Track Flashlight Assembly Instruction Manual

ENGR 480 Manufacturing

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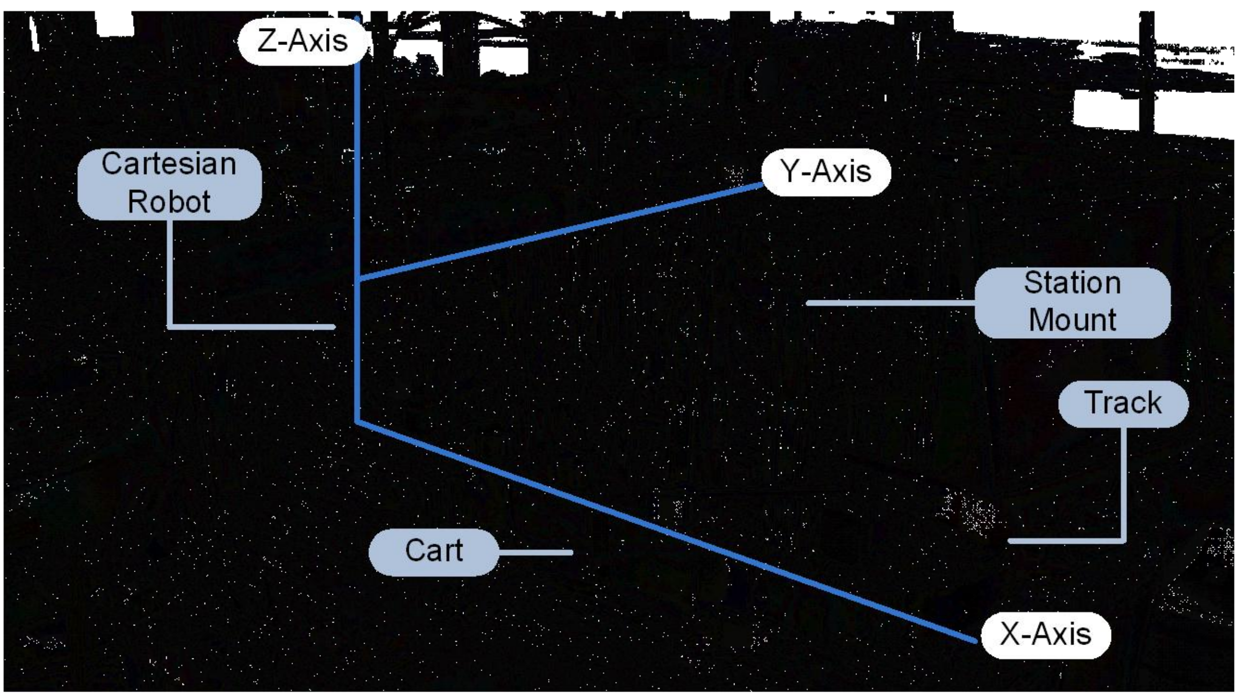
Track Assembly

This was the first year that this type of assembly system was used in the Manufacturing Systems class. This is a clever yet complicated system that provides some unique advantages for manufacturing. This system was not necessarily the optimal system for flashlights, but there could be specific applications where this means of manufacturing is preferred.

The track system will allow for independent motion in all three axes. The system is comprised of track that that loops around the center station mounts. Carts are moved around on the track using a series of stepper motors and pinion gears. Each station along the track has its own stepper motor and pinion gear. The system seen in Figure 1 used 10 sets of stepper motors and pinion gears to move the carts down the straight sections of the track and 2 additional stepper motors to move the carts around the curved ends.

Motion in the Y and Z axes is accomplished by Cartesian robots suspended on bar stock. To move in the Y –axis a stepper motor controls a belt that is linked to the Cartesian robot. A stepper motor attached to a lead screw enables the gripper end to move up and down in the Z-axis.

Figure 1. Overview of track system



Instructions

Starting

There are several different component groups that need to be initialized to get the machine into the ready state. The three groups that need to be started are the pneumatics, the steppers and the PLC.

To prepare the pneumatics for operation, make sure that the orange supply hose is plugged into the quick connect port on the wall. With the hose is plugged in check the pressure gage to ensure that the pressure is within a reasonable range. The pressure should be between 15 and 35 psi. If the pressure is not within this range adjust the top knob to keep it within this range.

The next step is to power up the stepper motors. Ensure are of the controller boards are plugged in and all of the PCs have been started up. Check the PCs to make sure LinuxCNC has been started. Without LinuxCNC started the stepper motors will not be able to operate.

The final operational component of the machine is the PLC. Make sure that the power cord is plugged in that the PLC is on. The PLC also needs to be flipped into "Run" mode.

When these three parts of the machine are ready then you are good to start the process. The machine can be started by flipping the first switch X101 to the on position.

System Description

Operation of Major Sections

The operation of our machine was broken up into distinct sections. Each team member was responsible for at least one operation. These responsibilities are listed below

Alex Banton - Magnet ring and Outer O-ring placement system.

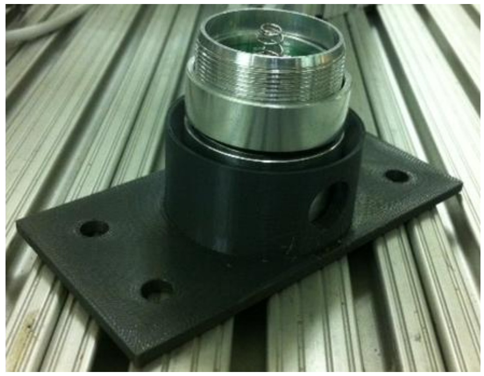
Jorge Cruz - Nosecone placement and nosecone holder.

Joshua Grant - Inner O-ring placement. Team Leader.

Ryan Gratias - Body and battery assembly, threading of body to nosecone and final flashlight removal from assembly line.

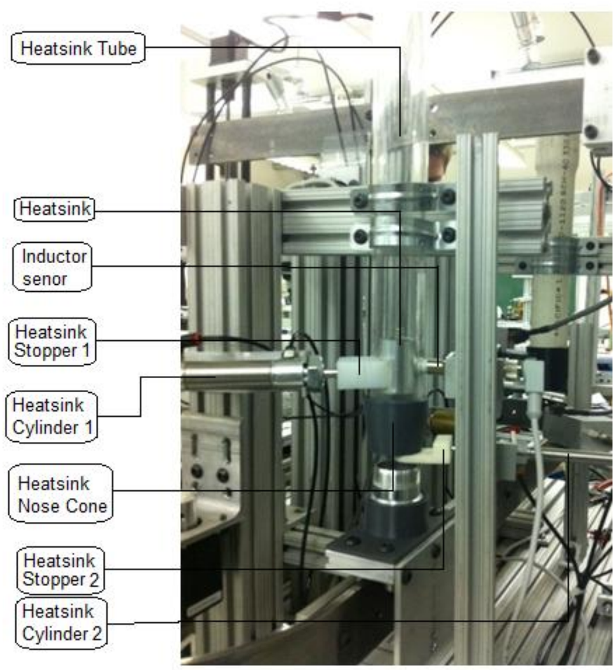
Nose holder

Figure 2. Nose holder part with flashlight parts inserted



The nose holder is the piece that holds the flashlight parts as it travels through the tract. The crucial stage for this part is when it starts with the nose dispenser station. The nose holder is design so that when it is under and completely centered with the nose cone of the nose dispenser the nose piece falls into the nose holder. In the inside of the nose holder the part, the top of it has a chamfer then about a third away funnel to a diameter off 38.2 mm. There is a small clearance for the nose to sit. It is important that the inside of the nose holder to be smooth so the nose can fall in with ease. From then on the cart will move and the remaining parts fall into the nose. On the nose holder there is also a diameter of 12mm that goes through the part, this is for the last station where an air cylinder will pin the so nose and the body and battery is screwed on.

Figure 3. Heat Dispenser Station



Heatsink Dispenser

This is the part of the system where the heatsink of the flashlight is inserted. Using double actuation system the heatsinks are the dropped into the nose. Similar to the nose dispenser, the heatsinks are loaded into the tube. The inductor sensor senses whether if there is a heat sink present or not. If not the stopper will pull out by the first air cylinder and the all the heat sink move down to the bottom of the heat sink nose cone and is held by the second stopper. When the inductor senses a heatsink, the heatsink stopper 1 will pin there heat sink to the tube preventing from all the rest of the heatsinks from falling. Then heatsink stopper 2 pulls into it's air cylinder dropping the heat sink into the nose.

