

SeeMeCNC™

H-1

Mechanical Assembly Manual

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These instructions are available free of charge on <http://seemecnc.org/assembly>

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SAFETY

The SeeMeCNC™ H-1 is a functional 3D printer and not a toy. It is important to read and understand the following safety information before building and operating the machine. **USE AT YOUR OWN RISK.**

CAUTION: RISK OF FIRE AND ELECTRICAL SHOCK. You do not need to modify any electronics inside the 12 volt power supply. Never work on your machine or its electronics with the power supply connected to the line voltage (120VAC or 240VAC line voltage). Pay particular attention to short circuits. A short circuit can cause damage, fire, or unexpected motion of the CNC machinery. Under no circumstance should you experiment or change anything electrically if you are unfamiliar with what you are doing. Only YOU know if you are capable of performing the electrical work required to build and operate your machine.

CAUTION: IT IS RECOMMENDED TO INSTALL AN EMERGENCY STOP SWITCH (not included) to quickly shut down the machine in an emergency.

CAUTION: THIS MACHINE IS NOT A TOY. USE THIS PRODUCT AT YOUR OWN RISK. You are responsible for injury or property damage resulting from use of this product.

CAUTION: THE MACHINE OPERATOR AND ALL OBSERVERS MUST WEAR Z87 RATED EYE PROTECTION. Children under 18 years of age must be supervised by adult. This machine is not a toy.

CAUTION: COMPUTER NUMERICAL CONTROLLED (CNC) MACHINERY CAN START UNEXPECTEDLY CAUSING INJURY. Keep hands, fingers, body parts, loose clothing, jewelry, or long hair away from moving parts. Always disconnect the machine from the power supply when building or modifying it.

WARNING: THE HEATED BARREL ASSEMBLY, NOZZLE, AND EXTRUDED PLASTIC RESIN WILL CAUSE SERIOUS BURNS IF TOUCHED.

RESPONSIBLE USE

Thank you for purchasing a SeeMeCNC H-1 machine. Please use this technology responsibly and ethically. By purchasing and using a SeeMeCNC machine, you are assuming all liabilities associated. Please respect the copyright of the intellectual property of others. Under no circumstance will Blackpoint Engineering, LLC, be responsible for uses of the equipment.

It is YOUR responsibility to research state and local laws for use of SeeMeCNC machines. **USE AT YOUR OWN RISK.** Further, use of your SeeMeCNC machine, by any operator, is your acknowledgement of all warnings, cautions, ethical use, and safety concerns written in this document or understood by the common practice of the art.

FOREWORD

Thank you for purchasing a SeeMeCNC H-1 3D printer.

The Open Source RepRap (see *RESOURCES* below) 3D printer community has popularized DIY desktop 3D printing. These machines typically use on-board controller electronics based on the Open Source Arduino platform and are designed to be able to print a copy of themselves; they are self-replicating machines.

The SeeMeCNC H-1 is a very powerful little machine based on the Open Source RepRap Huxley that anyone can use to unleash his or her imagination to create a physical real world object. We built the H-1 with two objectives:

1. significantly lower the cost of building a 3D printer by using injection molded rather than printed plastic parts
2. introduce the user to a more conventional and professional level of computer numerically controlled (CNC) machinery

To achieve the second objective, we have chosen a regular desktop personal computer and ArtSoft's Mach3™ software as the controller rather than the dedicated on-board Arduino controllers used in typical RepRap machines. Both hobbyists and professionals use Mach3 to control many types of CNC equipment. Mach3 users will have a lower learning curve entering 3D printing while users just starting out will be able to leverage their new CNC skills if they decide to expand to other machinery like lathes, routers, or milling machines.

The H-1 is controlled by g-code, a universal programming language developed decades ago as a way to control machinery using computers. While most g-codes are universal and common among machines, including the H-1, some machinery manufacturers have created custom codes not universal to all CNC machines. All CNC machines have their own startup and shutdown procedures as well. Please refer to the *Startup and Shutdown* section of this manual for these procedures for the H-1 3D printer. Following these procedures will ensure safe operation and that you do not damage the electronics of your machine.

3D printing involves a number of operations from design of the 3D part itself, to generating g-code, and sending that g-code to the machine to print the part. A number of Open Source and commercial software products are used in this software chain. The following sequence describes this process at a high level:

1. A three dimensional (3D) computer aided drawing (CAD) model is created. Commercial as well as free programs, such as Google SketchUp™, Blender, OpenSCAD, and FreeCAD are available for CAD model creation.
2. The 3D CAD model is exported to a sterolithography (STL) file.

3. Convert the STL file to g-code using a computer aided manufacturing (CAM) program. Slic3r or a special SeeMeCNC version of the Open Source ReplicatorG program is used for this step.
4. Open the g-code file in the Mach3 machine control software. Mach3 controls the H-1 through the stepper motor axis control board connected to the parallel port of your computer.
5. Turn on the heater to the “hot end” of the H-1. It takes about 3 minutes to warm up to 430°F.
6. Jog the H-1 to X, Y, Z home positions and set Zero.
7. Press “Cycle Start” to begin printing.

Even if you are not skilled at CAD or do not know what you'd like to print, a large community of shared STL files for thousands of interesting (and amazing!) printable things is available at Thingiverse® (see *RESOURCES* below). Starting with one of these STL files eliminates steps 1 and 2 in the sequence described above.

RESOURCES

General Background

RepRap: <http://reprap.org>

Open Source Huxley: <http://reprap.org/wiki/Huxley>

H-1: <http://reprap.org/wiki/SeeMeCNC>

g-code: <http://en.wikipedia.org/wiki/G-code>

Thingiverse: <http://www.thingiverse.com>

CAD Programs

Google SketchUp: <http://sketchup.google.com>

Blender: <http://www.blender.org>

OpenSCAD: <http://www.openscad.org>

FreeCAD: <http://sourceforge.net/apps/mediawiki/free-cad>

CAM Programs

Slic3r: <http://slic3r.org>

SeeMeCNC ReplicatorG: http://seemecnc.org/download/RepG_Skeinforge

Machine Control Programs

Mach3: <http://www.machsupport.com>

H-1 Construction Resources

SeeMeCNC Yahoo Group: <http://tech.groups.yahoo.com/group/SeeMeCNC>

SeeMeCNC.org: <http://seemecnc.org>

H-1 Assembly

There are three manuals available for building your H-1: this *H-1 Mechanical Assembly Manual* and the *H-1 Electronics Manual* and *H-1 Operations Guide*. This manual will guide you in constructing the mechanical parts of your new machine. The *H-1 Electronics Manual* guides you in assembling and wiring the H-1's electronics. The *H-1 Operations Manual* presents software, configuration, H-1 operations, and some useful modifications to enhance your machine. In addition to these manuals, the Yahoo "seemecnc" group (see *RESOURCES* above) is a great place to find more information and ask questions about building and using your machine.

We recommend that you follow the assembly steps in the order presented in the manual. In particular, several sub-assemblies must be built before putting them together to produce the completed mechanical assembly. It is a good idea to read through the entire manual and gather the required tools and supplies prior to starting construction.

The assembly steps and figures are numbered in this manual. These help you keep track of where you are and can be used to refer to a specific operation. For instance, *step 1-1*, refers to attaching a bar clamp on the front base frame sub-assembly and *Figure 1.1 - Front Base Frame Sub-assembly* is a drawing of this sub-assembly.

The stock H-1 is designed for 1.7mm plastic filament. Modification of the hot end to allow 3mm filament is presented in the *H-1 Operations Manual*.

Take your time assembling your machine and enjoy your new SeeMeCNC H-1!

Tools and Supplies

In addition to the kit, you will need a few basic tools and supplies to complete your machine.

Tools:

Note that you can substitute an adjustable wrench for the 1/4", 3/8" and 7/16" wrenches.

- hobby knife with sharp blade
- 3/32", 7/64", 5/32" and 3/16" Allen wrenches (*aka* hex keys)
- 1/4" wrench or 1/4" nut driver
- 5/16" wrench
- 3/8" wrench
- two 7/16" wrenches
- No 1 and No 2 Phillips screw driver
- ruler (at least 15") or tape measure
- a small (3" to 8") square
- electric hand drill with 5/64", 1/8", 3/16" and 1/4" drill bits
- "C" clamp with at least a 4" opening (optional)
- scissors
- needle nose pliers
- wire cutters
- soldering iron

Supplies

- 4" x 4" piece of fine (400 to 800 grit) sandpaper
- light machine oil or grease
- one 1-1/2" x 6" piece of aluminum foil
- high temperature silicone adhesive or gasket maker, like Permatex Ultra Copper™ (available at auto parts stores)
- non-lead electronics solder

Parts Identification

Many of the small injection molded parts and hardware (screws, threaded rod, etc) look similar. It is a good idea to familiarize yourself with these parts by looking at the assembly drawings and photos before beginning construction.

Tip: Use re-sealable plastic bags to store parts once you've removed them from their packaging. You can mark the bags with the part numbers to make it easier to locate parts as you build your machine.

Parts List

Hardware		Totals
30156	1/4-20 Nut	54
30512	1/4-20 Flat Washer	47
30513	1/4-20 Split Lock Washer	24
30160	10-32 Nylon Lock Nut	10
29995	10-32 x 1-1/2" Socket Head Cap Screw	6
30001	10-32 x 1" Socket Head Cap Screw	4
30610	5-40 x 1/2" Phillip Pan Head Screw	18
30617	5-40 x 1-1/4" Socket Head Cap Screw	40
30613	5-40 x 3/4" Phillip Pan Head Screw	36
30615	5-40 x 1" Phillip Pan Head Screw	16
30166	5-40 Nylon Lock Nut	114
30449	No 4 Washer	94
30500	No 8 Washer	16
30250	#4 x 3/8" Pan Head Sheet Metal Screw	18
30272	#8 x 1" Phillip Pan Head Sheet Metal Screw	16
30318	M3-.05 x 10mm Phillip Pan Head Screw	8
30157	1/4-20 Nylon Lock Nut	4
Threaded Rod		Totals
71502	1/4-20 X 12" Threaded Rod	4
71509	1/4-20 x 9-1/2" Threaded Rod	4
71523	1/4-20 x 13" Threaded Rod	4
71504	1/4-20 x 10-1/2" Threaded Rod (Z Axis Screw)	2
Linear Rail		Totals
71520	1/4" x 12" Linear Rail	4
71503	1/4" x 13-1/2" Linear Rail	2
Blue Plastic Parts	58703	Totals
71501	Bar Clamp 60 Degree	16
71508	Bar Clamp 90 Degree	28
71514	Triple Bearing Support	8
71517	Double Bearing Support	4
71519	Combo Bearing Cover	2
71518	Double Bearing Cover	2
71516	Triple Bearing Cover	6
Acetal Parts	58705	Totals

71511	1/4" ID x 1-1/16" OD Plastic Washer	16
71543	1/2" ID x 3/4" OD Plastic Idler	7
71535	3/16" ID x 1/2" OD Plastic Roller	7
71513	1/4" ID x 1/2" OD Plastic Busing	1
71544	200XL x 0637 PD x 5mm Shaft Timing Pulley	3
71545	200XL x 1273 PD x .25" Shaft Timing Pulley	2
Clear Plastic	58702	Totals
71506	Motor Mount	1
71531	Z Axis Bearing Plate	2
71532	X Axis Motor Mount	2
Table		Totals
71529	SeeMeCNC H-1 Table	1
Bearings	58706	Totals
35008	1/4" ID x 5/8" OD R4ZZ Ball Bearing	2
71505	1/8" ID x 3/8" OD Plastic Bearing	32
29951	1/8" Plastic Dowel Pin	32
Steppers		Totals
26501	NEMA 17 Stepper	4
Timing Belts	58704	Totals
71521	200XL x 1/4" x 31" x 155 teeth Timing Belt	1
71522	200XL x 1/4" x 26-12" Timing Belt Open Ended	1
71524	200XL x 1/4" x 41-1/2" Timing Belt	1
Feet		Totals
17505	Foot Leg	4
44010	Rubber Foot	4
Hot End		Totals
71574	Extruder Barrel Assembly	1
26138	6.8 ohm Resistor	2
26137	4k@200C Thermistor	1
Extruder		Totals
71555	Extruder Base (#1)	1
35008	1/4" ID x 5/8" OD x .196 W Ball Bearing (#3)	6
71550	Drive Roller for 1.75 mm and 3 mm Filament (#4)	2
30157	1/4-20 Nylon Lock Nut (#5)	3
71559	Extruder Motor Mount (#6)	1

30141	1/4-20 x 3-3/4" Hex Head Bolt (#7)	1
71560	Drive Idler Left (#8)	1
71551	Filament Guide (#9)	1
71567	1/4" ID x 3/8" OD x .64" Axel Spacer (#10)	2
71574	H-1 Extruder Barrel Assembly (11)	1
30407	1/4-20 x 2" Socket Head Cap Screw (#12)	1
71566	15 Tooth Gear (#13)	1
71565	28 Tooth Gear (#14)	1
71569	Combination 15 Tooth-28 Tooth Gear (#15)	2
71562	1/4" ID x 1/2" PD x 10 Tooth Gear (#16)	4
71570	Tensioner (#17)	1
30142	1/4-20 x 3-1/2" Hex Head Bolt (#18)	1
71573	Tension Bar (#19)	1
30160	Nylon Lock Nut (#20)	1
30002	10-32 x 3/4" Socket Head Cap Screw (#21)	1
30500	#8 Washer (#22)	2
71561	Drive Idler Right (#23)	1
30036	6-32 x 2" Socket Head Cap Screw (#24)	2
30164	6-32 Nylon Lock Nut (#25)	2
30450	#6 Washer (#26)	6
36509	007 Buna N070 Oring (#27)	4
71564	Drive Mount (#28)	1
30512	1/4 Flat Washer (#29)	1
71568	1/4" ID x .28" Drive Spacer (#30)	1
30318	M3-.05 x 10mm Phillip Pan Head Screw (#31)	4
30449	No 4 Washer (#32)	8
71534	Lower Extruder Mounting Plate (#33)	1

H-1 Overview

Figure A - Complete H-1 with Labeled Axes

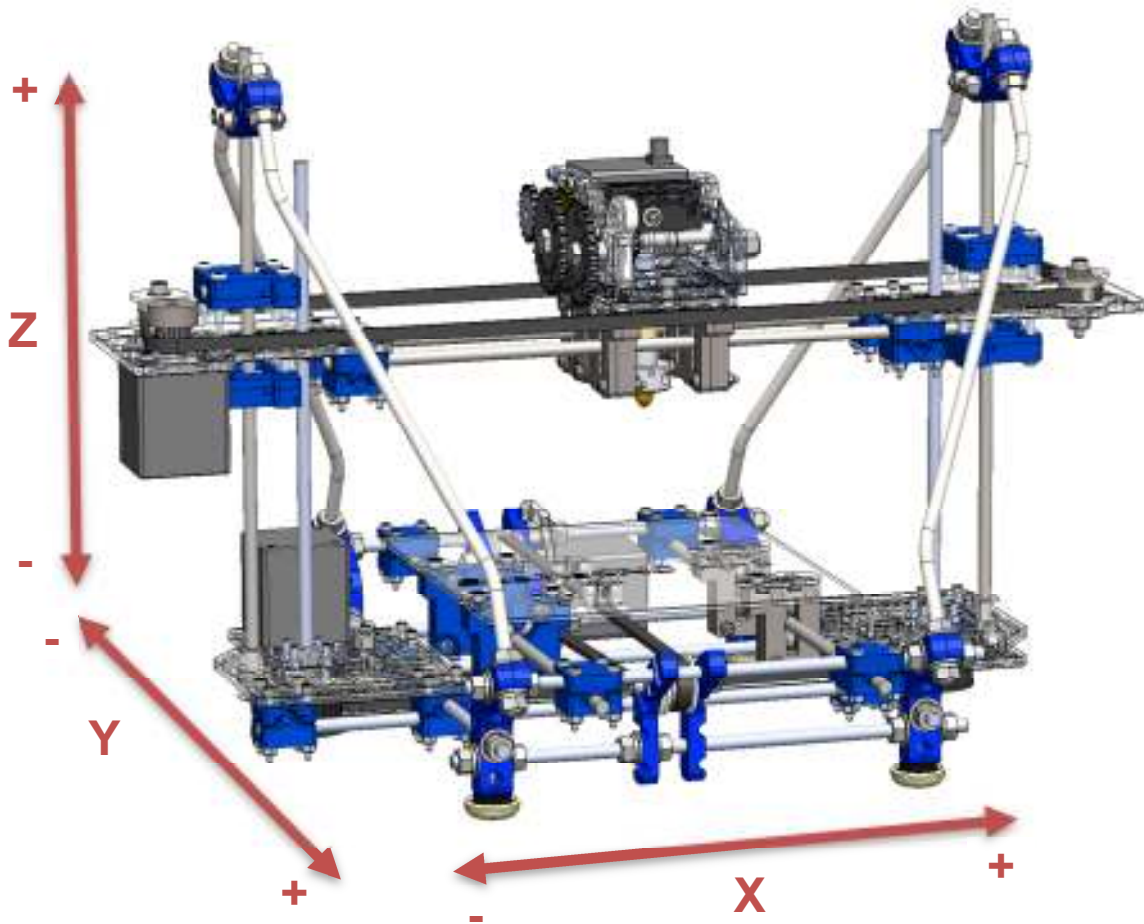


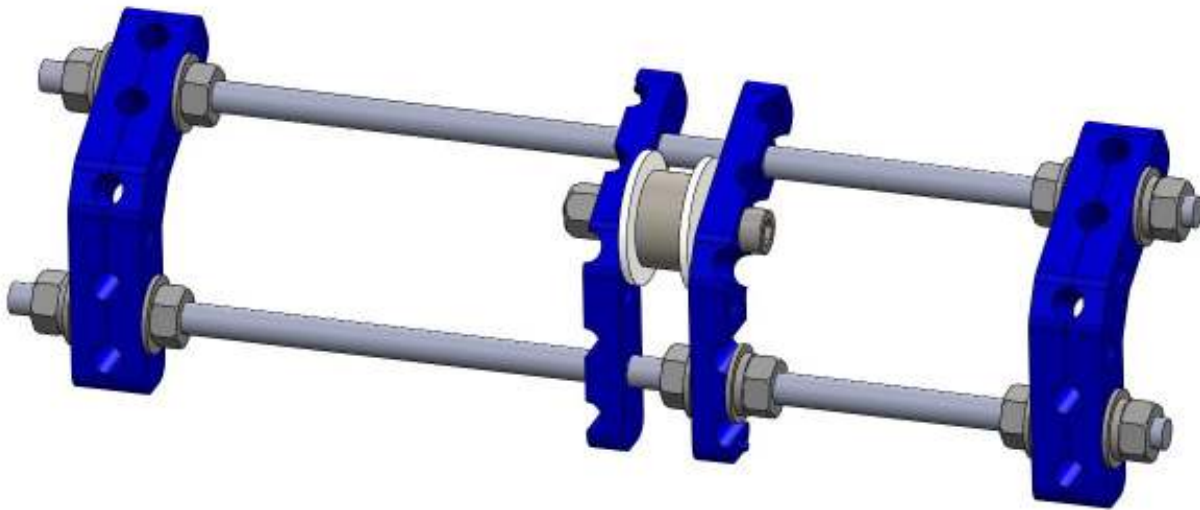
Figure A shows the complete H-1. The three axes, X, Y and Z, are indicated with arrows. The X direction is left-to-right as you face the machine. Y is front-to-back. Z is up and down. The + and – symbols show the axis movement. The 0, 0, 0 position is at the back left corner of the machine.

The table moves in the Y direction on a set of linear rails driven by a stepper motor and timing belt. The carriage with the extruder rides on the X axis linear rails and is driven by a stepper motor and timing belt. The X carriage rides on the Z axis linear rails. A stepper motor and timing belt drives two screws (one on each side of the machine) that move the X carriage up and down.

H-1 Mechanical Assembly

Step 1 – Front Base Frame Sub-assembly

Figure 1.1 - Front Base Frame Sub-assembly



Please refer to *Figure 1.2* for part identification.

Tools needed:

- 5/32" Allen wrench
- 7/16" and 3/8" wrenches
- hobby knife to trim molding flash from plastic parts
- electric drill with 3/16" and 1/4" drill bits (optional)

The 1/4" holes on the six **Bar Clamps (#71501)** may require reaming with a 1/4" drill bit so they can slide easily over the threaded rod. The mounting holes for the roller assembly on the inner two bar clamps may also require reaming with a 3/16" drill bit.

Tip: Save time reaming the holes by mating two bar clamps and then reaming holes in both at the same time.

