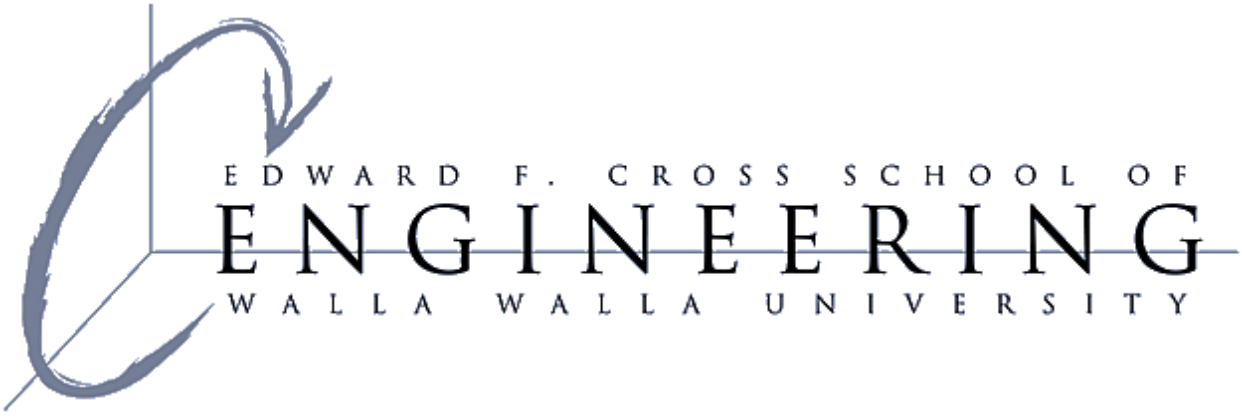
Flashlight Assembly Instruction Manual

Basic Instructions and Description of Flashlight Assembly Machine



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ENGR 480: Final Report

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Introduction

This paper documents the operation, functions, and design of the flashlight assembling machine built for ENGR 480, Manufacturing Systems.

Operation Procedure

This section provides instructions on how to start the machine assembling flashlights, how to load parts into the machine, and how to clear jams if the machine malfunctions.

Starting the Machine

1. Check to make sure all stations are clear of foreign objects and no collisions will occur when the system is powered on.
2. Power on the system by twisting the emergency stop button on the main control box.
3. Check to make sure each of the stations will not interfere with the rotation of the turret:
    a. Nose drop station must be in the raised position
    b. Internal O-ring station must have the O-ring alignment plug fully retracted
    c. Lens station must have the vacuum nozzle raised above the nose cone
    d. Magnetic ring and external O-ring stations must have the slides retracted away from the nose pocket.
4. Prime the system by placing the appropriate partially assembled flashlights at each station.
5. Start the assembly process by pressing the black button on the main control box

Loading the Machine

Each station must have at least one part present in order for the system to successfully complete an assembly cycle. Loading should only be done with the system powered down. Parts should be loaded in each station as follows:

1. Nose station – Load by inserting nose pieces into the top of the transparent tube. Noses should be oriented so that the large bore is facing the top of the tube.
2. Internal O-ring station – Load O-rings onto the screw threads. Only one O-ring should be in each thread pitch. Once the screw is full of O-rings, align the screw so that a single turn will cause the last O-ring to fall off the end.
3. Lens placement station – Load by placing the lenses through the square hole in the blue feeder track cover. The flat surface of the lens should be against the bottom of the track.
4. LED module station – Load by inserting LED modules into the top of the transparent tube. LED modules should be oriented with the LED facing down and the spring facing the top of the tube.
5. Magnetic ring station – Place magnetic rings on the back edge of feed track. The rings should be oriented horizontally with the axis of the ring pointing towards the bottom of the track. The edge closest to the magnet should be against the rails on the track.

6. External O-ring station - Load O-rings onto the screw threads one at a time. After an O-ring is placed, turn the screw counter-clock-wise one rotation to allow the next to be placed on the end. Only one O-ring should be in each thread pitch. Once the screw is full of O-rings, align the screw so that a single turn will cause the last O-ring to fall off the end.

Clearing Jams

Each station has the potential to jam. Anytime a jam occurs, immediately press the emergency stop button on the control box to shut down power. Clear the jam and ensure that all of the station's components can operate properly when power is restored. If the assembly sequence is going to continue, manually replace any damaged or missing parts on the partially assembled flashlights. To restart the assembly process, follow the startup procedure listed above.

Machine Description:

There are a total of 8 stations present on the assembly machine. Each position of the base turret represents a station point and the 8 stations occur as follows.

1. Nose drop
2. Internal O-ring placement
3. Lens placement
4. LED Module placement
5. Magnetic ring placement
6. External O-ring placement
7. Assembled Nose Removal
8. Part Gone Check

A description of each of the above stations will follow indicating how they work and what they do.

1) Nose Drop:

- The nose drop portion of the assembly machine is an intrusive station, and users must be wary of its position at all times. Noses are to be fed into the top acrylic cylinder and when the station has been cleared to start, it will lower into place over the nose holder mounted onto the turret. The purpose here is to make a closed connection with the nose holder to ensure the nose is seated properly. A properly seated nose is important, because everything builds off of it. After the nose station has lowered into position an inductive part present sensor will determine how to control the singulation in the tubing in order to drop a part into place. After this is done, part present reads false and the entire station will retract from the turret, and the station will signal complete.

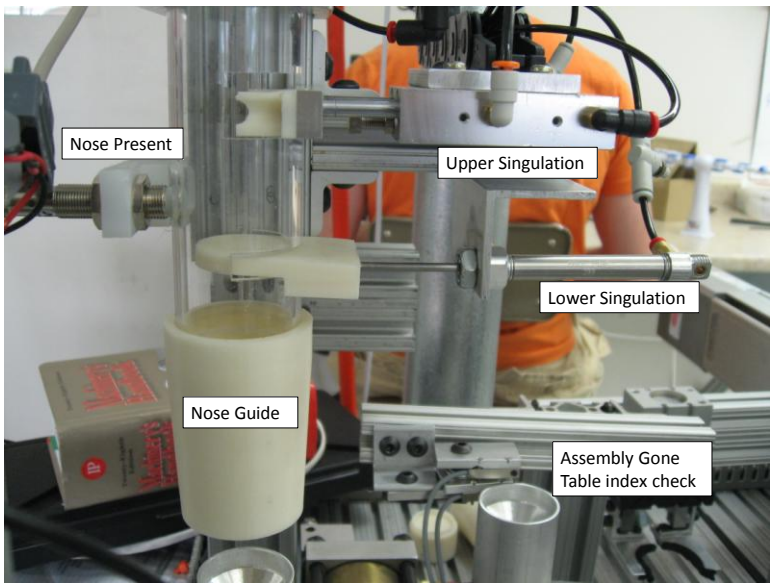


Figure 1

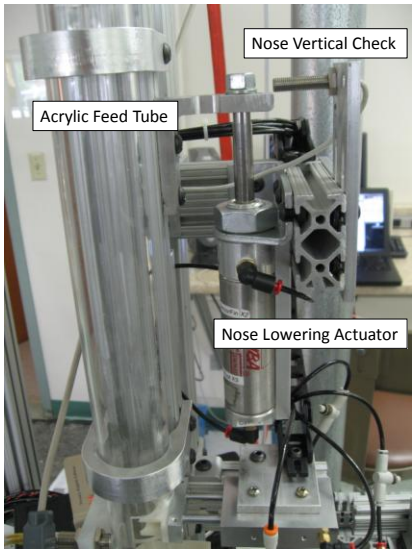


Figure 2

2) **Internal O-Ring Placement:**

- The Internal O-ring station consists of a slider tray, a number of air-hoses and a smart motor with a helical shaft. The o-rings are loaded onto the smart motor shaft and aligned at the end of the shaft. When the station receives its ready signal, a cylinder from below the turret triggers and pushes up a brass o-ring alignment plug located within the nose holder. With this alignment plug up, the smart motor is signaled to turn. As the motor turns it releases an o-ring and three air lines help the o-ring slide into place over the brass alignment plug. After this is done, the station will signal complete.