Figure 4. State diagram of heatsink dispencer station.

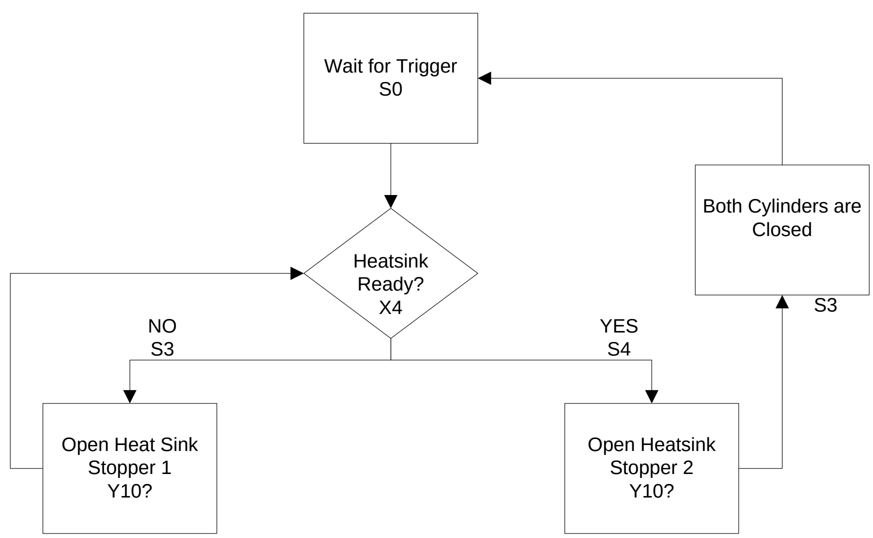
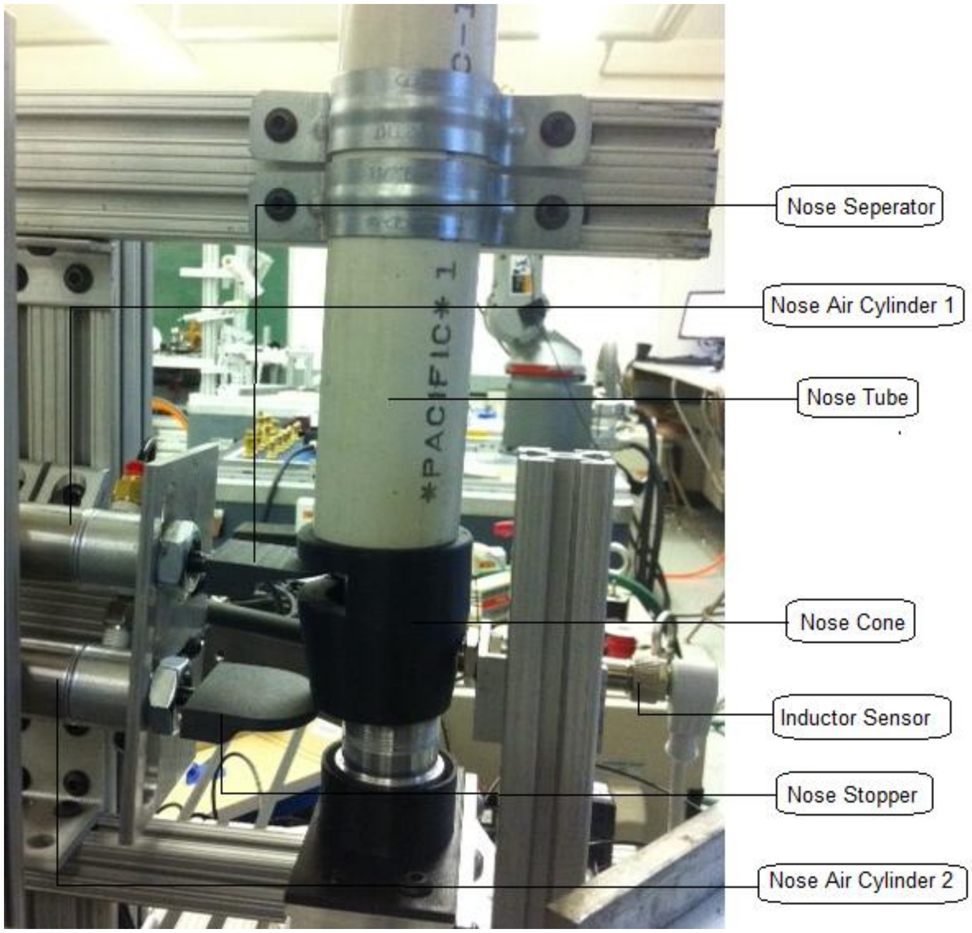


Figure 5. Nose Dispenser Station



Nose Dispenser

The nose dispenser is the first station where the flashlight production begins. The way that this system works is using double actuation by two cylinders moving back and forth dropping the nose cones one at a time. As the cart move into position, the nose holder come completely centered with the nose cone. Starting off, both the nose separator and the nose stopper are completely extended in tube. The noses are loaded into the tube. The inductor sensor senses whether if there is a nose present or not. If not the nose separator will pull out by the first air cylinder and then all the noses will move down to the bottom of the nose cone and then the separator goes back into the nose cone separating the bottom nose from all the other noses. The nose separator is designed to use the chamfer on the edge of nose to slide between noses and make the separation. The figure below shows this visually. When the inductor senses a nose piece, the nose stopper will pull back and the nose will fall into the nose holder.

Figure 6. A direct view on how each nose is separated.

The next phase is the nose stopper to pull back end, dropping the nose.

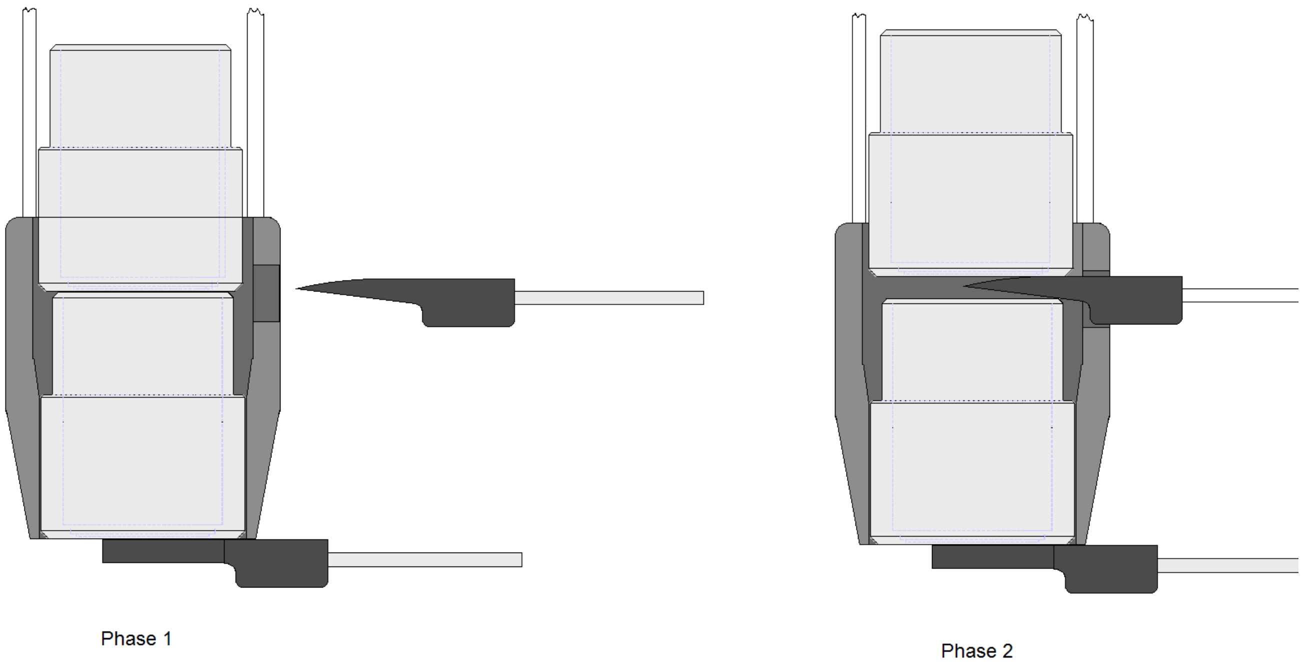
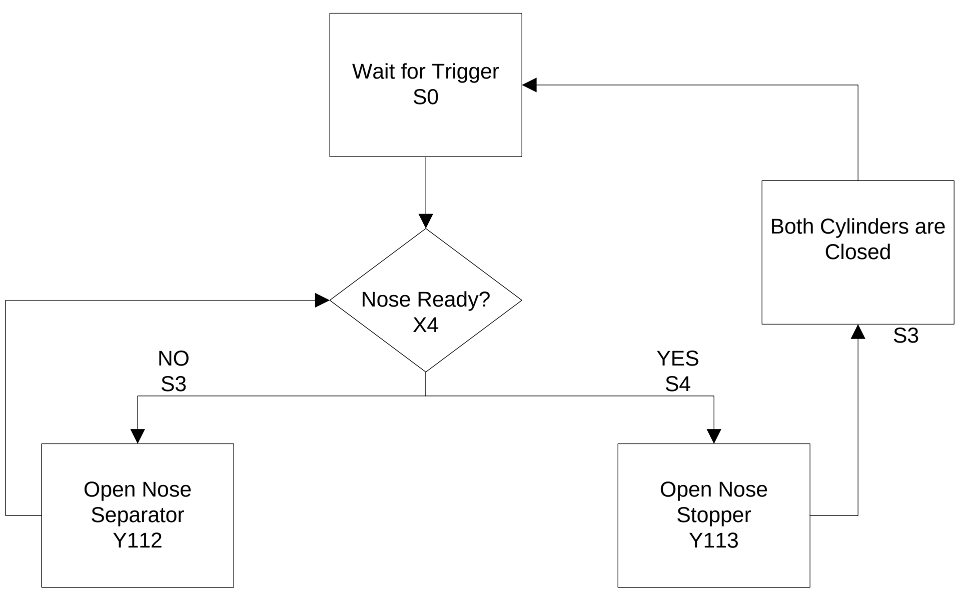