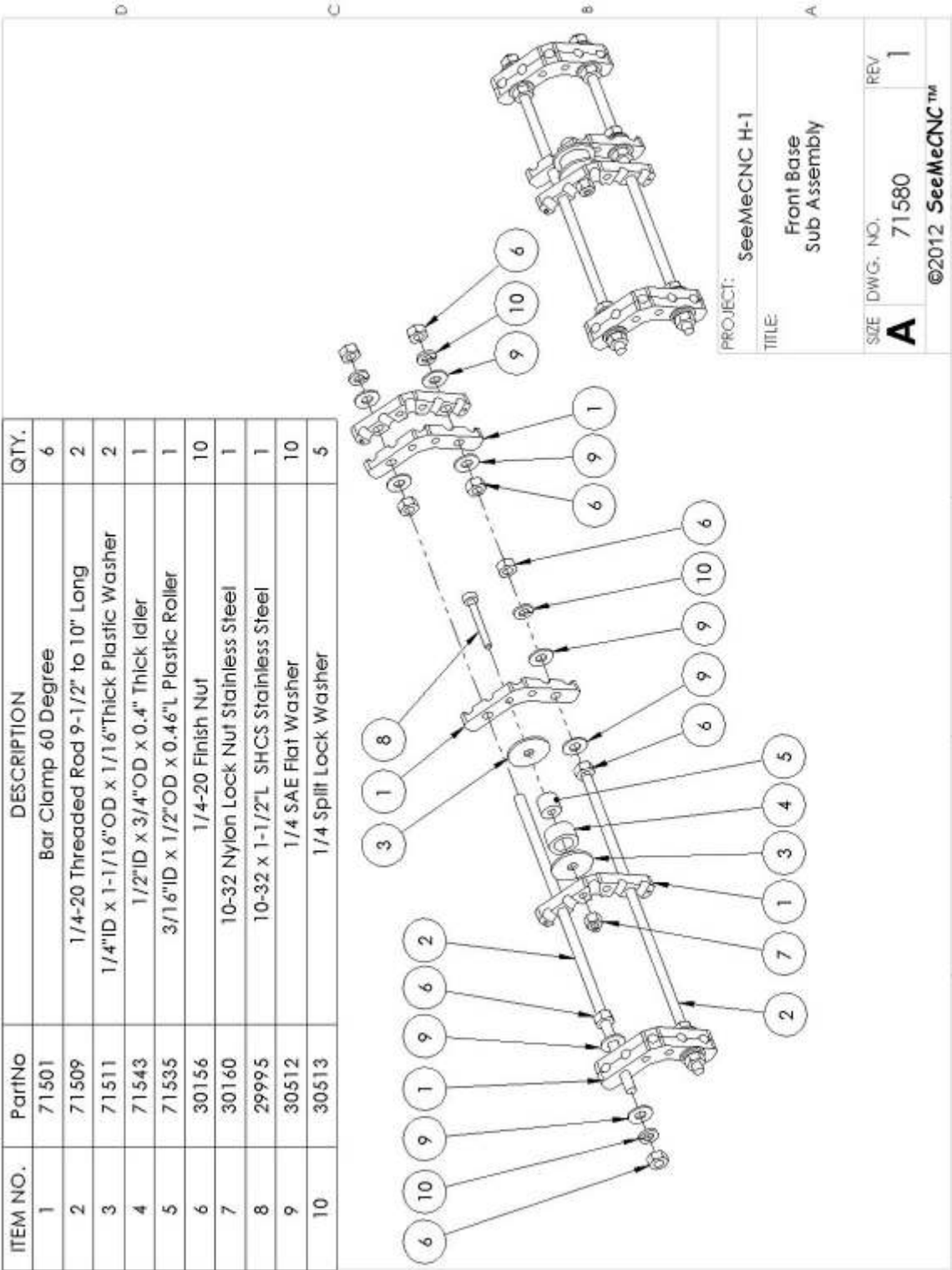
Prior to assembly, use a hobby knife to trim flashing off the plastic parts. Make sure to use the 9-1/2" **Threaded Rods (#71509)**. There are four of these; one pair is used on the Front Base Frame Sub-assembly and the other pair are used in step 2 on the Rear Base Frame Sub-assembly. Also make sure to use the **Plastic Roller (#71535)**; it has a 3/16" diameter center hole. It looks similar to the Plastic Bushing used in step 2 that has a 1/4" center hole.

Except where noted, assemble only finger tight. Note the orientation of the pairs of bar clamps used on each end of the sub-assembly and the pair used for mounting the roller in the center.

1.1 – Front Base Frame Sub-assembly

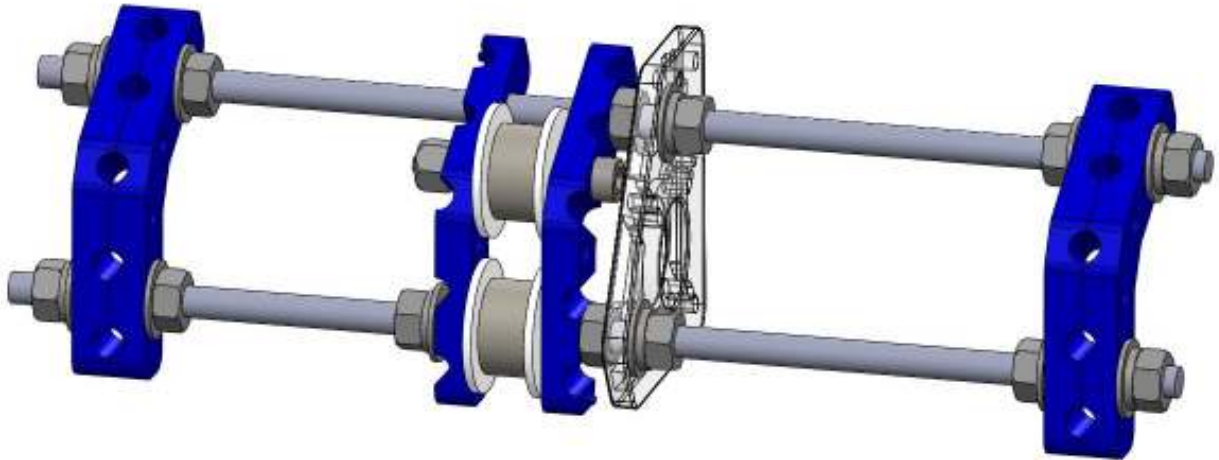
1. Attach the left side pair of bar clamps to the threaded rods using **1/4-20 Finish Nuts (#30156)** and **1/4" Flat Washers (#30512)** on each side of the bar clamp. Use **1/4" Split Lock Washers (#30513)** on the outermost nuts only as shown.
2. Slide one of the bar clamps used to mount the roller on to the rods.
3. Thread a 1/4-20 nut on the lower rod, positioning it about 4" from the end of the rod, and add a 1/4" washer.
4. Slide the mating bar clamp on the rods facing the opposite direction as shown in *Figure 1.1 - Front Base Frame Sub-assembly*. It is held in place with a 1/4" flat washer, 1/4" split lock washer and a 1/4-20 nut.
5. Attach the right side pair of bar clamps with 1/4-20 nuts, 1/4" flat washers, and 1/4" split lock washers on the outermost nuts only - the same as you did in step 1.
6. Use a **10-32 x 1 1/2" Stainless Socket Head Screw (#29995)** and **10-32 Nylon Lock Nut (#30160)** to install the two **Plastic Washers (#71511)**, **Idler (#71543)**, and **Roller (#71535)** as shown in *Figure 1.1 - Front Base Frame Sub-assembly*. You should tighten this screw (but do not over tighten it) and nut using the 5/32" Allen wrench and 3/8" wrench.

Figure 1.2



Step 2 – Rear Base Frame Sub-assembly

Figure 2.1 - Rear Base Frame Sub-assembly



Please refer to *Figure 2.2* for part identification.

Tools needed:

- 5/32" Allen wrench
- 7/16" and 3/8" wrenches
- hobby knife to trim molding flash from plastic parts
- electric drill with 3/16" and 1/4" drill bits (optional)

The 1/4" holes on the six **Bar Clamps (#71501)** may require reaming with a 1/4" drill bit so they can slide easily over the threaded rod. The mounting holes for the roller assembly on the inner two bar clamps may also require reaming with a 3/16" drill bit.

Tip: Save time reaming the holes by mating two bar clamps and then reaming holes in both at the same time.

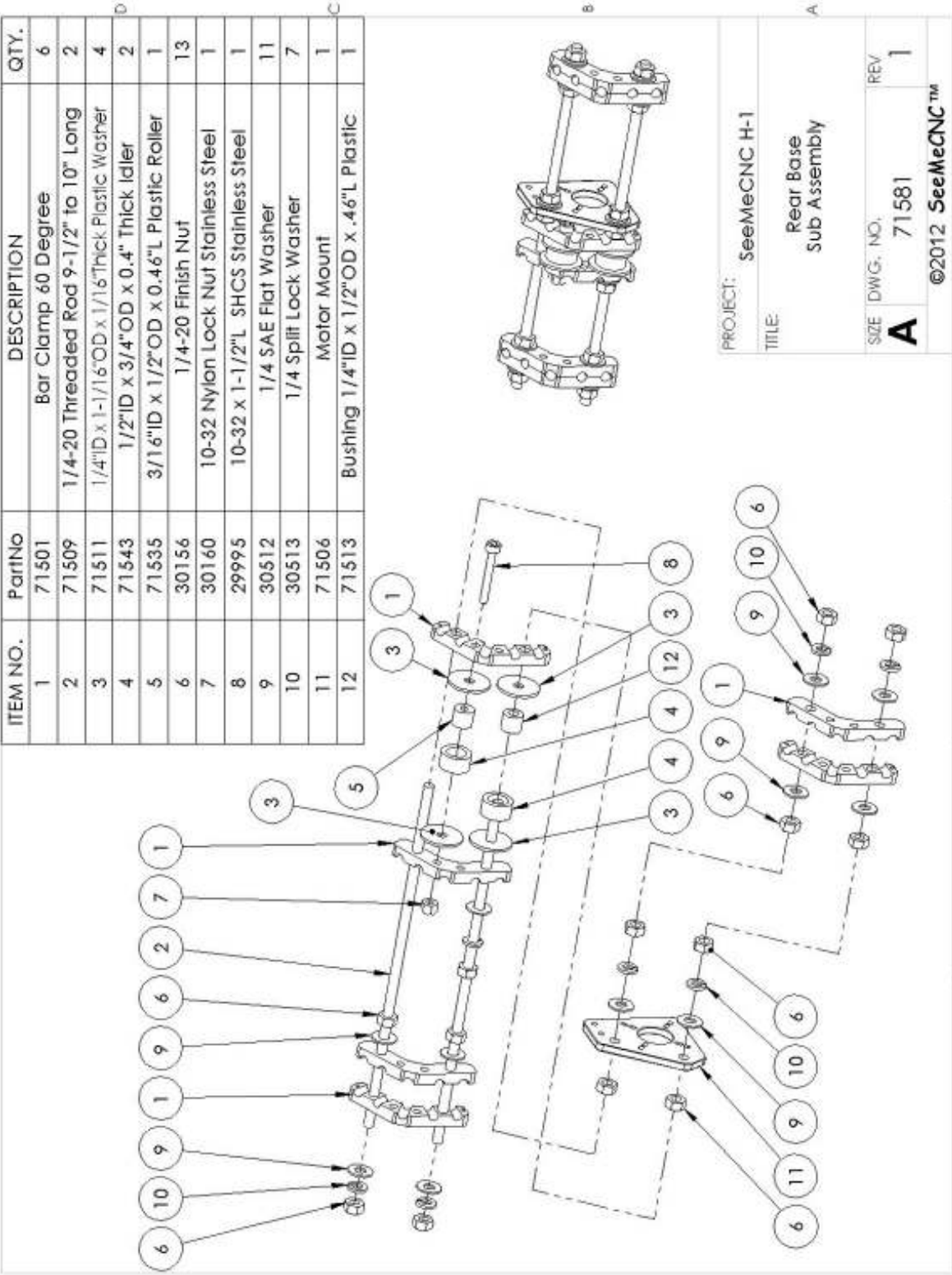
Prior to assembly, use a hobby knife to trim flashing off the plastic parts. Make sure to use the correct pair of **Threaded Rods (#71509)**, they are the mates to the rods used in *Step 1 - Front Base Frame Sub-assembly*.

Except where noted, assemble only finger tight. Note the orientation of the pairs of bar clamps on each end of the sub-assembly and the pair used for mounting the rollers in the center.

2.1 – Rear Base Frame Sub-assembly

1. Attach the left side pair of bar clamps to the threaded rods using **1/4-20 Finish Nuts (#30156)** and **1/4" Flat Washers (#30512)** on each side of the bar clamp. Use **1/4" Split Lock Washers (#30513)** on the outermost nuts only as shown.
2. Thread a 1/4-20 Nut, 1/4" Split Lock Washer, and 1/4" Flat Washer on to the lower rod about 5" from the end.
3. Slide one of the Bar Clamps used to mount the rollers on to the rods.
4. Slide the roller components on to the lower rod in the following order: **Plastic Washer (#71511)**, **Plastic Bushing (#71513)**, **Idler (#71543)**, and **Plastic Washer (#71511)**. Note that the plastic bushing has a 1/4" center hole.
5. Slide the mating Bar Clamp on the rods facing the opposite direction as shown in *Figure 2.1 - Rear Base Frame Sub-assembly*. It is held in place with two 1/4-20 Nuts, one on each rod.
6. Use a **10-32 x 1 1/2" Stainless Socket Head Screw (#29995)** and **10-32 Nylon Lock Nut (#30160)** to install the two **Plastic Washers (#71511)**, **Idler (#71543)**, and **Roller (#71535)** as shown in *Figure 2.2*. Tighten this screw and nut using the 5/32" Allen wrench and 3/18" wrench.
7. Slide the clear plastic **Motor Mount (#71506)** onto the rods. Make sure to orient it as shown in *Figure 2.1 - Rear Base Frame Sub-assembly*. Attach it with a 1/4" Flat Washers, 1/4" Split Lock Washers, and 1/4-20 Nuts on each rod.
8. Attach the right side pair of Bar Clamps with 1/4-20 Nuts, 1/4" Flat Washers, and 1/4" Split Lock Washers on the outermost nuts only - the same as you did in step 1.

Figure 2.2



Step 3 – Z Axis Base Sub-assembly

Figure 3.1 - Sub-assembly Top View

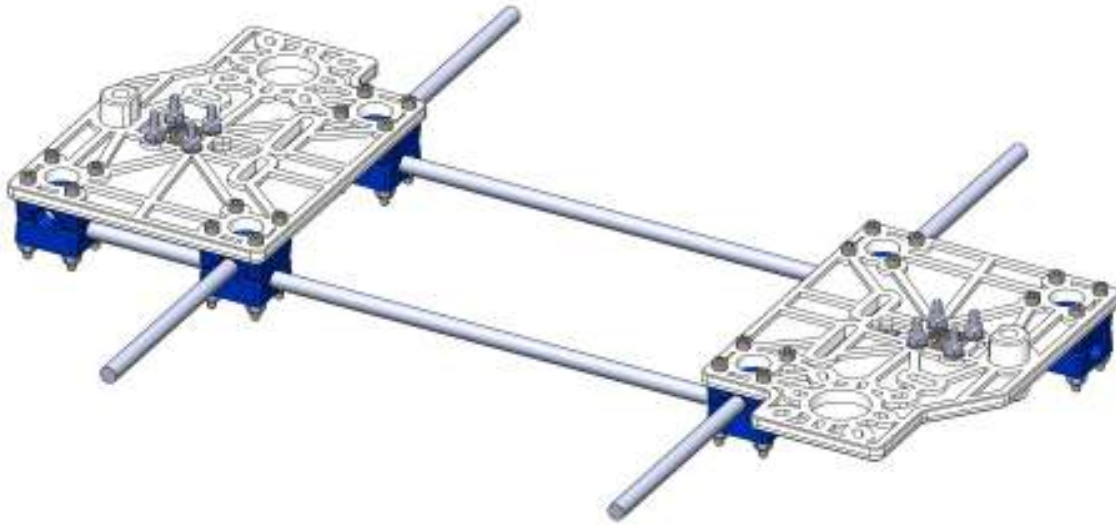
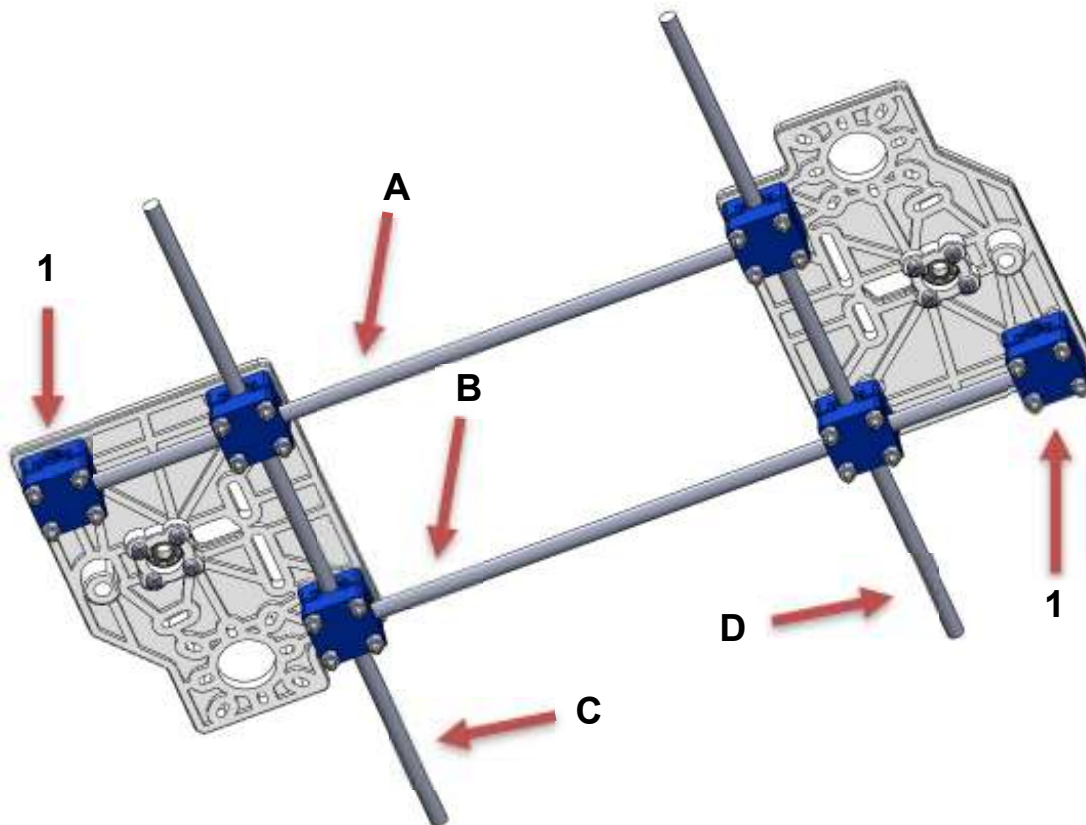


Figure 3.2 - Sub-assembly Bottom View



Please refer to *Figure 3.5* for part identification.

Tools needed:

- 3/32" Allen wrench
- 1/4" wrench or socket
- 7/16" wrench
- hobby knife to trim any molding flash from plastic parts
- electric drill with a 1/8" drill bit (optional)

The 1/8" holes on the six **Bar Clamps (#71508)** may require reaming with a 1/8" drill bit to allow the cap screws to insert easily.

Tip: Save time reaming the holes by mating two bar clamps and then reaming holes in both at the same time.

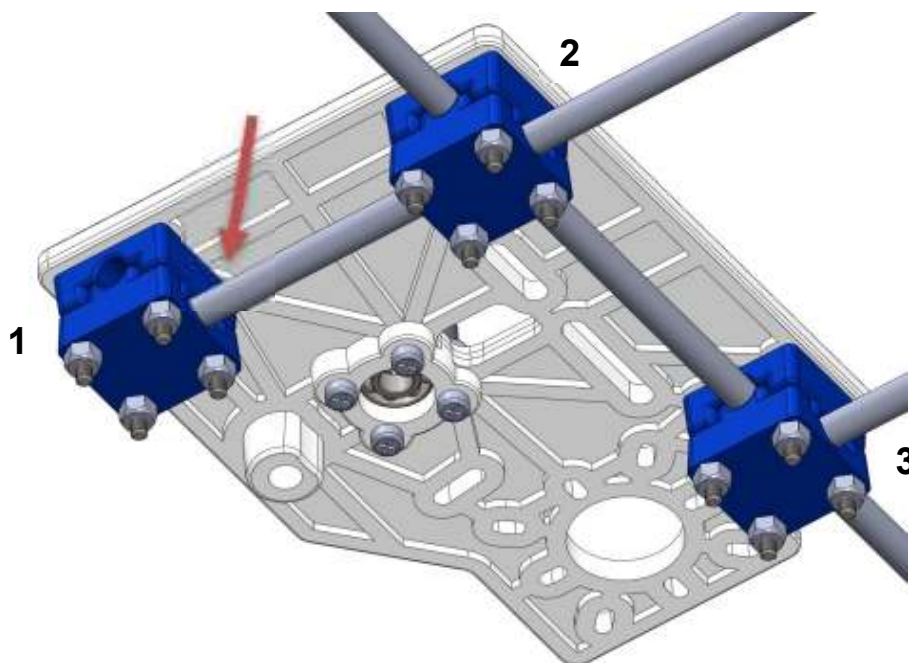
Except where noted, assemble only finger tight. Position is not important at this point as the sub-assembly will be adjusted later.

3.1 – Z Axis Base Sub-assembly

1. Press one of the **Ball Bearings (#35008)** into its hole in one of the **Z Axis Bearing Plates (#71531)**. It is retained by four **5-40 x 3/4" Pan Head Screws (#30613)**, four **No 4 Washers (#30449)**, and four **5-40 Nylon Lock Nuts (#30166)**. Insert the screw from the opposite side of the bearing opening. The washers go on the side with the nuts and hold the bearing in place. Tighten the screws.
2. Repeat step 1 for the second Z Axis Bearing Plate.

Tip: Refer to *Figure 3.3 - Base Assembly Bottom View (one side)* to make sure you orient the parts correctly for the next steps.

