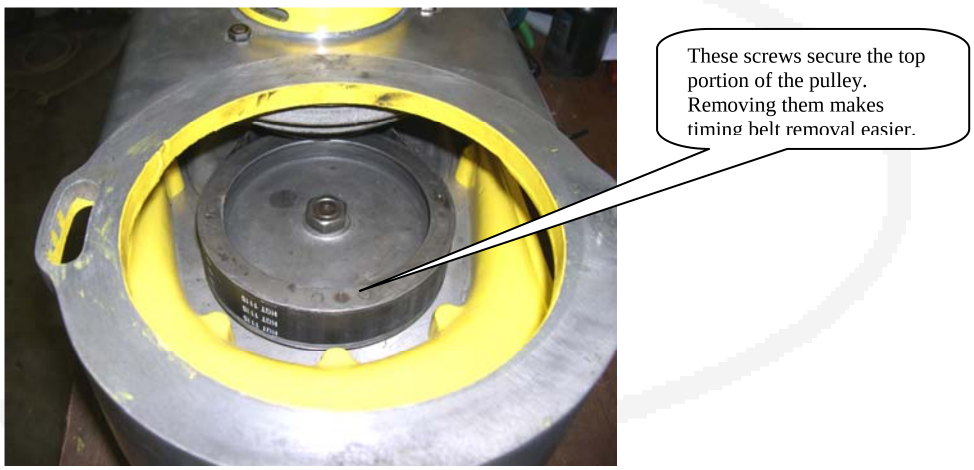

Figure 8 - Drive Housing Timing Belt

Once you have freed up the belt, you can then turn the unit over and remove the six bolts that fasten the two halves of the Drive Housing together as shown in Figure 9 below. There are two alignment pins that align the two halves of the casing together. Once you have separated the cases enough to clear these pins, the cases should slide apart easily. If not, check to be sure that the timing belt is not hampering your movements.

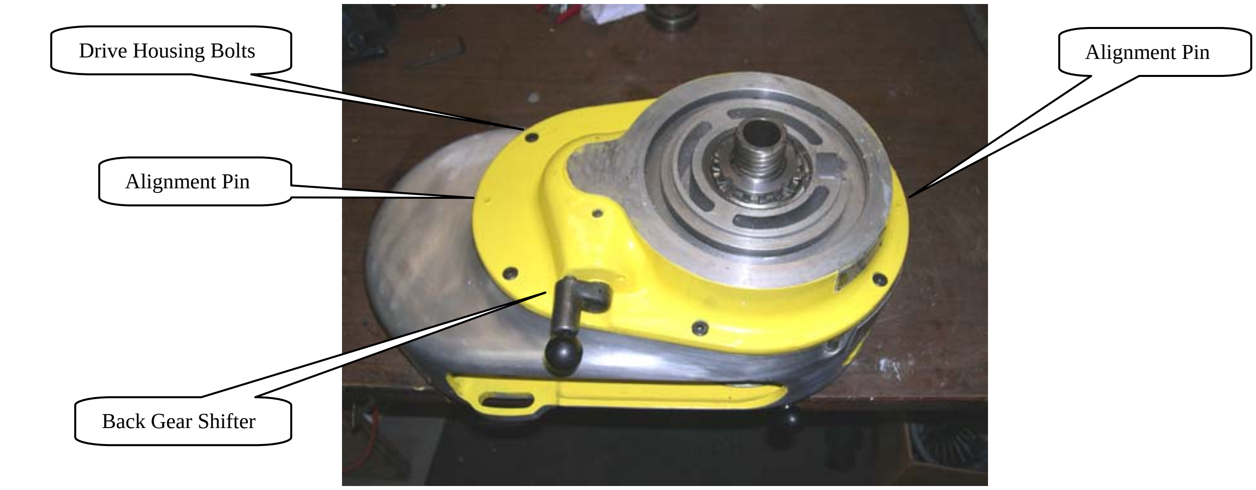

Figure 9 - Bolts Fastening Drive Housing Together

3.3.2 Drive Housing Inspection

There are several sets of bearings in the drive housing that should be inspected prior to placing the drive housing back in service. Two sets of these bearings are shown in Figure 10 below. The Spindle Bull Gear Bearings are located beneath the Spindle Bull Gear Assembly. To remove the Bull Gear Bearings you will have to remove the Bull Gear Assembly by removing the spanner nut located on the opposite side and the circlip that retains the bearings in the housing. The Back Gear Bearings are located one in each of the gear casings. To remove the Back Gear Bearing from the lower casing you will need a slide hammer puller much like those used for pilot bushings.

Figure 10 - Drive Housing Inspection

3.3.3 Drive Housing Reassembly

As you can see from Figure 10 above, you will want to grease all of the bearings very well during reassembly. Ensure that you grease the shift linkage as well. Check all items for freedom of movement and then reassemble the gear housing cover as shown in the Figure 11 below.

Figure 11 - Gear Housing Cover

You will note in Figure 11 above that the short shaft is awaiting the woodruff key, and the large timing belt pulley. Once you have installed the timing belt pulley, you can start prepping the upper portion of the drive housing by placing the v-belt on the upper most stepped pulley. I found that it made the installation easier if I clamped the v-belt around the pulley using a cable tie. You can then slide the timing belt over the spindle drive timing pulley. You are now ready to start assembling the drive housing. As you move the two housings together you will have to check the belts several times to ensure that they are not getting stuck beneath the pulleys, or by the cases.

Some people have indicated that the oil cup in the figure above should preclude the need for grease inside the gear housing and that it should be instead filled with oil. What I have found after tearing the mill down to inspect after a years worth of hard service as a CNC machining center is that the oil supplements the grease and fills the areas where the grease was unable to penetrate. Virtually no wear is visible in this section, and the bearings are all running free and true. I will leave the final decision here up to the user, although I do appreciate any feedback.

4.0 J-Head Section

This by far is the most important and most complex portion of the mill. The J-Head houses the Quill and Spindle which are the main moving parts responsible for the milling operations. The spindle holds the bits that you will use in your milling operations, and the quill provides for the vertical movement, and bearing surfaces for the spindle. The J-Head mill has a wide variety of options and functions that may be controlled, such as: quill feed speeds, quill feed directions, quill feed engagement, and quill lock. Figure 12 below shows all the major parts of the J-Head.

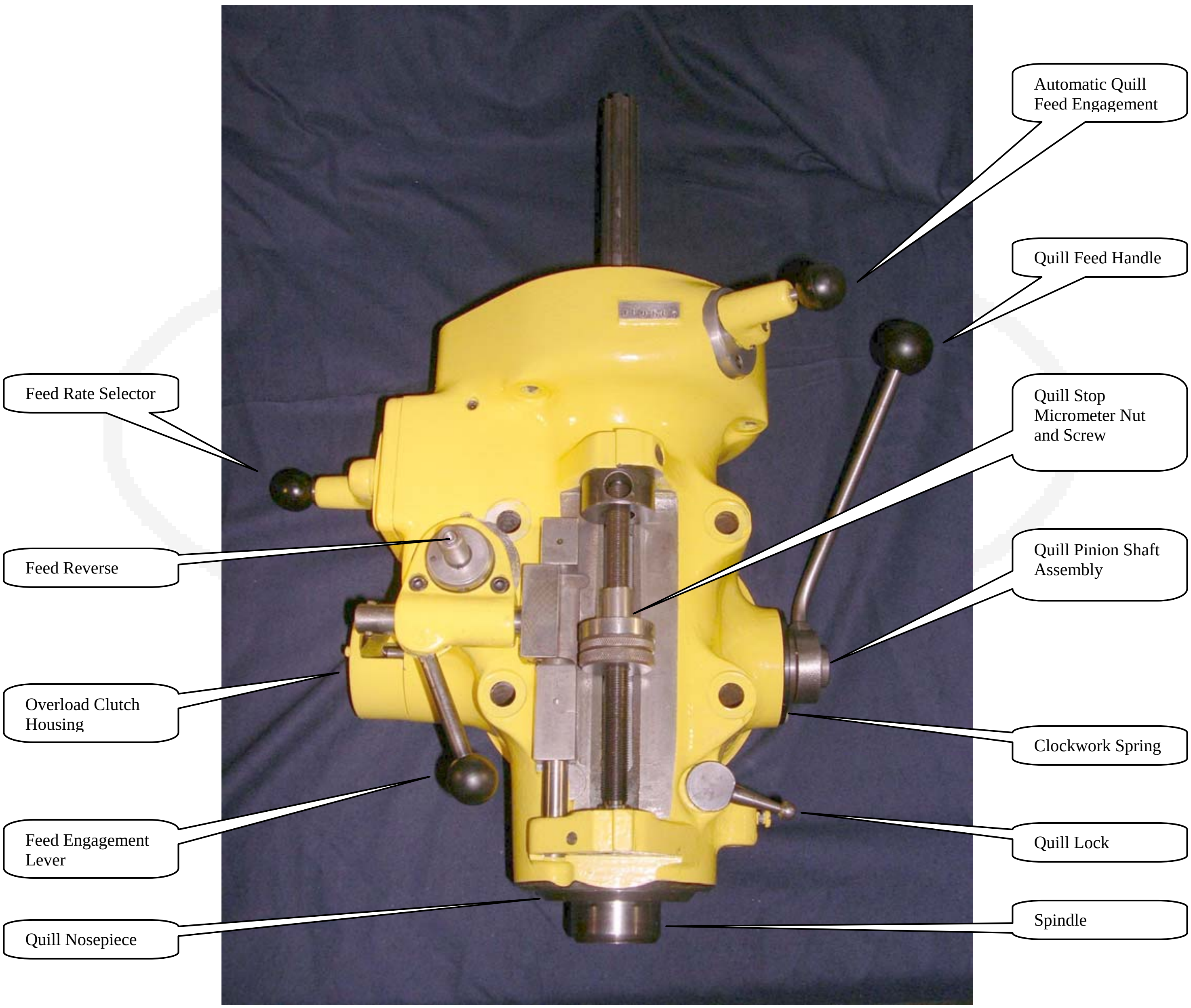

Figure 12 - J-Head

In this section of the document I will attempt to clarify the disassembly and reassembly of the various subassemblies that make up the J-Head. The order of disassembly allows someone to fully disassemble and categorize their parts on a subassembly basis.

Before attempting to work on any portion of the J-Head, remove power from the machine.

4.1 J-Head R & R

The J-Head as shown in Figure 13 below is secured to the front of the Ram Adaptor using 4 large bolts and nuts that ride in a T-Track on the Ram Adaptor. As you can see from this figure, I have removed the motor and drive assembly before attempting to remove the J-Head. This makes the unit more manageable and much lighter.

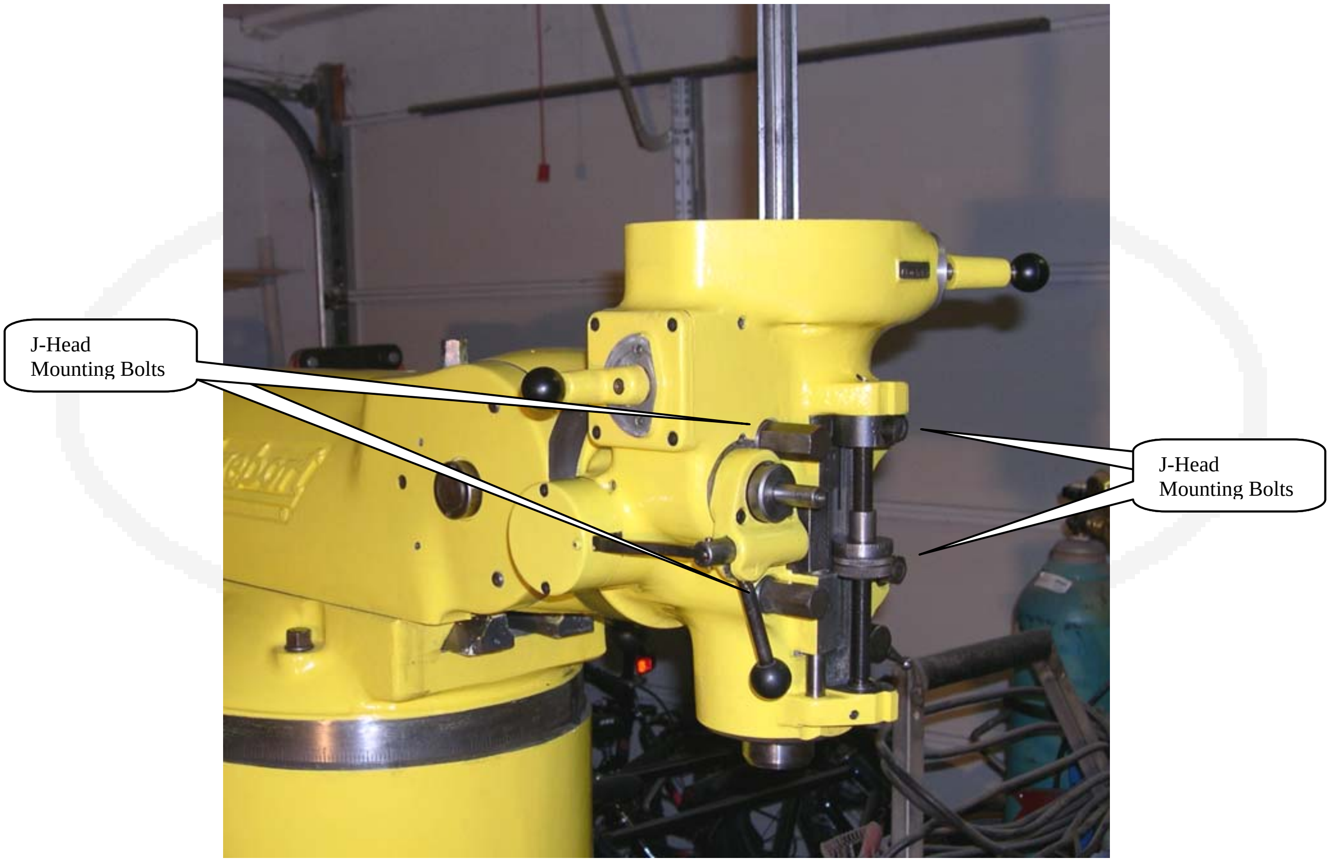

Figure 13 - J-Head Mounting

4.1.1 J-Head Removal

You should be sure to support the J-Head before loosening the 4 bolts that secure it to the Ram Adaptor. The J-Head weighs in the neighborhood of 60-70 pounds and is very awkward due to the length of the spindle shaft, and the rotation of the spindle. You may think you have a good grip, then something will spin and this unit will go flying out of your hands. You can remove the J-Head from the unit with the Power Head attached, but keep in mind that this makes the unit another 50-60 pounds heavier.