Figure 7. State diagram of nose dispenser station.



Inner O-Ring

To place the inner o-ring the station uses a simplistic solution. The singulation of the o-rings is done by using two spring retracted air cylinders. The upper air cylinder catches the second o-ring on its inside and keeps it from dropping. When the lower air cylinder opens a single o-ring will fall into the nose. The sensor is positioned so that the top of the o-ring turns off the sensor. If the sensor sees that there is no o-ring ready then it will open the upper gate to let it the o-rings drop.

After a single o-ring has been dropped in the nose the cart will advance approximately ½" and the air nozzle. The air nozzle turns on and settles the o-ring in the bottom of the nose. With the o-ring settled the cart is ready to progress to the next station.

Figure 8: Picture of Inner O-Ring dispenser

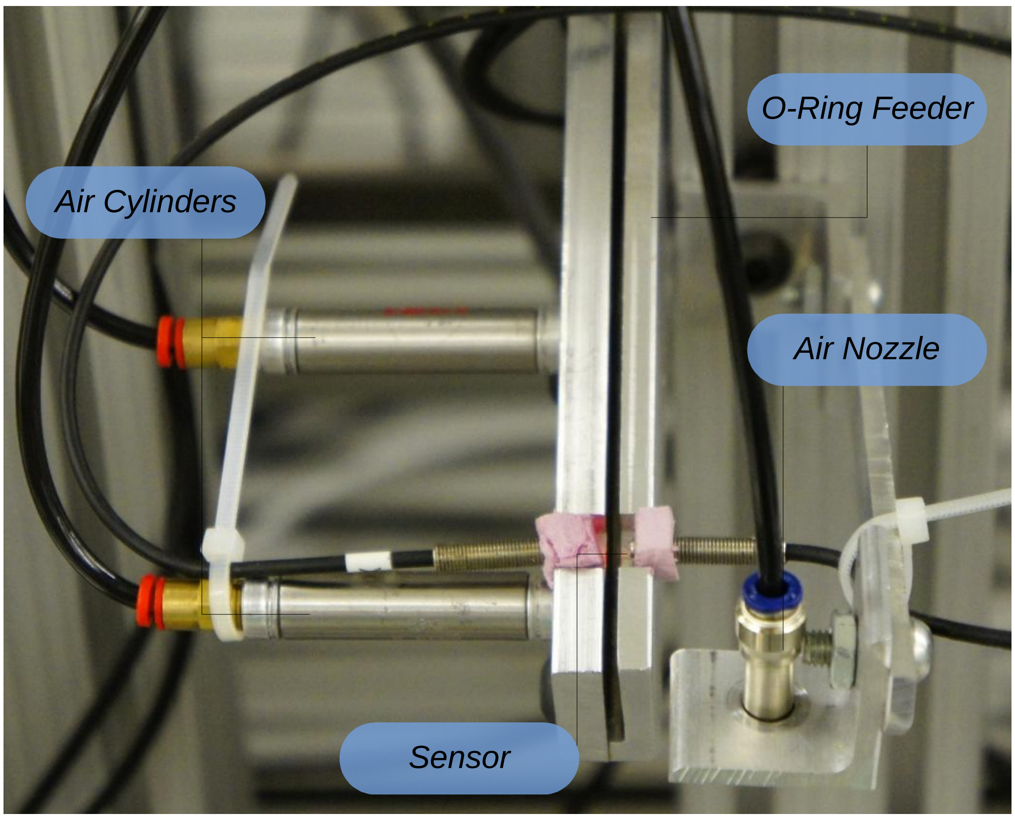
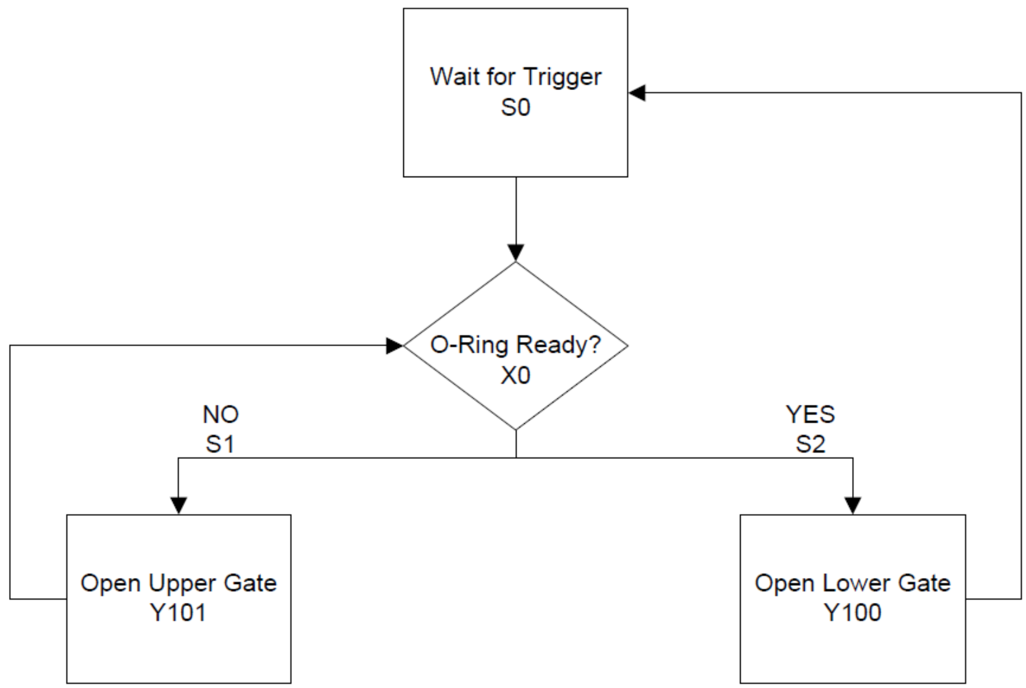


Figure 9: Logic Diagram for Inner O-Ring Dispenser



O-ring "Sammich"

The second station in the flashlight assembly line was the outer o-ring and magnet ring placer. Our group decided to use the Y-Z axis cart to pick and place the o-rings and magnet ring on the nose of the flashlight.