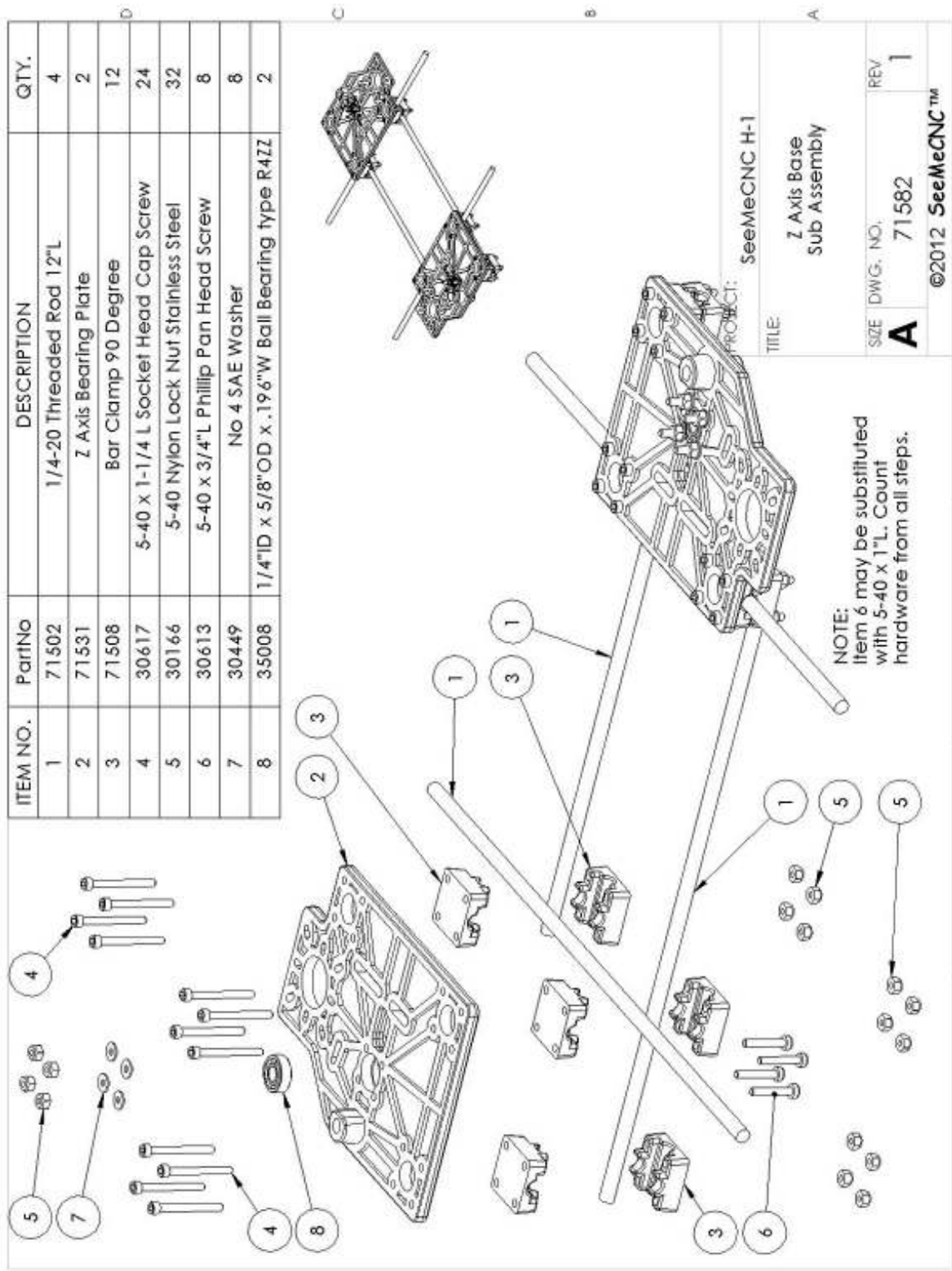
3. Start with the pair of **Bar Clamps (#71508)** at location **1** in the drawing. Loosely attach (the cross bar must be able to slide through the holes in the clamps) the Bar Clamps using four **5-40 x 1-1/4" Socket Head Cap Screws (#30617)** and four **5-40 Nylon Lock Nuts (#30166)** inserted down through the top of the Z Axis Bearing Plate as shown. Make sure that the cross bar clamp indicated by the arrow is positioned as shown.
4. Loosely attach the pair of Bar Clamps at location **2** in the drawing using four 5-40 x 1-1/4" Socket Head Cap Screws and four 5-40 Nylon Lock Nuts. Make sure it is oriented the same as the other Bar Clamp.
5. Loosely attach the pair of Bar Clamps at location **3** in the drawing using four 5-40 x 1-1/4" Socket Head Cap Screws and four 5-40 Nylon Lock Nuts. Make sure it is oriented the same as the other two Bar Clamps.
6. Repeat steps 3, 4 and 5 to attach the Bar Clamps to the other Z Axis Bearing Plate. When finished, the sub-assemblies should be identical to each other.

Figure 3.3 - Base Assembly Top View (one side)**Figure 3.4 - Base Assembly Bottom View (one side)**

Tip: Refer to *Figure 3.2 - Sub-assembly Bottom View* for the next steps.

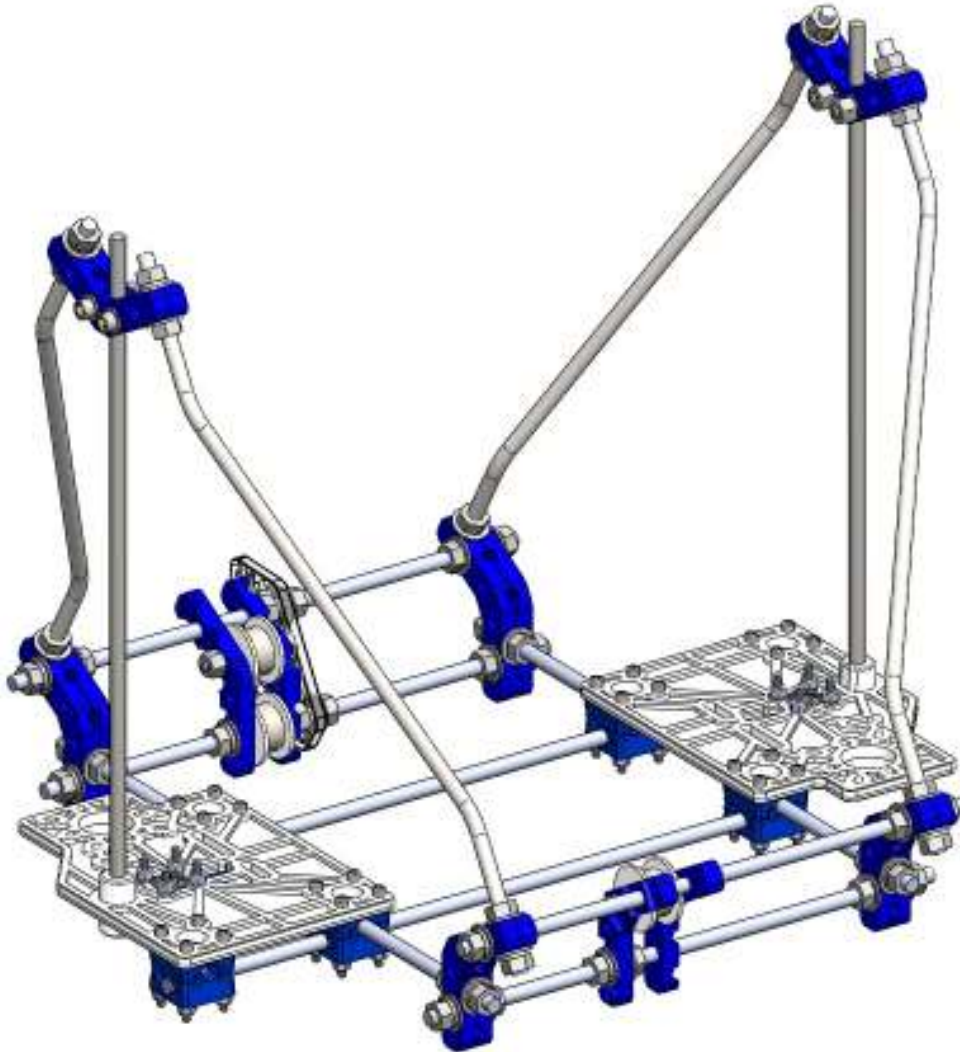
7. Insert the two **1/4-20 Threaded Rods (#71502)** marked **A** and **B** through the Bar Clamps in one of the Z Axis Bearing Plates. Note that one Threaded Rod will pass through two Bar Clamps and the other will pass through one Bar Clamp.
8. Slide the second Z Axis Bearing Plate onto the Threaded Rods.
9. Lightly tighten the Bar Clamps marked **1** in the drawing to hold the Threaded Rods in place.
10. Slide each of the two remaining Threaded Rods through two Bar Clamps on each Z Axis Bearing Plate as shown in the drawing, centering the plate as shown.

Figure 3.5



Step 4 – Base Assembly

Figure 4.1 - Base Assembly



Please refer *Figure 4.3* for part identification.

Tools needed:

- 5/32" Allen wrench
- two 7/16" and one 3/8" wrenches
- hobby knife to trim any molding flash from plastic parts
- ruler (at least 15" long) or tape measure
- a small square
- electric drill with a 3/16" drill bit (optional)

The 3/16" holes on the four **Bar Clamps (#71501)** may require reaming with a 3/16" drill bit.

Tip: Save time reaming the holes by mating two bar clamps, holding them together, and reaming holes in both parts at the same time.

4.1 - Base Assembly

1. Thread a **1/4-20 Nut (#30156)** onto each end of the two Threaded Rods you assembled to the Z Axis Base Sub-assembly completed in step **3.1-10**. Position the nuts about 1" from the end of the rod. You will use four nuts.
2. Place the Z Axis Base Sub-assembly on a flat surface with the clear plastic Z Axis Bearing Plates facing up and two of the Threaded Rods with the nuts you installed in step 4 facing you.
3. Place a **1/4-20 Flat Washer (#30512)** on each Threaded Rod, pushed up against the nut.
4. Attach the Front Base Sub-assembly you completed in *Step 1 – Front Base Frame Sub-assembly* by sliding the threaded rod ends into the second hole up from the bottom (not the center holes) holes in the Bar Clamps of the Front Base Sub-assembly. Refer to *Figure 4.1 - Base Assembly* for proper orientation; the roller should be above the centerline of the Bar Clamp and the "V" facing outwards as shown.
5. Hold the Front Base Sub-assembly in place with a 1/4" Flat Washer, a **1/4" Split Lock Washer (#30513)**, and 1/4-20 Nut on each Threaded Rod.
6. Rotate the Z Axis Base Sub-assembly around so the opposite ends of the Threaded Rods are facing you.
7. Place a 1/4" Flat Washer on each Threaded Rod, pushed up against the nut.
8. Attach the Rear Base Sub-assembly you completed in *Step 2 – Rear Base Frame Sub-assembly* by sliding the Threaded Rod ends into the second hole up from the bottom (not the center holes) holes of the Bar Clamps of the Rear Base Sub-assembly. The clear plastic Motor Mount should be to the left of the rollers with the Bar Clamp "V's" facing outwards.
9. Hold the Rear Base Sub-assembly in place with a 1/4" Flat Washer, a 1/4" Split Lock Washer, and 1/4-20 Nut on each threaded rod.

Tip: Before proceeding, compare your base assembly with the drawings to make sure everything is oriented properly.

10. Referring to the *Base Assembly Dimensions Top View* drawing below, tighten the four pairs of 1/4-20 Nuts indicated with the arrows labeled **A** on the left side of the base assembly. Leave about 1/2" of threaded rod exposed beyond the nut.
11. Adjust the distance between the centerlines of the two threaded rods to 7-7/8" using the 1/4-20 Nuts labeled **B** in the drawing. Take care that the distance between the Bar Clamps at their tops and bottoms are the same. Tighten the nuts.

Tip: To prevent twisting, keep the base assembly flat on your work surface while you make these adjustments. Once all eight pairs of nuts are tightened, you can straighten the assembly by gently twisting and checking against a flat surface.

12. Referring to *Figure 4.2 - Base Assembly Dimensions Top View*, tighten the set of 1/4-20 Nuts marked **C**. Leave about 1/8" of threaded rod exposed beyond the nut.

13. Adjust the distance between the centerlines of the two Threaded Rods to 12-1/8" using the 1/4-20 Nuts labeled **D** in the drawing. Tighten the nuts.
14. Straighten the Base Assembly (see Tip above) so it sits flat on your work surface.
15. Refer to the square symbol on *Figure 4.2 - Base Assembly Dimensions Top View* and square the Z Axis Base Sub-assembly to the base. Use a small square held at the position indicated on the drawing to check square. The Z Axis Base Sub-assembly is centered front to back. Once in position, tighten the twenty-four Bar Clamp screws (twelve on each side) that fix the Z Axis Base Sub-assembly to the base.

Tip: Only tighten one Bar Clamp screw on each side of the Z Axis Base Sub-assembly while you are squaring the assembly. Once square, tighten all twenty-four screws.

16. Loosely assemble two pairs of **Bar Clamps (#71501)** using two **10-32 x 1" Socket Head Cap Screws (#30001)**, four **#8 Flat Washers (#30500)**, and two **10-32 Nylon Lock Nuts (#30160)** in each. A washer goes on each side of the clamp.
17. Thread a 1/4-20 Nut onto each end of the four bent **Threaded Rods (#71523)**. Position the nuts about 1" from the end of the rod. You will use eight nuts.
18. Add a 1/4" Flat Washer to one end of a bent Threaded Rod and insert it into the outermost (first) hole in one of the corner Bar Clamps (e.g. one of the positions marked **A** in *Figure 4.2 - Base Assembly Dimensions Top View*). Affix with a 1/4" Flat Washer, 1/4" Split Lock Washer, and a 1/4-20 Nut.
19. Repeat step 18 for the remaining three bent Threaded Rods at positions **A** and **B**.
20. Add a 1/4" Flat Washer to the upper ends of the four Threaded Rods.
21. Attach one of the Bar Clamps you prepared in step 16 at the position indicated by the arrows labeled **1** in *Figure 4.2 - Base Assembly Dimensions Top View*.
22. Secure with a 1/4" Flat Washer, 1/4" Split Washer, and a 1/4-20 Nut on each rod.
23. Repeat steps 21 and 22 for the bent Threaded Rods at location **2** in the figure.
24. Slide one of the **Linear Rails (#71520)** through the center hole of the Bar Clamp installed in step 21. Slide it through the Bar Clamp and insert the other end into the pocket in the clear Z Axis Base Plate until the end is flush with the bottom of the pocket.

Tip: Use a small drop of liquid soap or water to help the end slide into the pocket.

25. Make sure the base assembly sits flat before proceeding
26. Tighten the 1/4-20 Nuts that secure the bent Threaded Rods to the lower Bar Clamps. Leave about 1/8" of threaded rod exposed beyond the nut at each end. Do not tighten the nuts at the top end at this time.

4.2 – Foot Installation

Tools needed:

- No 1 Phillips screwdriver
- electric drill with a 5/64" drill bit

1. Drill a 5/64" hole in the bottom of each of the base assembly's Bar Clamps.
2. Screw the four **Foot Legs (#17505)** into these holes using the small sheet metal screws and washers included in the Foot Hardware Package.
3. Snap the four **Rubber Feet (#44010)** onto the Foot Legs.

Figure 4.2 - Base Assembly Dimensions Top View

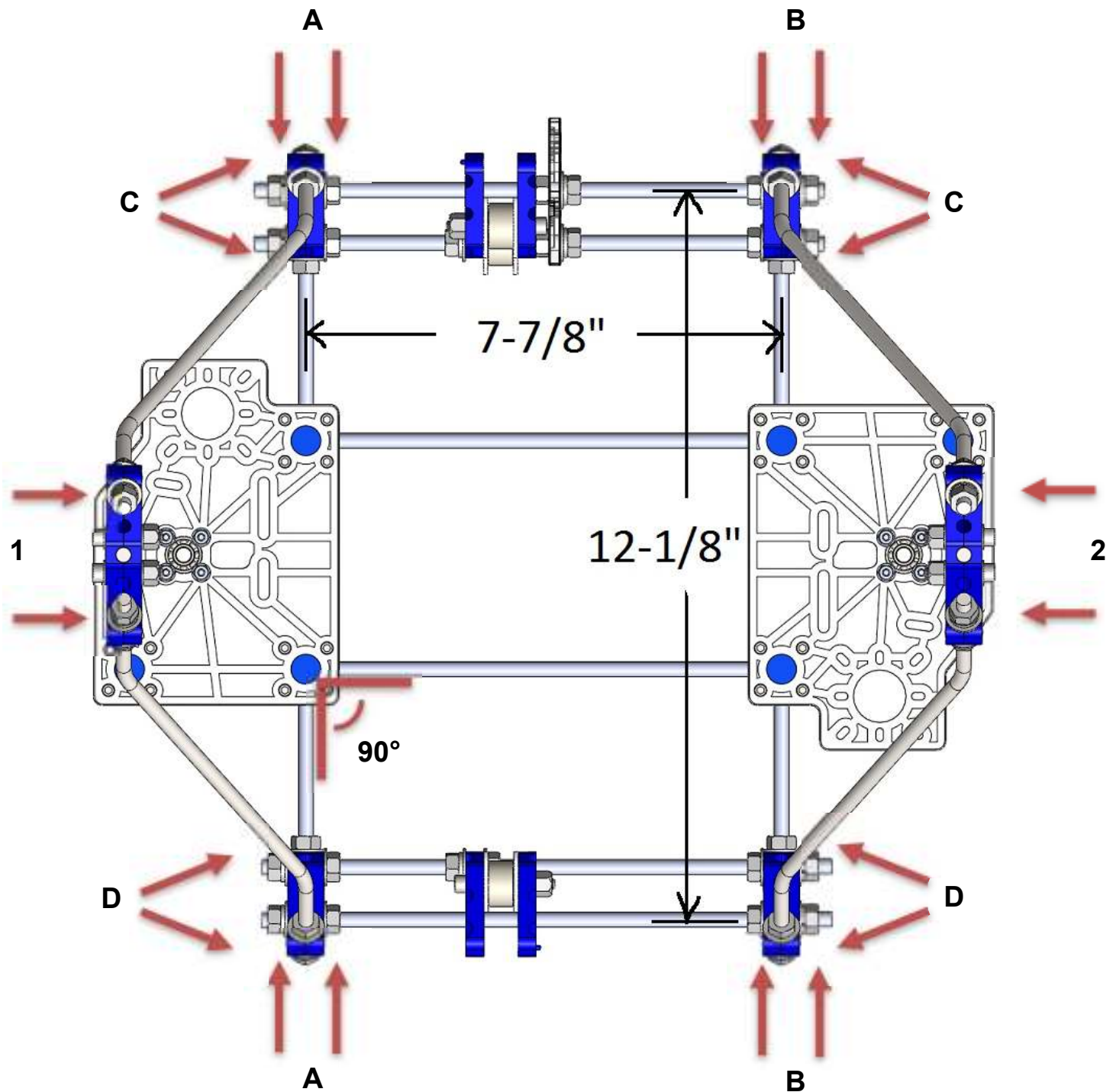
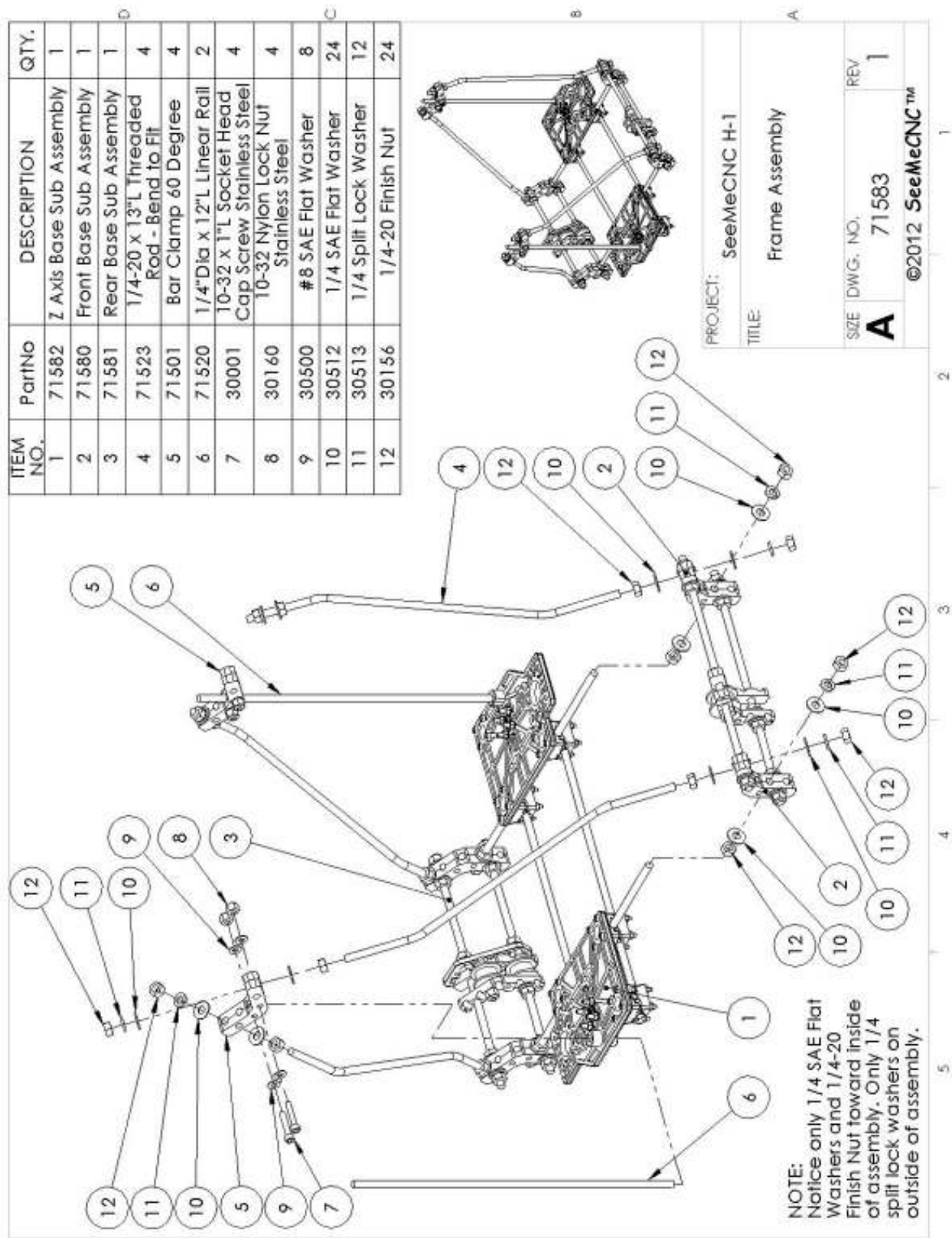


Figure 4.3



Step 5 – X, Y, Z Roller Bearing Assembly

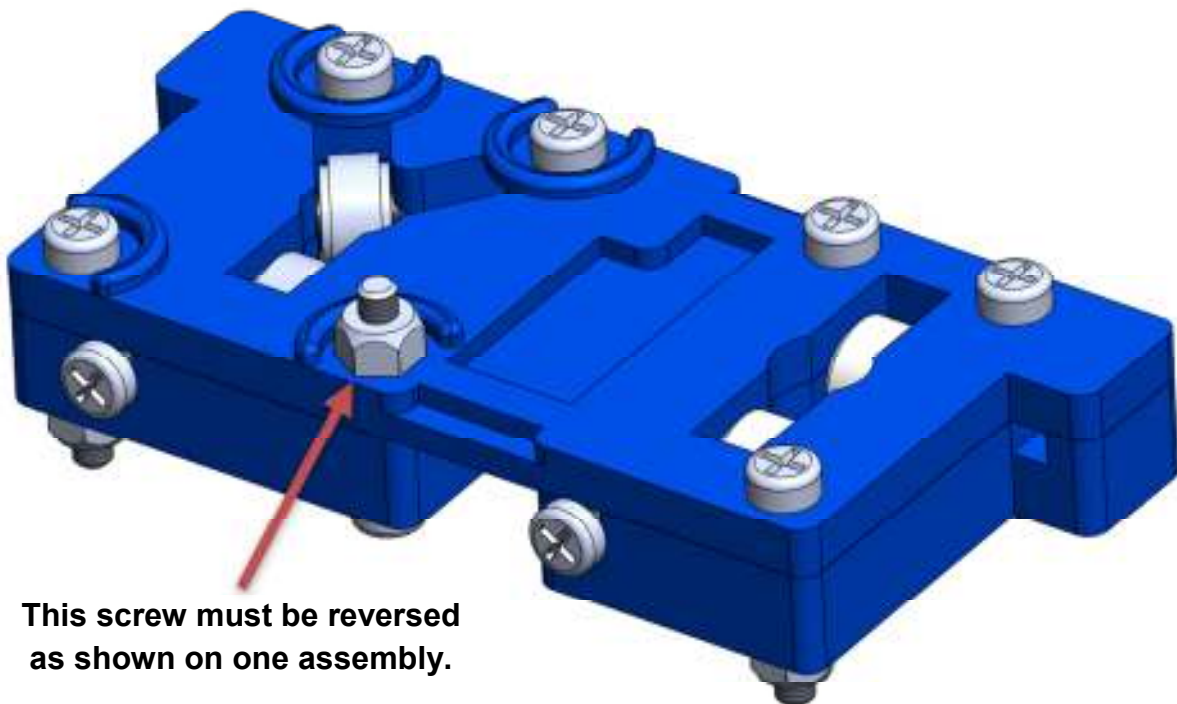
Note:

- If you have purchased the optional metal ball bearings, replace **Plastic Bearings (#71505)** with the metal bearings in the following steps.
- Test bearings during and after assembly for smooth motion. They should turn smoothly with little resistance.