Secure the J-Head to the lift being used, so that as the nuts that hold the J-Head onto the turret are loosened the J-Head does not fall or pivot. The J-Head is held to the Ram Adapter with four ½" bolts and nuts that ride in a T-Track on the Ram Adapter. These bolts can be either square head, or hex head depending on the year of your mill. Once you have removed the four nuts from the face of the J-Head, it may be slid away from the Ram Adapter face. Some people who have not been able to acquire a lift for the J-Head, will remove the motor and drive portions to lighten the load, and then get a friend to help lift the J-Head off. You can also use the table to assist by raising it up until it supports the nose of the quill. **Just be safe, that's all I ask.**

4.1.2 J-Head Reassembly

I reassembled the J-Head onto my machine by supporting it with an Engine Hoist, and sliding it over the bolts that I had slid into the T-Tracks on the Ram Adaptor. Once the unit is up against the Ram Adaptor, and the tilt gears are engaged, you can put the nuts on and tighten them up.

4.2 Quill Pinion Shaft RIR

The Quill Pinion Shaft provides the drive mechanism for raising and lowering the Quill both from gross manual movement which uses the Quill Feed Handle, to the micro adjustments available through the use of the hand wheel assembly, to automated using the Quill Feeds.

4.2.1 Quill Pinion Shaft Removal

To remove the Quill Pinion Shaft you will have to first remove the Pinion Shaft Hub Handle then remove the Pinion Shaft Hub by pulling it straight off the shaft. You will then have to remove the clockwork spring. Be careful when removing the screws securing the clockwork spring as the spring is under tension and the housing will want to rotate. I have included plans for a small tool that can be used to control the twisting of the clockwork spring in Appendix A. Please use this tool or something similar to release the spring tension in a controlled manner. Next you will need to remove the quill feed clutch cover, and extract the overload clutch.

I have not included any procedures for adjusting the overload clutch simply because unless something is broken in your clutch assembly, it rarely needs adjusting and the Bridgeport manual states that it should be done by an authorized Bridgeport Repair Facility.

Note: Be careful when removing the clutch cover not to lose the overload clutch lever spring or plunger as illustrated in Figure 14 below.

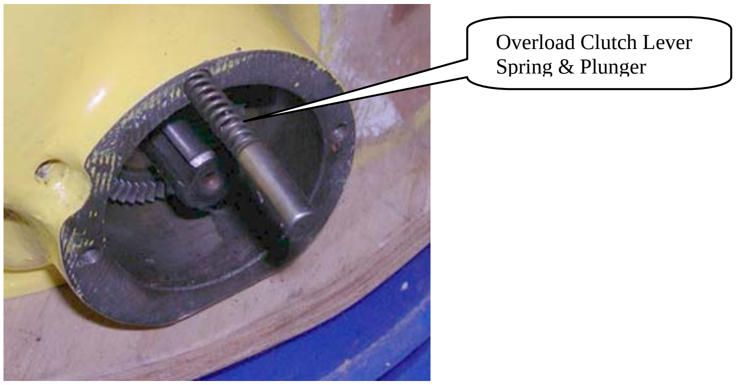

Figure 14 - Overload Lever Plunger and Spring

The next part that needs to be removed is the worm gear assembly which contains the overload clutch ring and the worm gear. This assembly is held in place by a small cir-clip as shown in Figure 15 below. Once you have removed this cir-clip, the Pinion Shaft may be pushed out towards the clock spring side. The worm gear assembly will then become free once the shaft has been pushed through. Note that there is a spacer behind the worm gear assembly.

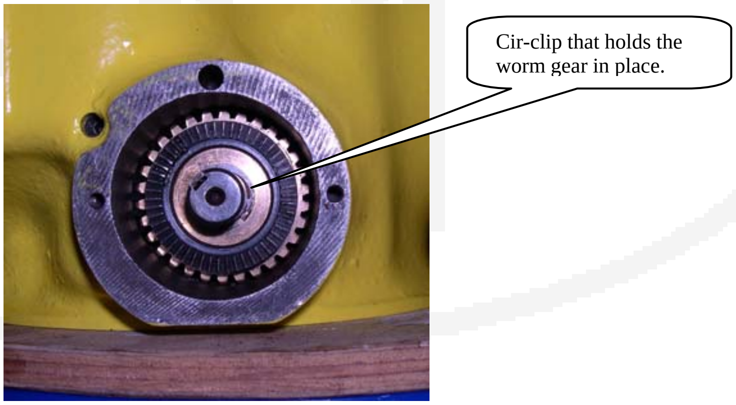

Figure 15 - Overload Clutch Ring and Circlip

4.2.2 Quill Pinion Shaft Inspection

Inspect the Overload Clutch Worm Gear for any excessive wear on the teeth. If worn, this gear may bind and cause problems when attempting to use the automatic quill feed. Check the clock spring to ensure that there are no breaks in the spring that might affect the spring's ability to reduce the load on the quill.

A note here, if you are having problems where your quill constantly wants to fall down, this section is vitally important to you. This is an indication that your clock spring is either broken or out of adjustment. Check it carefully for breaks as they may not be readily visible.

4.2.3 Quill Pinion Shaft Reassembly

Reassembly follows the reverse order of assembly with a few notes tossed in to help clarify things. I have found it best to slide the pinion shaft into the housing far enough that the pinion shaft protrudes on the clutch side just enough to install the spacer for the Worm Gear Assembly. This allows you to install the spacer (a dab of grease helps hold it in place), and then tilt the worm gear assembly while inserting it to engage the mating gears teeth. Once the worm gear assembly is lying flat against the spacer, the pinion shaft should slide easily through the worm gear assembly. If the shaft is pushed all the way through before this step, you will damage the worm gear assembly trying to force it into place. Now that you have the worm gear in place, you can install the cir-clip and complete the reassembly.

4.3 Quill Stop and Quill Indicator RIR

The Quill Stop and Quill Indicator are there to provide you with the ability to precisely return to the previously used quill height or depth. It also provides you with a means to turn off or trip the quill feed at a specified depth.

4.3.1 Quill Stop and Quill Indicator Removal

To remove the quill indicator scale there are two small 6-32 round head screws securing the aluminum indicator to the J-Head. Remove these screws and put them and the indicator in a small bag. Based on Figure 16 below, you will note that there are a few pieces that have to be removed before the micrometer screw can be removed. The Bridgeport Owners Manual covers the removal of the Micrometer Screw very well. There is a small screw pin that holds the trip lever in place. Remove this and the trip lever. There is also another screw at the top of the micrometer screw that holds a very interesting part in place. You may not be able to see it because of grease, but once you remove this upper screw there is a small dumbbell looking item, the ball reverse lever, that must be removed using a 6-32 bolt. Simply screw the bolt into the end of the ball reverse lever and wiggle the micrometer screw up and down while pulling on the bolt and the ball reverse lever should come out. Lastly you will need to remove the circlip at the bottom of the micrometer screw.

Figure 16 - Ball Reverse Lever, and Quill Stop Trip Lever

With these parts removed, you should be able to remove the micrometer screw by pulling down as you screw the micrometer dial and locknut towards the top. Once the screw has been removed, you can remove the quill stop by removing the 3/8" cap screw.

4.3.2 Quill Stop Inspection

Clean and examine all parts carefully for rust, and or abrasions that would impact the freedom of movement. The ball reverse lever is subject to wear, as is the trip plunger.

4.3.3 Quill Stop Reassembly

Lubricate all parts thoroughly and reassemble in the reverse order of disassembly. Once you have assembled the quill stop, you should adjust based on the following steps to ensure that the operation works well. Section 10.2 has been added to this document to describe the proper adjustments for the quill stop.

4.4 Quill and Spindle Removal

In order to remove the Quill and Spindle you will have to follow the steps for removing the Motor and Drive sections from the mill. This will free up the top portion of the spindle shaft. If you are going to be servicing the quill assembly, you will also want to remove the felt oil washer from the quill and the other screw that secures the quill skirt.

There are two ways to disassemble the Quill and Spindle Assembly. This method assumes you will be removing the quill and spindle as an assembly, and then disassembling on the bench. If you however just need to change spindle bearings, there is an On Machine Spindle Extraction procedure listed in section 4.5.

Note: If you intend to disassemble the quill and spindle assembly, this is a good time to loosen the spanner nut at the top of the quill assembly. At this point you have the ability to use the quill lock to help secure the quill while you attempt to hold the spindle and break the spanner nut loose. I was forced to build my own spanner nut wrench to break this nut loose. It is illustrated below in Figure 17. Once the quill assembly is out of the J-Head it becomes very difficult to hold onto the spindle without damaging the quill surface. If you do need to remove the spindle nut with the unit outside of the mill, my best suggestion is to chuck the splined portion of the spindle in a sizeable lathe, support the spindle nose with a live or fixed center, and loosen the nut using a tool such as the one illustrated.

Note: The quill assembly is heavy, and the surface of the quill is chromed to provide an exceptionally smooth interface. You should put supports under the quill assembly during removal to hold and protect it. If you are removing the quill while the J-Head is still attached to the Mill, you can move the table up to help support it. Under no circumstances should you attempt to clamp the quill or fasten it in any vice. You will damage this precision surface.

Figure 17 - Homemade Spanner Nut Wrench

Once you have the removed the motor and drive sections from the mill then follow the steps for removing the Quill Pinion Shaft and the Quill Stop. Once these parts are removed, lift the quill skirt out of the upper part of the J-Head, and the quill and spindle assembly should be able to be pushed down and out of the J-Head. Depending upon the tightness of the fit of the quill inside of the J-Head, you may have to tap the top of the spindle shaft with a rubber mallet to help extract the Quill Assembly.

4.4.1 Quill and Spindle Inspection

Generally you will not remove the Quill unless you already have a problem. Inspection of the Quill and Spindle involves completely disassembling the Quill and Spindle Assembly. This is the only way to get a look at the bearings and feel their motion to see if you have metal shavings, dirt, or in my case rust in the bearings. The following sections will detail the disassembly of the quill assembly, and then the subsequent reassembly.

4.4.1.1 Spindle and Bearing Removal

If you paid attention to the note above concerning the removal of the spanner nut, then your task ahead is really very simple. You will need to remove the nose piece from the quill. This nosepiece is secured by a small grub screw. Once the grub screw has been removed, the nosepiece can be removed by rotating it counter clockwise and unscrewing it from the quill. With the spanner nut off, and the nosepiece removed, you can now press the spindle out of the quill. Please keep in mind that you will be pressing out the spindle with the bearings attached so you will need to align your lower press plates to provide enough clearance for the spindle bearings, and not just the spindle.

Note: The spindle may be loose and want to fall out during the press operations. Make sure that you support the spindle to protect it.

It is very possible that one or more of your spindle bearings remained inside of the quill and the spindle was all that came out. This is fine, just flip the quill over and knock out the upper spindle bearing first. I do this because the upper spindle bearing is by far the least expensive, and if I damage it while knocking it out, it is no great loss. You can now flip the quill back over with the spindle bearings on the bottom, and use a large bearing tool (or chunk of flat round metal) to press out the spindle bearings.

4.4.1.2 Spindle and Bearing Inspection

Okay, now that you have everything apart you want to examine the parts closely. You want to make sure that the spindle is not bent in any way. You want to check the collet portion of the spindle for wear or being out-of-round. And last but not least you want to inspect each of the bearings for freedom of movement, and in the case of the spindle bearings, make sure that there is no side to side movement. These are precision bearings, and should be smooth and tight.

4.4.2 Spindle Bearing Reassembly/Replacement

The lower spindle bearings inside of the Bridgeport J-Head Quill are precision matched taper bearings with a pre-defined and set preload. What this means is that you have to buy the bearings as a matched set, and if purchased this way, the preload of the bearings is already set if you follow a simple guideline. The spacers that separate the spindle bearings must be the same length and should be true. If your inner spacer is longer than your outer spacer, then the preload will be wrong. In the case of the Bridgeport, you will be sloppy. If the outer spacer is too long, then the bearings will bind.

When I purchased the bearing set for my unit, they came in a single box packaged together and had a small set of instructions that detailed their installation guidelines. One of the items you must pay close attention to is the axial marking on the bearings. These markings indicate the “optimal” orientation of the bearings for maximum precision. In the case of my bearings, each race of each bearing had an asterisk (*) that needed to be aligned axially on each of the races. Figure 18 illustrates the method that I used to mark the bearings, and the orientation.

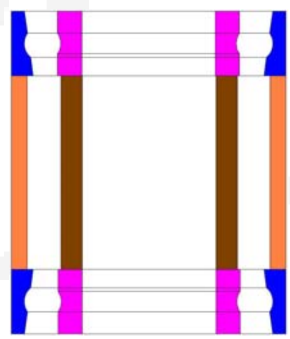

Figure 18 - Note the Axial Alignment Asterisk and the Bearing Orientation

The last item of interest of the spindle bearings is their orientation. Spindle bearings are taper bearings meaning that the race is not of the same thickness on both sides. Taper bearings are used in this mill to reduce the amount of slop in the spindle. If you examine the race carefully you will note that there is a thick side and a thin side to the faces. In the Bridgeport mill, the orientation is that the thick sides face each other, see figure 18 above.

4.4.2.1 Pressing the Bearings onto the Spindle

On the J-Head mill, it is easier to press the bearings onto the spindle, and then press the spindle into the quill. To make this job easier, I marked my spindle along the long axis utilizing a small pointed permanent marker. I placed my dirt shield onto the spindle and proceeded to align the asterisk (*) on the inner race of the first bearing with this mark on the spindle. I then pressed the first bearing down into place.