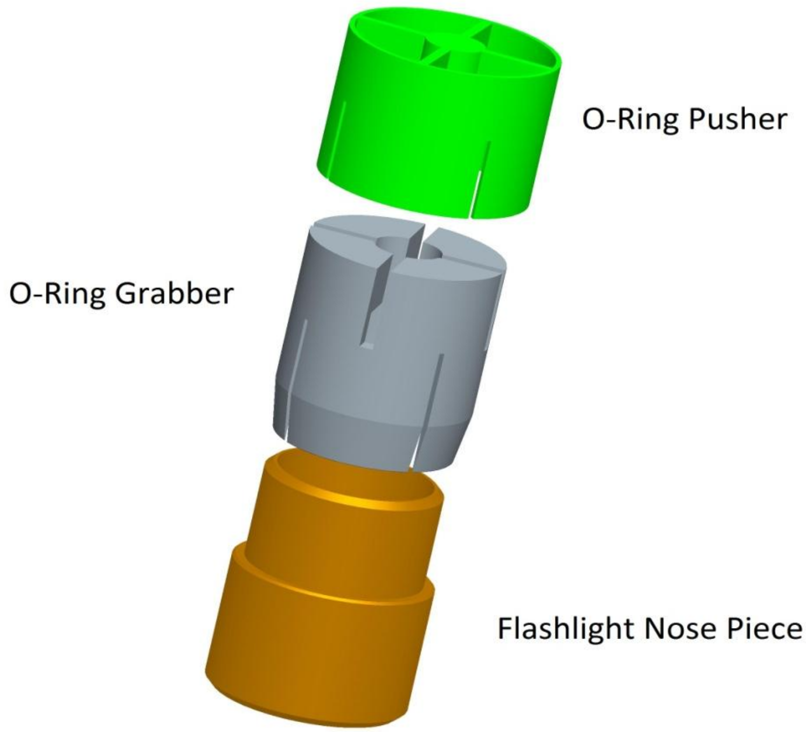
O-ring Placer:

Since the o-rings were the most difficult part of the flashlight assembly we decided to use a tapered slider device. The o-ring placer system consisted of two parts.

The first part was the o-ring grabber. We designed this part to be able to fit inside the o-ring and still fit over the flashlight nose piece. Once the o-ring was positioned correctly the o-ring placer system would plunge down through the o-ring approximately 10mm. This plunging action would cause the o-ring to travel up the grabber and stretch due to the taper of the grabber's lower section.

The second part of the system is the o-ring pusher. This part sits flush over the o-ring grabber and has a pneumatic piston connected to the top center of it. Once the o-ring grabber has picked up the o-ring and slid over the nose piece the pneumatic piston on the pusher will activate and slide the o-ring off, clearing the nose threads.

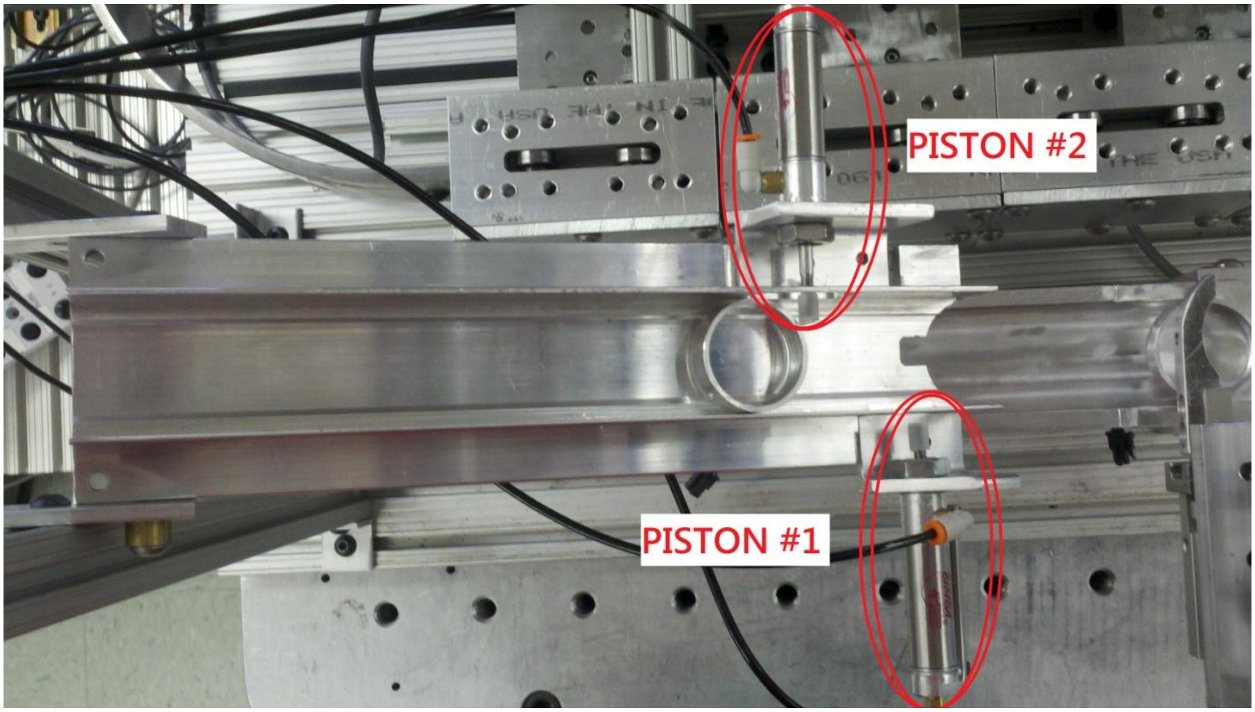
Figure 10: O-Ring Placer System



Magnet Ring:

We decided to separate the magnet rings by using two pneumatic pistons as shown below. Piston #1 will catch the rings while the piston #2 will separate the lowest ring from the others.

Figure 11: Magnet Ring Singulator



After separating the magnet rings the lower piston would open allowing the ring to fall onto the grooved tray below. Using a different, longer pneumatic piston, we were able to push the ring over to the flat surface where the pneumatic gripper could grab it