5.1 - X Axis (Extruder) Bearing Sub-assembly

Please refer to *Figure 5.2* for part identification.

Figure 5.1 - X Axis Bearing Sub-Assembly



Tools needed:

- No 1 or No 2 Phillips screwdriver
- 1/4" wrench
- hobby knife to trim any molding flash from plastic parts
- electric drill and 1/8" drill bit

The mounting 1/8" holes on the **Triple Bearing Supports (#71514)**, **Double Bearing Supports (#71517)**, and **Combo Bearing Cover (#71519)** may require reaming with a 1/8" drill bit to allow the cap screws to insert easily.

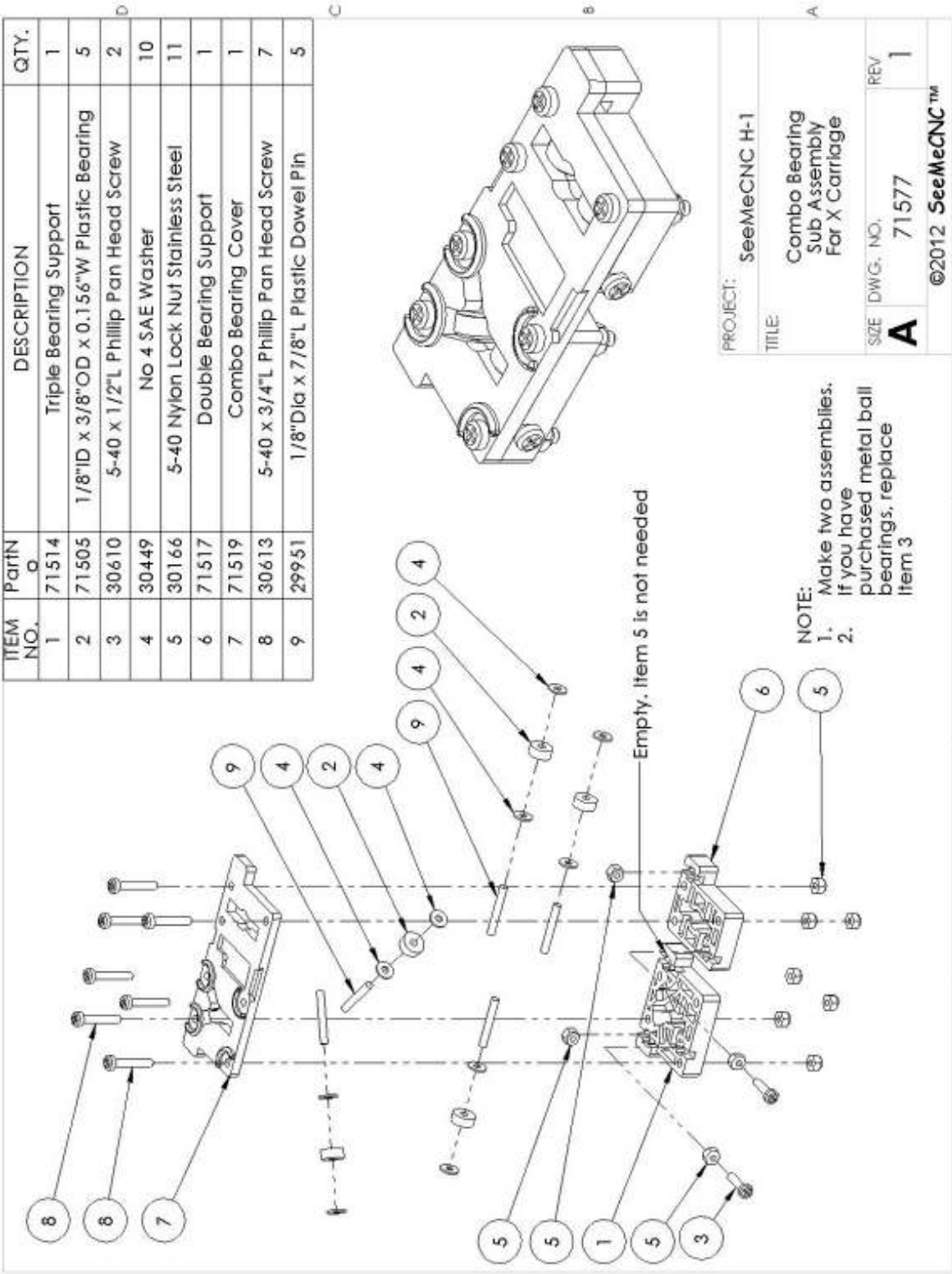
1. Assemble ten sets of **Bearings (#71505 or optional metal bearings)** onto their **Dowel Pins (#29951)** with a **No 4 Washer (#30449)** on each side of the bearing. Center the Bearing on the Dowel Pin.

Tip: The Dowel Pins can be a tight fit in the bearings. Slightly taper one end with 400 grit sandpaper and use a little light machine oil to help press it into the bearing.

Tip: While you're at it, go ahead and assemble all thirty-two sets Bearings, Washers and Dowel Pins used in upcoming steps.

2. Insert three Bearing assemblies into the **Triple Bearing Support (#71514)**. Note that one of the angled Bearing assemblies is recessed slightly below the other so their shafts (Dowel Pins) do not collide.
3. Insert two Bearing assemblies into the **Double Bearing Support (#71517)**.
4. Thread a **5-40 Nylon Lock Nut (#30166)** onto a **5-40 x 1/2" Phillips Head Pan Screw (#30610)** until about 1/16" of threads protrude past the nut.
5. Place this screw assembly into the slot provided in the Triple Bearing Support (see *Figure 5.2* for details).
6. Place a 5-40 Nylon Lock Nut in the slot in the Triple Bearing Support opposite the screw assembly.
7. Place the **Combo Bearing Cover (#71519)** over the Triple Bearing Support.
8. Using four **5-40 x 3/4" Phillips Pan Head Screws (#30613)** secure the cover to the support. Insert the screws from the cover side. Make sure the screw assembly (from step 4) and nut (from step 6) are properly captured in their slots. Tighten the screws.
9. Repeat step 4 for the other 5-40 x 1/2" Phillips Pan Head Screw and Nylon Lock Nut.
10. Place this screw assembly into the slot provided in the Double Bearing Support (see *Figure 5.2* for details).
11. Place a 5-40 Nylon Lock Nut in the slot provided in the Double Bearing Support.
12. Place the Combo Bearing Cover assembly over the Double Bearing Support.
13. Using three 5-40 x 3/4" Phillips Pan Head Screws secure the cover to the support. Insert the screws from the cover side. Make sure the screw assembly (from step 9) and nut (from step 11) are properly captured in their slots. Tighten the screws.
14. Repeat steps 2 through 13 to build the second Y Axis Table Bearing Sub-assembly. Make sure to reverse the screw indicated in *Figure 5.1 – X Axis Bearing Sub-assembly*.

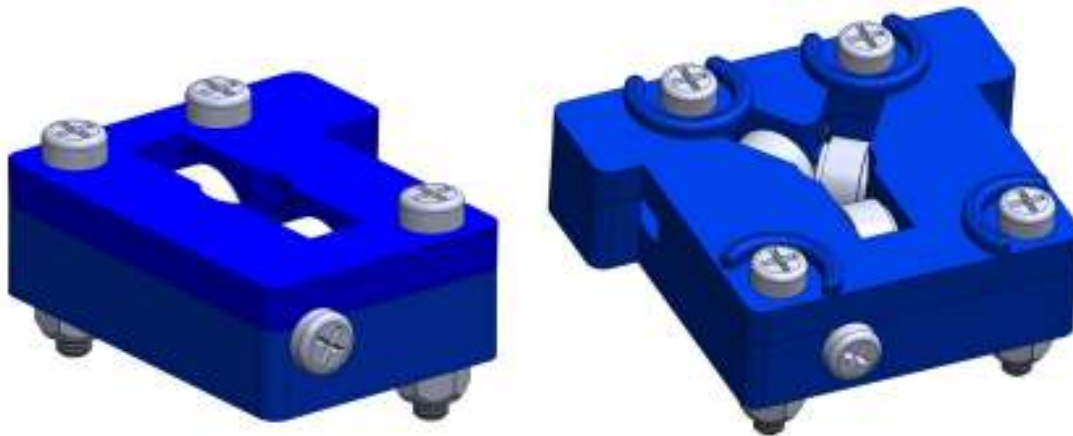
Figure 5.2



5.2 - Y Axis (Table) Bearing Sub-assemblies

Please refer to *Figure 5.4* and *Figure 5.5* for part identification.

Figure 5.3 - Double (left) and Triple (right) Bearing Sub-assemblies



Tools needed:

- No 1 or No 2 Phillips screwdriver
- 1/4" wrench
- hobby knife to trim any molding flash from plastic parts
- electric drill and 1/8" drill bit

The mounting 1/8" holes on the **Triple Bearing Supports (#71514)**, **Double Bearing Supports (#71517)**, **Triple Bearing Cover (#71516)**, and **Double Bearing Cover (#71511)** may require reaming with a 1/8" drill bit to allow the cap screws to insert easily.

1. Assemble ten sets of **Bearings (#71505 or optional metal bearings)** onto their **Dowel Pins (#29951)** with a **No 4 Washer (#30449)** on each side of the bearing. Center the Bearing on the Dowel Pin.
2. Insert two Bearing assemblies into the **Double Bearing Support (#71517)**.
3. Thread a **5-40 Nylon Lock Nut (#30166)** onto a **5-40 x 1/2" Phillips Pan Head Screw (#30610)** until about 1/16" of threads protrude past the nut.
4. Place this screw assembly into the slot provided in the Double Bearing Support (see *Figure 5.4* for details).
5. Place a 5-40 Nylon Lock Nut in the slot in the Double Bearing Support opposite the screw assembly.
6. Place the **Double Bearing Cover (#71518)** over the Double Bearing Support.
7. Using three **5-40 x 3/4" Phillips Pan Head Screws (#30613)** secure the cover to the support. Insert the screws from the cover side. Make sure the screw assembly (from step 3) and nut (from step 5) are properly captured in their slots. Tighten the screws.
8. Repeat steps 2 to 7 to build the second Double Bearing Sub-assembly except insert the three 5-40 x 3/4" Phillips Head Pan Screws (step 7) from the Bearing Support side.

9. Insert three Bearing assemblies into the **Triple Bearing Support (#71514)**. Note that one of the angled Bearing assemblies is recessed slightly below the other so their shafts (Dowel Pins) do not collide.
10. Thread a 5-40 Nylon Lock Nut onto a 5-40 x 1/2" Phillips Pan Head Screw until about 1/16" of threads protrude past the nut.
11. Place this screw assembly into the slot provided in the Triple Bearing Support (see *Figure 5.5* for details).
12. Place two 5-40 Nylon Lock Nuts in the slots in the Triple Bearing Support opposite the screw assembly.
13. Place the **Triple Bearing Cover (#71516)** over the Triple Bearing Support.
14. Using four 5-40 x 3/4" Phillips Pan Head Screws secure the cover to the support. Insert the screws from the cover side. Make sure the screw assembly (from step 4) and nut (from step 6) are properly captured in their slots. Tighten the screws.
15. Repeat steps 9 to 14 to build the second Triple Bearing Sub-assembly except insert the four 5-40 x 3/4" Phillips Pan Head Screws (step 14) from the Bearing Support side.

Figure 5.4

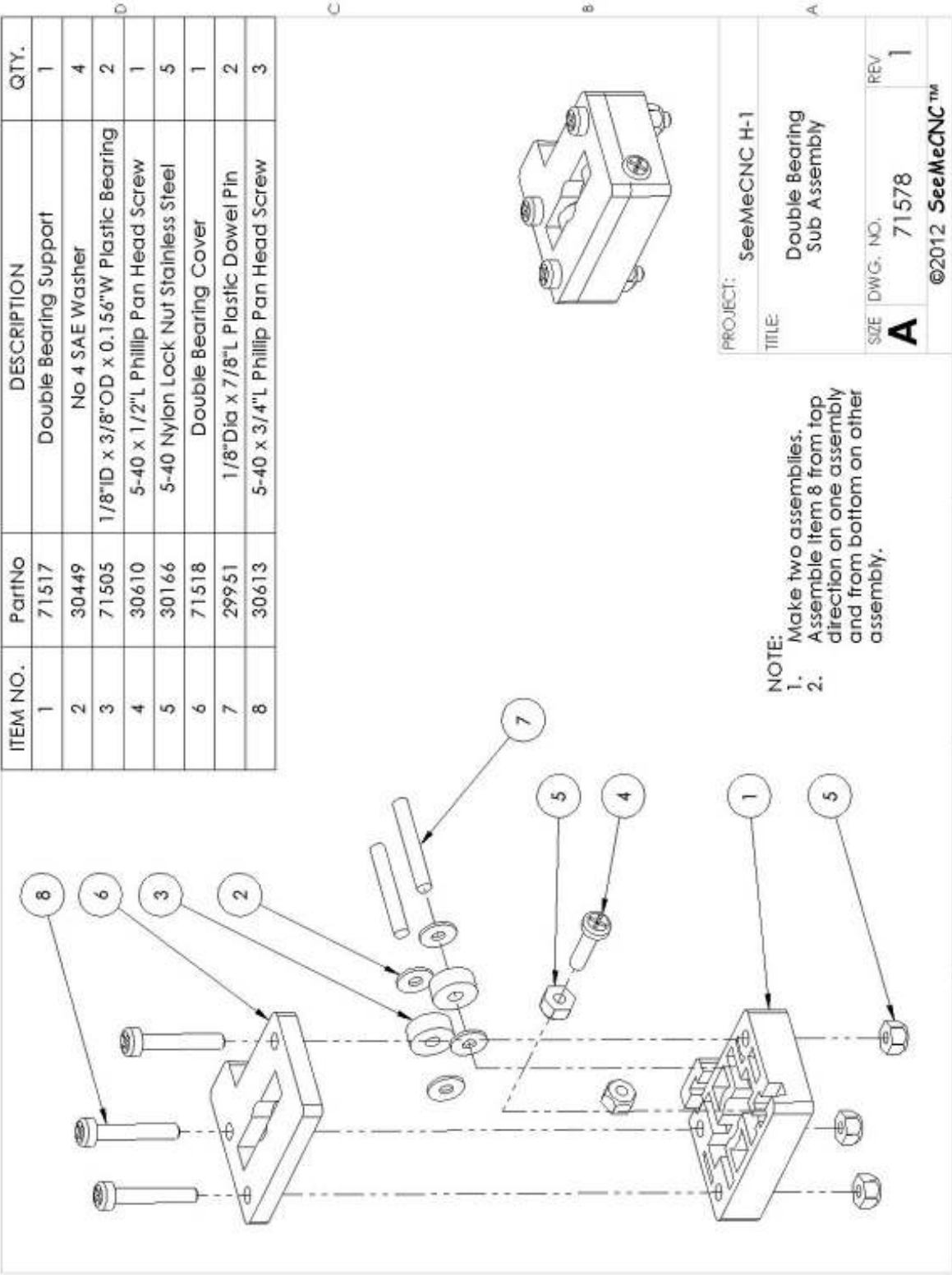
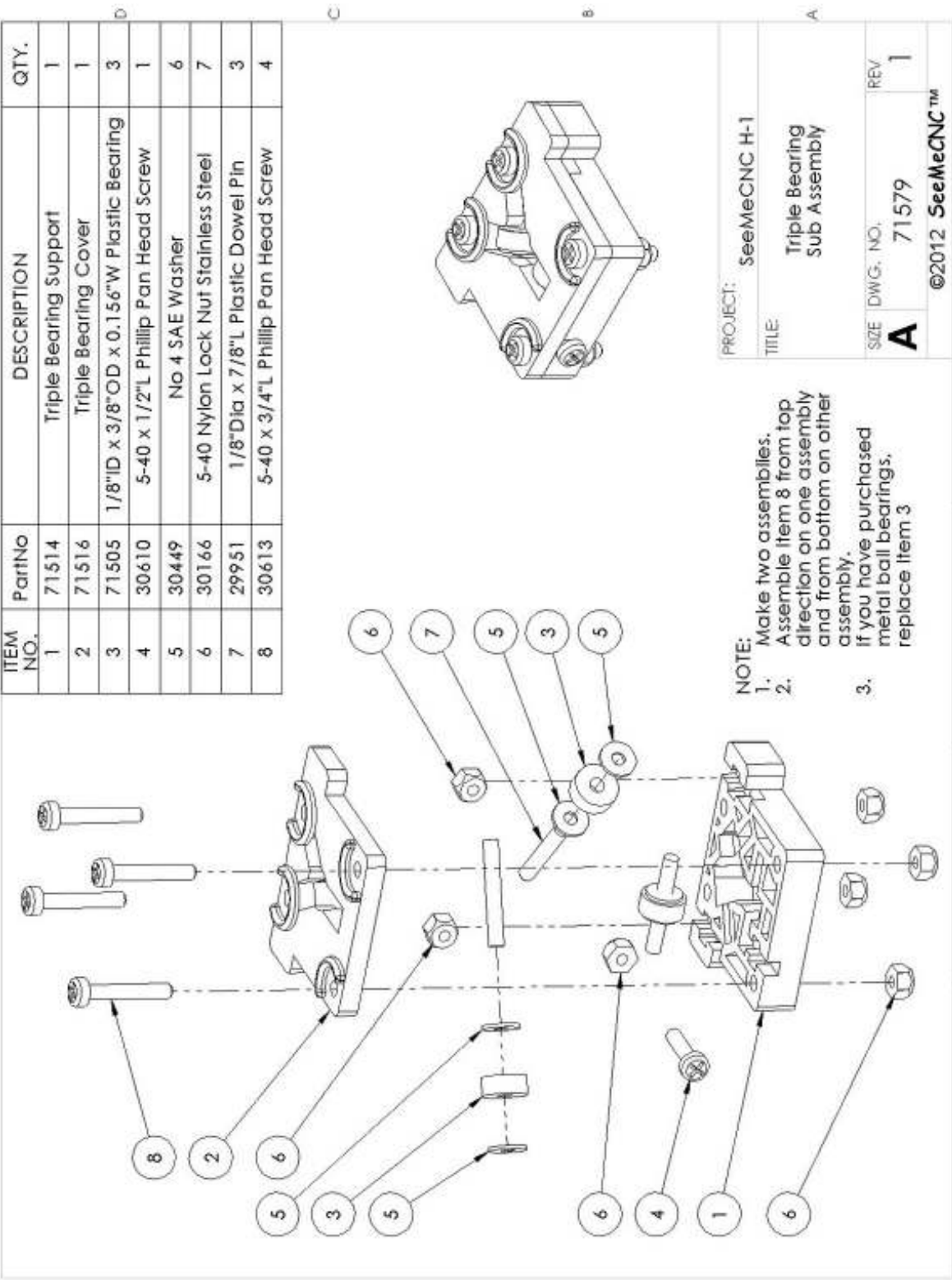


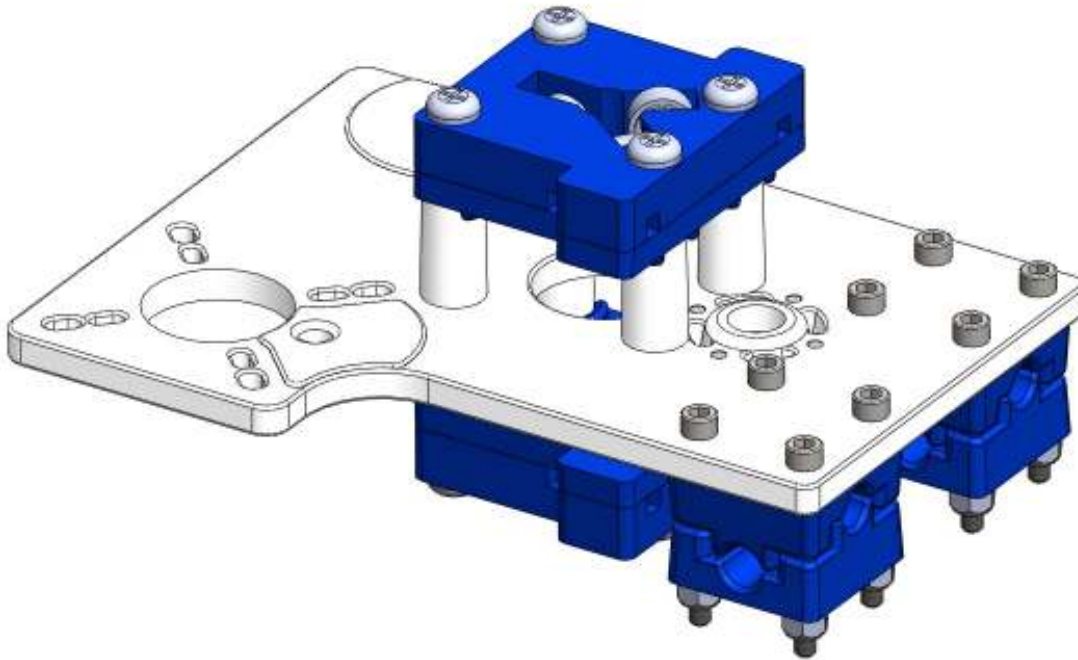
Figure 5.5



5.3 - Z Axis Bearing Sub-assembly (X Motor Mount)

Please refer to *Figure 5.7* for part identification.