After having checked to ensure that the bearing did not erase my mark, I slipped both the inner and outer bearing spacers onto the spindle, and taped the outer spacer to the outer race on the lower bearing just to keep it in place for the next pressing operation. I installed the second bearing being sure to check the orientation of the bearing, and to align the asterisk (*) with the mark on the spindle to ensure that my marks were aligned axially. I then pressed the assembly together and made sure that everything was still aligned. Figure 19 illustrates the spindle assembly ready to go into the quill. You will note that I used masking tape to hold the marks in alignment. The tape is removed as the parts are all pressed into the quill.

Figure 19 - Note the alignment marks on outer races preparing for next step

4.4.2.2 Pressing the Spindle into the Quill

Alignment of the outer races is just as important as the inner races, so once again I grabbed my trusted permanent marker and marked lines on the outer portion of the outer races that matched the positions of the asterisks (*). As I pressed the spindle into the quill, I aligned these marks with the nosepiece set screw hole so the outer races would be aligned axially along the axis of the nosepiece screw. In Figure 20 below you should also note the orientation of the dirt shield. I have had several people ask me about the orientation of the dirt shield.

Figure 20 - Aligning with Nosepiece Screw Hole

4.4.2.3 Pressing the Upper Spindle Bearing into the Quill

The upper spindle bearing is much simpler in both makeup and installation. Prior to installing the upper spindle bearing, you should install the upper spindle bearing spacer. You can now insert the bearing and press it into place. When pressing in this bearing, make sure that you have the nose of the spindle supported on your press. Supporting only the quill will result it you pressing the spindle back out of the quill again. Once you have pressed the upper spindle bearing in, install the lock washer and the spanner nut. Tighten the nut fully, and use the locking tabs on the locknut to hold the spanner nut. Figure 21 below shows the nut wrench that I constructed for performing this job.

Figure 21 – Homemade Spanner Nut Wrench

4.4.2.4 Re-Installing the Quill Assembly in the J-Head

I found it much easier to slide the quill assembly back into the J-Head from the bottom. I slid the assembly up until the quill was elevated a little above the cavity in the J-Head. This allowed me to form the quill skirt around the quill, and then slide it into place and secure it with one of the screws.

NOTE: On my mill, the quill skirt faced down with the tabs at the top, and the opening was towards the pinion gear for the quill. If you put the quill skirt in upside down, you will only have about 4” of movement on the quill. Do NOT force the quill down as you will most likely break the tabs off of the quill skirt.

Once in place I move the quill down a little and started re-installing all of the quill feeds, stops, and clutches. It was only after the quill was secured inside of the J-Head that I secured the spindle shaft and tightened the spanner nut securing the spindle bearings. Once again, it is easier to tighten this spanner nut while the quill assembly is in the machine.

4.5 On Machine Spindle Extraction

After disassembling my entire mill, it dawned on me that the spindle assembly could be removed from the machine without removing the J-Head, in fact, without even removing the Quill. This procedure requires you to build a custom press tool to press the spindle assembly out, and by rotating the J-Head upside down, the same press may be used to reinstall the spindle.

As with the Quill and Spindle Removal identified in section 4.3, you will need to remove the entire drive section from the top of the J-Head. Your goal is to free up the spindle so that nothing is attached to it, but leave the spanner nut tight as you will be pushing out the whole spindle assembly with bearings installed. Place a board or something on the table to protect the table in the event that the spindle falls out. You should then remove the grub screw securing the Quill Nosepiece, and remove the Quill Nosepiece. You will then want to bring the table up to within 6” of the quill. Use some 6” blocks to support the quill and bring the quill in contact with the support blocks and lock the quill in place using the quill lock. Make sure that you have allowed enough room for the spindle bearings to clear the Quill support blocks. You will then need to install the press tool and secure it to the table using T-Nuts. Place a block on the table underneath the spindle assembly to catch the spindle assembly should it fall out. As you crank down on the bolt at the top of the press tool, the spindle should start to push out of the quill. Once the spindle is free, you will need to lower the table to remove the spindle from the quill.

If after tightening the upper press bolt, the spindle does not appear to be moving, then you might be best removing the entire assembly as detailed in section 4.3 above, and all you have lost is the time to set up the blocks and press.

4.6 Feed Driving Gear Assembly RIR

The Feed Driving Gear Assembly provides you with 3 speeds and an on/off selector that can be used for driving the quill feed. The upper sliding gear assembly is shifted right and left using the Feed Gear Shift Fork, and the on/off with the Quill Feed Engagement Lever.

4.6.1 Feed Driving Gear Assembly Removal

To disassemble this unit, you will need to first remove the Cluster Gear Shift Fork Cover and the Feed Engagement Cover. You can then remove the Worm Gear Cradle Assembly. The Worm Gear Cradle Assembly is held in place by the Worm Gear Cradle Grub Screws as shown in Figure 23, and the nut on the top of the Input Shaft. The top of the Input Shaft is shown in Figure 22.

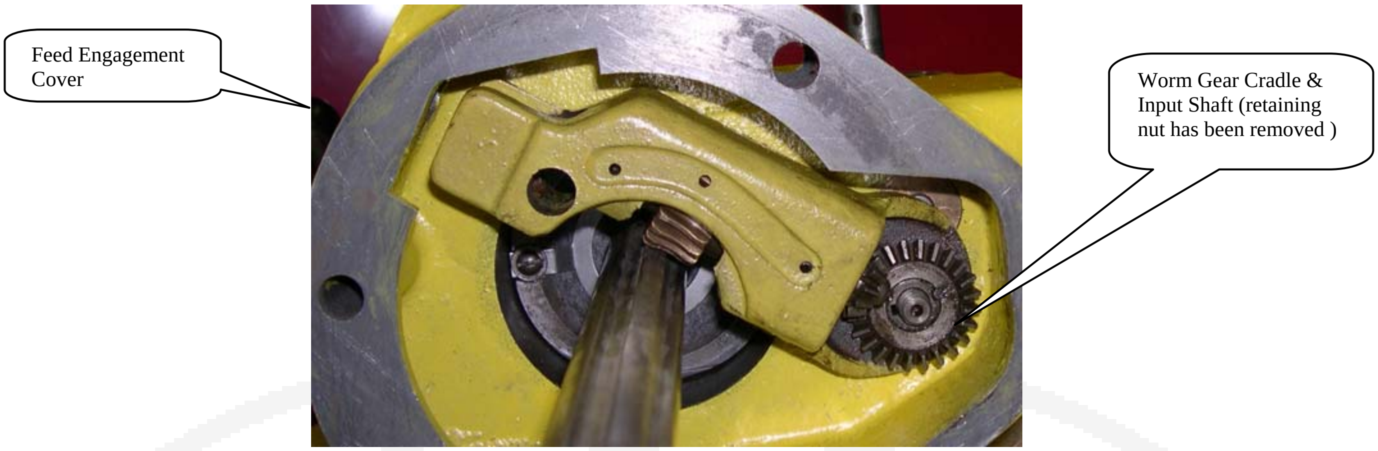

Figure 22 - Worm Gear Cradle Assembly

Once you have removed the Worm Gear Cradle Assembly, you can remove the rest of the Feed Driving Gear Assembly. Start by removing the grub screws that secure the Cluster Gear Shaft as illustrated in Figure 23 below. You start by removing the Input Shaft first, then using the hole created by removing this shaft to assist with the removal of the Cluster Gear Shaft. Note that once these shafts have been removed, you may now remove the remaining ring gear from the Quill Feed Pinion Shaft.

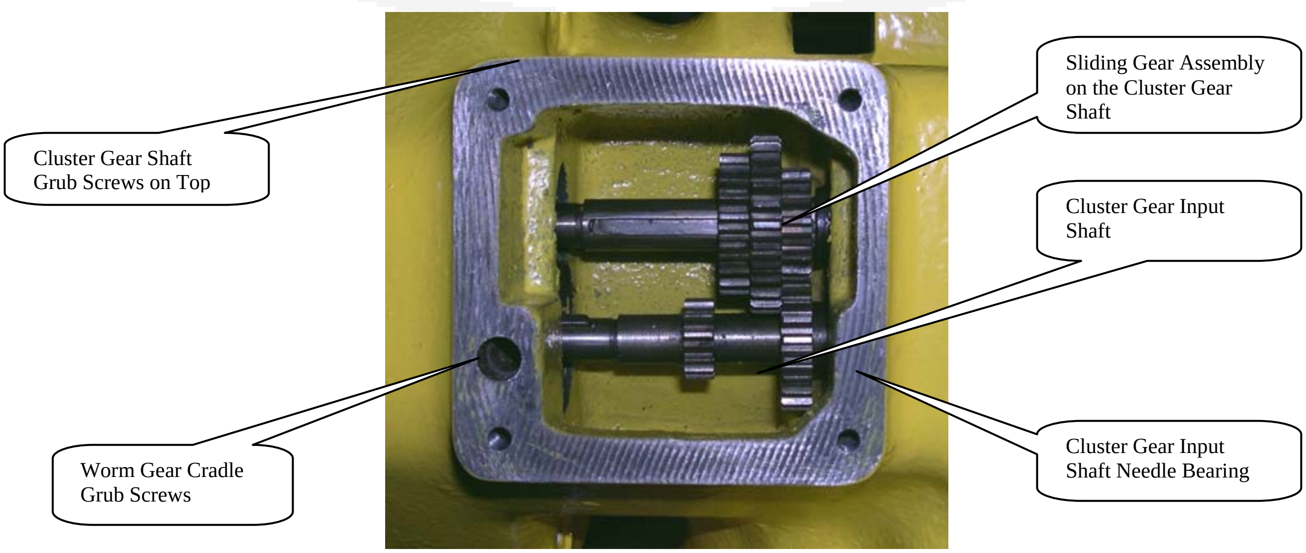

Figure 23 - Feed Driving Gear Assembly

4.6.2 Feed Driving Gear Assembly Inspection

Inspect all of the gear teeth to ensure that they are not worn, and that there are no teeth missing. If you find excessive wear, or absent teeth, replace the offending part. You will want to inspect the roller bearing at the end of the Cluster Gear Input Shaft for dirt, rust, or jerky movement. Gravity tends to deposit dirt in this bearing, and most times it is safer to replace than hope it doesn't fail in the future. You will also want to inspect the sliding gear assembly to ensure that it moves freely on the shaft.

4.6.3 Feed Driving Gear Assembly Reassembly

Assembly follows the reverse order of disassembly except that you must adjust the pinion gear that makes contact with the overload clutch ring gears. This adjustment is made by adjusting the height of the pinion gear during reassembly. The goal during reassembly is to ensure that the pinion gear does not bind on the overload clutch assembly ring gears, but is also not so loose that the teeth chatter excessively. Experiment with tapping this shaft downwards until the gears no longer move smoothly, and then backing the shaft up until the gears once again move smoothly. Once you are happy with the setting, you can secure the height of the shaft by securing it with the grub screws.

4.7 Feed Reverse Gear Assembly RIR

The Feed Reverse Gear Assembly is responsible for providing you with the ability to reverse the Quill Feed direction, as well as providing a hand wheel for micro adjustments to the quill height.

4.7.1 Feed Reverse Gear Assembly Removal

When removing the Feed Reverse Gear components you have to be careful. There is a small ball bearing, 3/16 to be exact that acts as a detent ball for the Feed Reverse Selector Shaft. There is also a very small spring that is applying pressure to the detent ball. Figure 24 below shows this ball bearing, the spring, and the retaining cup that holds everything in place. Before removing the Hand wheel Clutch you will want to remove these items and place them into a baggie.

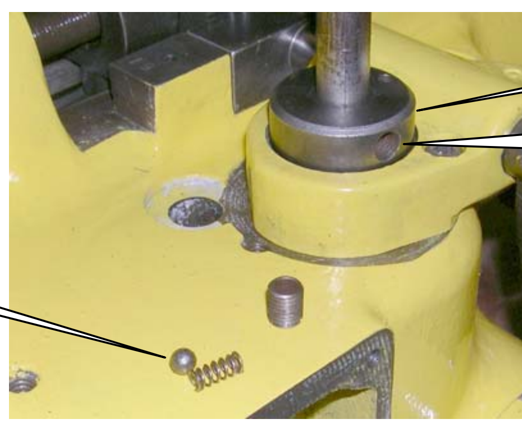

Figure 24 - Reverse Feed Gear Assembly

Once the hand wheel clutch has been removed, you can remove the 2 allen bolts that secure the feed trip lever assembly to the J-Head and slide the feed trip assembly outwards. If the unit does not slide freely, you may have to release the feed trip by pressing up on the feed trip plunger. Remove the Reverse Feed Gear Grub Screws, then you can slide the reverse feed gear assembly out of the J-Head as shown in Figure 25 below:

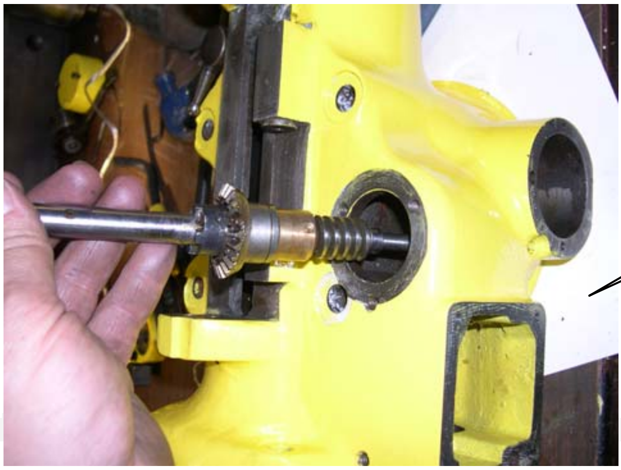

Figure 25 - Reverse Feed Gear Removal

5.0 Turret Section

The turret section of the mill provides you with several options for adjusting the position of the J-Head. You can rotate the J-Head along the horizontal axis, move the J-Head in and out, and tilt the J-Head forward and back. Each of these movements is controlled by different components, each with their own set of maintenance.