Figure 12 : Magnet Ring Platform

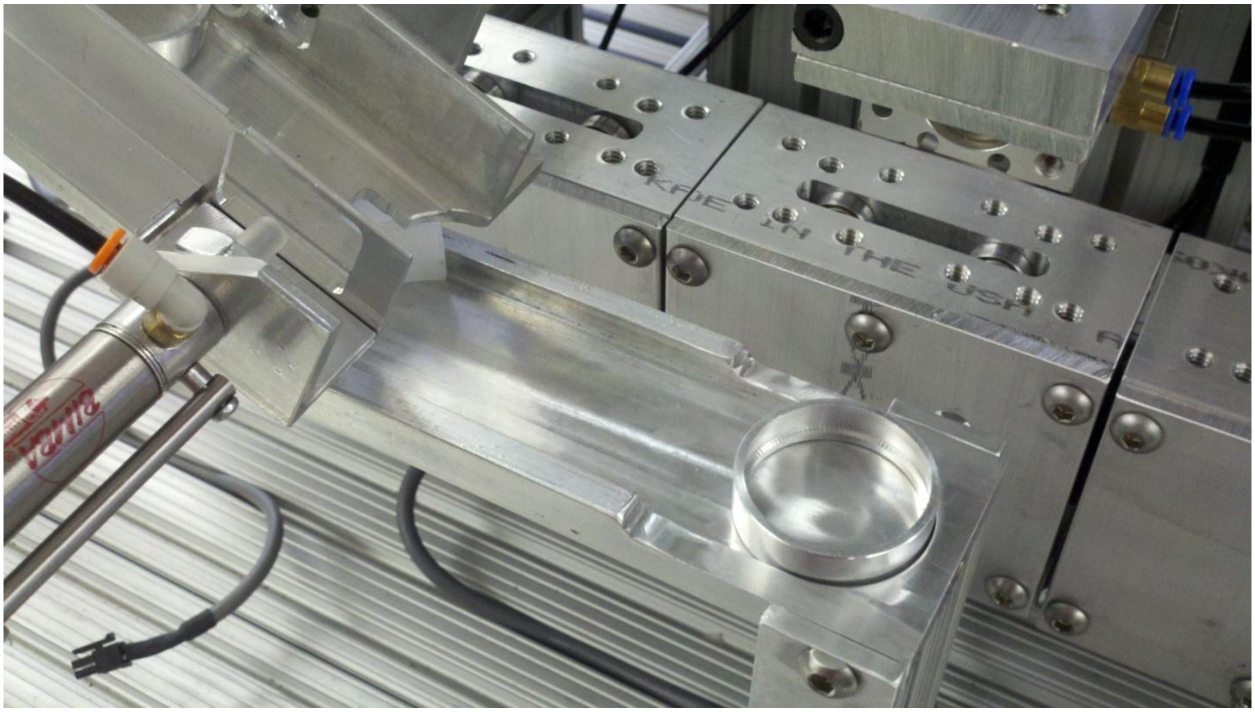
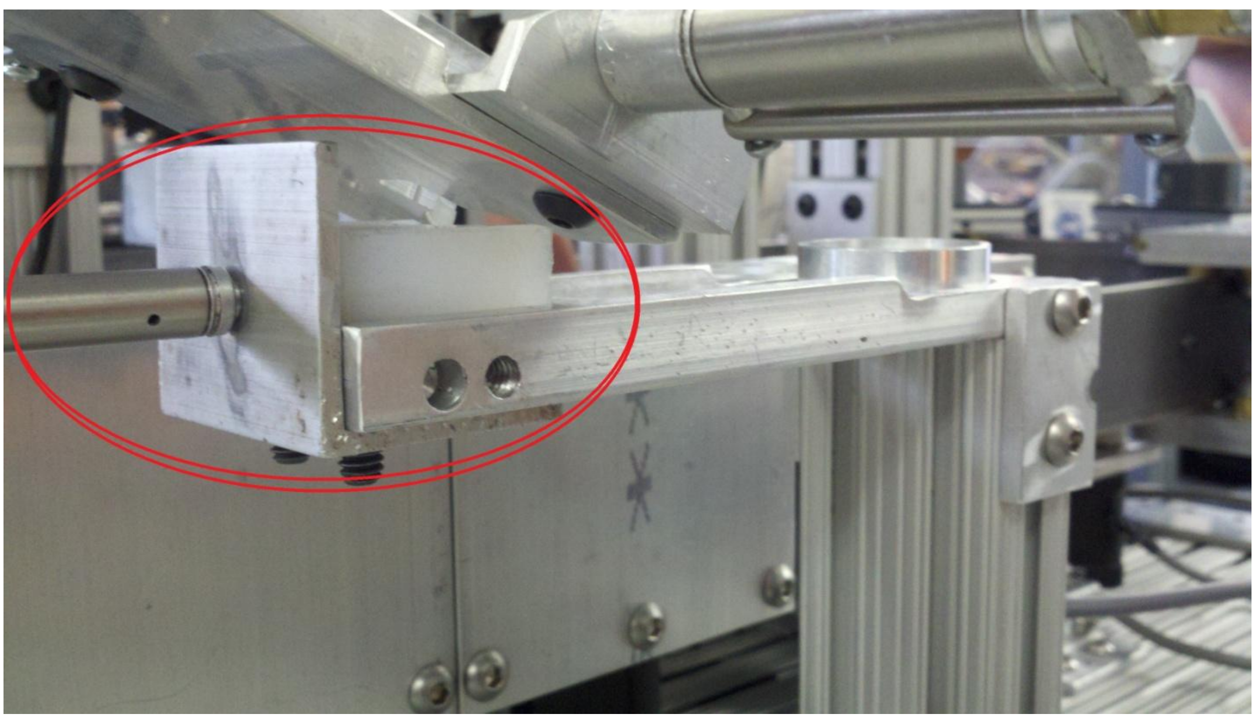


Figure 13 : Magnet Ring Platform Piston & Pusher



We decided the best way to place the magnet ring on the nose was to use a pneumatic two jaw gripper. Taking advantage of the Y-Z axis cart we connected the two jaw gripper to the bottom of the cart, positioning the grippers inward following the Y-axis to conserve space around our system. The gripper would move from the home position, out and down over the magnet ring, then use the pneumatics to grab the ring. From this position it would then move up and over the nose piece, centering about the center axis of the nose piece. Using the Z-axis it would then slide the ring down over the threads of the nose piece and release it.