Figure 5.6 - Z Axis Bearing Sub-assembly



Tools needed:

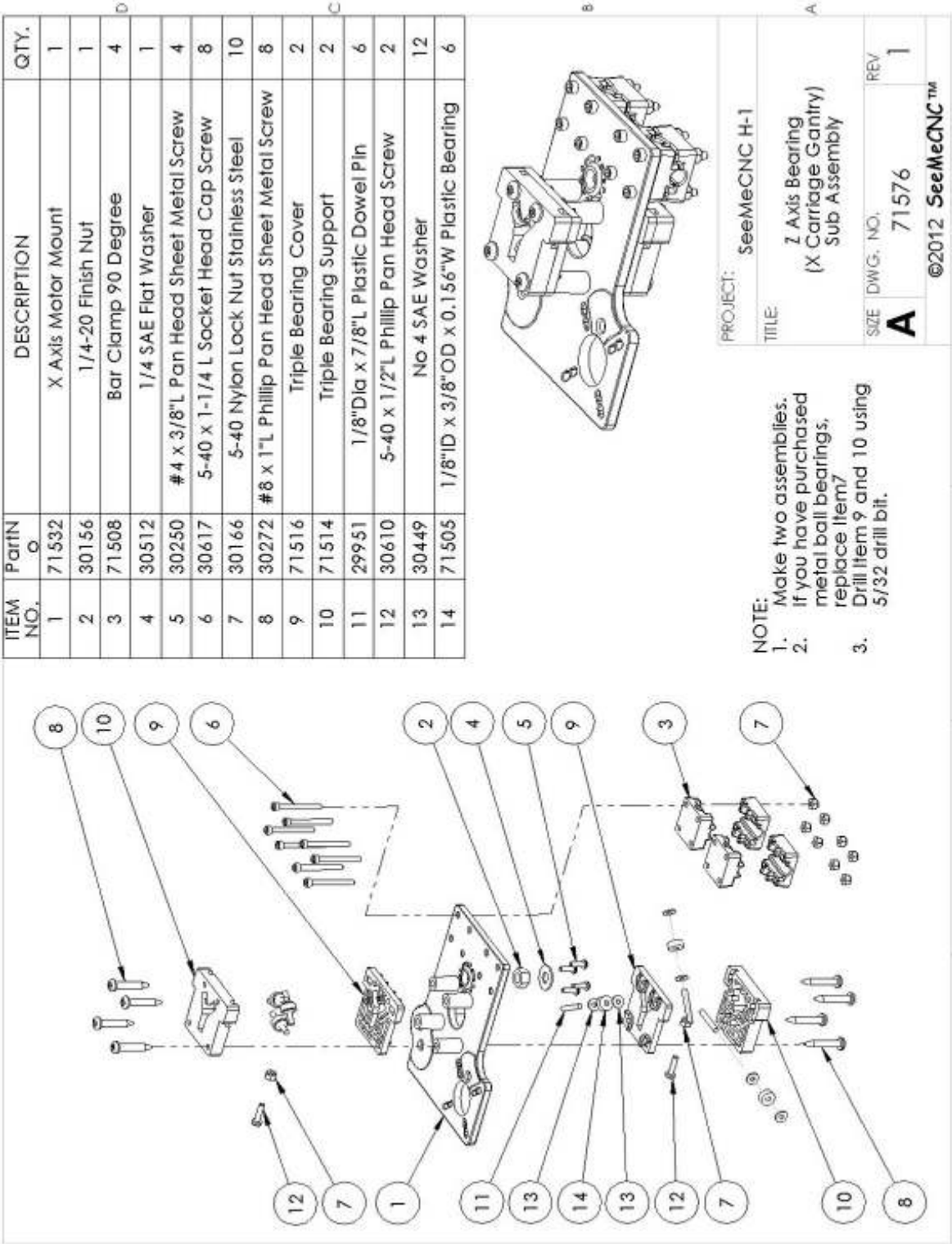
- No 1 and No 2 Phillips screwdriver
- 1/4" wrench
- hobby knife to trim any molding flash from plastic parts
- electric drill and 1/8" and 5/32" drill bit

The 1/8" holes on the **Bar Clamps (#71508)** may require reaming with a 1/8" drill bit to allow the cap screws to insert easily.

1. Assemble twelve sets of **Bearings (#71505 or optional metal bearings)** onto their **Dowel Pins (#29951)** with a **No 4 Washer (#30449)** on each side of the bearing. Center the Bearing on the Dowel Pin.
2. Insert a **1/4"-20 Nut (#30156)** into the hexagonal opening in the bottom of one of the **X Axis Motor Mounts (#71532)**.
3. Place a **1/4" Flat Washer (#30512)** over the nut.
4. Secure the washer with four **#4 x 3/8" Pan Head Sheet Metal Screws (#30250)**. Tighten these screws.
5. Repeat steps 2 through 4 for the other X Axis Motor Mount.
6. Assemble two **Bar Clamps (#71508)**.
7. Refer to *Figure 5.6 - Z Axis Bearing Sub-assembly* to orient the Bar Clamp properly and loosely attach it to the X Axis Motor Mount with four **5-40 x 1-1/4" Socket Head Cap Screws (#30617)** and four **5-40 Nylon Lock Nuts (#30166)**. The screws insert through

- the X Axis Motor Mount first. Make sure the Bar Clamp is aligned as shown in the drawing.
8. Repeat steps 6 and 7 to attach the second Bar Clamp to the X Axis Motor Mount.
 9. Insert three Bearing assemblies into the **Triple Bearing Support (#71514)**. Note that one of the angled Bearing assemblies is recessed slightly below the other so their shafts (Dowel Pins) do not collide.
 10. Thread a **5-40 Nylon Lock Nut (#30166)** onto a **5-40 x 1/2" Phillips Pan Head Screw (#30610)** until about 1/16" of threads protrude past the nut.
 11. Place this screw assembly into the slot provided in the Triple Bearing Support (see *Figure 5.7* for details).
 12. Place the **Triple Bearing Cover (#71516)** over the Triple Bearing Support.
 13. Hold the cover and support together and bore the four holes with a 5/32" drill through both the cover and support.
 14. Attach the bearing assembly to the four posts on one side of the X Axis Motor Mount with four 5-40 x 3/4" Phillips Pan Head Screws. Insert the screws from the support side (the cover has locator ridges to locate the bearing block on the posts) and align the bearing assembly as shown in the drawing. Make sure the screw assembly (from step 11) is properly captured in its slot. Tighten the screws.
 15. Repeat steps 9 through 14 to install the second bearing block on the other side of the X Axis Motor Mount.
 16. Repeat steps 6 through 15 to assemble the second Z Axis Sub-assembly.

Figure 5.7



Step 6 – Table Y Axis and Carriage Z Axis Assembly

Please refer to *Figure 6.5* for part identification.

Tools needed:

- No 1 or No 2 Phillips screwdriver
- 1/4" wrench
- 5/32" and 3/16" Allen wrenches
- 3/8" socket or 3/8" nut driver
- two 7/16" wrenches
- small square
- electric drill and 1/8" drill bit

Supplies:

- light machine oil

The 1/8" holes on the **Bar Clamps (#71508)** may require reaming with a 1/8" drill bit to allow the cap screws to insert easily.

Figure 6.1 - Table Y Axis and Carriage Z Axis Assembly

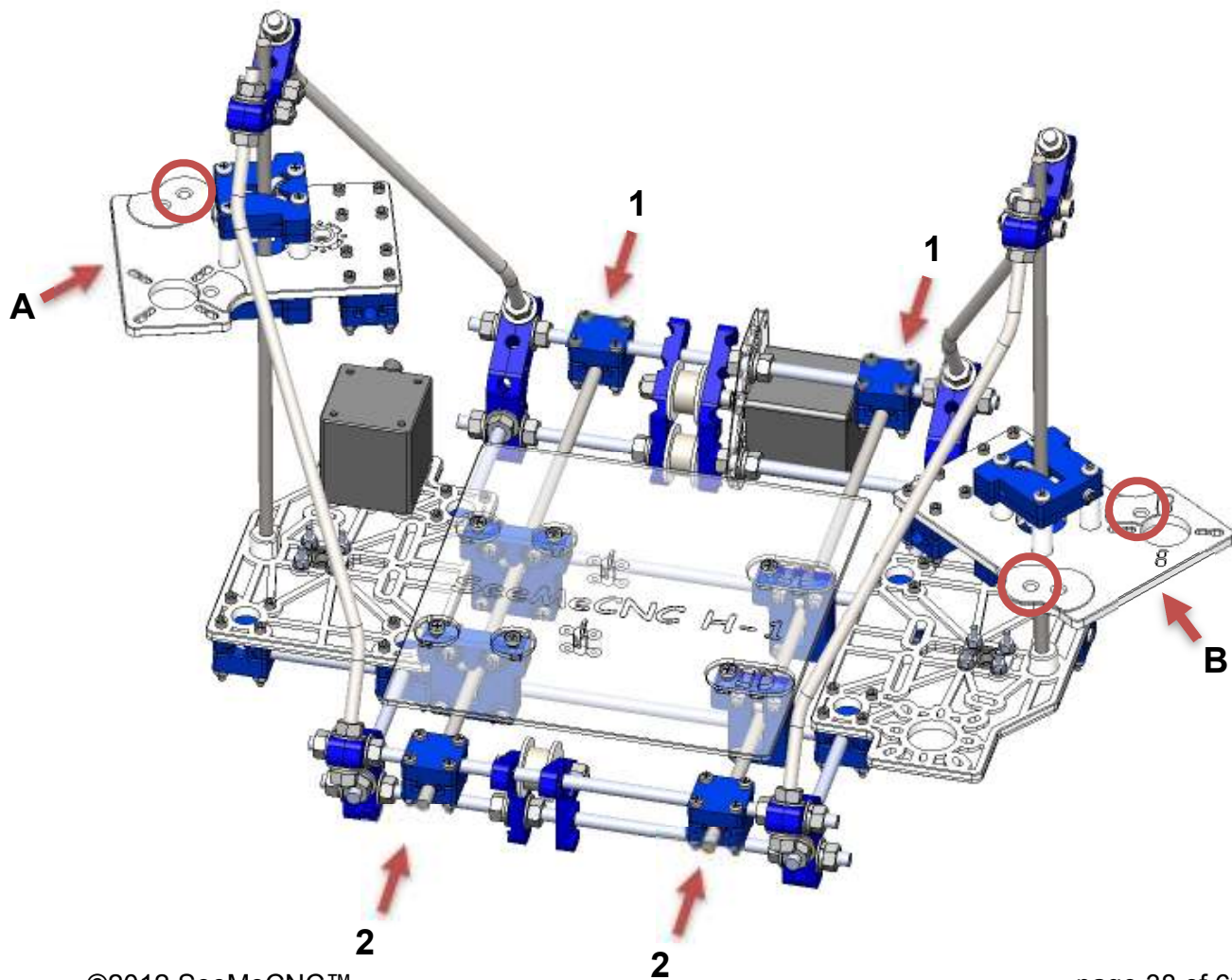
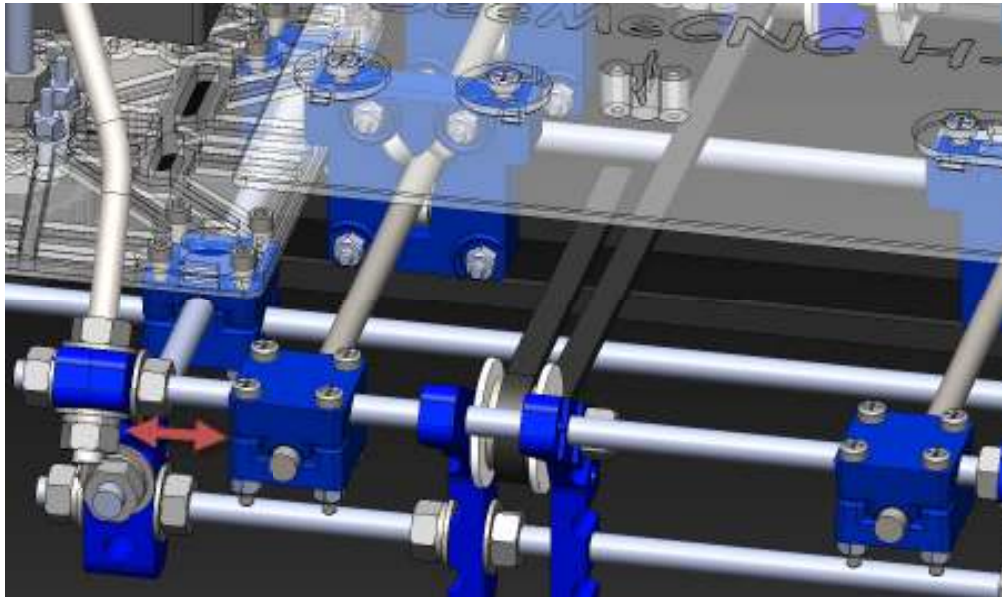


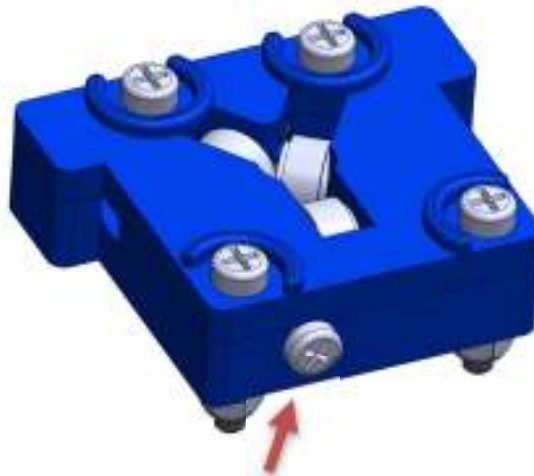
Figure 6.2 - Linear Rail Bar Clamp Position Detail

6.1 – Table Y Axis Assembly

1. Refer to *Figure 6.1 - Table Y Axis and Carriage Z Axis Assembly* to attach the two Double Bearing Sub-assemblies from step 5.2 to the right side of the **SeeMeCNC H-1 Table (#71529)** using two **5-40 x 1/2" Phillips Pan Head Screws (#30610)**. The "L" extension of the Double Bearing Sub-assembly should face to the left as shown. Note that the Double Bearing Sub-assemblies are mirror images of each other. The screw heads used to assemble them should face to the outside of the table. Tighten the screws.
2. Attach the two Triple Bearing Sub-assemblies from step 5.2 to the left side of the SeeMeCNC H-1 Table using four 5-40 x 1/2" Phillips Pan Head Screws. Note that the Triple Bearing Sub-assemblies are mirror images of each other. The screw heads used to assemble them should face to the outside of the table. The table has locator tabs that prevent them from installing incorrectly. Tighten the screws.
3. Loosely assemble four pairs of **Bar Clamps (#71508)** to the upper Threaded Rods at the front and rear of the machine. Refer to *Figure 6.1 - Table Y Axis and Carriage Z Axis Assembly* for location and orientation as indicated by the arrows labeled **1** and **2**. Use four **5-40 x 1" Phillips Pan Head Screws (#30615)** and four **5-40 Nylon Lock Nuts (#30166)** in each Bar Clamp. These must be able to move easily on the threaded rods to allow adjustment.
4. Insert the pair of **1/4" x 13-1/2" Linear Rails (#71503)** into the bearing sub-assemblies attached to the bottom of the SeeMeCNC H-1 Table. Lubricate each bearing with a drop of light oil.
5. Adjust the bearing adjustment screw on the Triple Bearing Sub-assembly to remove wiggle yet allow the Linear Rail to slide smoothly through it. The adjustment screw is shown in the *Figure 6.3 - Bearing Adjustment Screw*.
6. Position the base assembly with the Front Base Sub-Assembly from *Step 1 - Front Base Frame Sub-assembly* facing you.

7. Align the table with the Linear Rails inserted with the Triple Bearing Sub-assembly on the left – you should be able to read the text molded into the table.
8. Insert the ends of the two Linear Rails into the Bar Clamps on the Rear Base Sub-Assembly indicated by the arrows labeled **1** in the *Table Y Axis and Carriage Z Axis Assembly* drawing.
9. Push the rails about 2" through the Bar Clamps and slide their ends nearest you into the Bar Clamps on the Front Base Sub-assembly indicated by the arrows labeled **2** in *Figure 6.1 - Table Y Axis and Carriage Z Axis Assembly*.
10. Center the rails front to back so the same amount of rail protrudes from the Bar Clamp at each end.

Figure 6.3 - Bearing Adjustment Screw



11. Position the table in the center of the base.
12. Slide the table gently front-to-back to make sure it does not interfere with the base assembly. If it does, move it left or right slightly until it slides freely without rubbing.
13. Tighten the four screws that fasten the Bar Clamp at the left front of the base.
14. Measure the distance between the Bar Clamps as indicated by the double-headed arrow in *Figure 6.2 - Linear Rail Clamp Position*.
15. Position the Bar Clamp at the left rear of the base so it has the same gap measured in step 14. Also, make sure this Linear Rail is square to the Z Axis Base Sub-assembly crossbars. If it is not, you can slide the Bar Clamp a little left or right until the assembly is square.

Tip: Use a small square to check your work.

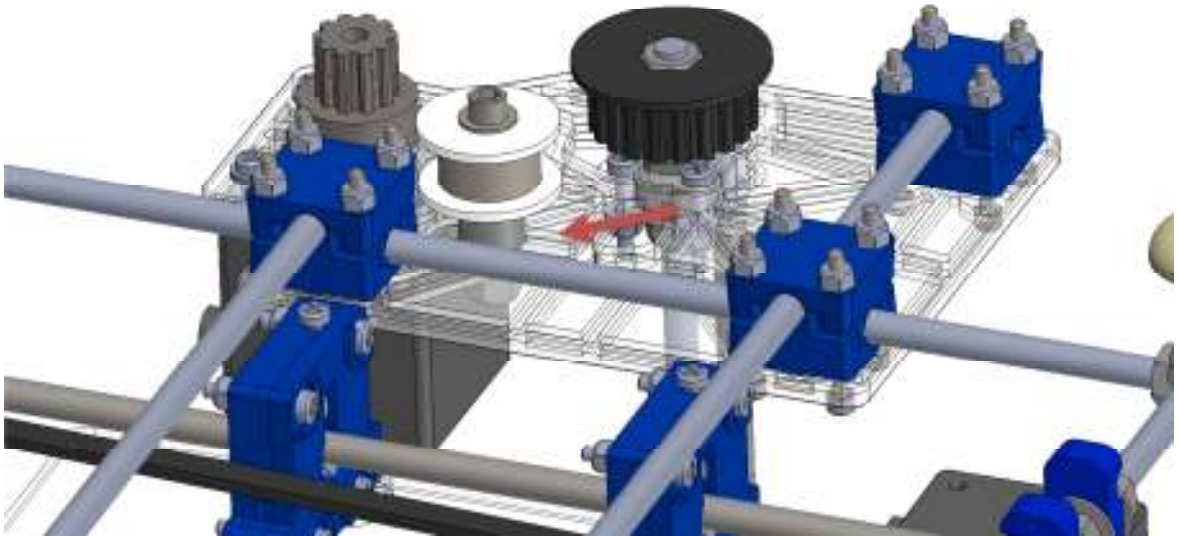
16. Tighten the four screws that fasten the Bar Clamp at the left rear of the base.
17. Slide the table all the way forward.
18. Position the Bar Clamp at the right front so the Linear Rail is centered in the Double Bearing Sub-assembly attached to the table.
19. Tighten the four screws that fasten the Bar Clamp at the right front of the base.
20. Slide the table all the way to the rear.
21. Position the Bar Clamp at the right rear so the Linear Rail is centered in the Double Bearing Sub-assembly attached to the table.

22. Tighten the four screws that fasten the Bar Clamp at the right rear of the base.
23. Adjust the Bearing Adjustment screws on the Double Bearing Sub-assemblies to remove wiggle but allow the table to run smoothly on the Linear Rails.
24. Attach the Y axis **Stepper Motor (#26501)** to the clear plastic Stepper Motor Mount on the Rear Base Frame Sub-assembly using four **M3-.05 x 10mm Phillips Pan Head Screws (#30318)** and eight **No 4 Washers (#30449)**. Two washers go on each screw and then the screw is inserted through the Stepper Motor Mount and threads into the Stepper Motor mounting holes. Face the wires coming out of the motor towards the back of the machine.

Tip: You can loosen the screws that position the Stepper Motor Mount and roller assembly to allow you to reach the screws. The final position of these components will be adjusted later.