I don’t think I can emphasize enough that the Bridgeport is a heavy machine, and some of these components are just dangerous to move. The turret assembly is one of the heaviest and most awkward components. Add to that the fact that it sits 5’ off the ground, and you can see my concern. People can be seriously injured, or killed if this part starts to fall.

The only reason you should ever have to remove the turret section from the mill is if something is wrong with it. In my case, I had no choice. The turret slide was stuck, and stuck well.

I want to make something very clear before I proceed. The J-Head and the turret assembly are HEAVY. Do not attempt to remove these assemblies without a lift of some sort, and be sure not to exceed the weight rating of the chosen lift. Bridgeport recommends 2 methods for removing the turret. The first involves the use of straps wrapped around the turret. While I have seen this done, I prefer the second method which advocates the use of a lift eye in a hole on the top of the turret.

5.1 Ram Adapter RIR

The Ram Adapter allows you to tilt the J-Head forward and back through an arc of 90 degrees, 45 degrees up and 45 degrees down. It also provides you with the ability to rotate the J-Head along the Z axis through an arc of 360 degrees.

5.1.1 Ram Adapter Removal

You will want to start by removing the J-Head from the Ram Adapter. Once you have the J-Head removed, you can remove the Ram Adaptor by removing the 3 bolts and the pivot pin that secure the Ram Adapter to the turret as shown in Figure 26 below. Save the pivot pin for last as it's easier to hold the Ram Adapter and tap out a single pin.

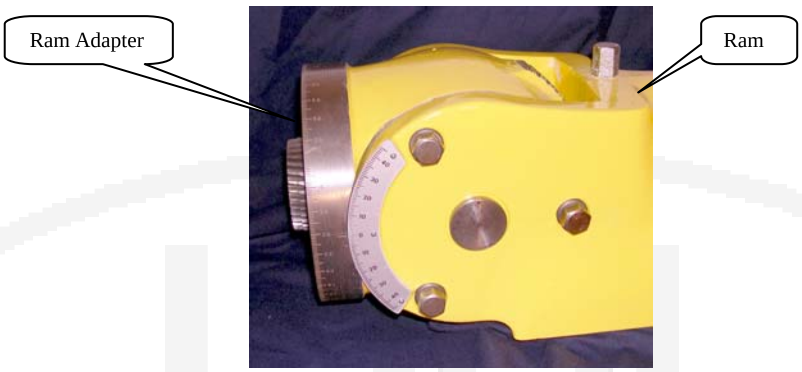

Figure 26 - Ram Adapter

5.1.2 Ram Adapter Inspection

My Ram Adapter was very difficult to remove, and required liberal use of a lubricating solvent, and wiggling back and forth before it would come off the ram. Once it was off I could see that the internal cavities of the Ram Adapter had acquired some rust and hardening of grease. Cleaning the entire unit in a good solvent, then wire brushing the whole assembly went a long way to freeing up the movement again. As most people do not move the Ram Adapter very much, you will probably not see a lot of wear. My unit, though 42 years old and used quite heavily had a very nice and tight slip fit during reassembly. I did polish the pivot surface with some 320 grit paper and a sharpening stone to remove some of the surface rust, and to provide a more slippery surface.

5.1.3 Ram Adaptor Reassembly

To reinstall the Ram Adapter you should lubricate the pivot surface and the pivot shaft well with high quality grease. You can then slide the Ram Adapter into place and insert the pivot shaft. Once the shaft is in place, the locking bolts can be inserted one by one to complete the assembly.

5.2 Ram RIR

The Ram allows you to move the J-Head in and out utilizing a Locking Rack and Pinion arrangement.

Figure 27 - Ram Assembly

5.2.1 Ram Removal

Figure 28 below shows the clamps that are used to lock the Ram to prevent movement. Loosen these clamps prior to attempting removal of the Ram. You do not need to extract the bolts out of the clamps, just loosen them. Once the clamps are loose, you should slide the ram out as far as possible with the Ram Pinion. Remove the retaining bolt for the Ram Pinion, and slide the Ram Pinion out of the Turret base. You should then be able to slide the Ram off of the turret base. Please keep in mind that this unit is **extremely heavy**, and cannot be managed alone. When I slid this unit off of my mill, it was supported with an engine lift, and the sliding was performed using a hydraulic ram (remember, my ram was stuck to the turret).

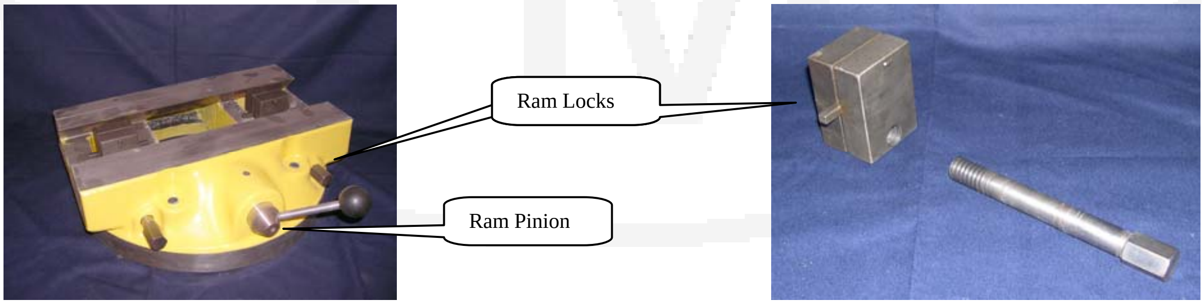

Figure 28 - Turret Base and Ram Lock

5.2.2 Ram Inspection

There aren't many moving parts on the Ram to inspect. There is the pivot surface for the Ram Adaptor, the sliding surface of the ram, the worm gear for pivoting the Ram Adaptor, and the rack/pinion for moving the Ram in and out on the turret base.

One of the things that I had to do was to thoroughly clean the ram locks. My ram locks were filled with metal chips and were not working very well.

I haven't really mentioned it so far, but one of the methods I use to clean and polish the flat sliding surfaces on the mill is a method that utilizes a long flat sharpening stone lubricated with oil. It creates a nice flat surface without removing too much material, and if kept lubricated, leaves a nicely polished surface that will slide easily. The stones are also relatively cheap.

Please keep in mind that this procedure is for cleaning an already trued surface. If your surface is not flat to start with, you may be required to scrape it true first.

5.2.3 Ram Reassembly

Reinstall the Ram Locks in the turret base, and center them in the base so that the Ram will not hit them when slid back on. Lubricate the slides liberally with a high quality lubricant and slide the ram back onto the turret base. While this may seem like an easy thing to do, keep in mind that the ram weighs near 300 pounds and doesn’t slide all that well. If you look at Figure 29 below, you will see the arrangement that I used to get the Ram in place. And Figure 30 below shows a fixture that I used to help me slide the ram into place. Once the Ram is in place and the pinion gear is installed, it should slide easily.

Figure 29 - Ram Installation

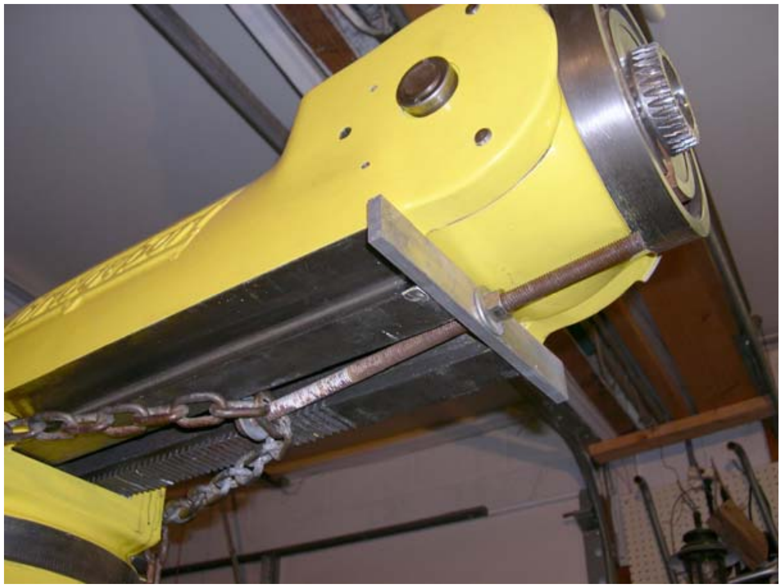

Figure 30 - Ram Sliding Fixture

You can then reinstall the pinion gear for the Ram. You may have to jiggle the ram back and forth to engage the teeth of the ram pinion. Once it has been inserted, you can insert the ram pinion retaining bolt which completes the Ram Reassembly.

5.3 Turret RIR

The Turret allows you to swing the RAM around through an arc of 360 degrees, and contains the pinion gear for moving the RAM in and out as well.

5.3.1 Turret Removal

You should first follow all of the procedures for removing the Power Head, J-Head, and Ram from the Turret. Once you have completed these, there are 4 bolts that secure the Turret to the Base Pedestal as shown in Figure 31 below. Be careful as you remove these bolts. They are threaded into an “X” shaped cross member inside of the pedestal that is free floating, and will fall if you do not hold it up when removing the last of the 4 bolts. Once you have the turret off the base pedestal, you will note that there are boss extrusions inside of the base pedestal that act as shelves for this cross member when reassembling the turret.

Figure 31 - Turret Bolts and Cross Member

5.3.2 Turret Inspection

The sliding surfaces on the turret for the Ram Assembly should be cleaned and lubricated to ensure smooth movement of the Ram Assembly. You should also examine the Ram Pinion Gear and the Ram to ensure that none of the teeth are broken or chipped. My unit was rusted quite a bit and I was also required to clean the dial indicator portion of the turret.

5.3.3 Turret Reassembly

The Turret assembly weighs about 75-80 pounds, and can be lifted by hand, but I didn't want this thing to get away from me and damage either the Turret, or myself, so I chose to use a lift to reassemble the turret onto the base pedestal as shown in Figure 32 below.

Figure 32 - Turret Reassembly

Once the turret is in place on the base pedestal, you can reach through the pedestal door with one arm to hold the cross brace while inserting the bolts through the turret. Figure 33 below shows a view of the cross member that most people don’t generally see. I took this picture from inside of the base pedestal looking up to illustrate the boss extrusions that the cross member will rest on during the installation process. Make sure that you have installed **all** bolts and gotten them finger tight before attempting to tighten the bolts or move the turret.

Figure 33 - Turret Cross Member

6.0 Table Section

The Bridgeport Table was designed for a very specific set of purposes. It was designed to hold the work piece, and to provide a precision flat surface. To accomplish these tasks, the table has been designed with T-Slots to assist with the holding of work pieces, and milled and scraped to a precision flatness to increase the accuracy of milling operations.

There are various styles and sizes of tables out there. Mine is a 9" x 36" table. The advantage of a table this size is that for the home machinist the overall footprint of my mill in the garage is smaller. A secondary advantage as it turns out is that most automotive shops can easily perform a fly cut resurfacing and grinding of this size table as some diesel engines have heads that are roughly 9" x 36".

My table was fairly rusty since the unit had been stored outside, but this is no reason to discard a perfectly good table. Automotive heads warp and bow after years of use and abuse and sometimes need to be resurfaced to restore the original flatness of the heads. Machine tables are very much the same. They can be machined, ground and scraped just as with automotive heads.

As with the turret assembly I feel the need again to warn you, this table is **HEAVY**. A lift of some sort is recommended if you are attempting to remove the table. For servicing the lead screws it is not necessary to completely remove the table. I have read forums where people built strong tables to support the weight of the milling table as they jogged it completely out to one side. I have no personal experiences with this, but wanted to relay what I have read. I personally used an engine lift to lift my table from the mill.

6.1 Lead Screw Bearings & Brackets RIR

The Lead Screw Bearings and Brackets help hold the Lead Screws in place and provide the rotational and thrust bearing surface for the Lead Screw.

6.1.1 Lead Screw Bearings & Brackets Removal

To remove the Lead Screw Bearings and Brackets, you start by removing the table handles which are secured with a nut as shown in Figure 34 below.

Figure 34 - Table Handle, Dial and Nut

6.1.2 Lead Screw Bearings & Brackets Inspection

The lead screw bearing brackets house the bearings that support the lead screws, and because of the force applied by the lead screws, they need to be inspected for cracks and wear. On my mill, one of the brackets was broken where the lead screw bearings had been forced out through the back of the bracket by the table power drive. These brackets are made of cast iron, and cannot be easily repaired. I was fortunate enough to find a bracket from a gentleman who had performed a CNC Conversion on his Bridgeport and made up new brackets. Figure 35 below illustrates the broken bracket, and the replacement bracket is illustrated in Figure 36.

Figure 35 - Broken Bracket

6.1.3 Lead Screw Bearings & Brackets Reassembly

I began my reassembly of the brackets by pressing the bearings back into the brackets. This is not really a press fit, but a slide in fit. There was no need for a true press fit on these bearings since the bearing retainer will press the outer bearing races against the casting of the Bearing Bracket. Figure 36 below shows the bearings installed in the bracket and waiting to be installed on the lead screw and table.

Figure 36 - Bearing Bracket with Bearings Installed

6.2 Table X&Y-Axis Gib RIR

The X-Axis Gib slides in from the left front portion of the Saddle. It is adjusted with the Gib Adjusting Screw as seen in Figure 37 below.

Figure 37 - Gib Adjusting Screw

As you can see from Figure 38 below, the Gib and the Saddle form a parallel with matching angles. By sliding the Gib in, you effectively increase the thickness of the saddle wall which squeezes in on the table. I would normally apologize for the slight rustiness of the Gib, but in this case it helps you see where the Gib ends and the Saddle begins.

Figure 38 - Gib Parallels

The Y-Axis Gib provides the tightening body for the Y-Axis and slides in from the left forward portion of the Saddle.

6.2.1 Table X&Y-Axis Gib Removal

Removal of the Gib starts with the removal of the chip wiper covers and felt chip wipers. The chip wiper covers are secured to the Saddle with small Flat Head Screws as shown in Figure 39. The aluminum chip wiper cover seen here actually holds two small felt chip wipers in place that wipe the way surface as the axis is moved. The rear chip wiper cover may be removed by raising the knee until the dovetails for the knee clear the dovetails on the base pedestal. At this point the chip wiper cover may be slid backwards towards the base pedestal and off the unit. Once you have removed the chip wiper cover you will see the Gib Adjusting Screws.