Figure 14: Magnet Ring Grabber

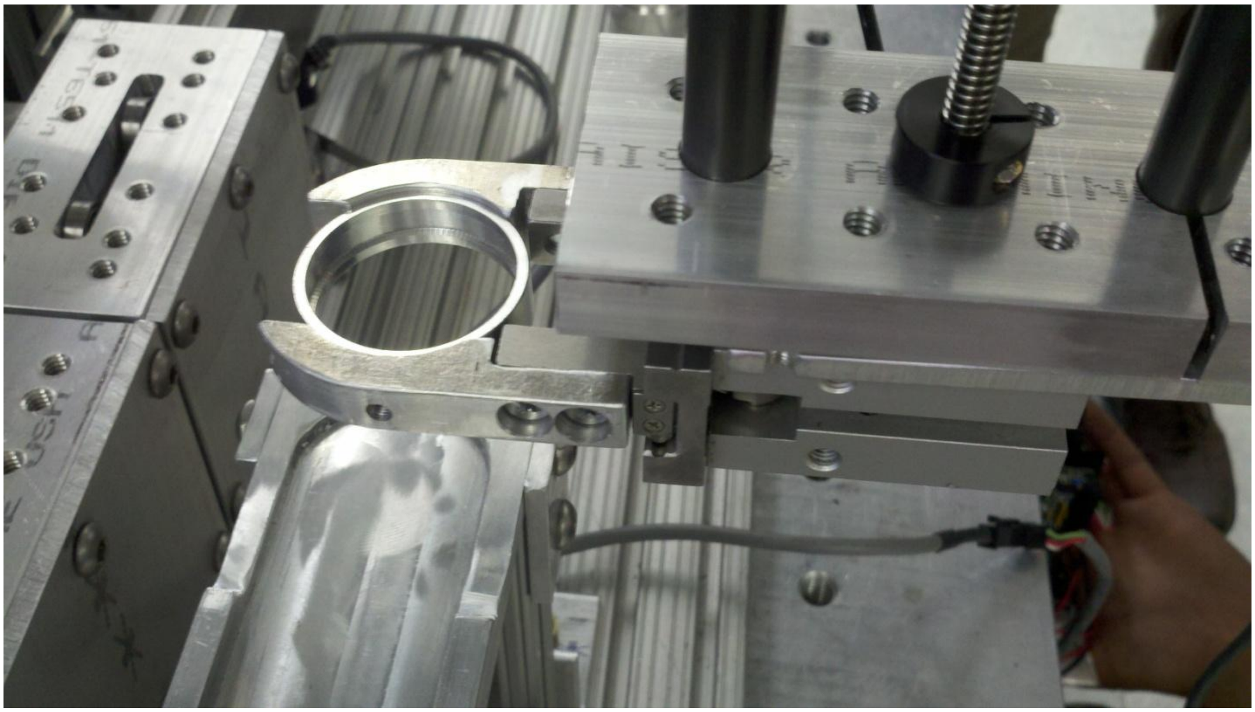


Figure 15: Y-Z Axis Cart

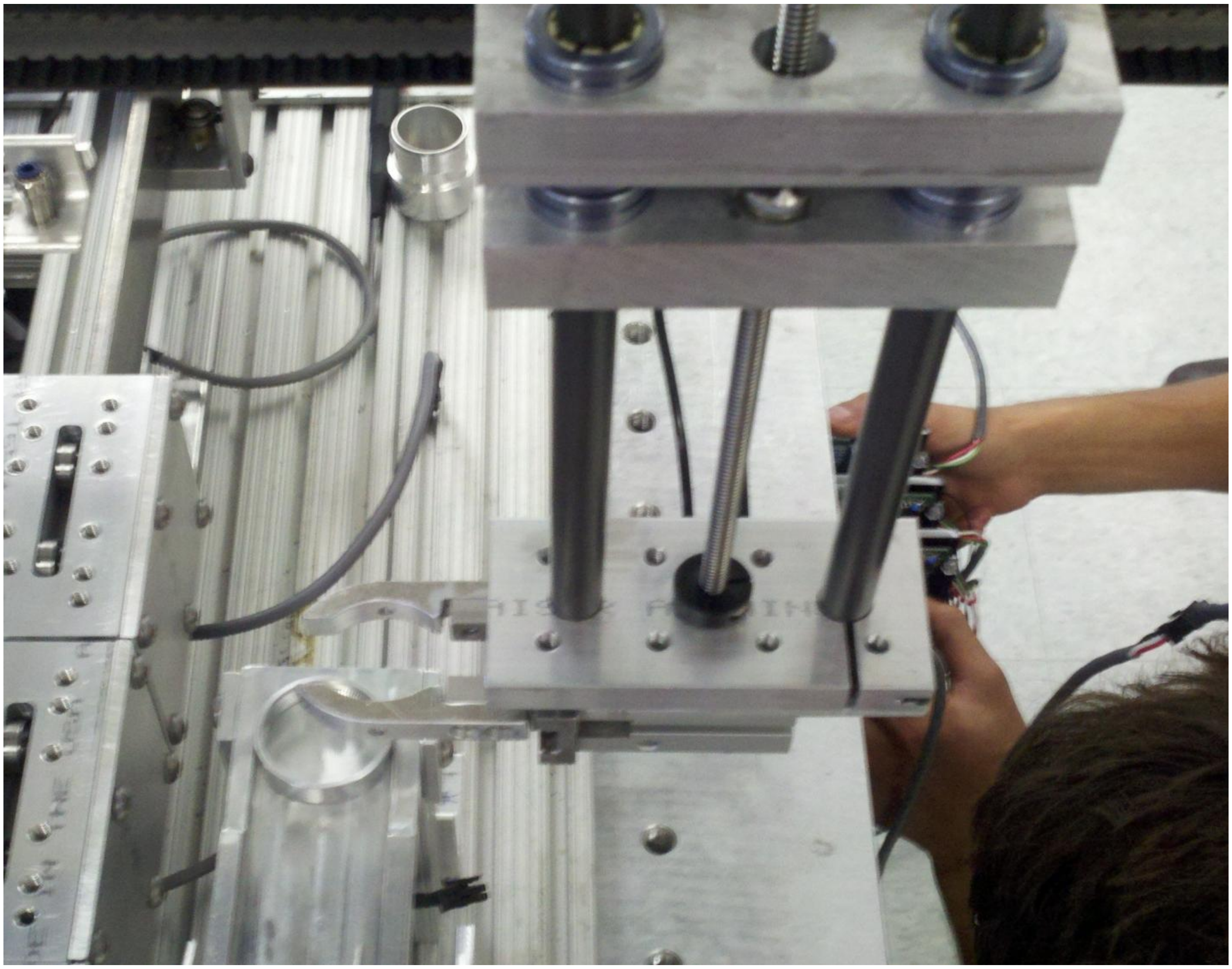
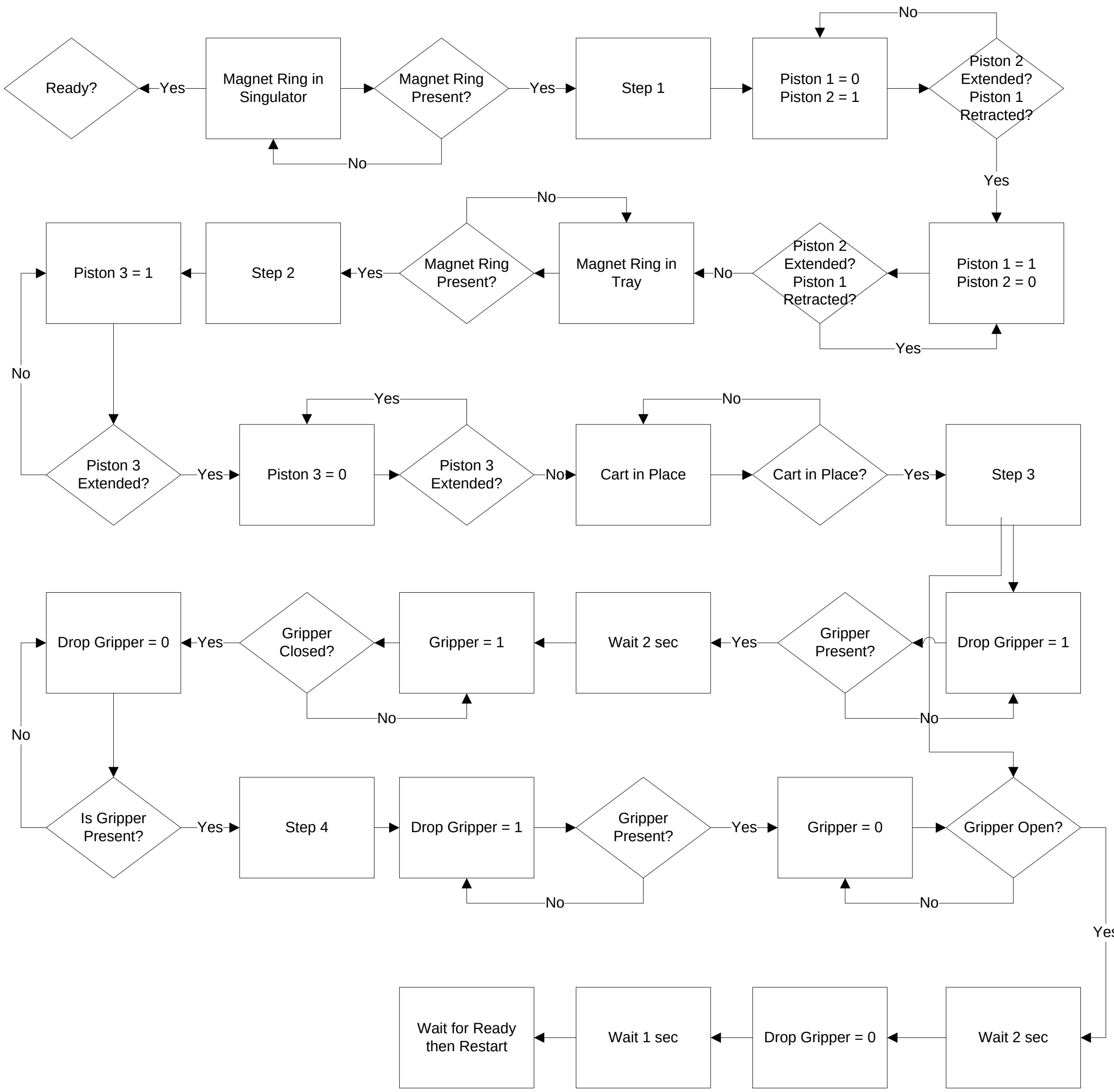


Figure 16 : Y-Z Axis Cart

Order of Operation:

The Y-Z cart will support both of the o-ring grabber and the magnet ring grabber. Since the nose will need an o-ring on both sides of the magnet ring, this station will have 3 total operations per cycle. First the o-ring will be placed. Second the magnet ring will be placed on the first o-ring. Third the final o-ring will be placed on the magnet ring.

Figure 17: Magnet Ring/Outer O-Ring State Diagram:

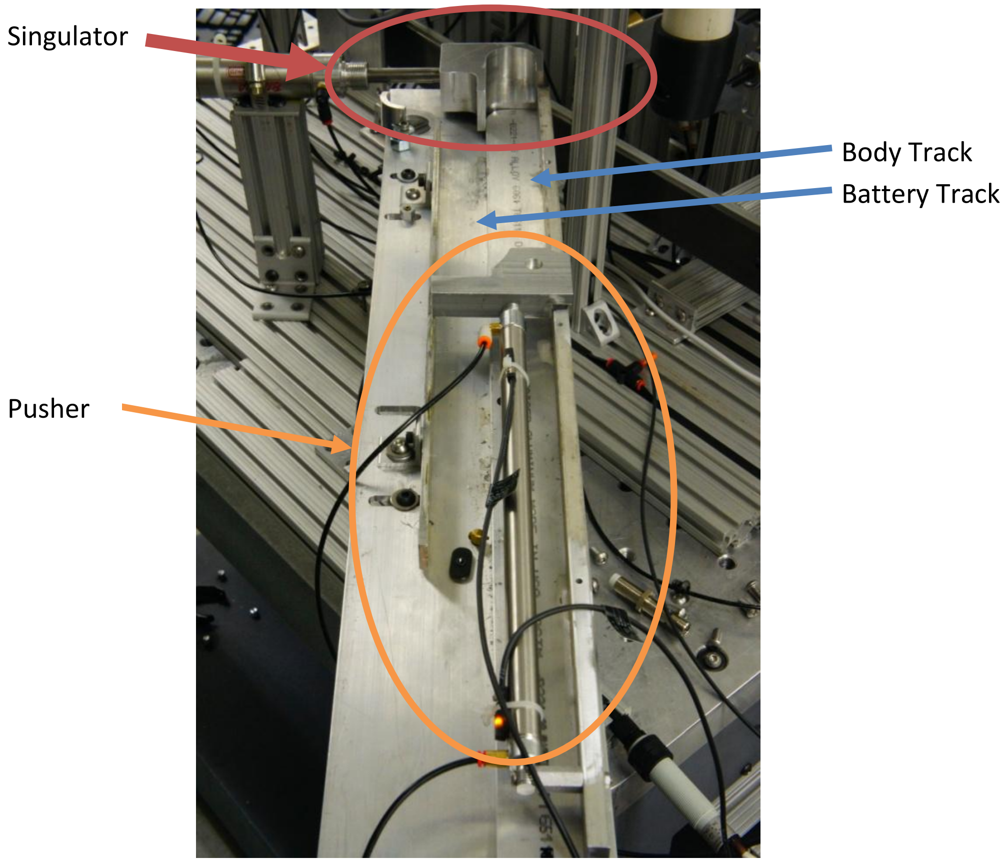


Handle and Battery Assembly, Threading and Flashlight Removal

The final station involved combining the handle and battery, then threading the handle onto the nosecone and finally removing the flashlight from the cart. This station is the most complex and has the most number of operations.