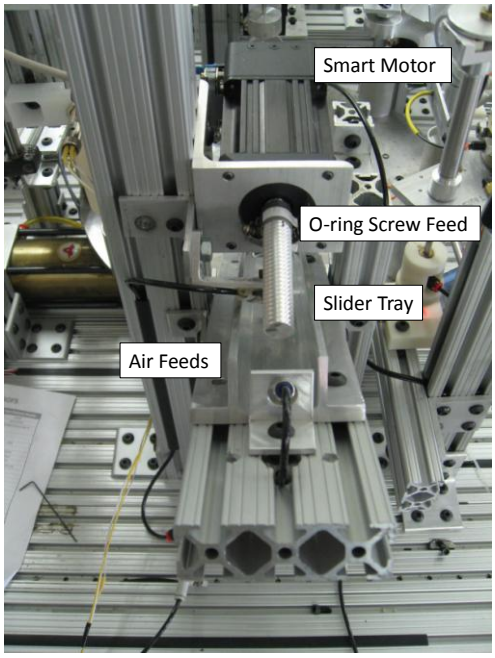


Figure 3

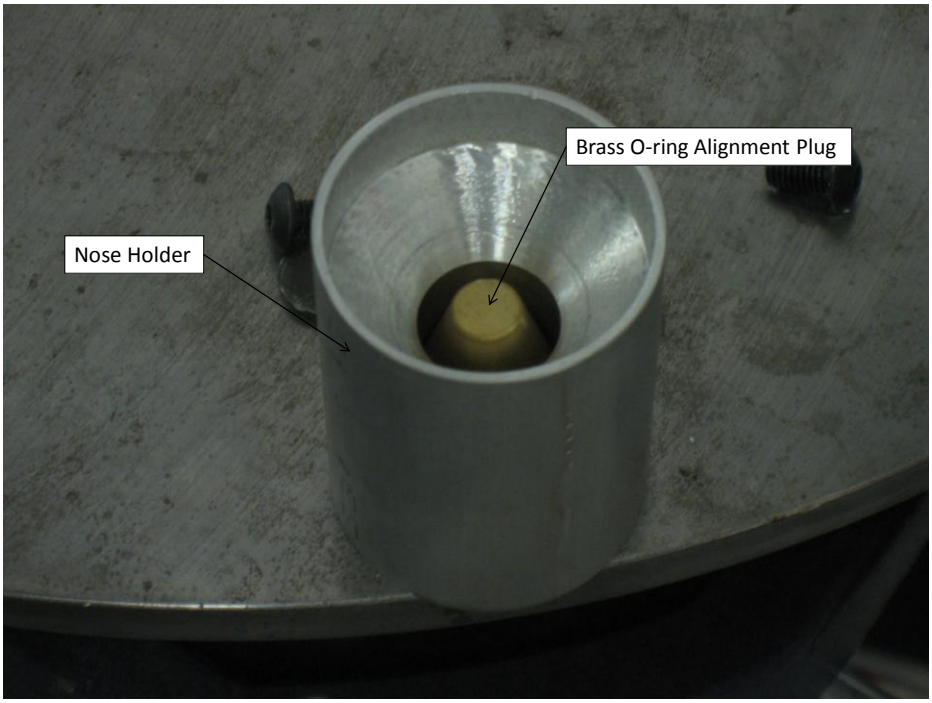


Figure 4

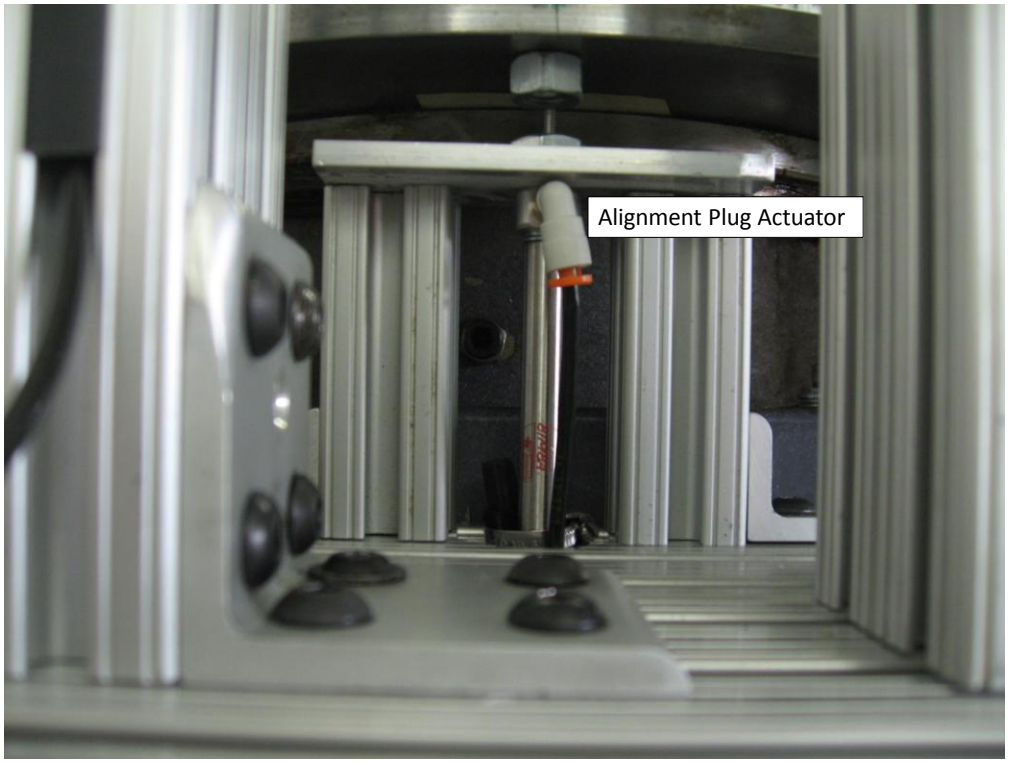


Figure 5

3) Lens Placement:

- Lens placement begins in the singulation track, where up to 9 lenses can be loaded for assembly. A lens holder tray is positioned below this track with a reflective sensor which signals the station when a lens is present. The singulation in the station is controlled by this sensor and will respond accordingly if a lens is initially present or initially not present. Once a lens arrives in the holder tray, a vacuum assembly will be lowered with a vertical cylinder over the lens and the vacuum turned on. This vacuum will suction the lens and enable the vertical cylinder to retract with the lens still attached to the end. After a sensor on the cylinder reads retracted, the entire lens vacuum system will be rotated by a rotary cylinder which will place the system directly over a waiting nose, at which point the vertical cylinder will lower into the nose and the vacuum will release. Once the vertical cylinder has retracted the station will return to its original position and signal complete.