Figure 39 - Y-Axis Chip Wiper Cover

The Gib Adjusting Screw for the X-Axis is located in the forward left portion of the Saddle. The Gib Adjusting Screw for the Y-Axis is located to the left side of the saddle. Turning the Gib Adjusting Screws counterclockwise will start to extract the Gibs. If the Gibs are stuck, I have found that they will come out easier if you slide the Table/Saddle away from the Gib Screw while turning the screw counterclockwise.

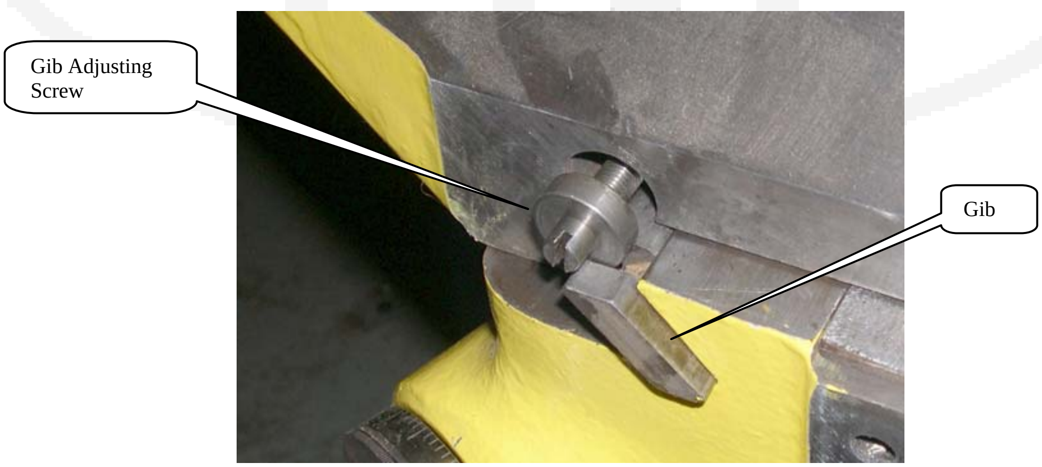

Figure 40 - Y-Axis Gib and Adjusting Screw

6.2.2 Table X&Y-Axis Gib Inspection

The Gib should be inspected for scratches, rust, metal shavings, rough edges, etc. The Gib tends to wear on the outer ends, so be sure to check the Gib for flatness. If your Gib has a lubricating hole, you should also check this to make sure that it is clear and unobstructed.

6.2.3 Table X&Y-Axis Gib Reassembly

Using “Way Oil”, lubricate both sides of the Gib, the ways, and the cavity in the Gib for the Gib Adjusting Screw. Move the saddle or table so that the Gib cavity is maximized. This will allow you to insert the Gib into place. Once you have the Gib slid in with about an inch showing you should start inserting the Gib Adjusting Screw while engaging the screw collar in the slot in the Gib as shown in Figure 40 above.

The Bridgeport manual indicates that the Gib Adjusting Screw should be tightened in until a slight drag is felt.

NOTE: You should also remove all chip wipers and covers before adjusting the gibs. There are three good reasons for doing this. Firstly, you don’t want the gib to press on the aluminum chip wiper cover and break it, secondly it provides an opportunity to clean the ways and chip wiper cover, and lastly is provides the opportunity to examine the felt chip wipers for wear.

If you are rebuilding or reassembling the machine, you should operate the Saddle or Table back and forth several times and then recheck the Gib adjustment. You may also want to check it at differing positions along its axis of travel. If everything is adjusted properly, you should feel the same tension on the hand cranks through the entire field of travel.

NOTE: As the Bridgeport machine wears, the centers of the ways will wear first. Your first indication of this might be binding on the ends of travel if you happen to adjust the Gib while the axis is in the center of its field of travel.

If after adjusting the gib and getting the proper feel out of the table movement, the gib is extending beyond the table blocking the installation of the chip wipers, you will need to mark the gib where it extends from the table, remove it from the machine and trim it. The Bridgeport manual states that the gib should be marked where it exits the table, and trimmed an additional 0.25” back to allow for future adjustments. If you are unable to remove the slop by adjusting the gib all the way in, then it might be time for you to replace the gib. New gibs can be purchased in varying thicknesses.

6.3 Table RIR

The table on the Bridgeport Mill comes in various sizes. My table is 36” x 9”, and I have seen the following table sizes as well: 32” x 9”, 42” x 9”. Most of the tables on the Mills are interchangeable as long as you are willing to change the X-Axis Lead Screw, and scrape the ways to match the table to the Saddle.

6.3.1 Table Removal

To remove the Table from the Mill you begin by removing the X-Axis Lead Screw Brackets as described in section 6.1.1. Your will then remove the chip wipers and the X-Axis Gib as described in section 6.2.1. On mills with power feed, you may have to remove the power feed unit, trip levers, and rods. Figure 41 below shows the table with all brackets removed, the only item remaining is the Gib.

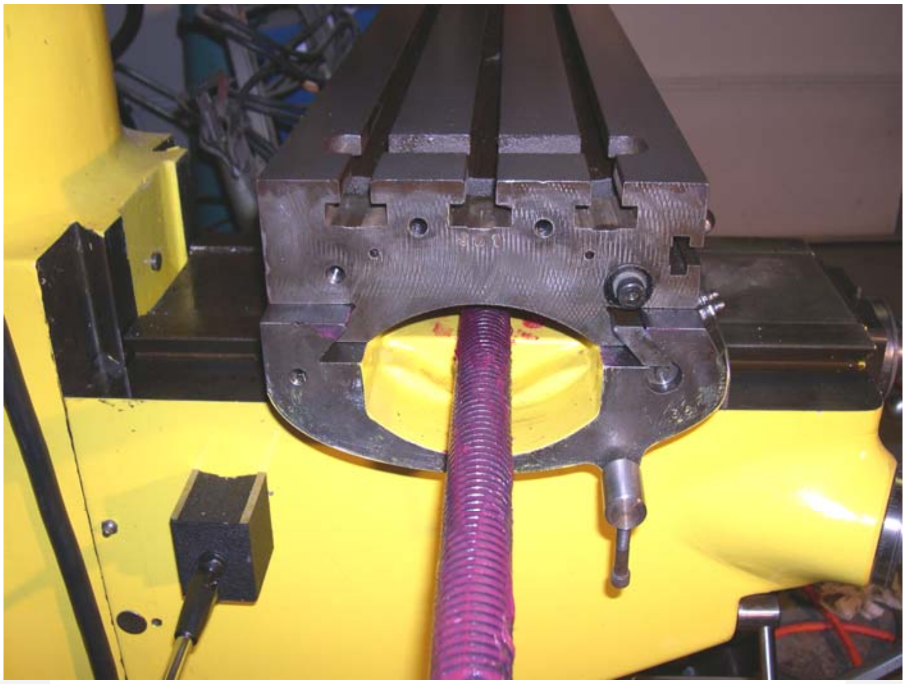

Figure 41 - Table Nearly Ready for Removal

With all of these components removed, the table should be free to slide off of the mill. The only exceptions could be any way oiling, or flood fluid return plumbing that may be connected. Please ensure that all peripherals are removed prior to sliding the table off. The table weighs approximately 200 pounds, and has a precision surface, and ways. You do not want to damage any of these surfaces, so take care to lift the table with an appropriate lift, and set it on a surface that will not mar the ways. I tend to fasten chains to the bearing retainer holes and use an engine lift to slide the table off. As I tend to do much of my work alone I find an engine lift invaluable.

6.3.2 Table Inspection

Many people have asked me how I inspected my table, and what I was looking for. First and foremost we want to inspect the ways for any excessive wear. At machinery rebuilding facilities this is done with the use of specially built granite or cast standards. These standards are manufactured to the correct angle and dimension of the ways and used with surface plate dye will help to show inconsistencies in the surface.

I placed my table upside down on a granite surface plate first and used a dial indicator to categorize the way surfaces to determine the extent of wear on the way surfaces. I then turned the table over, blocked it up and used the same dial indicator to measure the surface. If your table surface or ways are extremely bad, I would recommend a machine rebuilding service. While you are able to acquire all of the tools required to true the table, saddle, knee and pedestal; you will find that it quickly becomes cost prohibitive to purchase all of this equipment for a single use.

The ways on my table were acceptable for the types of work I was going to be performing, but the table surface had been abused over its lifetime. Fortunately for me I found a machine shop capable of resurfacing my table. They elevated the table onto custom made parallels that were made to fit the way surfaces and milled the surface to remove most of the defects. I still have some small drill marks, but these do not adversely affect the accuracy of the surface.

6.3.3 Table Reassembly

Table reassembly follows the reverse order of disassembly. You begin by ensuring that all way surfaces are free of debris and lubricated with quality way oil. Before attempting to install the table, you should ensure that the table locks are fully withdrawn, and the gibs are removed. You can now maneuver the table onto the saddle by aligning the dovetails and sliding it onto the saddle. You should install the gib next and loosely secure it before you remove you lifting device from the table. If your ways are extremely well done, it is possible for this table to slide because of its own weight. The bearing brackets are then installed along with the dials and handles.

You should reinstall any lubrication recovery systems, and automatic oilers.

Complete the assembly by installing the power feed if equipped, and the power feed trip levers and rods. Finally you should check the table for movement and adjust the gib based on the procedures described in section 6.2.3

If there is enough interest, I will be converting this mill to automatic oiling and will document this procedure as well. It could just become an appendix to this manual.

7.0 Saddle Section

The saddle is used to support the table and to house the acme lead screws which are used to control the X and Y axes for the table. There are several lubricant fittings on the saddle. It should be noted that these are not grease fittings. You should not use grease in these fittings as they are responsible for lubricating the ways. Way lubricant should be used. There is a special lubricant gun that can be used to lubricate the ways. I have found that McMaster Carr carries oil guns, and some people have modified grease guns to be able to contain way oil by sealing the back cap on the grease gun which normally holds the grease plunger. If you add an automatic or manual pump lubricant system to the mill, you will most likely replace these fittings with tubing and fittings to supply the lubricant. The Saddle is shown in Figure 43 below:

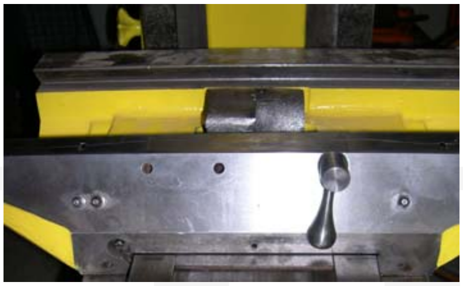

Figure 43- Saddle

7.1 Saddle Section Removal

To remove the saddle you will need to follow the procedures for removing the table as shown in section 6.3. Once you have removed the table, you have exposed the X-Axis lead screw and are now able to remove it and inspect it for wear. There are 2 ways to remove a lead screw from the machine. You can unscrew the lead screw from the lead screw nut and bracket, or you can remove the bolts that secure the brass lead screw nut to the lead screw nut bracket and push out the lead screw nut leaving the lead screw inside of it. Figure 44 below shows the lead screw nut after having been removed from the lead screw nut bracket.

Figure 44- Lead Screw Nut

NOTE: If your machine utilizes ball screws instead of lead screws be sure to secure the ball screw nut so that the ball screw cannot be removed from the ball screw nut. In the case of ball screws there are generally bolts that secure the ball screw nut to the ball screw nut bracket. Remove these bolts and then carefully lift the ball screw from the machine.

Lead screws and ball screws are generally precision ground, so you will want to protect them by lubricating them and wrapping them in plastic.

With the X-Axis lead screw removed, you will now remove the Y-Axis lead screw. The Y-Axis lead screw is secured through the lead screw nut, and by the lead screw bearing bracket located on the front of the knee. Follow the procedures identified in section 6.1 to remove the lead screw brackets. Much like the X-Axis lead screw you once again have the same two options for removing the lead screw.

NOTE: Again, if your machine utilizes ball screws you want to do everything you can to make sure the ball screw nut does not come off the ball screw.

Once the lead screws or ball screws have been removed, you can remove the lead screw nut bracket from the saddle by removing the 4 bolts securing it to the saddle. There are roll pins used to align the bracket to the saddle and these may make the bracket difficult to remove. Just be sure to pry evenly on both sides of the bracket and it should pop loose easily. Figure 45 below shows the lead screw nut bracket.

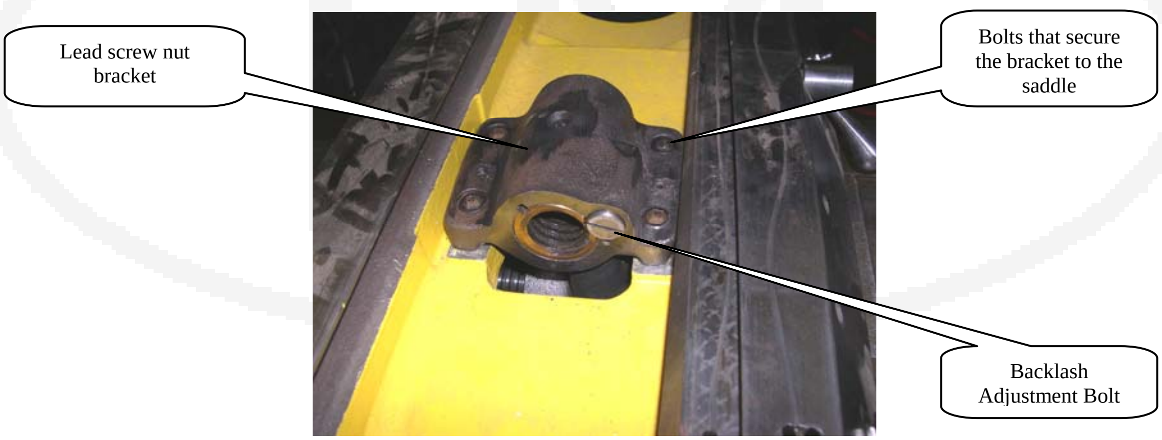

Figure 45- Lead Screw Nut Bracket

NOTE: The saddle is heavy, either utilize a lifting device, or get another person to help you remove it from the knee.