The first part of the system makes the assumption that the body and battery are able to be directed into their respective tracks. Once in place the pusher cylinder pushes the body parts into the singulator. Range of motion of the pusher is verified by two hall effect sensors on the piston The Singulator setup can be seen below

Figure 18: Pusher Cylinder



The puller singulates the battery and body. It does so by pulling them away from their respective tracks. This allows the gripper to access the body without interference from other bodies. The puller motion also positions the battery over the battery lifter cylinder which is needed to ensure the battery is inserted fully into the body. Piston retraction for the puller is verified by a single Hall Effect cylinder on the piston.

Figure 19: Puller mechanism

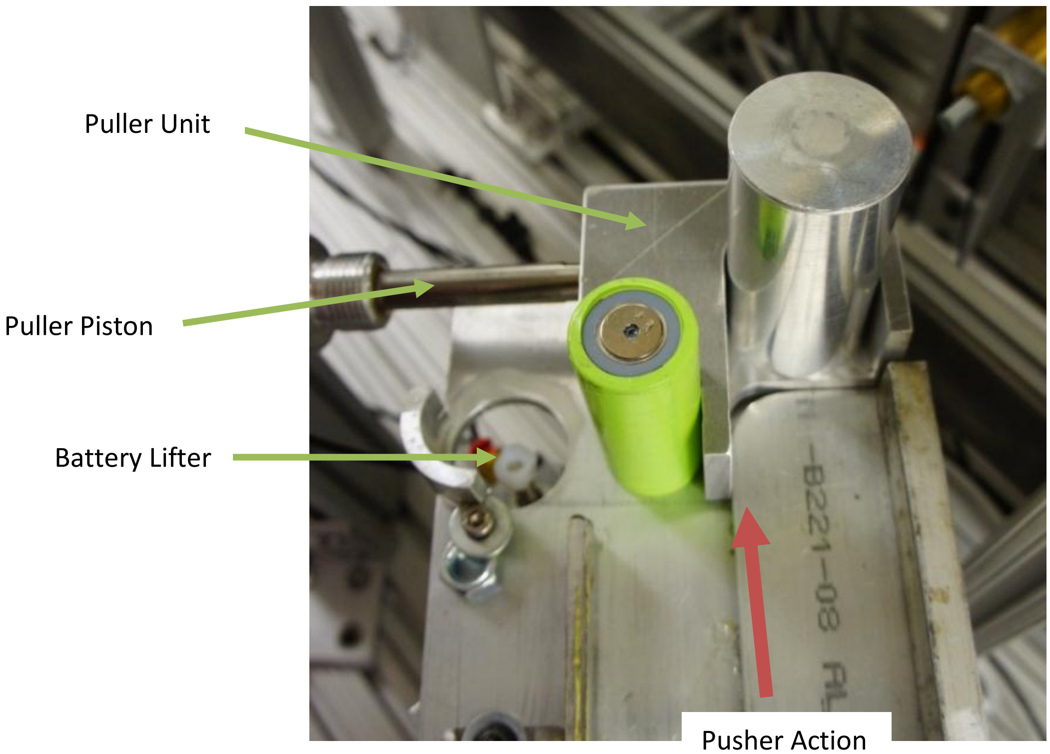


Figure 20: Actuated Puller Mechanism

Note how the battery is now placed directly over the battery lifter.

The next step is to pick up the body and the battery. To do this operation we used a three jaw gripper with a magnet attached to it. This enabled the gripper to pick up the body using the jaws and then when the battery was pushed up into the body the magnet would act on it and hold it in place inside the body. The figure below shows the gripper in position to pick up the body, after which it will pick up the battery. The puller aligns both the battery and the body so that the gripper only has to move in the y and z axis to pick them up. Battery placement inside the body is verified by a Hall Effect sensor on the lifter piston.

Figure 21: Gripper and Puller Mechanism

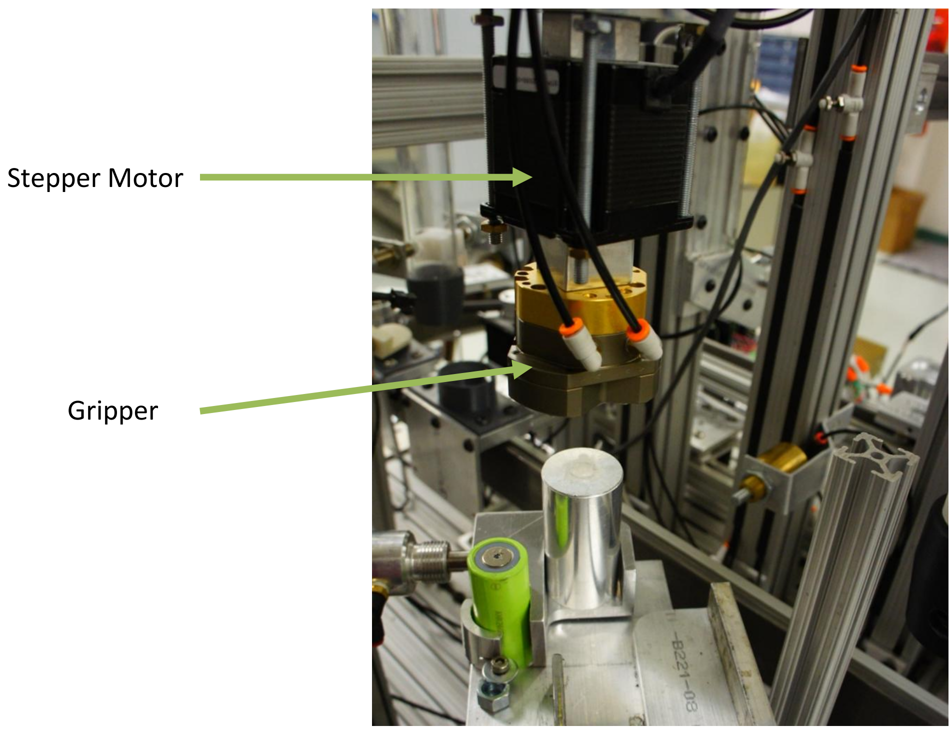
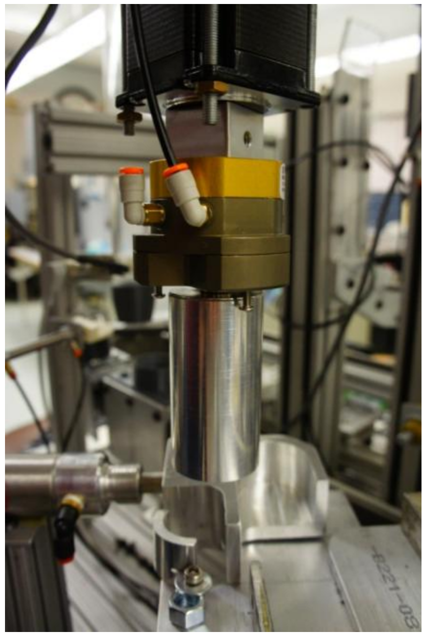
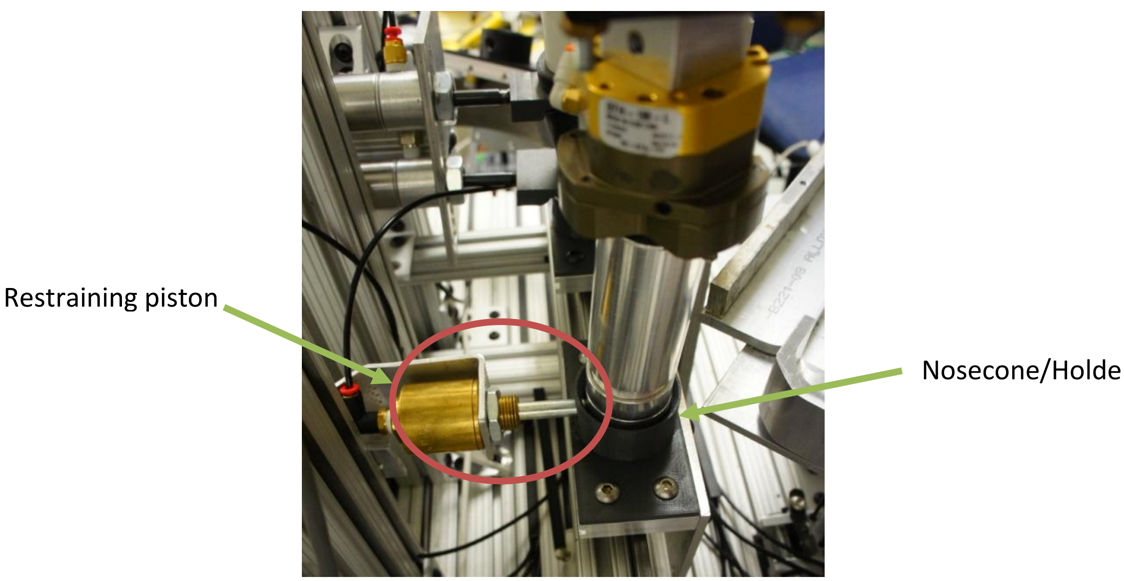