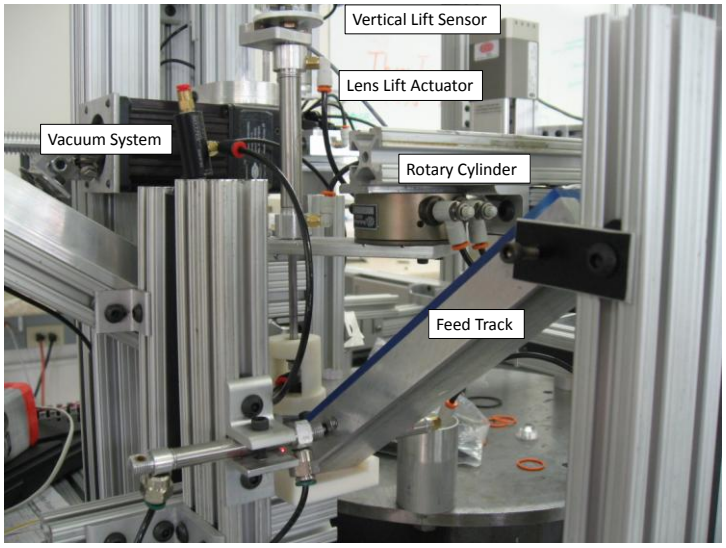


Figure 6

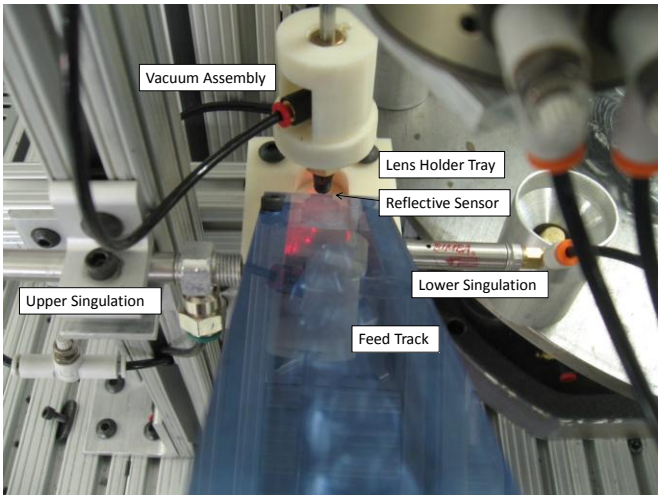


Figure 7

4) LED Module Placement:

- LED Module placement is very straightforward and simple. Similar acrylic tubing as used in the nose station holds the heat sinks. A through-beam sensor signals the upper and or lower singulation to release a part, and then the station signals complete.

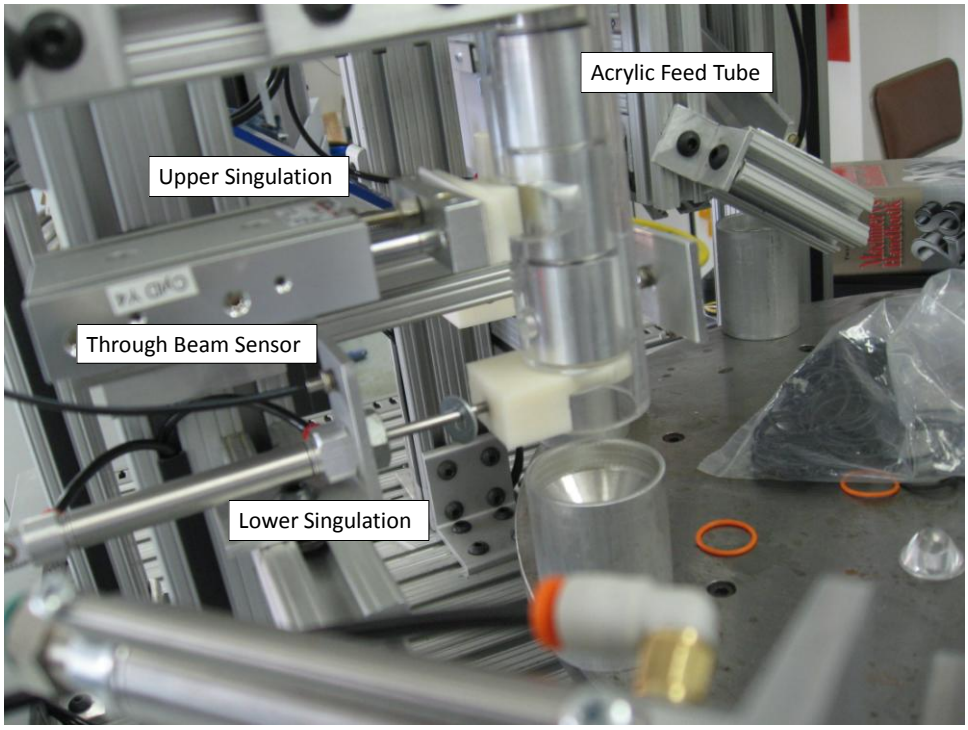


Figure 8

5) Magnetic ring Placement:

- Ring singulation is a similar set-up to the lens singulation. The only difference is that no part present sensor is installed, so instead of a sensor controlling the singulation, the singulation always begins with the upper singulation and then the lower singulation in order to place a part. However, before singulation even begins, a ring tray extends to the turret and positions itself right next to the nose. After the tray has fully extended, and the singulation has been carried out, a pusher slides along the surface of the tray and forces the ring overtop of the nose. At this point both the slider and the tray retract, which then signal a hammer piston to push on top of the ring/nose assembly to ensure the sing is properly seated. At this point the hammer retracts and the stations signals complete.