With the bracket removed, you should be able to slide the chip shield from under the saddle, and then slide the saddle forward off of the knee.

7.2 Saddle Section Inspection

The Saddle contains a lot of oil passages for the oiling of the ways. Most of these passages were clogged on my machine which I think eventually led to all of the surfaces being stuck. Please run cleaners through these passages to ensure that they are unobstructed. I used a combination of cleaning brushes designed to clean oil ports in automotive engines, and pipe cleaners.

You will also want to check all the way surfaces to ensure that they are clean and free from rust, and debris. As part of the saddle inspection you should also take this opportunity to examine your lead screws and lead screw nuts for excessive wear. If you intend to convert your mill to a CNC Capable mill, you will probably want to take this opportunity to replace the lead screws with ball screws.

7.3 Saddle Section Reassembly

Saddle reassembly follows the reverse order of disassembly. Be sure to lubricate all way surfaces, and the lead screws. There are a couple of key items to remember while installing the saddle. You should slide the aluminum rear chip wiper cover onto the knee dovetails prior to installing the saddle. This aluminum chip wiper cover can be installed after, so do not panic if you forget it, it’s just easier to do it prior to installing the saddle. You should also ensure that any way locks are backed out of the way. These can prevent you from being able to install the gibs, and are harder to back out once the saddle is installed. In addition, please make sure that once lead screws or ball screws have been installed that they are well lubricated.

8.0 Knee Section

The knee provides the gross vertical movement for the table. In most cases you will perform your gross vertical movements with the knee crank, and then use the quill micro feed for any fine adjustments.

8.1 Knee Section Removal

To remove the knee from the base pedestal, you will need to first follow all the procedures for removing the table and the saddle. Once you have removed these, you need to loosen the Gib and remove it from the knee. I found it easier to loosen the Gib adjusting bolt while slowly moving the knee downwards. This puts less pressure on the section of the Gib that the Gib adjusting bolt presses against. I have heard numerous reports of people breaking off the top portion of the gib by trying to remove the gib adjusting bolt without lowering the knee at the same time, please be careful here, no need to replace parts if we don't have to.

Figure 46- Knee Gib Area

With the Gib removed you can raise the knee using the crank handle. As you get close to the top, it is a good idea to support the weight of the knee with a lift, or chain hoist capable of supporting roughly 120lbs. Figure 47 below shows the arrangement that I used for removing and reinstalling my knee.

Figure 47– Removing/Reinstalling the Knee

Once you have removed the knee from the mill base, you can start to disassemble the knee by removing the crank assembly. Start by removing the crank and dial assembly as shown in Figure 48 below to expose the Bearing Plate Bolts. With the Dial removed you can remove the bearing plate bolts and pull the elevating shaft from the knee.

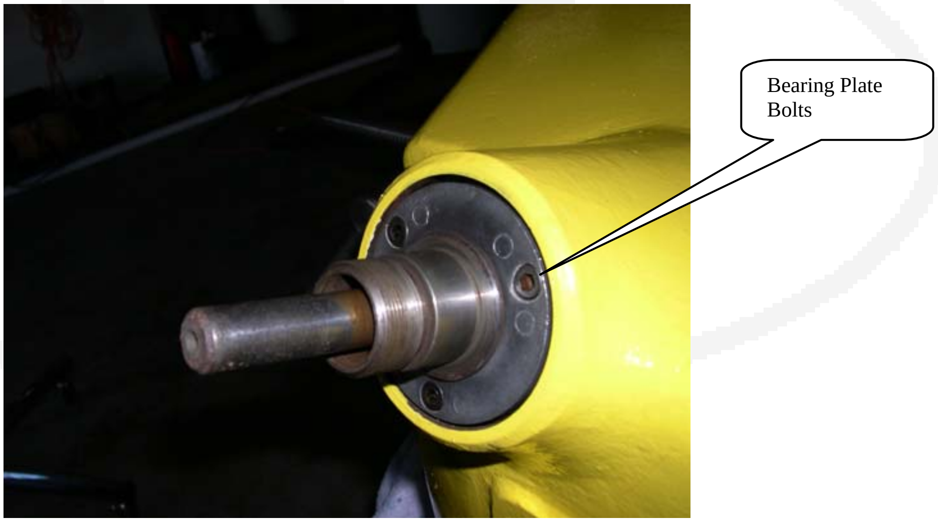

Figure 48 - After the Crank and Dial have been Removed

With the elevating shaft removed from the knee, you can also now remove the elevating screw and bevel gear. The bevel gear is attached to the elevating screw with a nut as shown in Figure 49 below.

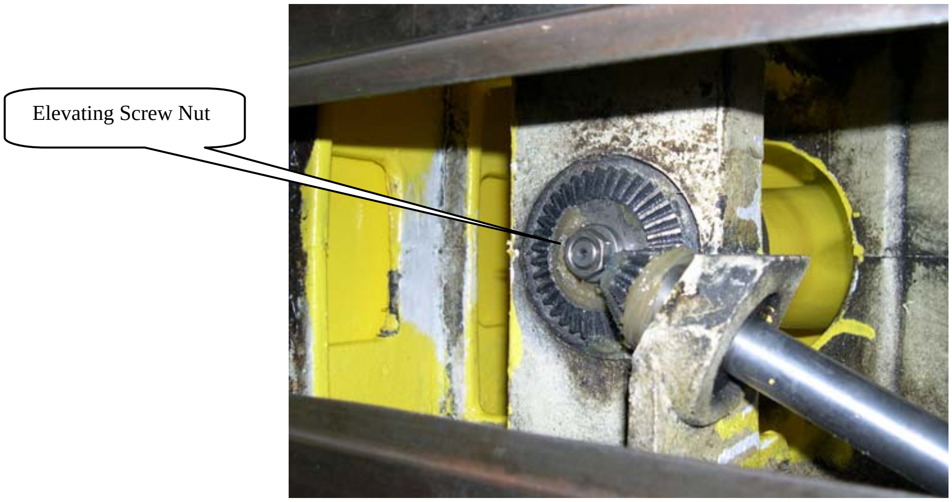

Figure 49 - Knee Elevating Bevel Gears

Once you have removed the nut, the bevel gear can be slid off the elevating screw. You should then remove the bevel gear key from the elevating screw. The elevating screw can then be pushed through the bearings and out of the knee. If the elevating screw bearings need to be changed you will need to turn the knee over and remove the bearing retainer ring as shown in Figure 50 below. The bearings can then be pressed out through the bottom of the knee.

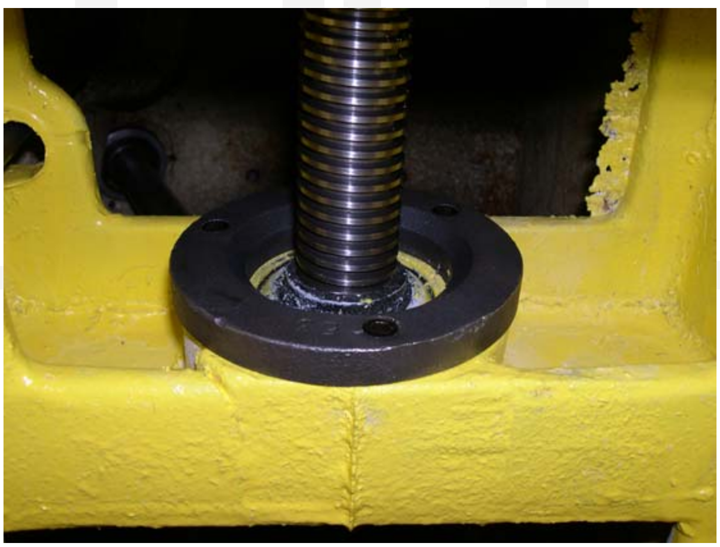

Figure 50 - Elevating Screw Bearing Retainer Ring

8.2 Knee Section Inspection

There is very little that can go wrong with the knee section of the mill. In the case of my mill, the knee was rusted to the base pedestal. This made it very difficult for me to remove the knee from the mill. Routine lubrication of the ways can prevent this from happening.

The bearings on both the elevating screw and the elevating shaft should all be inspected for wear.

All of the bearings are easy to change, and thanks to the knee lock and removable elevating screw housing, even the elevating screw bearings can be removed with or without disassembling the entire knee and table assembly. If you intend to attempt this, you will need to raise the knee as high as it will go with the elevating screw, attach a lift to the table, and then raise it another inch and lock the knee in place using the knee lock. Once the knee has been locked, you can then remove the elevating screw housing and follow the above procedures for removing the elevating screw bearings.

8.3 Knee Section Reassembly

The Knee assembly is installed onto the base pedestal by sliding it down over the dovetail joint. I accomplished this using a chain hoist to lift the knee into the air, aligned the dovetail, and slowly lowered knee until the knee lead screw started to make contact with the lead screw nut on the elevating screw housing.

You should start by lubricating all surfaces with a high quality way lubricant to ensure ease of movement. You should then fasten a lifting device to the cross member inside of the knee and raise it above the dovetail joint on the base pedestal. Lower the knee down until the lead screw makes contact with the lead screw nut on the elevating screw housing. You can then slowly thread the lead screw into the nut and release some of the pressure on the hoist as you crank the knee downwards. Please note that the Gib is not present at this time. The Gib can be installed and adjusted after the knee has been lowered onto the base pedestal.

9.0 Tramming the Mill

Tramming, what an interesting term. Don't bother checking the dictionary, as most of them won't have it. Basically, tramming is the act of aligning the mill with respect to all of its axes. Since there are several ways to do this, I have broken this section up to illustrate the Bridgeport method, and the bearing race method. As people provide me with additional methods, or improvements on these methods, I will include those as well.

9.1 Bridgeport Method

Within the Owner's Manual for the Bridgeport mill, there is a very small procedure for tramming the mill. I included the basic steps for tramming the mill below:

- Align the J-Head Front to Back Tilt Position
    1. Set the table position with the quill centered over the table.
    2. Insert a dial indicator with a 4 ½" arm in the spindle (for a 9" table).
    3. Rotate the Spindle so that the dial indicator provides a reading for the outer edge of the table.
    4. Rotate the Spindle so that the dial indicator provides a reading for the inner edge of the table.
    5. Adjust the tilt on the J-Head to remove half of the error. Repeat this procedure starting with step 3 until you have achieved the precision that is required/desired.
- Align the J-Head Side to Side Tilt Position
    1. Set the table position with the quill centered over the table.
    2. Insert a dial indicator with a 4 ½" arm in the spindle (for a 9" table).
    3. Rotate the Spindle so that the dial indicator provides a reading for to the left of the table.
    4. Rotate the Spindle so that the dial indicator provides a reading to the right of the table.
    5. Adjust the side to side tilt on the J-Head to remove half of the error. Repeat this procedure starting with step 3 until you have achieved the precision that is required.

9.2 Bearing Race Method

You will note that in the above procedures you have to be very careful with the dial indicator while tramming the mill. The interference caused by the T-slots can be annoying, induce inaccuracies, and be downright dangerous to your precious dial indicator. The idea behind the “Bearing Race” method of tramming a mill is to utilize a device that has a uniform thickness, a high level of rigidity, and a radius consistent with the indicator arm to assist with the alignment of the Mill. Now most machinists I know don’t buy things if they don’t have to, so what low cost or free device has uniform thickness and a decent radius? A bearing race off of some rather large bearings does.

Many people have been able to get bearing races free of charge from Heavy Equipment Service Centers. This device simplifies the tramming process because you no longer have to lift the Dial indication to clear the T-Slots, lessening the chance of inducing error in your measurements. It also spreads the measurement over a larger portion of the table thus reducing the errors that can be induced by taking measurements from what could be potential high or low spots in an older table. I tend to make sure that I tram my mill utilizing the area of the table where I will be working. If you are very industrious, and looking for the ultimate in precision, you could acquire races of many sizes and ensure that the mill is trammed to the area and size of the project being machined.

I have also been checking the machine catalog a lot lately and have noticed that the price of granite standards has dropped significantly in the past 5-10 years. These granite standards can be purchased in various sizes and can easily be used for tramming a mill. I currently has a 9x12x3” granite on order and am looking forward to seeing how accurately my mill is currently trammed.

Please keep in mind that tramming to the table is only required if you are fastening your work pieces directly to the table. It is also important to be sure that your table is known to be true. If you are fastening your work pieces in a vice, you will want to look at the section below.

9.3 Tramming to the Vice

Tramming to the vice is exactly like the procedures outlined above in section 9.1 The primary difference is that you will be aligning the head of the mill to the flat base surface of the vice. When tramming to the vice, parts are generally placed in the vice using parallels to elevate the work to be cut. These parallels are generally laid flat on the base of the vice.

10.0 Maintenance & Lubricants

The Bridgeport mill utilizes basically two types of lubricants. The spindle lubricant which keeps the spindle bearings lubricated, and the way lubricant which keeps the way surfaces free of rust and lubricated. There are several manufacturers of each of these lubricants.

10.1 Backlash Adjustment

When adjusted properly, the Bridgeport lead screws have only .004-.005" of backlash. Figure 53 below shows the feed nut bracket and the backlash adjusting screws that will be adjusted during this procedure.