Figure 22: Gripper holding body with battery inside.



After the body and battery are held the gripper moves over to the cart to do some threading. The cart is holding the nosecone with all of its components attached/inside. In order to thread on the nosecone, the nosecone must be constrained so that it will not rotate. We constrain the nosecone using a single piston that presses against the side of the nosecone. There is no verification of this action.

Figure 23: Actuated Restraining Piston



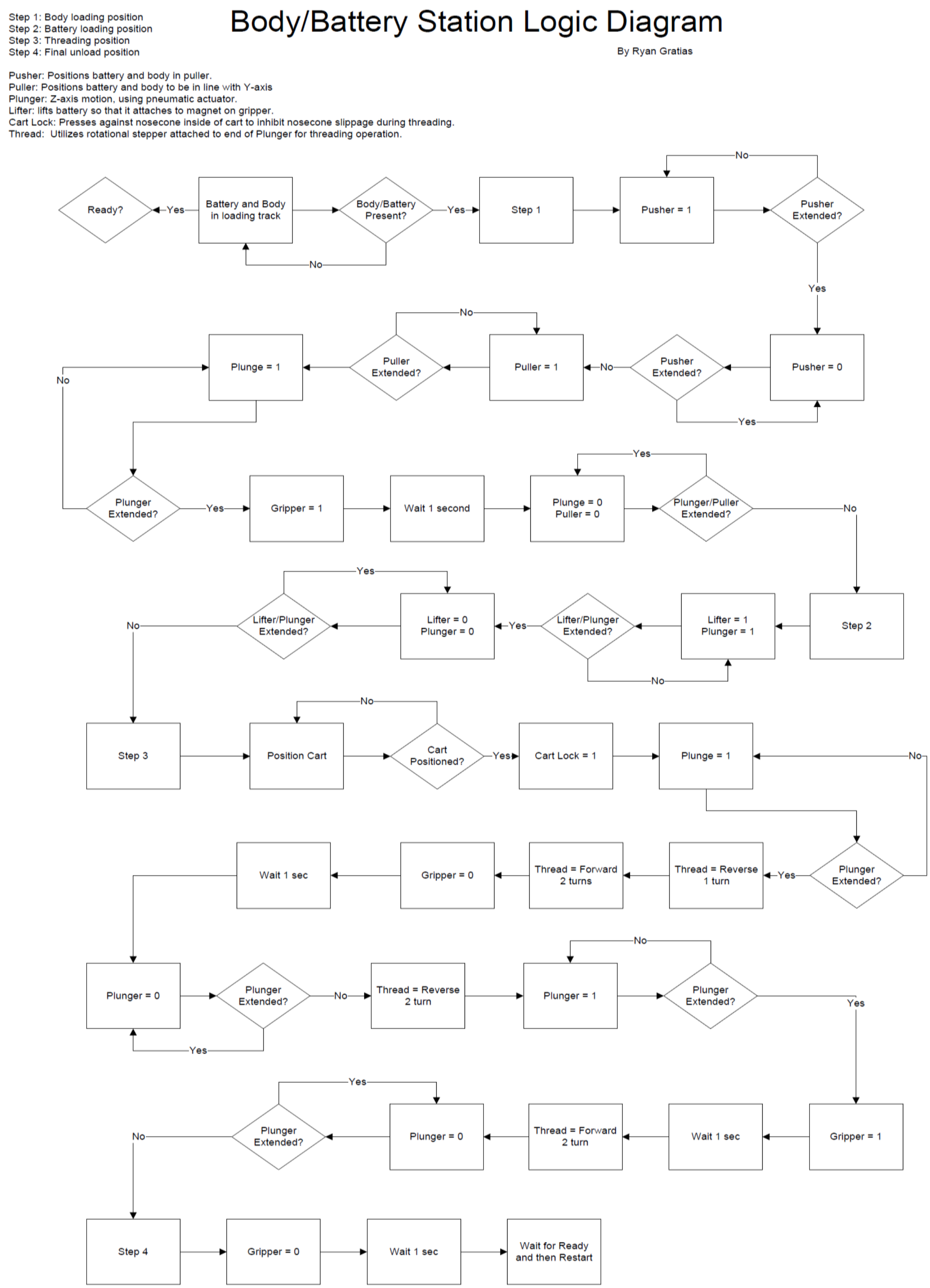
The threading system uses a stepper motor in conjunction with the gripper to thread the body onto the nosecone. Because of the Pneumatic lines going to the gripper it is necessary that the threader grip, then twist, ungrip, untwist, regrip and twist again. This action is similar to that of humans as they thread things. This gripping methodology is depending on the gripper to hold the body perfectly straight when the thread is started. This step is what I believe is the weakest part of the system.

After the body is threaded to the nose the restraining piston releases and the gripper removes the flashlight from the assembly line. A logic diagram for this station is located below

Programming:

The station was never fully operational because there was no x, y or rotary axis motion. These axes were dependent on stepper motors and that part of the infrastructure was not built by the end of the quarter. Therefore, to test the operation of the station I put together a program using switches to trigger the different motions. For the motions in the x and y direction I moved the parts by hand. This was a very primitive program that did not utilize the sensors, but it worked for debugging the actual operation of the system.

Figure 24: Final Station Logic Diagram



Future Improvements

This was the first year that this type of assembly system was used in this class. Because of this the infrastructure was much less developed than that of robotic arm and turret assembly systems. There were quite a number of things that had to be figured out. Not everything was developed far enough to get the system completely functional in the ten weeks we had to build the system. Due to these factors it is difficult to give specific ways of improving individual stations; however, there are two system features that could be improved for future iterations.

One of the benefits that was touted for this system was the fact that you would be able to move the carts in the x-axis independently. With the system in its current state the motion allowed in the x-axis is very limited. It is restrained to ½” in either direction. This is not a very large distance when compared to the diameter of the piece. Ideally the x-axis motion would be able to go from one side of the flashlight nose to the other. One possible way to do this would be to reduce the length of the carts. The carts are quite a bit larger than they need to be because the cart was designed first and the holder was made to fit the cart. If the cart were to be redesigned it could be shortened. The limiting factor for length in this case would most likely be the distance between the stepper gears.

There is some inaccuracy produced in the system by the play of the carts on the track. In one of our stations we use an air cylinder to apply pressure to the nose to hold it in place. When the air cylinder is applying pressure to the nose, the play between the cart and the track allows the nose to be pushed out of vertical alignment with the gripper. It is possible to make adjustments to the cart bearings to decrease this play. The problem with this is that each cart will need to be adjusted and it would be a time consuming process to adjust all the carts identically.