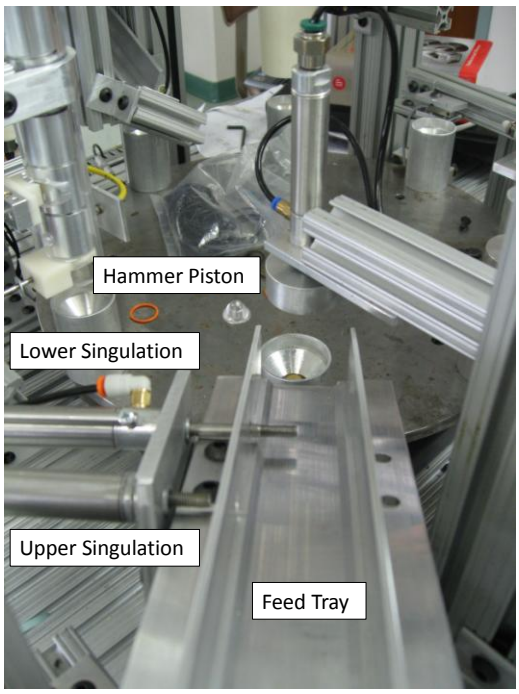


Figure 9

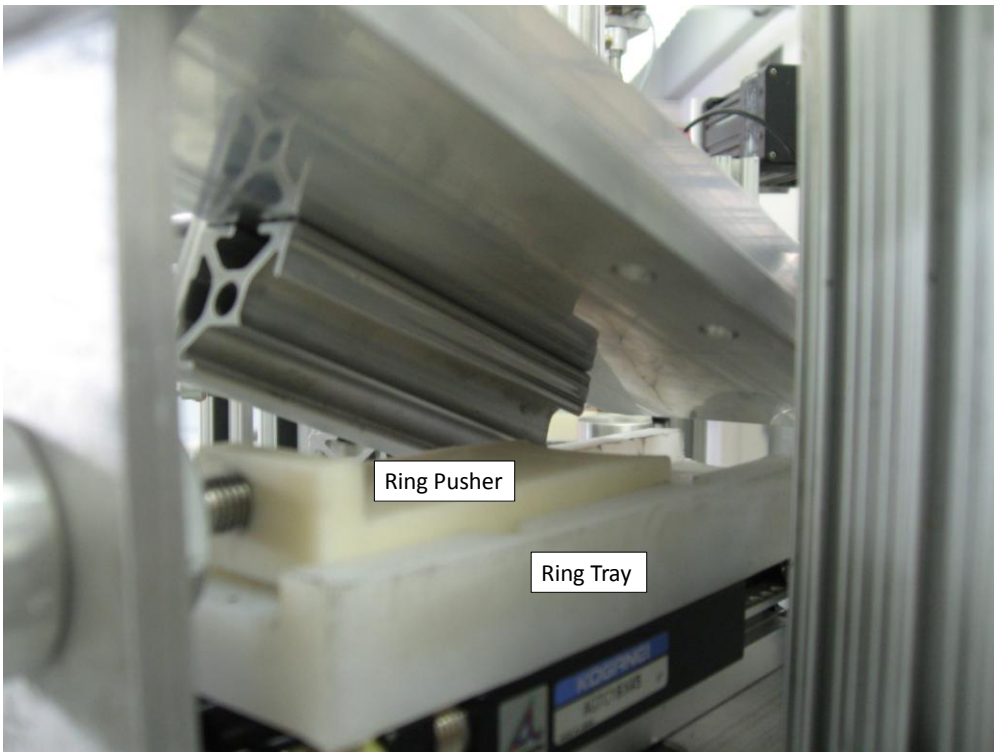


Figure 10

6) External O-Ring Placement:

- External O-Ring placement combines features from both the Internal O-Ring placement and the magnetic ring placement station. The singulation on the External O-Ring station closely resembles that of the Internal O-Ring station, where a smart motor rotates to deliver an o-ring. However, like with the magnetic ring station, before the singulation occurs, a tray is extended up to the nose. Once this occurs, an o-ring is dropped onto the tray and a pusher slides the o-ring into place where it is then pushed into position by a hammer. When everything retracts the station signals complete.

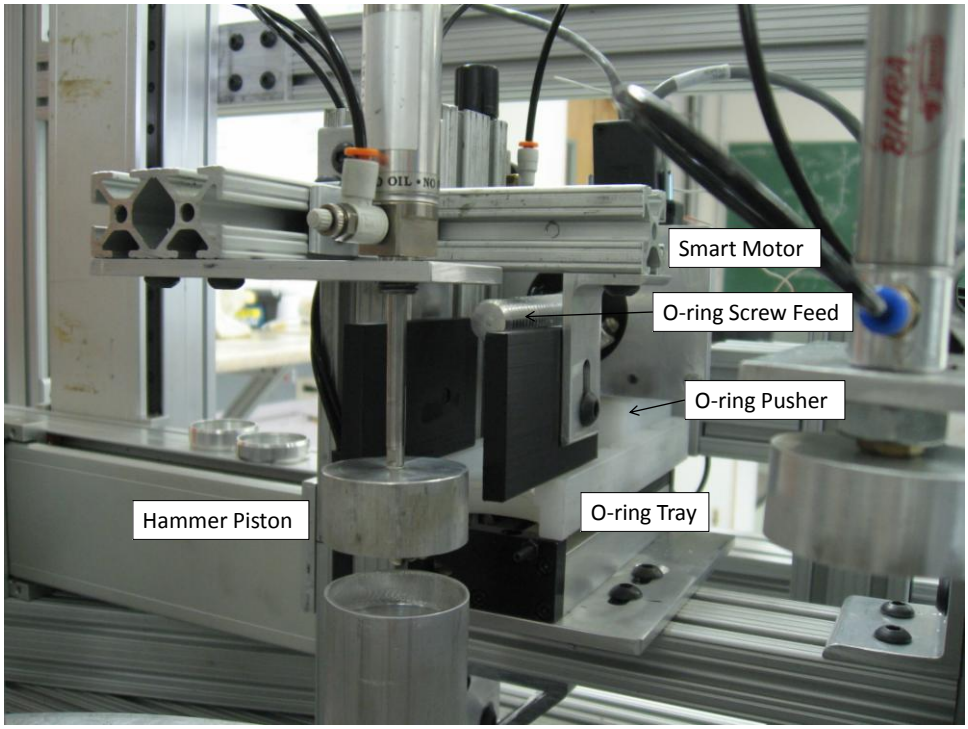
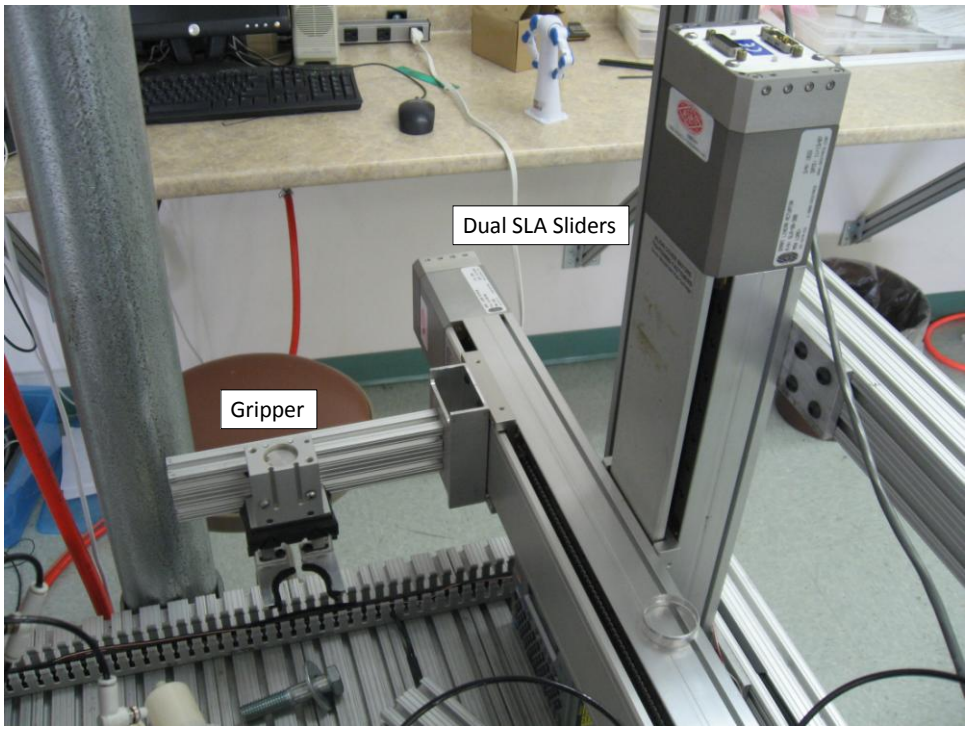


Figure 11

7) Assembled Nose Removal:

- Nose assembly removal consists of a gripper mounted onto a dual SLA slider which gives it 2 degrees of freedom. With this freedom, the gripper will lift a nose assembly off the turret and place the nose into a rotary screwing station. After the nose is placed, the robot will then grab a body/battery combination and slowly lower them onto the nose, which will at this point be spinning due to the rotary motor. Effectively, this will screw the entire assembly together, at which point the gripper will be moved over to a box and the finished flashlight will be released. After this, the station will return to its default position and signal complete.