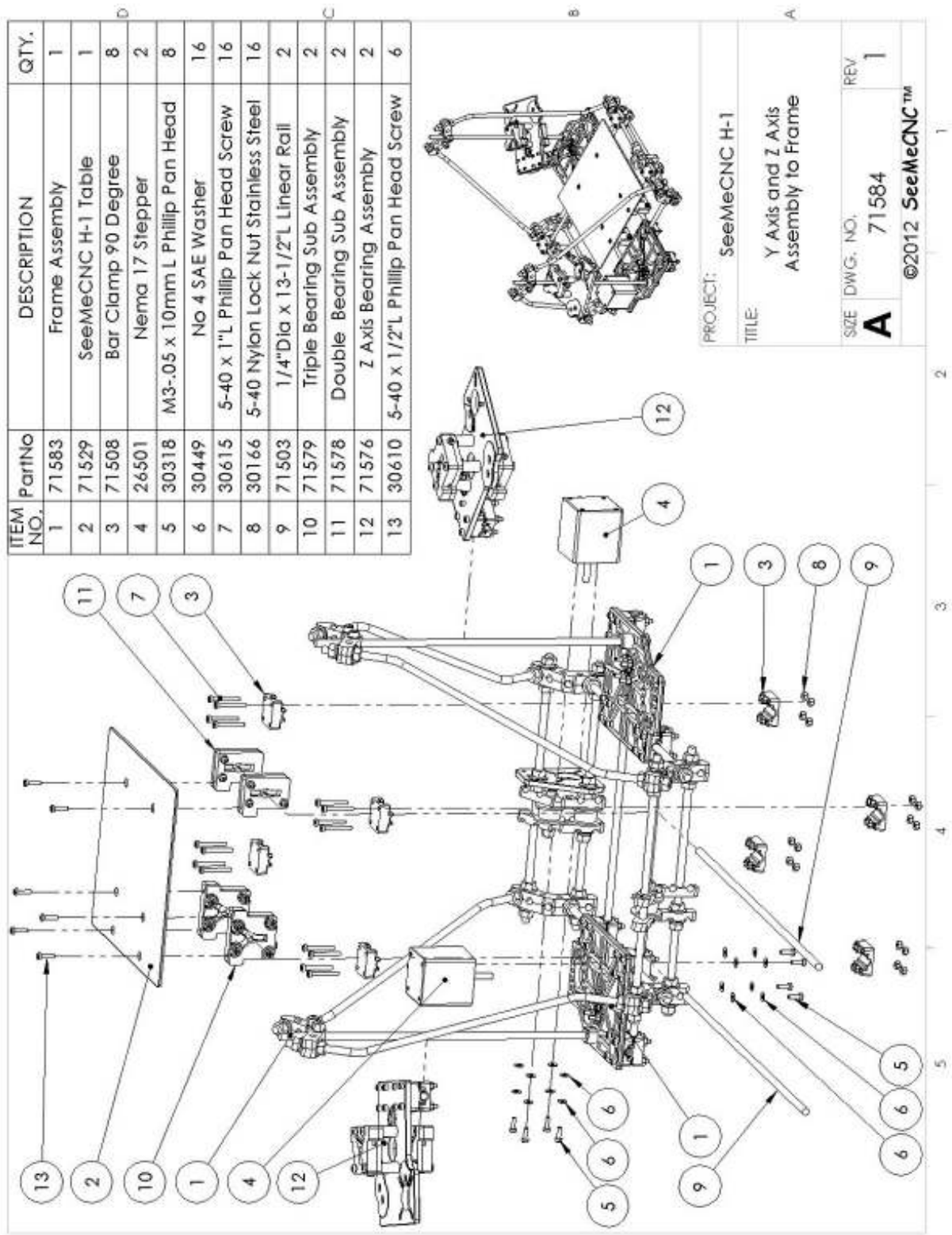
1. - Carriage Z Axis Assembly

1. Attach the Z axis **Stepper Motor (#26501)** to the clear plastic Z Axis Bearing Plate on the left side of the Base Frame Sub-assembly using four **M3-.05 x 10mm Phillips Pan Head Screws (#30318)** and eight **No 4 Washers (#30449)**. Two washers go on each screw and then the screw is inserted through the Z Axis Bearing Plate and threads into the Stepper Motor mounting holes. Face the wires coming out of the motor towards the rear of the machine.
2. Remove the Z Axis Linear Rail from the left side of the machine. This was installed in step 4.1-24.
3. Slide the Linear Rail into the two Triple Bearing Supports in one of the Z Axis Bearing Assemblies completed in step 5.3. Lubricate the bearing with light machine oil.
4. Adjust the Bearing Adjustment Screws so the Linear Rail slides smoothly without wiggling or binding.
5. Refer to *Figure 6.12 - Table Y Axis and Carriage Z Axis Assembly* and orient the Z Axis Bearing Assembly with the Linear Rail installed as shown by the arrow labeled **A**.
6. Insert the upper end of the Linear Rail into the Bar Clamp at the top of the base.
7. Insert the lower end of the Linear Rail into the Z Axis Bearing Plate. Push the lower end of the Linear Rail through the opening until it is flush with the bottom of the opening.
8. Repeat steps 2 through 7 to install the right side Z Axis Bearing Assembly. Refer to the arrow labeled **B** in *Figure 6.1 - Table Y Axis and Carriage Z Axis Assembly* for correct orientation.
9. Install a roller assembly on the left Z Axis Bearing Assembly with a **10-32 x 1 1/2" Socket Head Screw (#29995)**, two **No 8 Flat Washers (#30500)**, and **10-32 Nylon Lock Nut (#30160)** to install the two **Plastic Washers (#71511)**, **Idler (#71543)**, and **Roller (#71535)** at the circled location shown in *Figure 6.1 - Table Y Axis and Carriage Z Axis Assembly*. You should tighten this screw using an Allen wrench and 3/8" wrench.
10. Repeat step 9 to install two roller assemblies on the right Z Axis Bearing Assembly at the circled locations shown in *Figure 6.1 - Table Y Axis and Carriage Z Axis Assembly*.

Figure 6.4 - Z Axis Idler

11. Install the idler roller assembly on the bottom of the left Z Axis Bearing Plate in the long slot nearest the Stepper Motor installed in step 1. Use a 10-32 x 1-1/2" Socket Head Cap Screw, two No 8 Flat Washers, and a 10-32 Nylon Lock Nut. Use a Roller (#71535) as a standoff to raise the idler assembly as shown in *Figure 6.4 - Z Axis Idler*.

Figure 6.5



Step 7 – Z Axis and X Carriage Installation

Please refer to *Figure 7.2* for part identification.

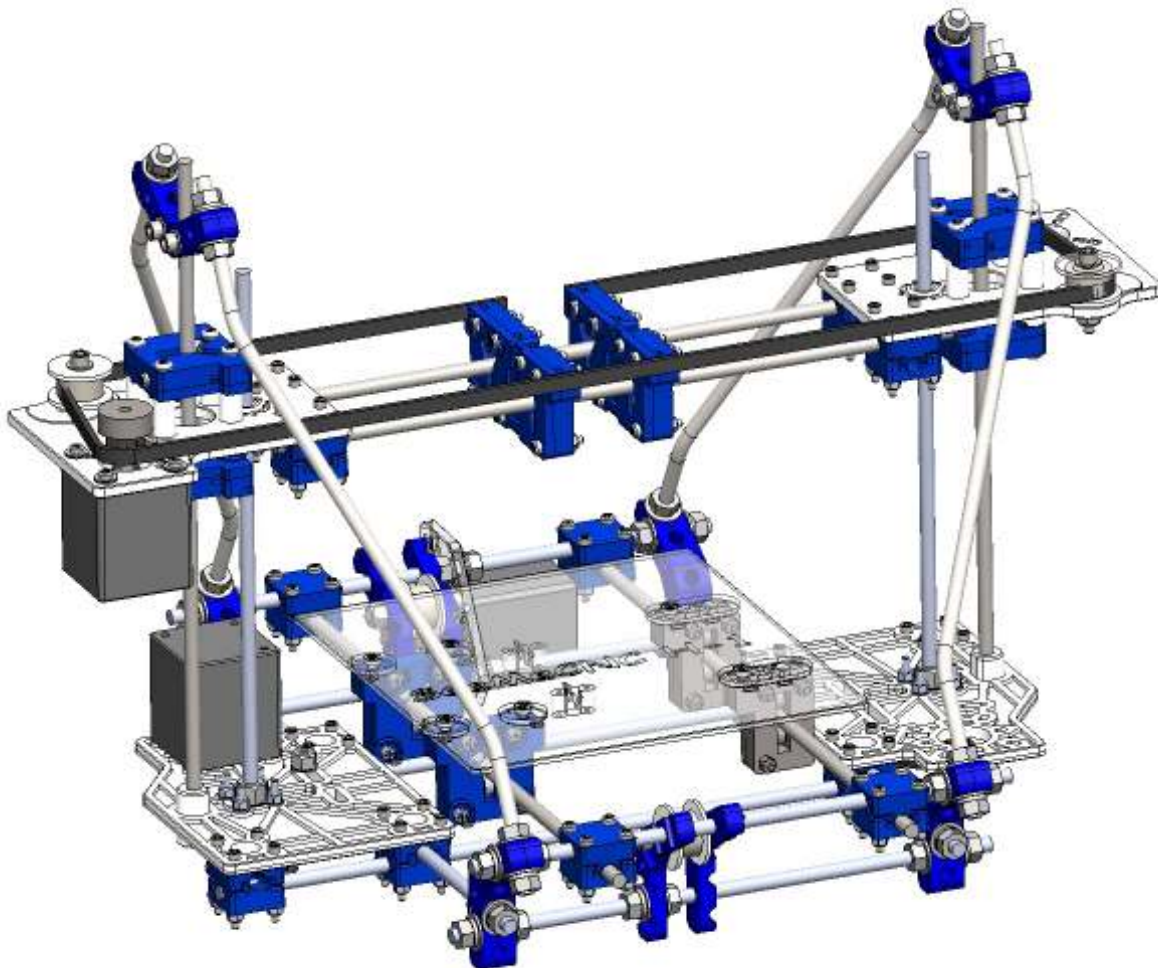
Tools needed:

- No 1 or No 2 Phillips screwdriver
- 1/4", 3/8" and two 7/16" wrenches
- 5/32" and 3/16" Allen wrenches
- small square

Supplies:

- light machine oil

Figure 7.1 - Z Axis and X Carriage



7.1 - Z Axis Screw Assembly

1. Screw one of the **Z Axis Screws (#71504)** into the captive 1/4-20 Nut in the left Z Axis Bearing Assembly, starting from the top and screwing it about half way in.
2. Thread a **1/4-20 Nylon Lock Nut (#30157)** onto the lower end of the Z Axis Screw with the flat face towards the end of the screw. Position it about 3" from the end of the Screw.
3. Insert the lower end of the Z Axis Screw into the bearing in the Z Axis Bearing Plate.
4. Thread two **1/4-20 Nuts (#30156)** onto the lower end of the Z Axis Screw. Position them about 2" from the end of the Z Axis Screw.
5. Insert a 1/4-20 Nylon Lock Nut into the hexagonal recess in one of the **Acetal Timing Pulleys (#71545)** with its flat face against the timing pulley.
6. Thread the Acetal Timing Pulley with its 1/4-20 Nylon Lock Nut onto the bottom of the Z Axis Screw with the nut and pulley flange facing down. Allow about 1/8" of the Z Axis Screw to protrude past the nut.
7. Thread the two 1/4-20 Nuts on the Timing Pulley side of the Z Axis Screw down to the Timing Pulley and tighten them in place with two 7/16" wrenches.
8. Push the Timing Pulley up until the nuts contact the bearing.
9. Thread the 1/4-20 Nylon Lock Nut above the Z Axis Bearing Assembly down to the bearing.
10. Snug the lock nut against the bearing. The Z Axis Screw should turn freely but not have any excess play or backlash.
11. Repeat steps 1 through 10 to install the Z Axis Screw on the right side of the machine.

7.2 - X Carriage Assembly

1. Raise or lower the left side Z Axis Bearing Assembly by turning the Z Axis Screw until it is about 1" above the right side Z Axis Bearing Assembly.
2. Insert one of the **1/4" x 12" Linear Rails (#71520)** into the triple bearing side of both X Axis Bearing Sub-assemblies (completed in step 5.1). Make sure they are both oriented the same.

Note: See the comment in step 5.1 – the bearing assembly with the reversed screw head must be on the left side (facing the machine) so the reversed screw's head is on the inside. Lubricate the bearings with light machine oil.

3. Adjust the bearing adjustment screws on the triple bearings to remove wiggle yet allow the Linear Rail to slide freely.
4. Insert the second Linear Rail into the double bearing side of both X Axis Bearing Sub-assemblies. Do not adjust the bearing adjustment yet but do lubricate the bearings with light machine oil.
5. Slide the end of the Linear Rail inserted in the double bearing into the front-most Bar Clamp on the left side Z Axis Bearing Assembly.
6. Insert the other Linear Rail into the rear-most Bar Clamp.
7. Lower the left side Z Axis Bearing Assembly until it is level with the right side Z Axis Bearing Assembly.

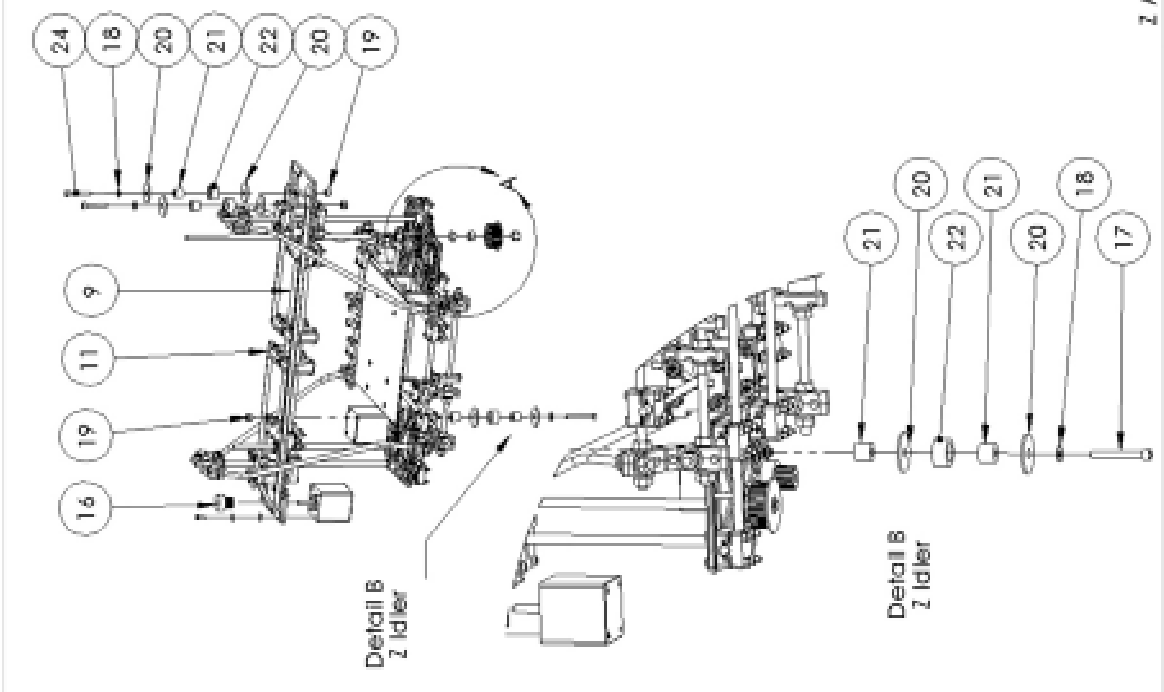
8. Slide the other ends of the Linear Rails into the Bar Clamps on the right side Z Axis Bearing Assembly.
9. Center the Linear Rails so the same amount protrudes from each end.
10. Tighten the eight screws that secure the left side Bar Clamps.
11. Measure the distance between the Z Axis Screws at their lowest point (just above the lock nuts that secure them to the lower bearing).
12. Slide the Linear Rails in their Bar Clamps until the distance between the top of the Z Axis Screws is the same as the distance you measured at the bottom.
13. Tighten the eight screws that secure the Linear Rails in the Bar Clamps. Make sure the Z Axis Bearing Sub-assembly is square to the Linear Rails.
14. Check that the Z Axis Screw is square to the Z Axis Base Sub-assembly in the “X” direction (left to right). If it isn’t check your work in steps 10 and 11.
15. Refer to *Figure 4.2 - Base Assembly Dimensions Top View* and carefully tighten the four socket head cap screws (two on each side) that attach the Bar Clamps to the Z Axis Linear Rail.
16. Carefully tighten the 1/4-20 Nuts that attach the Bar Clamp to the tops of the bent rods on the left side of the machine. Make sure the Z Axis Screw is square in the “Y” (front to back) direction.

Tip: You may have to slightly bend and tweak the bent upright Threaded Rods (#71523) to keep everything square as you tighten the nuts.

17. Repeat step 16 for the four nuts on the right side of the machine.
18. Attach the X axis **Stepper Motor (#26501)** to the left side Z Axis Bearing Sub-assembly using four **M3-.05 x 10mm Phillips Pan Head Screws (#30318)** and eight **No 4 Washers (#30449)**. Two washers go on each screw and then the screw is inserted through the Z Axis Bearing Plate and threads into the Stepper Motor mounting holes. The motor mounts from below with its shaft facing up. Face the wires coming out of the motor towards the back of the machine.

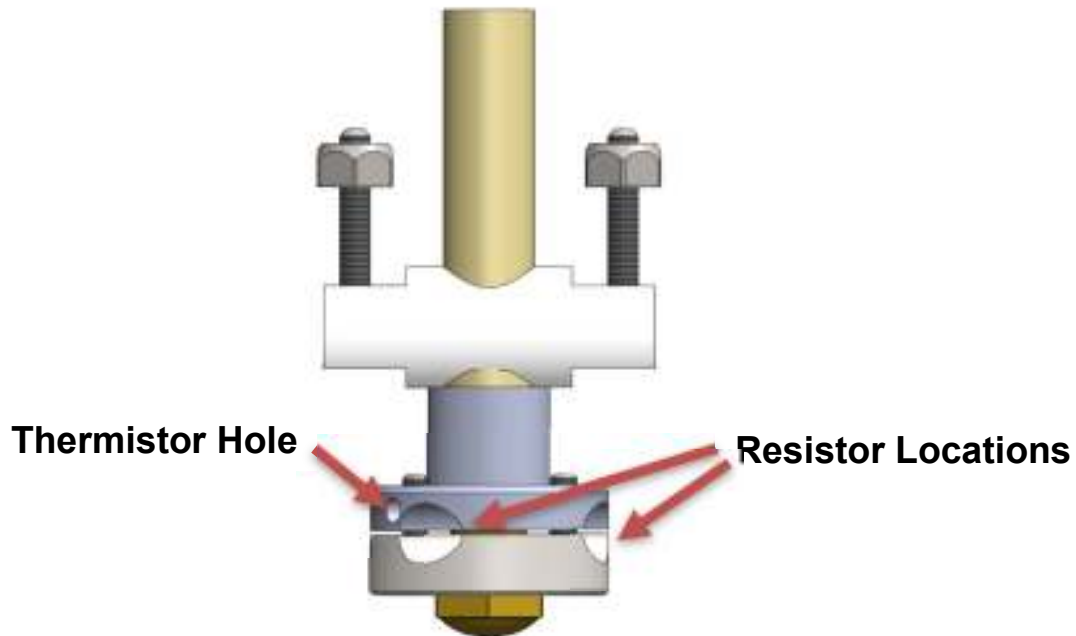
Figure 7.2

ITEM NO.	PartNo	DESCRIPTION	QTY.
11	71577	Combo Bearing Sub Assembly	2
12	30157	1/4-20 Nylon Lock Nut Stainless Steel	4
13	71504	1/4-20 x 10-1/2" L Threaded Rod	2
14	71545	Timing Pulley 200XL x 1.273PD x 1/4" Shaft	2
15	30156	1/4-20 Finish Nut	4
16	71544	Timing Pulley 200XL x 0.637PD x 5mm Shaft	3
17	29995	10-32 x 1-1/2" SHCS Stainless Steel	1
18	30500	#8 SAE Flat Washer	5
19	30160	10-32 Nylon Lock Nut Stainless Steel	4
20	71511	1/4" ID x 1-1/16" OD x 1/16" Thick Plastic Washer	8
21	71535	3/16" ID x 1/2" OD x 0.46" L Plastic Roller	5
22	71543	1/2" ID x 3/4" OD x 0.4" Thick Idler	4
24	29994	10-32 x 1-1/4" Socket Head Cap Screw	3



Step 8 – Hot End Barrel Assembly

Figure 8.1 - Hot End Barrel Assembly



Refer to *Figure 8.2*, you should find the Hot End Barrel pre-assembled.

Tools needed:

- scissors
- 7/16" wrench
- No 1 Phillips screw driver

Supplies needed:

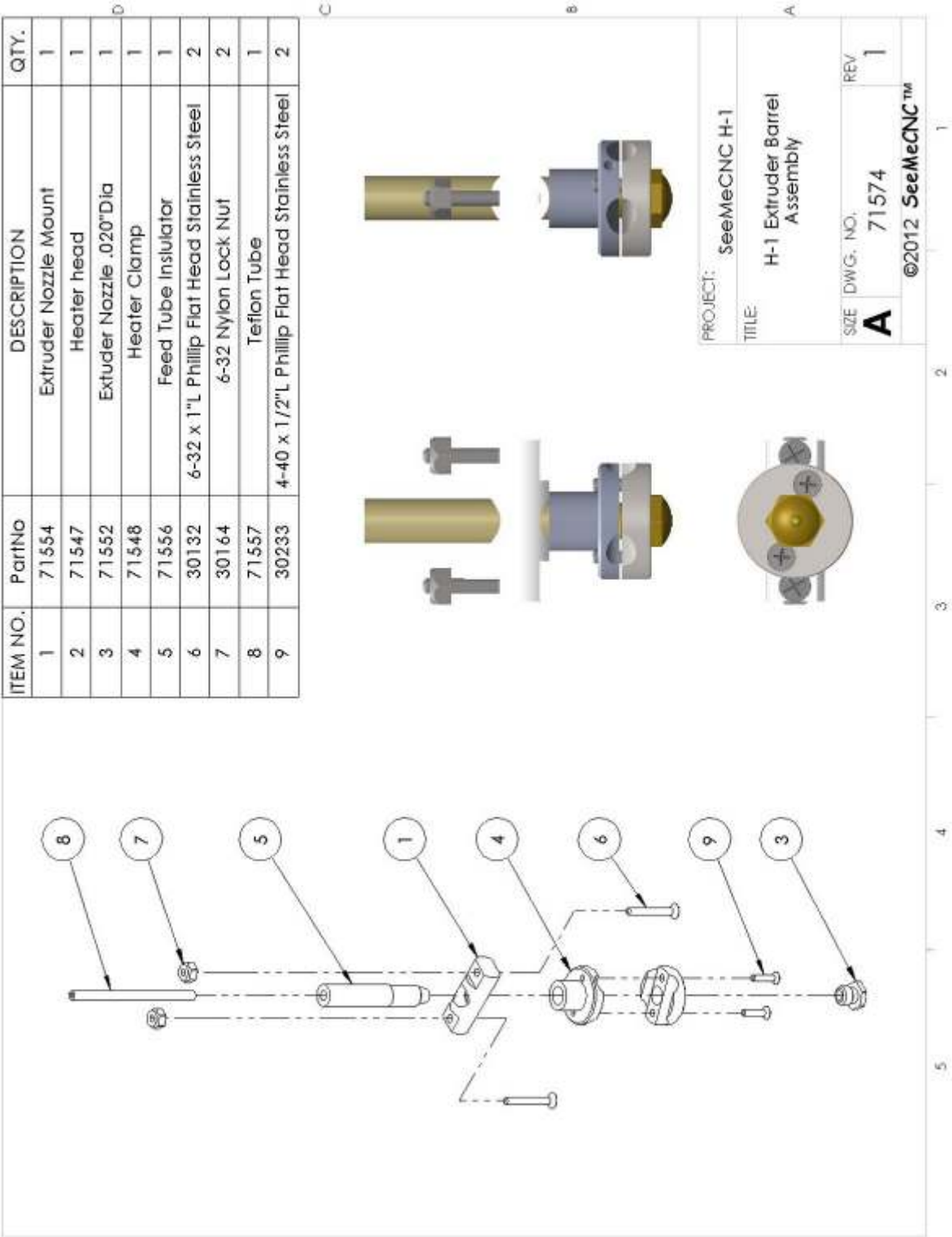
- one 1-1/2" x 6" piece of aluminum foil
 - high temperature silicone adhesive or gasket maker, or JB Weld™
1. Locate the two dark green **Heating Resistors (#26138)**, these are the heating elements. The manufacturing of ceramic resistors leaves a wide variation in the diameter. They are also oval shaped.
 2. Trim the piece of aluminum foil into two pieces about 1/16" less than the width of the resistor bodies and 6" long.
 3. With the scissors, cut a "V" notch shape out of the center of one end of aluminum foil about 1" to 1-1/2" inches deep.
 4. Wrap the foil around a resistor starting at the "V" notched end. Wrap until the resistor is about 1/4" diameter or slightly larger. It should fit the half-round shape of the heating head. The purpose of the "V" shaped aluminum foil is to bring the resistor's oval shape closer to a uniform cylinder. The aluminum also conducts well.