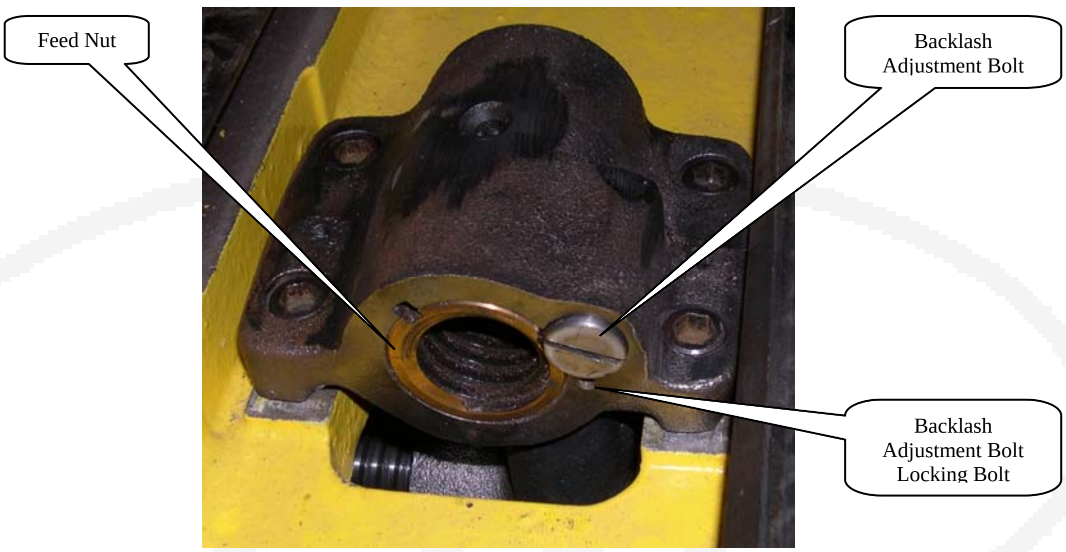

Figure 53 - Feed Nut Bracket

To adjust the X-Axis feed nut backlash, you should first move the table all the way to the left. Reset the Bridgeport dial to 0. While watching the dial on the X-Axis handle, start to turn the handle to move the table back towards the right and observe how many tick marks pass before the table starts to move. A dial indicator may be used on the table to help determine when movement starts. Each tick mark on the Bridgeport Dials is equivalent to 0.001". If this movement exceeds 0.005" then loosen the Backlash Adjustment Bolt Locking Bolt, and tighten the Backlash Adjustment Bolt until you can achieve the backlash adjustment of 0.004 and 0.005". Once the adjustment is complete, you should retighten the Backlash Adjustment Bolt Locking Bolt to keep the Backlash Adjustment Bolt from moving during use.

If you are unable to tighten the Backlash Adjustment Bolt enough to get within the 0.004 to 0.005" range, then your feed nut may be worn beyond serviceable limits and need to be replaced.

10.2 Feed Trip Adjustment

The Bridgeport Quill Feed is a very useful feature of the Bridgeport Mill, but it must be adjusted properly to prevent damage to the feed mechanism within the mill. Figure 54 below illustrates the components used during the feed trip adjustment.

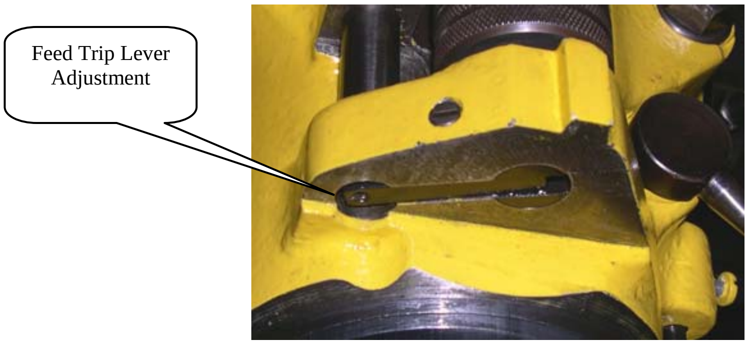

Figure 54 - Feed Trip Lever

With the cir-clip for the quill stop screw resting on the lower boss, bring the quill stop nut down to the quill feed nut. Loosen the locknut for the quill feed trip lever adjustment and loosen the quill feed adjustment screw about 4-5 turns. Engage the quill feed lever, and slowly turn the trip lever adjustment screw upwards until the quill feed lever trips and tighten an additional ½ turn. Re-tighten the locknut. Not all Feed Trip Levers have the locking nut. On my machine you will note that instead the feed trip lever acts as the locking mechanism for the adjustment bolt.

10.3 Spindle Lubricant

The spindle lubricant is a low viscosity lubricant used to lubricate the spindle bearings. Oil is applied using the oil cup located on the top right side of the machine as shown in figure 55 below. Spindle oil may also be applied to those cups that provide oil to the gearing as well.

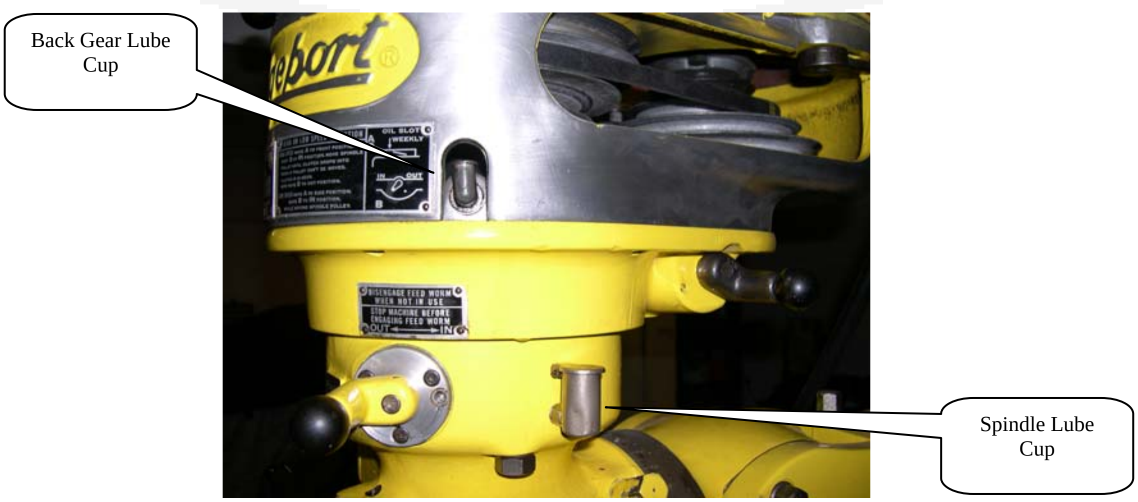

Figure 55 - Spindle and Back Gear Lube Cups

10.4 Way Lubricant

Way lubricant is used to provide the sliding surface protection and lubrication for the way surfaces. Because the way oil must remain on vertical surfaces it is designed to grip and stay on all surfaces. This makes it a wonderful lubricant for surfaces, but it has a tendency to clog pores, or lubrication holes so it should not be used as a spindle lubricant, or any other lubricant that needs to flow. Way lube is applied to the machine through the Zerk fittings that are installed on the mill as shown in figures 56& 57 below.

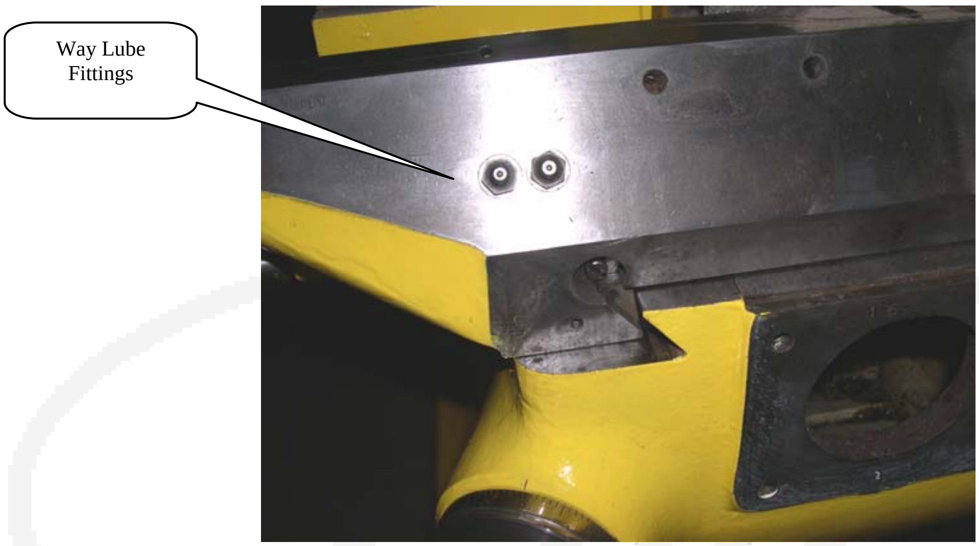

Figure 56 - Way Lube Fittings

Figure 57 - Knee Lube Fittings

11.0 Troubleshooting

11.1 Quill does not go more than 3-4 inches down.

Generally this is an indication that the quill skirt has either been placed in the machine upside down, or has been reversed front to back.

11.2 Quill feed does not disengage when the quill stop is hit.

The quill stop adjustment either needs to be readjusted, or the quill stop mechanism needs to be lubricated. For adjustments, please see the quill stop adjustment as seen is section 4.3.3

11.3 I try to install a gib and it stops short. It feels like it is hitting something.

The table locks on the mill work by pressing the gib against the ways much like a vice works by pressing its faces against the part. Please ensure that the table locks are extracted, and their plungers are extracted as well.

11.4 My quill keeps falling down, I have to lock the quill in place for it to stay up.

The weight of the quill will cause the quill to fall down unless the clock spring mechanism is working and adjusted properly. Please review the clock spring section in section 4.

12.0 CNC Conversion

12.1 Why would you convert to CNC?

I really think after having run my mill as a CNC mill for over 2 years now that the better question would be why wouldn't you? I now have a great respect for the machine and the things that I am able to do with it. I have parts sitting on my desk that have been made with the mill that are well beyond my machining skills, and they are done with a precision and repeatability that I could not duplicate manually. I am not trying to sell myself short here, I am just stating the facts. If the machine is tuned properly, and the drive system is reliable, then making parts over and over again, even complex parts, is no chore at all. There is also some great satisfaction is designing a part on a CAD/CAM program, downloading the files to the mill, clamping down a raw piece of metal and watching that design become reality. Having been that kid who was always building things as I was growing up, I REALLY wish I had this mill back then. My go-carts, bicycles, trailers, and boats would have been awesome!

12.2 Where do you start?

You start by evaluating your need for a CNC machine and the costs involved. I am going to save you a lot of time here by letting you know exactly what I had to change, the exact prices I paid, and the contact information for each manufacturer. Why am I doing this? Because I want to give something back. I have only changed the price of this document once in the 5 years I have been producing it, and now that I have added the CNC data, I have no intention of changing the price.

I decided to convert my machine in stages or phases. This allowed me to actually use the machine itself to help me advance from one stage to another thus minimizing the manual labor required to complete the process. Phase 1 of the project included the replacement of the lead screws with ballscrews, Phase 2 included the electronics, Phase 3 the stepper motors for the X and Y axes, Phase 4 included the stepper motor and mount for the Z-Axis, and finally Phase 5 included the addition of a Planetary Gearhead for the Z-Axis.

If you are curious of the overall cost, I spent approximately $2000 to get to Phase 3 on this conversion. For Phase 5, the prices were dependant upon what I could find on eBay, and I was able to add all planetary to the Z-Axis for less than $100. I have since been able to regularly find planetary gearheads on the online auctions for around $129-200. Obviously if you start with a machine that already has ballscrews you are well ahead of the game. There are a lot of surplus mills out there, do not be shy about grabbing an older CNC mill that has a bad controller. There are people in the CAMS group that have taken older Bridgeport CNC machines and converted them to use the Gecko drives and Mach3 software with the existing stepper motors. There are others that have had to replace the existing drive systems completely. The bottom line is that starting with a machine that was designed for CNC but may not be working, just saves you money.

12.3 Phase 1 – The Ball Screws

My machine was old enough that it still had the ACME lead screws installed. I had checked my backlash before disassembling the machine and knew that something would have to be done. Knowing that the end result of this machine was a CNC conversion, I bit the bullet and ordered new ball screws from Rockford Ballscrew Company. The Rockford Ballscrew company has ball screws for all Bridgeport Mills, and their clones. The gentleman I spoke with was very knowledgeable and very helpful with ensuring that I ordered the correct parts for my table. Please note that the part numbers and prices in the table below were for my specific mill. The part numbers may change slightly for your mill depending upon the X and Y dimensions of your table.

Part #	*Manual Desc*	*Vendor*	*Qty*	*Price*	*Units*
BRP2209	Y-Axis Ballscrew 9" Table Depth	Rockford Ballscrew	1	$262.50	Each
BRP2236	X-Axis Ballscrew 36" Table Width	Rockford Ballscrew	1	$168.75	Each
B2350	Ballscrew Feednut Bracket	Rockford Ballscrew	1	$87.05	Each
7204	Bridgeport XY Ballscrew Bearing Kit	Rockford Ballscrew	1	$127.88	Each

As for the installation of the ball screws, it pretty much follows the installation of the lead screws with a couple minor exceptions. You never remove the ball screw from the feednut, and the feednut bracket has actually been cut away to make installation a bit easier. Rockford also includes a full set of instructions for replacing the ballscrews.

12.4 Phase 2 – The Electronics

What does it take to run a CNC machine? It takes a computer to issue the commands, a motor controller to interpret the commands and issue motor signals, motor drivers to amplify the motor signals to the appropriate voltages and pulses, and a drive mechanism to attach the motor to the machine.

There are 2 basic types of CNC systems when broken down to the least common denominator. There is what is called an open loop system, and a closed loop system. On an open loop system, motor movements are made with an expectation of their being made. On a closed loop system, the motor movements are made and checked against a feedback system to ensure that they were made. So as I am sure you can tell, the closed loop system is obviously the preferred method, but on many home CNC machines, it is cost prohibitive. The CNC system I have installed is an open loop system, and except on some of my more complex machining operations, I have never seen any issues with this system. Knowing that people may want to invest the money in a closed loop system though, I will also address one of those as well.

There are also 2 basic motor systems for CNC mills. There are stepper motors and servo motors. With stepper motors, the motors are provided a pulse of power and direction and they are designed to turn a known amount, generally 1.8 degrees. This yields a motor that can be moved 200 individual steps per revolution. A servo motor is very similar to most of the motors that we use on a daily basis. They can be either DC or AC powered, and generally have no idea how far they have moved. This is where encoders come into play. An encoder is an optical switch combination that reads the pulses from a translucent disk with black lines on it. These pulses, and the manner in which the encoder reads the disk helps the encoder provide both positional information, but directional information as well. The encoders are used to provide the feedback system to ensure that the positions are accurately reached.