8) Part Gone Check:

- The final station on this assembly machine consists of two safety checks for the entire machine. The first check is an inductive sensor which tells the machine if the table is indexed and in position. The other, also an inductive sensor, is used to determine if the finalized nose assembly piece did indeed get removed from the turret. See Figure 1.

Limitations and Suggestions

A large limitation to the machine is the limited information available to verify specific part placement. During some of the steps it is difficult to verify that the operation is completed successfully. Implementation of more sensors could accomplish this in some cases. More sensors could also be included in the system operation to verify positions of certain actuators. This would eliminate the need for some of the timers currently in place.

The way the current design is, continual operation is not possible for o-ring feeding. It is necessary to load the screw feeds by hand every 20 or so operations. This is more of a problem for the OD O-ring station, where the feed is located in a tight location. To fix this issue, a completely new direction would be necessary, though time did not allow this. To have a completed flash light, it would be necessary to complete the last station, which is a pick and place operation done by a linear robot. The robot is currently in place, though there is no system to thread the body and nose assembly together. Also there is limited space to create the sub-assembly system to insert the battery into the body for the robot to pick-up and thread onto the nose assembly. To accomplish this, it would be necessary to have more space on the table, or build the sub-assembly system underneath the table.

Appendices

Flashlight Bill of Materials

1) Nose Piece – Machined on Mori from 1.5” diameter aluminum stock. See attached G code
2) Internal O-ring – 20 mm OD, 1.5 mm width – McMaster Carr part # 9262K132
3) Lens - 20 mm diameter lens – LED Supply Part # 10199
4) LED Module – Aluminum heat sink machine from 1.5” diameter aluminum stock. See attached G code for 3 operations. Circuit provided by Ralph Stirling
5) External O-ring – 33 mm OD, 1.5 mm width – MCMaster Carr part # 9262K651
6) Magnetic Ring - Machined on Mori from 1.5” diameter aluminum stock. See attached G code
7) Battery – 18650 size battery – BatterySpace.com part # LFP-18650-1200
8) Body - Machined on Mori from 1.5” diameter aluminum stock. See attached G code