WARNING: Make sure the aluminum foil does not contact the resistor leads and cause a short circuit. Trim the width of the foil if it is too wide.

5. Repeat steps 3 and 4 for the second resistor.
6. Referring to *Figure 8.2*, remove the Extruder Nozzle (#3).
7. Remove the Heater Head (#2) by removing Screws (#9).
8. Sandwich the Heating Resistors between Heater Head and Heater Clamp (#4).
9. Replace and tighten Screws (#9).
10. Replace the Extruder Nozzle.
11. Locate the **Thermistor (#26137)** and insert it in the hole indicated in *Figure 8.1 - Hot End Barrel Assembly*.
12. Secure the Thermistor with the high temperature adhesive. Be certain the Thermistor lead wires do not short to the edge of the hole and are not shorted.

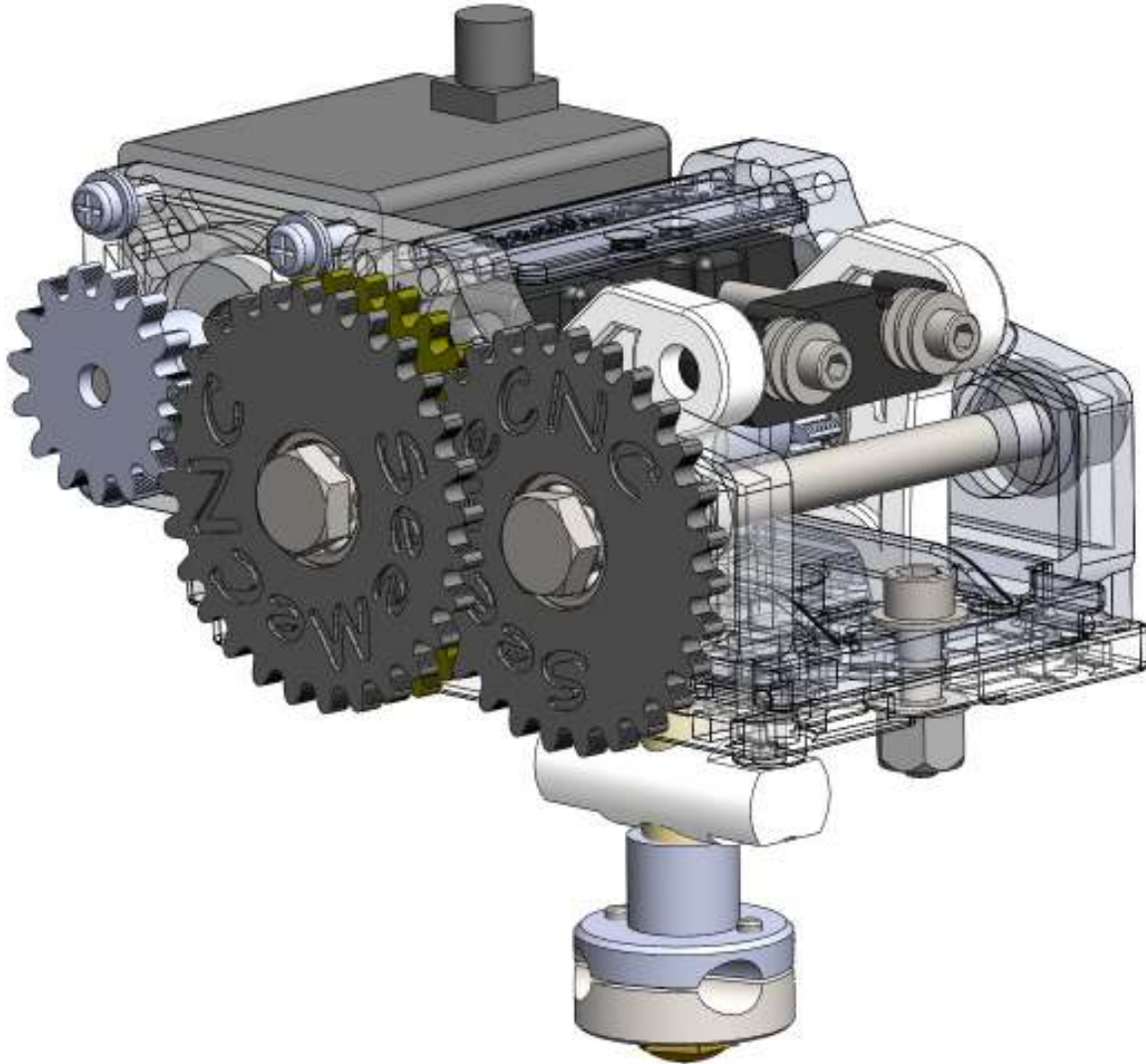
Tip: It is a good idea to coat the Thermistor wires with high temp silicone to insulate them from each other and from conductive parts of the machine. If the Thermistor short circuits, the extruder temperature will increase dramatically and may damage the machine or start a fire.

Figure 8.2



Step 9 – Extruder Assembly and Installation

Figure 9.1 - Extruder Assembly



Please refer to *Figure 9.4* for part identification. The parts for the Extruder Assembly come bundled in their own packaging. This section also deviates slightly from the rest of the manual by using the item numbers shown in *Figure 9.4* rather than part numbers.

Tools needed:

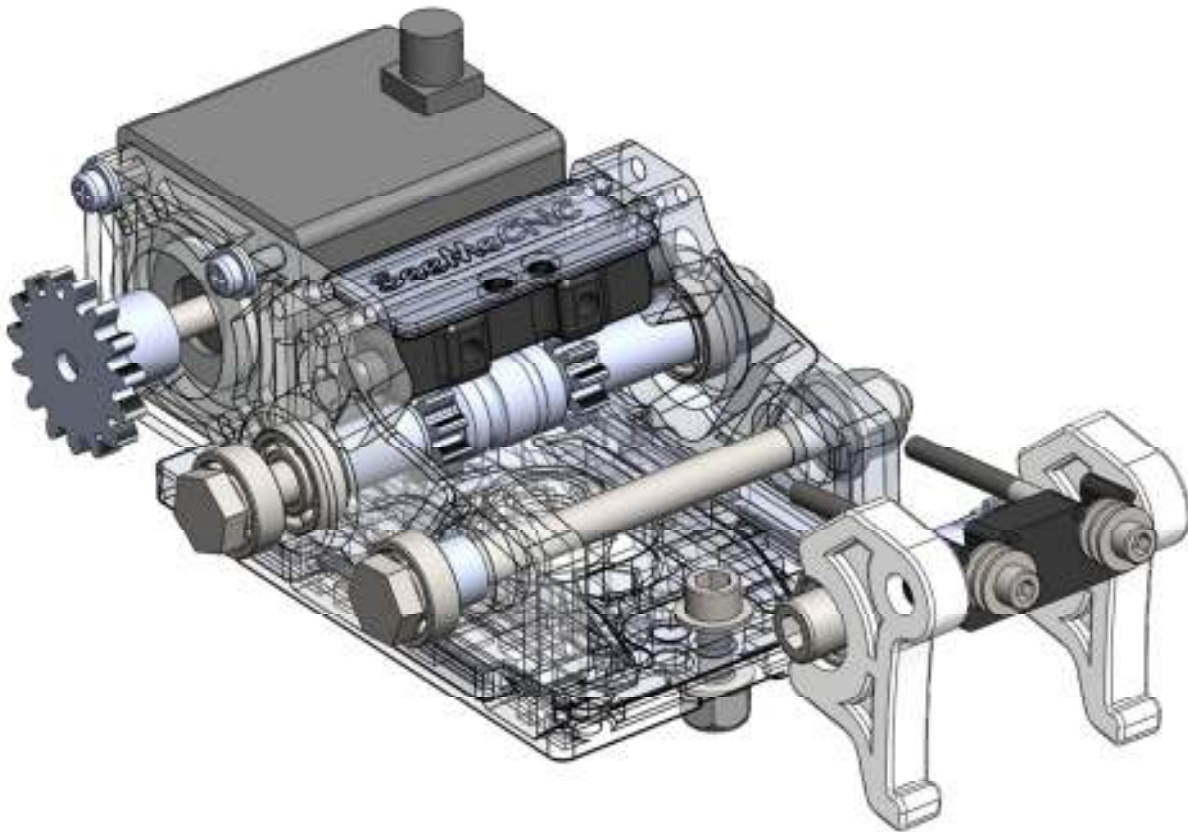
- scissors
- 5/16" and 7/16" wrench
- 7/64" and 3/16" Allen wrench
- No 1 Phillips screw driver
- optional "C" clamp
- hobby knife to trim molding flash from plastic parts

Supplies:

- light machine oil

Prior to assembly, use a hobby knife to trim flashing off the plastic parts.

Figure 9.2 – Extruder Assembly Detail



1. Locate the 1/4-20 x 2" Socket Head Cap Screw (#12) and stack a Bearing (#3), 10 Tooth Gear (#16), 1.75 mm - 3mm Drive Roller (#4), 10 Tooth Gear (#16), Bearing (#3), and 1/4-20 Nylon Lock Nut (#5). Tighten the stack snug so that the small gears cannot spin with finger pressure. Lubricate the bearings with light machine oil.

Tip: Refer to Figures 9.2 and 9.3 for more details on extruder assembly.

2. Press one of the bearings on the stack from step 1 into its recess in the Left Drive Idler (#8).
3. Insert the pin at the end of the Tension Bar (#19) into the mating hole in the Left Drive Idler. The small dimples on either side of the “U” slots should face out; they help locate the Washer/O-ring stacks installed in step 8 from sliding out of the slot.
4. Attach the Right Drive Idler (#23), making sure the bearing and pin on the Tension Bar fit into their respective holes.
5. Press a Bearing (#3) into each of the two 15 and 28 Tooth Combination Gears (#15). Lubricate the bearings with light machine oil.

Tip: A “C” clamp can be used to press in the bearings. Make sure the bearings are seated all the way into the gears. Also, a little light machine oil helps.

6. Press a Bearing (#3) into the Extruder Motor Mount (#6) and Drive Mount (#28). Lubricate the bearings with light machine oil.
7. Attach the **Stepper Motor (#26501)** as shown in *Figure 9.2 – Extruder Assembly Detail* with four M3-.05 x 10mm Screws (#31) with two No 4 Washers (#32) on each screw. Orient the motor with the wires pointing up as shown in the figure.
8. Slide a #6 Washer (#26), Rubber O-ring (#27), #6 Washer, Rubber O-ring, and #6 Washer onto a 6-32 x 2” Socket Head Cap Screw (#24).
9. Insert the screw assembly into the Tensioner (#17) through the side with the single “U” shaped indent as shown in *Figure 9.4* and attach a 6-32 Nylon Lock Nut (#25). Slide the nut into the slot on the opposite side of the Tensioner to hold it in place.
10. Repeat steps 5 and 6, inserting this assembly into the other hole in the Tensioner.

Tip: These two bolts adjust the tension on the filament. It is possible to apply too much pressure to the filament, causing feeding to stop. Please keep this in mind. Also remember, if you just crush a section of filament, you should feed forward by manually helping the extruder for a few seconds.

11. Slide one of the Combination Gears (#15) with its pressed in bearing onto the 1/4-20 x 3-3/4” Hex Head Bolt (#7) (it is the longest of the 1/4-20 bolts). The bearing should face the bolt head.
12. Slide the 28 Tooth Gear (#14) onto the bolt.

Tip: Test the gears. With Gear #14 pressing against the Gear #15’s bearing race, Gear #15 should spin freely. If it does not, disassemble the gears from the Hex Head bolt and sand the smaller face (15 tooth) of Gear #15 slightly to provide extra clearance. Reassemble and retest until Gear #15 spins freely.

13. Install the bolt and gear sub-assembly through the bearing pressed into the Extruder Motor Mount (#6). Pay attention to the proper orientation as shown in *Figure 9.2 - Extruder Assembly Detail*.
14. Slide one of the 1/4” ID x 3/8” OD x .64” Axel Spacers (#10) onto the bolt.
15. Slide one of the 10 Tooth Gears (#16) onto the bolt.
16. Slide the second 1.75mm – 3mm Drive Roller (#4) onto the bolt.
17. Slide a second 10 Tooth Gear (#16) onto the bolt.
18. Slide the second 1/4” ID x 3/8” OD x .64” Axel Spacers (#10) onto the bolt.

19. Attach the Filament Guide (#9) to the Extruder Motor Mount (#6) by inserting its two pins in the mating holes in the motor mount. It can only insert one way (the two small holes near the edge of the guide should be furthest away from the stepper motor).
20. Press the end pin on the Tensioner (#17) with its two attached bolts and Washer/Oring stacks into the mating hole in the Extruder Motor Mount (#6). The Washer/Oring stacks should face out as shown in *Figure 9.2*.

Tip: It may be necessary to trim molding flash from the pins and holes to get an easy sliding fit.

21. Slide the tabs on the Extruder Base (#1) into the mating slots on the Extruder Motor Mount (#6). Hold this in place for the next steps.
22. Slide the tabs on the Drive Mount (#28) onto the Extruder Base (#1). Note that the pins on the end of the Filament Guide (#9) and Tensioner (#17) insert into mating holes on the Drive Mount.
23. Screw a 1/4-20 Nylon Lock Nut onto the bolt (#7) protruding through the Drive Mount. Do not fully tighten the nut; the gears (#15 and #16) must be able to turn freely.
24. Place the hook-shaped tabs at the bottom of the tensioner assembly built in steps 1 through 4 into the mating slots in the Extruder Base (#1). See *Figure 1.1 – Extruder Assembly* for more detail.
25. Rotate the Tensioner (#17) up so the protruding Cap Screws (#24) do not interfere.
26. Now, rotate the tensioner assembly forward until the two gears mate with the gears mounted on the extruder.
27. Look down into the extruder to make sure that the 1.7 mm and 3 mm grooves in the Drive Rollers (#4) are aligned. If they are not, remove the tensioner assembly and flip the Gear and Drive Roller sub-assembly around.
28. Slide the Washer/Oring stacks to the Cap Screw heads. This is easiest to do by holding the unit with the Cap Screw heads facing down.
29. Rotate the Cap Screws and Tensioner (#17) unit down until the Cap Screws engage the “U” shaped openings in the Tension Bar (#19). All of the Washers and Orings should be on the outside face of the Tension Bar. See *Figure 9.1 - Extruder Assembly* for more detail.
30. Slide the remaining Combination Gear (#15) into the slot between Gears #14 and #15 on the extruder with the smaller 15 tooth side facing the extruder body.

Tip: If you insert the Combination Gear the wrong way, it will be locked to the Combination Gear mounted on the extruder base and will not rotate.

31. Pass the 1/4-20 x 3-1/2” Hex Head Bolt through the bearing in the gear.
32. Pass the bolt through the 1/4" ID x .28" Drive Spacer (#30) and through the hole in the Extruder Motor Mount (#6).
33. Pass the bolt through the hole in the Drive Mount (#28).
34. Place the 1/4" Flat Washer (#29) on the bolt and secure with a 1/4-20 Nylon Lock Nut (#5). Do not over-tighten, the gear needs to spin freely.
35. Test for free rotation of all of the gears. If they are difficult to turn or bind, slightly loosen the nuts on Hex Head Bolts #7 and #18.
36. Press the 15 Tooth Gear (#13) onto the Stepper Motor with the gear facing out as shown in *Figure 9.3 - Extruder Top View*.

Tip: Use a “C” clamp to gently press the gear into place. You may also drill the gear with a 5mm or 3/16” drill bit to enlarge the hole slightly.

37. Attach the Hot End completed in *Step 8 – Hot End Barrel Assembly* to the Lower Extruder Mounting Plate (#33). The Hot End nuts fit into recess in the bottom of the plate.
38. Attach the Lower Extruder Mounting Plate and Hot End to the extruder body by sliding the plate under the hooks at the back of the Extruder Base (#1). Note that the plate can fit in one of two positions to align with either the 1.7 mm or 3 mm side of the Drive Roller (#4).
39. Loosely secure the Lower Extruder Mounting Plate to the Extruder Base with a 10-32 x 3/4" Socket Head Cap Screw (#21), #8 Washer (#33), and 10-32 Nylon Lock Nut (#20).

Figure 9.3 – Extruder Top View

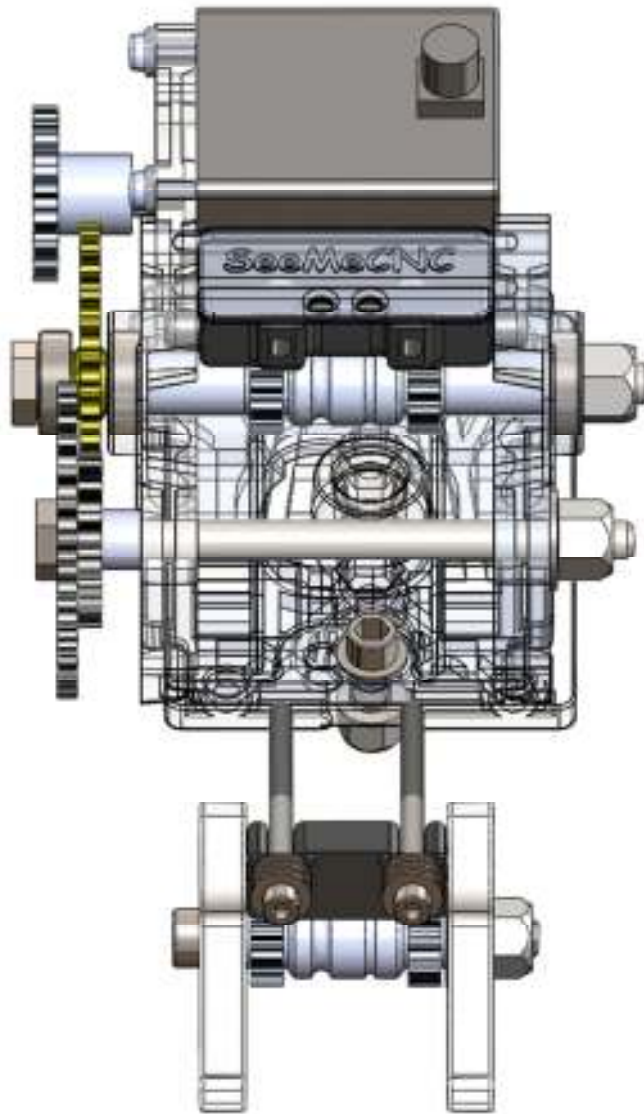
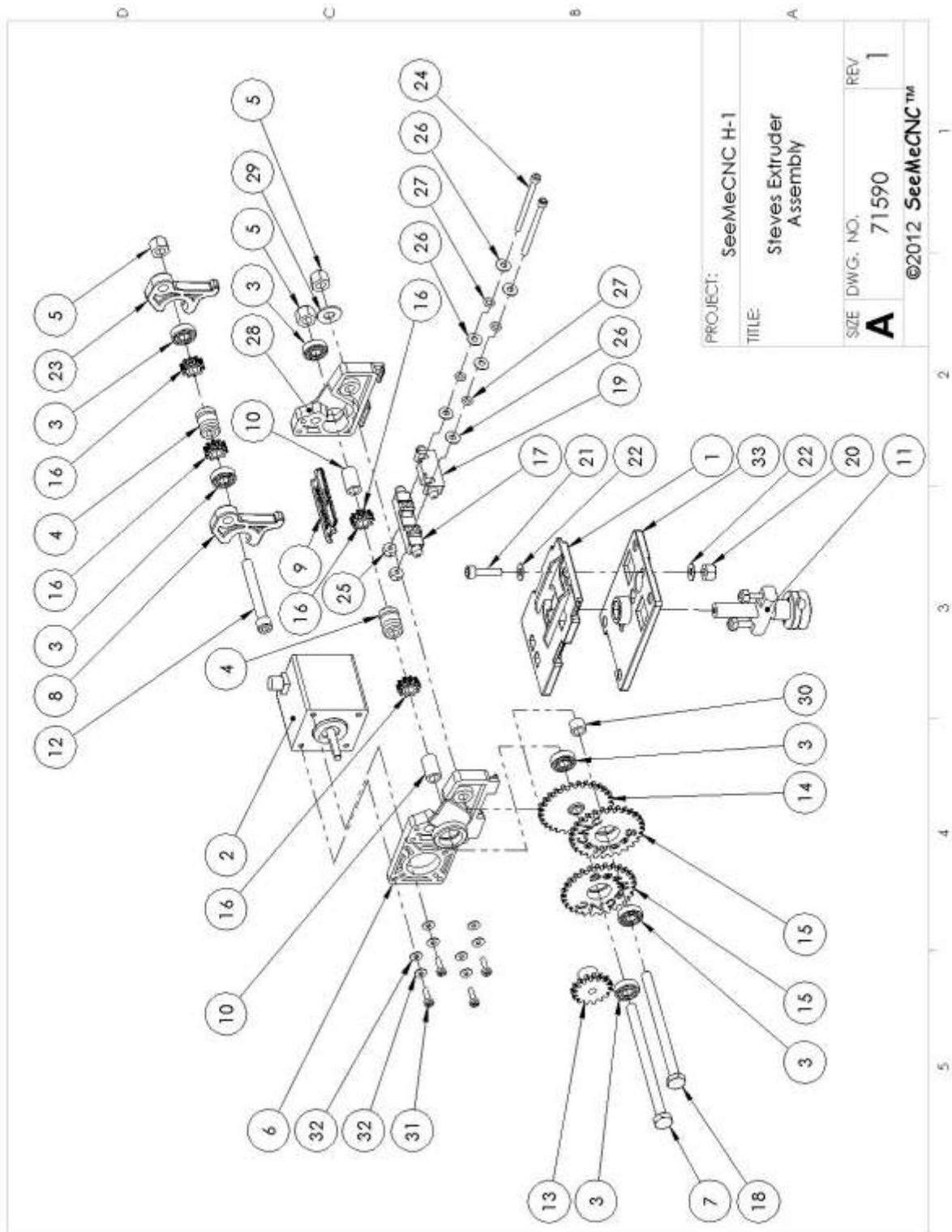