With the advent of large stepper motors and inexpensive stepper motor controllers, stepper motor systems are proving to be much cheaper for the home user to implement into hobby mills. Even with open loop systems, accuracy can be met reliably and easily.

12.4.1 Open Loop System

For my Bridgeport Mill, I was fortunate enough to have an old HP eVectra computer. It is a small frame computer with a 1Ghz processor, 1gb of memory, and a 40gb hard drive. While this system cost me nothing, you can figure on spending about $200-400 for a decent computer capable of running a CNC mill. The only real requirement is that it has a parallel port and be capable of running either DOS or Windows XP depending on your software of choice.

From the computer you will connect a parallel cable to a “parallel port breakout board”. For the purposes of my conversion I used the PMDX-131 available from http://www.pmdx.com/ . This board provided me with the easiest hookup, and since the company was local to me, it gave me someone whom I could ask questions. I met Steve Stallings, the owner of Practical Micro

Design, during a meeting of the Chesapeake Area Metalworking Society and have always found him to be more than helpful. His products are well thought out and the interfaces are painless.

As motor drives, I used the Gecko Drive products from https://www.geckodrive.com . These motor drivers connected directly into the PMDX board and required only that I find a suitable heatsink. For the power to the drives and for the motors I chose a large 50V toroidal transformer that I purchased from PMDX, and conditioned the power using the PMDX-135 power conditioning board.

The following table outlines the electronics that I was required to purchase for my installation.

Part #	*Manual Desc*	*Vendor*	*Qty*	*Price*	*Units*
G201	DC Stepper Driver	www.Geckodrive.com	3	$114.00	Each
PMDX-131	4-Axis Breakout Motherboard	http://www.pmdx.com/	1	$189.00	Each
PMDX-135	Power Prep Module	http://www.pmdx.com/	1	$119.00	Each
Toroidal-50V	50V Toroidal Transformer	http://www.pmdx.com/	1	$100.00	Each

I was fortunate enough on my mill to have a NEMA enclosure bolted to the side of my mill, so I stripped the contents out of this enclosure and mounted all of my CNC Electronics within this enclosure. This provided me with not only a water tight enclosure, but a convenient platform for all of my electronics as can be seen in figure 58 below. You'll note a serious lack of wiring in this box, one of the features I truly liked using the PMDX solutions. The GeckoDrive G201 motor drivers are actually located beneath the PMDX-131 board and connect directly to the board without wires.

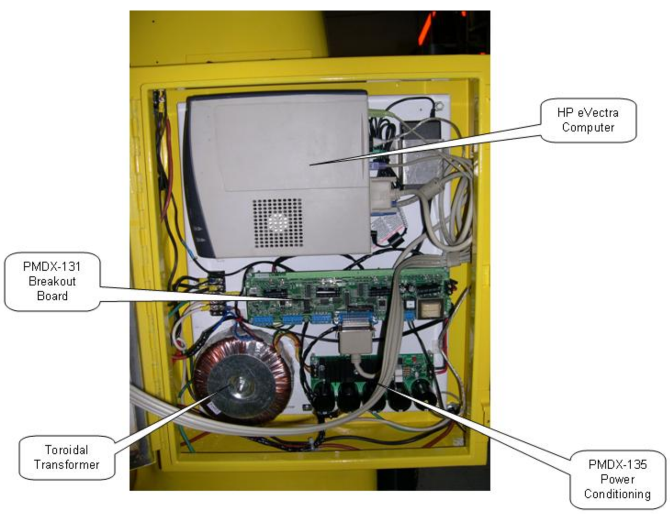

Figure 58 – CNC Electronics

12.4.2 Closed Loop System

For my Bridgeport Mill, I could like to complete the mill as a closed loop system. To date I have looked at two options; the GRex-G100, and a full fledged PCI Stepper controller.

If you read the literature on the GRex-G100 module carefully, it looks as though it will replace the PMDX-131 module that I used, and would provide the additional digital input/output pins that would be needed to connect encoders to the drive system thus providing full feedback and closing the loop of movement. The cost of the GRex-G100 is approximately $400, so in effect you could build a closed loop system for an additional $200 over the open loop system, plus the cost of encoders. I haven’t got any experience with the GRex so my main concern is whether or not the USB or Ethernet interfaces could keep pace with a system running at approximately 50ipm.

The PCI stepper controller options range anywhere from $200 to $1000 for a 4 axis board depending on the level of features desired, and compatibility with Mach3 or EMC.

If I close the loop on this discussion, I will keep everyone posted on the direction I have taken and why. I have a feeling more research is required for this next venture.

12.5 Phase 3 – The X and Y Axes

To connect the X and Y Stepper motors to the mill, my intent was not to modify the mill unless I absolutely had to. What good is a conversion if it destroys the machine in the process? To this end my drive tubes connect to the mill via the bolts that hold the bearing retainers for the ball screws. My drive components were purchased from http://www.sdp-si.com and consisted of timing pulleys and timing belts. For the determination of belt length I tried to keep the belts as short as possible to reduce any stretching, and used the SDP-SI calculator to help me determine the appropriate centerlines and belts for my application. I was trying to get the maximum ratio I could while still providing a drive belt that would handle daily use. The components I chose are listed in the following table.

Part #	*Manual Desc*	*Vendor*	*Qty*	*Price*	*Units*
A 6A 4-10DF05016	Timing Pulley (10 slot)	www.sdp-si.com	3	$10.91	Each
A 6F 4-30DF050	Timing Pulley (30 slot)	www.sdp-si.com	3	$29.85	Each
A 6R 4-042050	Timing Belt (42 tooth X-AXIS)	www.sdp-si.com	1	$7.49	Each
A 6R 4-058050	Timing Belt (58 tooth Y-AXIS)	www.sdp-si.com	1	$8.57	Each
A 6R 4-054050	Timing Belt (54 tooth Z-AXIS)	www.sdp-si.com	1	$8.80	Each

The following pictures show the X-Axis drive tube being machined by hand in preparation of the installation. You will note the triangular pattern of holes for the leadscrew bearing retainers, and the slots for the stepper motors. Note that I allowed for some adjustment to tension the belts. You will also note that I wasn’t really concerned with how “pretty” these tubes were. My intent was to machine a new set once the axes were connected and at that time I would also correct any drawing issues. You will also see that in the drive tube pictures, the hole for the Y axis handle is significantly different from the hole for the X axis handle. This is because the X axis bearing cap could easily be assembled with the drive tube and then installed on the mill, but the Y axis could not. This necessitated cutting a much larger hole in the drive tube, large enough to feed the 30 tooth gear through.

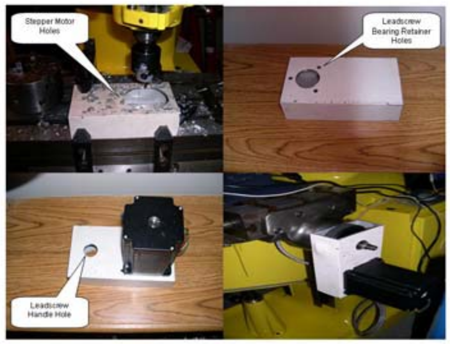

Figure 59 – X Axis Drive Tube

Figure 60 – Y Axis Drive Tube

Figure 61 below shows the new drive tubes that were milled using the CNC XY portion of the mill connected. At this time, the Z Axis had not been completed and I issued program stops for all Z-Axis depth changes. You will note the difference in the accuracy of the cuts, and the repeatability of the slots and logos.

There is a change I am planning for my mill. After having used the mill for about a year now, I intend to turn the X axis stepper motor inward. The will give me a little more room in front of the mill. I would like to turn the Y axis inward as well, but may not have the clearance with my new planetary gearheads to do this.

From a performance standpoint I am able to reliably drive my mill at 30ipm in both the X and Y during rapid move operations. I have been playing with the drive parameters within Mach3 and feel that by modifying the settings I could probably get the system to travel as fast as 50ipm during rapid moves.

12.6 Phase 4 – The Z Axis

I have looked at a lot of commercial CNC mills based on the Bridgeport design and I have been less than thrilled with their implementations of the Z Axis. Mine is not the most accurate, but does preserve the original machine without destruction. Most models replace the quill stop micrometer screw with a ballscrew and drive the Z Axis from a bracket attached to the quill stop collar that bolts to the quill with a single bolt. While this provides the most accurate depth, I have seen many mills that have had to have their quill replaced after this bolt eventually ripped out. I have also seen installations where the motor drive system was attached to the microfeed handwheel, but these are problematic from an installation standpoint. For my installation I chose to drive the Z from the rack and pinion of the hand crank. I did not want to lose the ability to pivot the head on the mill, so I centered the drive system at the pivot shaft. While a 3:1 reduction was not ideal for this installation, it did suffice until I was able to find a planetary gearhead for this axis. Figure 62 below shows my installation. Note that I preserved the feed handle for the initial installation, but once the gearhead is installed the feed handle will have to be removed.

Figure 62 – Z Axis Installation

12.7 Phase 5 – The Planetary Gearhead for Z Axis

After searching on the online auctions for some cost friendly gearheads, I stumbled upon a 60 series mount 20:1 gearhead that I knew I could alter to fit the NEMA 34 mount used by my stepper motors. I bid on the item, and to my surprise, I won the gearhead for $15. This does not happen often and you can expect to pay closer to $150 for used NEMA 34 or 60 series gearheads online.

The first thing I did when the gearhead arrived was to turn the input shaft. I felt some resistance and figured I would disassemble the gearhead. Planetary gearheads are not very complicated and after about 15 minutes I had this unit completely disassembled and awaiting new bearings. I went searching through vendors and online auctions, and after about 10 minutes a new set of bearings was found for, yes, you guessed it $15. While I had the gearhead apart, I turned the output shaft down to 0.5” from the original shaft diameter. This would allow me to keep my existing timing gear setup intact. With the addition of this planetary gearhead I would be able to increase the resolution of the Z Axis from 3:1 to 60:1.

The series 60 gearhead required me to make a few more modifications while I was waiting on the bearings. The Z Axis brackets that I had made would not work for the series 60 footprint, so a new set was designed and machined while the old setup was still in place. I also had to mill out the holes on the NEMA 34 motor, but decided to wait on those until I was ready to install the gearhead.

Figure 63 below shows my new installation with the planetary gearhead installed. I am much happier with the resolution of the Z Axis.

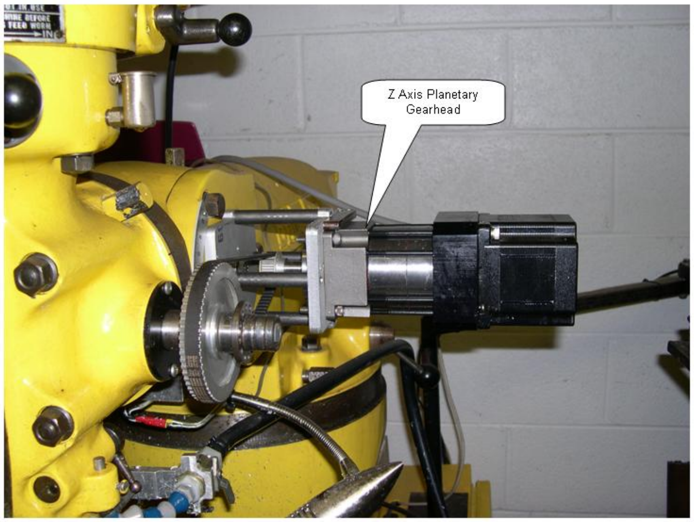

Figure 63 – Z Axis Planetary Gearbox Installation

12.8 Software packages

I am not going into a great deal of detail here because too many other people have already done this and I would only be plagiarizing their work. Suffice it to say that I currently run MACH3 software on my mill from http://www.artofcnc.ca and my CADCAM program of choice right now is TurboCAD.

I originally installed TurboCNC on my mill as the software of choice, but wanted the ability to run Windows on my mill and gain the benefits of networking. Now I do all my designs on one machine and transmit them to the milling machine for machining. It provides better configuration management and keeps the mill uncluttered with design files.

I have also considered the EMC software package as a means to be able to “close the loop” of my movements.

12.9 The Moral of the Story

Now the moral of this story is actually a very simple one. It is not overly difficult to CNC a machine.

As you can see from my exploits with this particular machine, if you are not happy with the installation or have improvements you want to do then these changes can be made relatively easily without disabling the machine for long periods of time. It all comes down to having a good base to work from. It is possible to buy ready made CNC Conversion kits for many of today’s and yesterday’s mills, but part of the fun for me was doing this all myself and learning more about the capabilities of my machine as I moved forward. There was even a great satisfaction in using the machine to build its own parts.

As for all the parts, I have drawings for all of them. Some need some tweaking, others are just fine the way they are. I will be more than happy to email them to anyone that wants them, free of charge as long as they are not used for commercial resale in any way.

13.0 Reference Documents and Websites

13.1 Documents

Bridgeport Series I Vertical Milling Machine Operation and Maintenance Manual, Part # 1800234.

Bridgeport Machines Inc, Operators Manual, 1966.

13.2 Websites

Chesapeake Area Metalworking Society	http://www.cams-club.org/
CNC Zone	http://www.cnczone.com/
Flint Machine Tools	http://www.flintmachine.com
High Quality Tools	http://www.hqtinc.com/
H & W Machine Repair	http://www.machinerypartsdepot.com
Enco Tooling	http://www.use-enco.com
Practical Micro Designs	http://www.pmdx.com
MACH3 Software	http://www.artofcnc.ca
Stock Drive Products	http://www.sdp-si.com
Rockford Ball Screw	http://www.rockfordballscrew.com/
IMSI Software (TurboCAD)	http://www.imsisoft.com

Appendix A

The following image depicts the drawing I used to develop the spanner wrench that could be used to adjust the clockwork spring on my Bridgeport Mill. If you need specifics on this wrench, please let me know. I actually even have the TurboCAD and CNC g-code to generate this handy little tool.