Nose G-Code

```
%
O1;  (FLASHLIGHT HEAD)
;    (STOCK: ALUM 1.5" x 35 + 10 mm)
;    (Alum cutting speed: 75 m/min rough, 185 m/min finish)
;
;    (Variables)
#500=38.1         (STOCK DIAMETER)
#501=34.24        (STOCK LENGTH)
#502=75.0         (ROUGH SURFACE M/MIN)
#503=0.2          (ROUGHING FEED: MM/REV)
#504=185.0       (FINISH SURFACE M/MIN)
#505=0.05        (FINISH FEED MM/REV)
;
;(FACING PROCEDURE)
N1
G54                    (WORK OFFSET)
G21                    (CHOOSE METRIC SYSTEM)
G28    U0    W0            (GO HOME)
G50    S2000                (SET MAX SPINDLE SPEED)
G00    T1010                (SELECT CUT-OFF TOOL)
G96    S#502                (SET CONSTANT SURFACE SPEED)
G99                    (FEED PER REV)
M03                    (SPINDLE ON)
G00    X[#500+1.0] Z#501
M08
G01    X-1.0    F#503
G01    Z[#501+1.0]    F1.0
M09
M05
G28    U0    W0
M01
;
; (ROUGH PASS - ROUGH USING 2.0 MM DOC/PASS)
;
N2
G28 U0 W0                  (GO HOME FOR TOOL CHANGE)
G50 S2000                  (SET MAX SPINDLE SPEED)
G96 S#502                  (SET SURFACE SPEED)
G99
G00 T0101                        (CHANGE TO ROUGHING TOOL)
G00 X[#500+1.0] Z[#501+1.0]     (GO TO INITIAL POINT FOR ROUGHING)
M03                              (START SPINDLE)
M08
N020 G71 U2.0 R1.0               (ROUGHING CYCLE CODE)
```

```
N021 G71 P022 Q028 U1.0 W0.5 F#503
N022 G01 X30.032 Z[#501+1.0]    (INITIAL ROUGHING POINT)
N023 G01 X30.032 Z25.74
N024 G01 X33.032 Z25.74
N025 G01 X33.032 Z20.74
N026 G01 X35.032 Z20.74
N027 G01 X35.032 Z-3.05
N028 G01 X[#500+1.0] Z-3.05
M09
M05
G01 X[#500+1.0]
G28 U0 W0                        (GO HOME FOR TOOL CHANGE)
M01                        (OPTIONAL STOP)
G00 T0202                        (FINISHING TOOL)
G50 S2000                  (SET MAX SPINDLE SPEED)
G96 S#504                  (SET SURFACE SPEED)
G99
G00 X[#500+1.0] Z[#501+1.0]     (RETURN TO PART)
M03                        (SPINDLE ON CCW)
M08                              (COOLANT ON)
N028 G70 P022 Q028 F0.05           (FINISHING PASS)
G01 X[#500+1.0]                 (MOVE TOOL AWAY FROM WORK)
M09                              (COOLANT OFF)
M05                              (STOP SPINDLE)
G28 U0 W0                        (GO HOME)
M01                              (OPTIONAL STOP)
;
; (THREADING)
N3
G28 U0 W0
G00 T0303       (THREADING TOOL)
G50 S2000       (SET MAX SPINDLE SPEED)
G96 S#502       (SET SURFACE SPEED)
G99
G00 X30.032 Z36.0
M03                  (SPINDLE ON FORWARD)
M08                  (COOLANT ON)
G76 P160060
G76 X28.3 Z25.24 P866 Q100 F1.0
M09                  (COOLANT OFF)
M05                  (SPINDLE OFF)
G28 U0 W0            (HOME)
M01                  (OPTIONAL STOP)
;
; (CENTER DRILL PILOT HOLE)
N4
```

```
G28 U0 W0
G00 T0505                   (CENTER DRILL, TOOL 5)
G97 S1000                   (SET SPINDLE SPEED)
G99
G00 X0.0 Z[#501+2.0]        (SAFE POINT)
M03                         (SPINDLE ON CCW)
M08                         (COOLANT ON)
G01 X0.0 Z[#501-2.0] F#503
G01 X0.0 Z[#501+2.0] F2.0   (SAFE POINT)
M09                         (COOLANT OFF)
M05                         (SPINDLE OFF)
G28 U0 W0
M01
;
; (PECK DRILLING WITH 1/2" DRILL)
N5
G28 U0 W0       (HOME)
G00 T1212       (TOOL CHANGE TO 1/2" DRILL)
G97 S1200        (SET SPINDLE SPEED)
G99
G00 X0.0
G00 Z36.0       (SAFE POINT)
M03             (SPINDLE ON CCW)
M08             (COOLANT ON)
G01 Z30.0 F#503       (CUTTING)
G01 Z36.0 F1.0
G01 Z25.0 F#503       (CUTTING)
G01 Z36.0 F1.0
G01 Z20.0 F#503       (CUTTING)
G01 Z36.0 F1.0
G01 Z15.0 F#503       (CUTTING)
G01 Z36.0 F1.0
G01 Z10.0 F#503       (CUTTING)
G01 Z36.0 F1.0
G01 Z5.0 F#503 (CUTTING)
G01 Z36.0 F1.0
G01 Z0.0 F#503 (CUTTING)
G01 Z36.0 F1.0
G01 Z-1.0 F#503       (CUTTING)
G01 Z40.0 F1.0 (SAFE POINT)
M09             (COOLANT OFF)
M05             (SPINDLE OFF)
G28 U0 W0       (HOME)
M01             (OPTIONAL STOP)
;
; (PECK BORING WITH 3/4" END MILL)
```

```
N6
G28 U0 W0      (HOME)
G00 T0707      (TOOL CHANGE TO END MILL)
G97 S1200       (SET SPINDLE SPEED)
G99
G00 Z36.0
G00 X18.7      (SAFE POINT)
M03            (SPINDLE ON CCW)
M08            (COOLANT ON)
G01 Z30.0 F#503      (CUTTING)
G01 Z36.0 F1.0
G01 Z25.0 F#503      (CUTTING)
G01 Z36.0 F1.0
G01 Z20.0 F#503      (CUTTING)
G01 Z36.0 F1.0
G01 Z15.0 F#503      (CUTTING)
G01 Z36.0 F1.0
G01 Z10.0 F#503      (CUTTING)
G01 Z36.0 F1.0
G01 Z5.0 F#503 (CUTTING)
G01 Z36.0 F1.0
G01 Z1.5 F#503 (CUTTING)
G04 F0.5 (DWELL)
G01 Z40.0 F1.0 (SAFE POINT)
M09            (COOLANT OFF)
M05            (SPINDLE OFF)
G28 U0 W0      (HOME)
M01            (OPTIONAL STOP)
;
; (ROUGHING CYCLE WITH 3/4" END MILL)
N7
G28 U0 W0      (HOME)
G00 T0707      (TOOL CHANGE TO END MILL)
G96 S#502       (SET SURFACE SPEED)
G50 S2000       (SET MAX SPINDLE SPEED)
G99
G00 X18.7 Z36.0      (SAFE POINT)
M03            (SPINDLE ON CCW)
M08            (COOLANT ON)
G71 U1.0 R0.5
G71 P40 Q50 U-0.6 W0.3 F#503
N40 G01 X26.4 Z34.24
    G01 X25.4 Z33.74
    G01 X25.4 Z4.915
    G01 X21.05 Z3.24
N50 G01 X21.05 Z1.0
```

```
G01 X18.7 Z36.0      (SAFE POINT)
M09            (COOLANT OFF)
M05            (SPINDLE OFF)
G28 U0 W0      (HOME)
M01            (OPTIONAL STOP)
; (MANUAL CHIP CLEARING)
;
; (14.5MM BORING BAR ROUGHING CYCLE)
N8
G28 U0 W0            (HOME)
G00 T0909            (TOOL CHANGE TO BORING BAR)
G50 S2000            (SET MAX SPINDLE SPEED)
G96 S#502            (SET SURFACE SPEED)
G99
G00 X14.8 Z36.0            (SAFE POINT)
M03                  (SPINDLE ON CCW)
M08                  (COOLANT ON)
G01 Z-1.5 F#503            (CUTTING)
G01 X14.7 Z1.6 F1.0
G01 X15.2
G01 Z-1.5 F#503            (CUTTING)
G01 X14.8 Z1.6 F1.0
G01 X15.9
G01 Z-1.5 F#503      (CUTTING)
G00 X15.0 Z36.0 F1.0 (SAFE POINT)
M09                  (COOLANT OFF)
M05                  (SPINDLE OFF)
G28 U0 W0            (HOME)
M01                  (OPTIONAL STOP)
; (MANUAL CHIP CLEARING IF NECESSARY)
;
; (BORING BAR FINISHING CYCLE)
N9
G28 U0 W0      (HOME)
G00 X16.0 Z36.0      (SAFE POINT)
G50 S2000
G96 S#504
G99
M03            (SPINDLE ON CCW)
M08            (COOLANT ON)
G70 P60 Q70 F#505
N60 G01 X26.4 Z34.24
    G01 X25.4 Z33.74
    G01 X25.4 Z4.915
    G01 X21.05 Z3.24
    G01 X21.05 Z1.0
```

```
    G01 X16.7 Z1.0
N70 G01 X16.7 Z-1.5
G01 X16.0 Z36.0      (SAFE POINT)
M09            (COOLANT OFF)
M05            (SPINDLE OFF)
G28 U0 W0      (HOME)
M01            (OPTIONAL STOP)
;
; (END AND NOSE CHAMFER)
N10
G28 U0 W0     (GO HOME FOR TOOL CHANGE)
G50 S2000
G96 S#502
G99
G00 T0202
M03
G00 X[#500+1.0] Z[#501-1.0]
M08
G01 X30.032 Z[#501-1.0]F#503
G01 X29.032 Z#501
G01 X[#500+1.0]
G00 X[#500+1.0] Z13.0
G71 U1.0 R0.5
G71 P030 Q033 U1.0 W0.5 F#503
N030 G01 X37.032 Z7.0
N031 G01 X21.032 Z-1.0
N032 G01 X21.032 Z-3.5
N033 G01 X[#500+1.0] Z-3.5
G70 P030 Q033 F0.05 S#504
M09
M05
G28 U0 W0
M01
;
;(CUTOFF)
N11
G28 U0 W0
G00 T1010
G50 S2000        (SET MAX SPINDLE SPEED)
G96 S#504        (SET SURFACE SPEED)
G99
G00 X[#500+1.0] Z-3.0
M03
M08
G01 X-.5 Z-3.0 F#505
G01 X[#500+1.0] F#505
```

```
M09
M05
G28 U0 W0
M30
```