Figure 9.4



ITEM NO.	PartNo	DESCRIPTION	QTY.
1	71555	Extruder Base	1
2	26501	Nema 17 Stepper	1
3	35008	1/4"ID x 5/8"OD x .196"W Ball Bearing type R4ZZ	6
4	71550	1.75mm - 3mm Drive Roller	2
5	30157	1/4-20 Nylon Lock Nut Stainless Steel	3
6	71559	Extruder Motor Mount	1
7	30141	1/4-20 x 3-3/4"L Hex Head Bolt	1
8	71560	Drive Idler Left	1
9	71551	Filament Guide	1
10	71567	1/4"ID x 3/8"OD x 0.64"L Axle Spacer	2
11	71574	H-1 Extruder Barrel Assembly	1
12	30407	1/4-20 x 2" Socket Head Cap Screw	1
13	71566	Gear 15 Tooth	1
14	71565	Gear 28 Tooth	1
15	71569	Combination Gear 15T 28T	2
16	71562	1/4"ID x 1/2"PD x 10T Gear	4
17	71570	Tensloner	1
18	30142	1/4-20 x 3-1/2"L Hex Head Bolt	1
19	71573	Tension Bar	1
20	30160	10-32 Nylon Lock Nut Stainless Steel	1
21	30002	10-32 x 3/4"L Socket Head Cap Screw	1
22	30500	#8 SAE Flat Washer	2
23	71561	Drive Idler Right	1
24	30036	6-32 x 2"L Socket Head Cap Screw Stainless Steel	2
25	30164	6-32 Nylon Lock Nut	2
26	30450	#6 SAE Flat Washer	6
27	36509	007 Buna N070 Oring	4
28	71564	Drive Mount	1
29	30512	1/4 SAE Flat Washer	1
30	71568	1/4"ID x 0.28"L Drive Spacer	1
31	30318	M3-.05 x 10mm L Phillip Pan Head	4
32	30449	No 4 SAE Washer	8
33	71534	Lower Extruder Mounting Plate	1

PROJECT: SeeMeCNC H-1

TITLE: Steves Extruder
Bill of MaterialsSIZE DWG. NO. REV
A 71590 1

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Step 10 – Timing Gears, Belts and Extruder

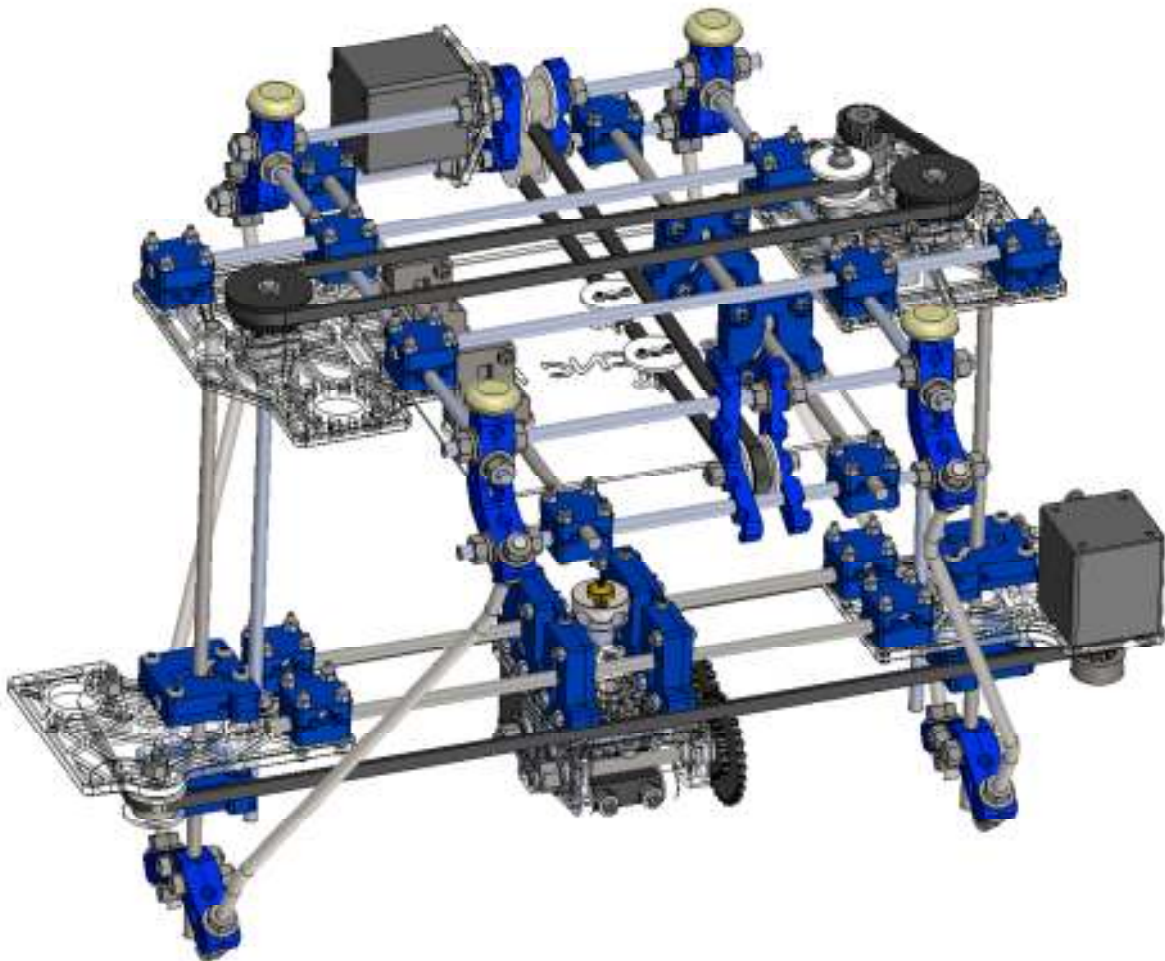
Please refer to *Figure 10.6* for part identification.

Tools needed:

- No 1 Phillips screw driver
- 5/16" wrench
- 3/16" Allen wrench
- 5/64" drill bit and electric drill

10.1 - Z Axis Belt

Figure 10.1 - Z Axis Belt



1. Loosen the screw attaching the tensioning idler and install the **Z Axis Timing Belt (#71521)** as shown in *Figure 10.1 - Z Axis Belt*.

2. Tension the belt by sliding the tensioner idler in its slot to remove excess slack and then tighten the idler in place.

Tip: Make sure the idler can rotate freely. If it does not, the belt will bind and not turn the Z Axis screws freely.

10.2 - Y Axis Belt

1. Install the **200XL x 0637 PD x 5mm Shaft Timing Pulley (#71544)** onto the shaft of the Y Axis Stepper Motor as shown in *Figure 10.2 - Y Axis Belt Rear View*.
2. Loosen the 1/4-20 nuts on the threaded cross rods that attach the Stepper Motor Mount / Idler Assembly to the Rear Base Frame Sub-assembly. Adjust the assembly so the Timing Pulley aligns with the belt attachment posts on the bottom of the table. These are indicated with arrows in *Figure 10.2 - Y Axis Belt Rear View* (this is a bottom view of the assembly).
3. Align the Idler Assembly on the Front Base Frame Sub-assembly so the idlers are aligned with the belt attachment posts as shown in *Figure 10.3 - Y Axis Belt Front View* (this is a bottom view of the assembly).
4. Secure one end of the **Y Axis Timing Belt (#71522)** (it is the shorter of the two timing belts) to the rear table post using a **1/4" x 1-1/16" Plastic Washer (#71511)** and two **#4 x 3/8" Pan Head Sheet Metal Screws (#30250)** as shown by the arrow labeled **A** in *Figure 10.2 - Y Axis Belt Rear View*. You will have to drill two holes for the screws with a 5/64" drill. The belt teeth should face towards the white 1-1/16" washer.

Figure 10.2 - Y Axis Belt Rear View

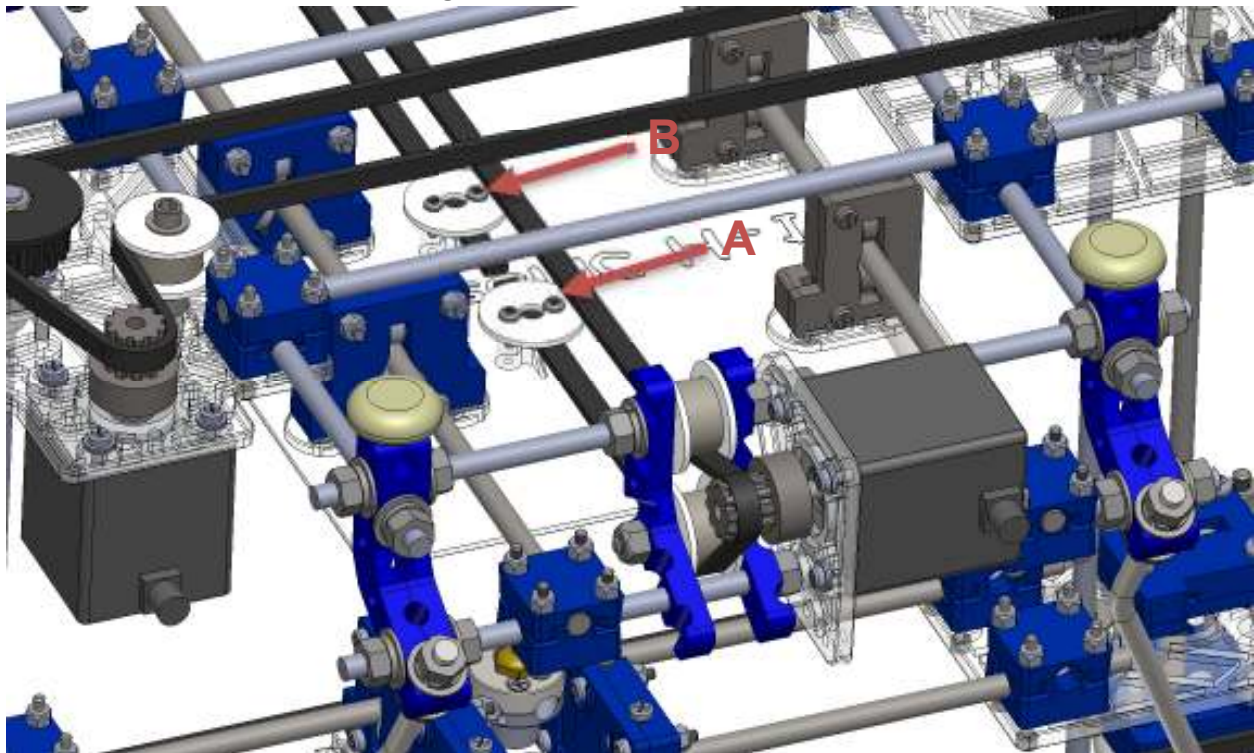
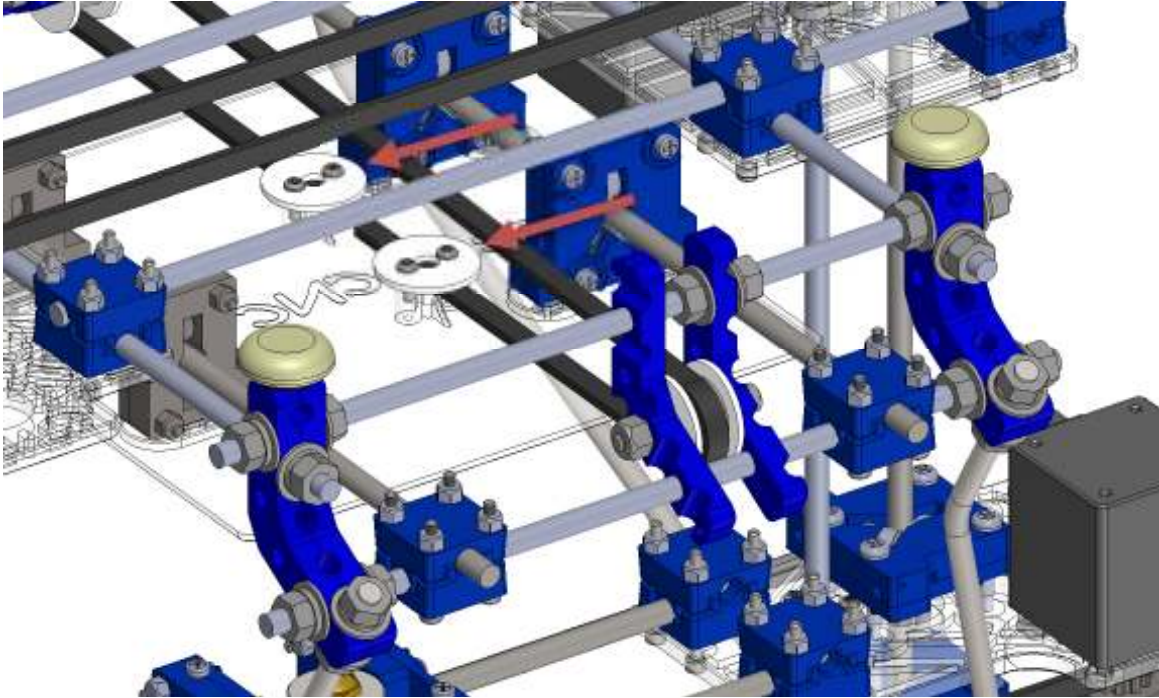


Figure 10.3 - Y Axis Belt Front View



5. Route the timing belt through the idlers and around the timing pulley as shown in *Figure 10.2 - Y Axis Belt Rear View*.
6. Continue routing the timing belt around the front idler assembly as shown in *Figure 10.3 - Y Axis Belt Front View*.
7. Secure the timing belt to the front table post using a **1/4" x 1-1/16" Plastic Washer (#71511)** and two **#4 x 3/8" Pan Head Sheet Metal Screws (#30250)** as shown by the arrow labeled **B** in *Figure 10.2 - Y Axis Belt Rear View*. You will have to drill two holes for the screws with a 5/64" drill. The belt teeth should face towards the white 1-1/16" washer. Tension the belt to remove slack and tighten the retaining screws.

10.3 - X Axis Belt

1. Install the **200XL x 0637 PD x 5mm Shaft Timing Pulley (#71544)** onto the shaft of the Y Axis Stepper Motor as shown in *Figure 10.5 - X Axis Belt Routing*.
2. Install the **Lower Extruder Mounting Plate (#71534)** (see *Figure 9.4*) with four **5-40 x 1/2" Phillips Pan Head Screws** as shown in *Figure 10.6*. Make sure the keyhole for securing the Extruder Assembly is towards the front of the machine.
3. Drill a 5/64" hole about 3/4" from one end of the **X Axis Timing Belt (#71524)**.
4. Drill a 5/64" hole in the back of each Combo Bearing Block Sub-assemblies as shown at positions **A** and **B** in *Figure 10.4 - X Axis Belt*.
5. Attach one end of the X Axis Timing Belt to the Combo Bearing Block Sub-assembly with a **#4 Washer (30449)** and **#4 x 3/8" Pan Head Sheet Metal Screw (#30250)**. The belt teeth should face the Combo Bearing Block.
6. Route the belt as shown in *Figure 10.5 - X Axis Belt Routing*.
7. Attach the other end of the timing belt to the Combo Bearing Block at position **B** as shown in *Figure 10.4 - X Axis Belt*. Stretch the belt slightly and drill a 5/64" hole in the

belt to align with the hole in the Combo Bearing Block. Attach the timing belt with a #4 Washer and a #4 x 3/8" Pan Head Sheet Metal Screw.

Figure 10.4 - X Axis Belt

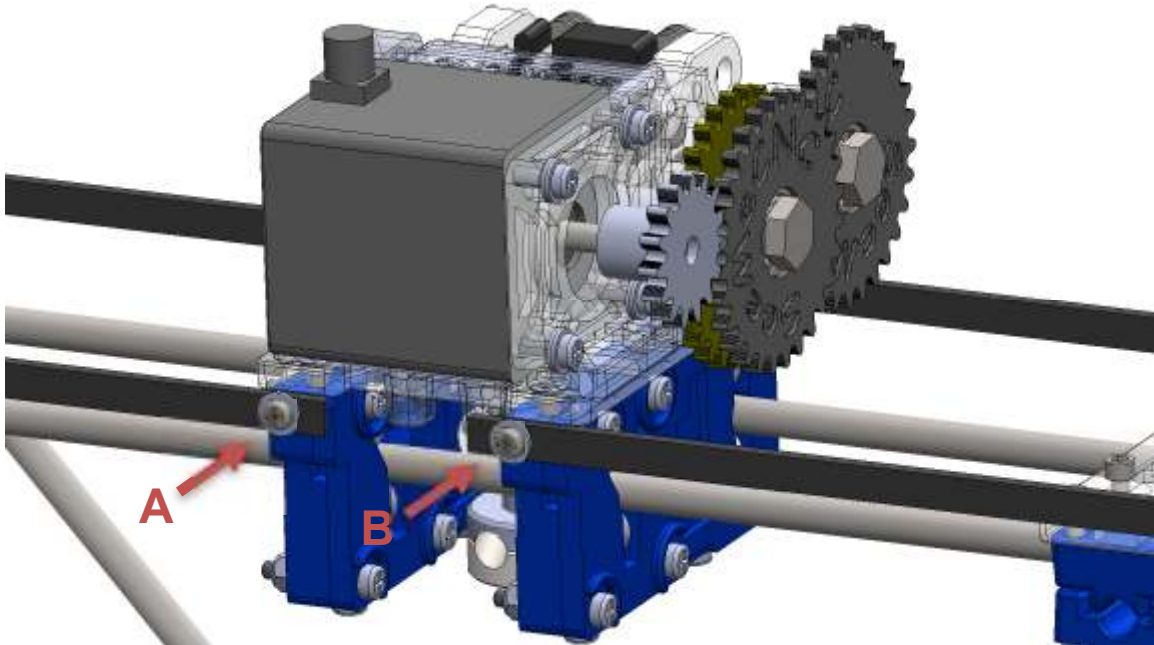
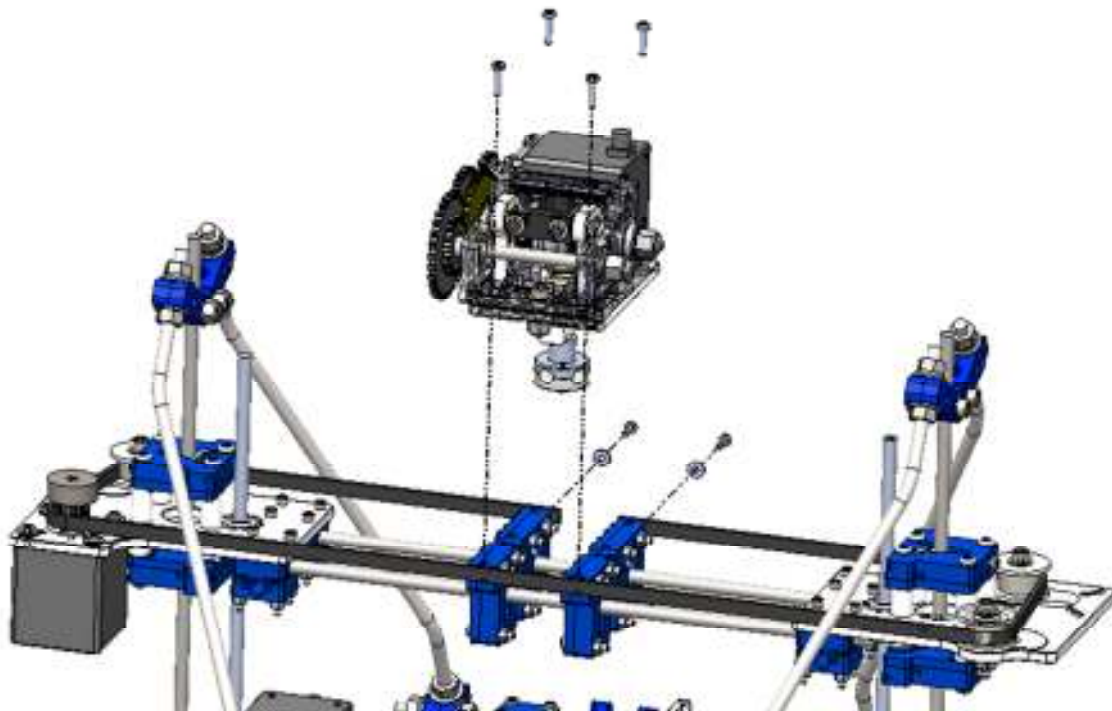


Figure 10.5 - X Axis Belt Routing



10.4 - Extruder

1. Attach the Extruder to the Lower Extruder Mounting Plate using a **10-32 x 3/4" Socket Head Cap Screw (#30002)**, two **#8 Flat Washers (#30500)**, and a **10-32 Nylon Lock Nut (#30160)** as shown in *Figure 9.4*.

Figure 10.6