Heat Sink Mori Op #1

```
%
O1; (FLASHLIGHT HEATSINK 2010-04-27)
; (STOCK: ALUM 1.5" X 27MM + 10MM)
; (ALUM CUTTING SPEED: 75M/MIN ROUGH, 185M/MIN FINISH)
;
; (VARIABLES)
#500=38.1    (STOCK DIAMETER)
#501=27.0    (STOCK LENGTH)
#502=150.0   (SURFACE M/MIN)
#503=0.2     (ROUGHING FEED: MM/REV)
#504=0.05    (FINISH FEED: MM/REV)
#510=25.0    (OD OF HEATSINK)
;
N1
G54          (WORK OFFSET)
G21          (METRIC)
G28 U0 W0    (GO HOME)
G50 S2000    (MAX SPINDLE SPEED)
;
; (FACE WITH PARTING TOOL AND SPEED LIMITING)
;
G00 T1010          (CUTOFF TOOL)
G50 S1000          (CLAMP SPEED AT 1000RPM)
G96 S#502          (CONST SURF SPEED)
G99                (FEED PER REV)
;
M03                (SPINDLE ON, NORMAL DIR)
G00 Z#501          (INITIAL Z POSITION)
G00 X[#500+1.0]    (INITIAL X POSITION)
M08                (TURN ON COOLANT)
G01 X-0.1 F#503    (FACE FROM OUTSIDE DOWN TO -0.1)
G01 Z[#501+1.0] F1.0 (MOVE OFF FROM FACE)
M09                (TURN OFF COOLANT)
M05                (TURN OFF SPINDLE)
G28 U0 W0          (RETURN TO HOME)
M01                (OPTIONAL STOP)
;
; (ROUGH OD 38.0 TO 26.0MM)
; (USE 2.0MM DOC -> 8 PASSES)
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```
;
N2
G00 T0101          (55DEG DIAMOND TOOL, TOOL 1)
G50 S2000          (CLAMP SPEED AT 2000)
G96 S#502          (CONST SURF SPEED)
G99                (FEED PER REV)
G00 X[#500 + 10.0] Z[#501 + 10.0]  (GET CLOSE)
M03                (SPINDLE ON)
G00 X[#500] Z[#501 + 2.5]   (INITIAL POINT FOR ROUGHING)
M08                (TURN ON COOLANT)
G71 U2.0 R0.75     (2MM DOC, 0.75MM RETRACT)
G71 P100 Q110 U4.0 W0.25 F#503
N100 G00 X13.7 Z28.0    (ENTRANCE POINT, STARTING ON CHAMFER)
G01 X#510 Z22.15 F#504
X#510 Z20.0 F#504
X#510 Z-3.0 F#504
N110 G00 X39.0 Z-3.0 F#503  (EXIT)
M09
M05
G28 U0 W0
M01
;
; (FINISH OD 25.0MM)
;
N3
G00 T0202          (35DEG DIAMOND, TOOL 2)
G50 S2000          (CLAMP SPEED AT 2000)
G96 S#502          (CONST SURF SPEED)
G99                (FEED PER REV)
G00 X[#500 + 10.0] Z[#501 + 10.0]  (GET CLOSE)
M03                (SPINDLE ON)
G00 X#500 Z[#501 + 7.0]   (INITIAL POINT FOR FINISHING)
M08                (TURN ON COOLANT)
G71 U1.0 R0.75     (1MM DOC, 0.75MM RETRACT)
G71 P120 Q130 U1.0 W0.125 F#503
N120 G00 X[#510-8.0] Z[#501+2.0]    (ENTRANCE POINT, STARTING ON CHAMFER)
G01 X#510 Z[#501-2.0] F#504
X#510 Z20.0 F#504
X#510 Z-3.0 F#504
N130 G00 X39.0 Z-3.0 F#503  (EXIT)
(G41 ENGAGE TOOL NOSE RAD COMP)
G70 P120 Q130 F#504
G42
G00 X[#500 + 2.0]       (BACK OFF)
M09
M05
```

```
G28 U0 W0
M01
;
; (CENTER DRILL)
;
N4
G00 T0505          (CENTER DRILL, TOOL 5)
G97 S1000          (1000RPM)
G99
G00 X0 Z[#501 + 2.0]
M03
M08
G01 X0 Z[#501 - 2.0] F0.5
G01 X0 Z[#501 + 2.0] F2.0
M09
M05
G28 U0 W0
M01
;
; (DRILL)
; (12.65MM DEEP BORE - POINT OF 118DEG 1/2IN DRILL)
;
N5
G00 T1212          (0.5IN DRILL, TOOL 5)
G97 S1000          (1000RPM)
G99
G00 X0 Z[#501 + 2.0]
M03
M08
G01 X0 Z[#501 - 12.65 + [0.5*25.4/2.0]*TAN[90.0 - 118.0/2.0]] F0.5
G01 X0 Z[#501 + 2.0] F2.0
M09
M05
G28 U0 W0
M01
;
; (ROUGH BORE)
; (10.5MM DEEP BORE, 18.7MM DIAM)
;
N6
G00 T0707          (18.7MM END MILL, TOOL 7)
G97 S800          (800RPM)
G99
G00 X18.7 Z[#501 + 2.0]
M03
M08
```

```
G01       Z[#501 - 4.00] F0.3
G01       Z[#501 + 2.0] F2.0
G01       Z[#501 - 3.95] F2.0
G01       Z[#501 - 8.00] F0.3
G01       Z[#501 + 2.0] F2.0
G01       Z[#501 - 7.95] F2.0
G01       Z[#501 - 10.50] F0.3
G04 U1.0           (DWELL 1 SEC)
G01       Z[#501 + 2.0] F2.0
M09
M05
G28 U0 W0
M01
;
; (CUTOFF)
;
N8
G00 T1010
G00 Z-3.0          (CUTOFF BLADE IS 3.0MM WIDE)
G00 X[#500+2.0]
M03
M08
G50 S1000          (CLAMP SPEED AT 1000RPM)
G96 S#502          (CSS)
G01 X-0.4 F0.05    (CUTOFF)
G01 X[#500+2.0] F4.0 (RETRACT)
M09
M05
G28 U0 W0
M30                (END PROGRAM)
%
```

Heat Sink Haas Op #2

```
%
O1111
(K:\Common\ENGR 480\Common Flashlight Parts\G Code\sink1.ncl.8)
(06/06/10-14:33:56)
N0010T7M06
S1000M03
G00X2.Y.685
G43Z.5H07
G81X2.Y.685Z-.03R.05F6.
G80
G00Z.5
N0020T8M06
```

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S1200M03
G00G43Z.5H08
G83X2.Y.685Z-.6654R.05Q.125F6.
G80
G00Z.5
N0030T5M06
S1800M03
G00X1.9634Y.7006
G43Z.5H05
Z.05
G01Z-.05F10.
X2.0366
G02X2.0826Y.7322I.0736J-.058
G03X2.1693Y.7767I-.0826J.2678
G01X1.8307
G02X1.7615Y.8527I.1693J.2233
G01X2.2385
G03X2.2711Y.9288I-.2385J.1473
G01X1.7289
G02X1.7198Y1.0049I.2711J.0712
G01X2.2802
G03X2.2683Y1.0809I-.2802J-.0049
G01X1.7317
X1.7395Y1.1035
G03X1.7442Y1.157I-.0871J.0346
G01X2.2558
X2.2562Y1.159
G02X2.2764Y1.199I.0914J-.0209
G01X2.2821Y1.2043
X2.2657Y1.2266
X2.2592Y1.2331
X1.74
G02X1.8112Y1.2937I.26J-.2331
G01X1.8377Y1.3092
X2.1623
X2.1468Y1.3168
G03X1.7357Y1.2282I-.1468J-.3168
G01X1.718Y1.2044
X1.7347Y1.183
X1.743Y1.162
G02X1.7395Y1.1035I-.0906J-.0239
G03X1.9174Y.7322I.2605J-.1035
G02X1.9773Y.6763I-.0276J-.0896
G03X2.0227Y.6763I.0227J.0087
G02X2.0826Y.7322I.0875J-.0337
G03X2.2605Y1.1035I-.0826J.2678
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```
G02X2.2764Y1.199I.0871J.0346
G01X2.2821Y1.2043
X2.2657Y1.2266
X2.2305Y1.2623
G03X2.1623Y1.3092I-.2305J-.2623
G01Z-.1
X1.8377
X1.8112Y1.2937
G03X1.74Y1.2331I.1888J-.2937
G01X2.2592
X2.2657Y1.2266
X2.2821Y1.2043
X2.2764Y1.199
G03X2.2562Y1.159I.0712J-.0609
G01X2.2558Y1.157
X1.7442
G02X1.7395Y1.1035I-.0918J-.0189
G01X1.7317Y1.0809
X2.2683
G02X2.2802Y1.0049I-.2683J-.0809
G01X1.7198
G03X1.7289Y.9288I.2802J-.0049
G01X2.2711
G02X2.2384Y.8527I-.2711J.0712
G01X1.7615
G03X1.8307Y.7767I.2385J.1473
G01X2.1693
G02X2.0826Y.7322I-.1693J.2233
G03X2.0366Y.7006I.0276J-.0896
G01X1.9634
G02X1.9773Y.6763I-.0736J-.058
G03X2.0227Y.6763I.0227J.0087
G02X2.0826Y.7322I.0875J-.0337
G03X2.2605Y1.1035I-.0826J.2678
G02X2.2764Y1.199I.0871J.0346
G01X2.2821Y1.2043
X2.2657Y1.2266
X2.2305Y1.2623
G03X1.7357Y1.2282I-.2305J-.2623
G01X1.718Y1.2044
X1.7347Y1.183
X1.743Y1.162
G02X1.7395Y1.1035I-.0906J-.0239
G03X1.9174Y.7322I.2605J-.1035
G02X1.9634Y.7006I-.0276J-.0896
G01X1.9637Z-.1378
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```
X2.037
X2.039Y.7036
X2.0557Y.7188
X2.0765Y.7299
X2.0826Y.7322
G03X2.1694Y.7767I-.0826J.2678
G01X1.8306
G02X1.7615Y.8528I.1694J.2233
G01X2.2385
G03X2.2711Y.9289I-.2385J.1472
G01X1.7289
G02X1.7198Y1.0051I.2711J.0711
G01X2.2802
G03X2.2682Y1.0812I-.2802J-.0051
G01X1.7318
X1.7395Y1.1035
X1.7435Y1.1164
X1.7461Y1.1396
X1.7436Y1.1573
X2.256
X2.2562Y1.159
G02X2.2764Y1.199I.0914J-.0209
G01X2.277Y1.1996
X2.2824Y1.2054
X2.2597Y1.2334
X1.7403
G02X1.8385Y1.3095I.2597J-.2334
G01X2.1615
G03X1.7176Y1.2054I-.1615J-.3095
G01X1.7207Y1.2021
X1.7219Y1.2009
G02X1.7428Y1.1626I-.0556J-.0553
G01X1.7461Y1.1396
X1.7435Y1.1164
X1.7395Y1.1035
G03X1.9174Y.7322I.2605J-.1035
G01X1.9207Y.731
X1.9417Y.7206
X1.9593Y.7054
G02X1.9773Y.6763I-.0535J-.0532
G03X2.0227Y.6763I.0227J.0087
G01X2.0263Y.6843
X2.039Y.7036
X2.0557Y.7188
X2.0765Y.7299
X2.0826Y.7322
```

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G03X2.2605Y1.1035I-.0826J.2678
G01X2.2572Y1.1135
X2.2539Y1.1365
X2.2562Y1.159
G02X2.2764Y1.199I.0914J-.0209
G01X2.277Y1.1996
X2.2824Y1.2054
G03X2.1616Y1.3095I-.2824J-.2054
G01X2.1142Y1.33
Z-.1878
X1.8858
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01Z-.2378
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01X2.1142
Z-.2878
X1.8858
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01Z-.3378
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01X2.1142
Z-.3878
X1.8858
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01Z-.4378
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01X2.1142
Z-.4878
X1.8858
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01Z-.5378
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01X2.1142
Z-.5878
X1.8858
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01Z-.6378
```

```
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01X2.1142
Z-.6878
X1.8858
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01Z-.7283
X2.1142
G03X1.8858Y1.33I-.1142J-.33
G01X2.1142
Z.5
N0040T6M06
S1900M03
G00X2.3042Y1.1831
G43Z.5H06
Z.05
G01Z-.04F8.
X2.3193Y1.1938
G03X2.3218Y1.2029I-.0029J.0057
G01X2.3089Y1.2221
X2.3042Y1.1831
Z-.08
X2.3193Y1.1938
G03X2.3218Y1.2029I-.0029J.0057
G01X2.3089Y1.2221
X2.3042Y1.1831
Z-.12
X2.3193Y1.1938
G03X2.3218Y1.2029I-.0029J.0057
G01X2.3089Y1.2221
X2.3051Y1.184
Z-.1378
X2.3193Y1.1938
G03X2.3218Y1.2029I-.0029J.0057
G01X2.3089Y1.2221
X2.1142Y1.2987
Z-.1778
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.2178
X2.1626
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G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.2578
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.2978
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.3378
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.3778
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.4178
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.4578
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
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```
G01X2.1142Y1.2987
Z-.4978
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.5378
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.5778
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.6178
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.6578
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.6978
X2.1626
G02X2.2641Y1.2557I0.J-.1412
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01X2.1142Y1.2987
Z-.7283
X2.1626
G02X2.2641Y1.2557I0.J-.1412
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```
X2.311Y1.1961I-.2641J-.2557
G03X2.3218Y1.2029I.0054J.0034
X2.1266Y1.3587I-.3218J-.2029
G01Z.5
G00X1.6912Y1.2221
Z.05
G01Z-.04
X1.6782Y1.2029
G03X1.6807Y1.1938I.0054J-.0034
G01X1.6953Y1.1835
X1.6912Y1.2221
Z-.08
X1.6782Y1.2029
G03X1.6807Y1.1938I.0054J-.0034
G01X1.6953Y1.1835
X1.6912Y1.2221
Z-.12
X1.6782Y1.2029
G03X1.6807Y1.1938I.0054J-.0034
G01X1.6953Y1.1835
X1.6912Y1.2221
Z-.1378
X1.6782Y1.2029
G03X1.6807Y1.1938I.0054J-.0034
G01X1.6946Y1.184
X1.6951Y1.1835
X1.8734Y1.3587
Z-.1778
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.2178
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.2578
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
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```
G01X1.8858
X1.8734Y1.3587
Z-.2978
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.3378
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.3778
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.4178
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.4578
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.4978
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.5378
G03X1.6782Y1.2029I.1266J-.3587
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X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.5778
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.8734Y1.3587
Z-.6178
G03X1.6782Y1.2029I.1266J-.3587
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.872Y1.3582
Z-.6578
G03X1.6782Y1.2029I.128J-.3582
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.872Y1.3582
Z-.6978
G03X1.6782Y1.2029I.128J-.3582
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
X1.872Y1.3582
Z-.7283
G03X1.6782Y1.2029I.128J-.3582
X1.689Y1.1961I.0054J-.0034
G02X1.7359Y1.2557I.311J-.1961
X1.8374Y1.2987I.1015J-.0982
G01X1.8858
Z.5
N0050T5M06
S1800M03
G00X1.9953Y1.3346
G43Z.5H05
Z-.7571
G01Z-.8671F8.
```

```
G03X1.9977Y1.3387I.0047J0.
G01X1.9967Y1.338
X1.9957Y1.3364
X1.9953Y1.3346
Z.5
M30
%
```

Heat Sink Haas Op #3

```
%
O4272
(K:\Common\ENGR 480\Common Flashlight Parts\G Code\sink2.ncl.1)
(04/27/10-11:42:26)
G56
N0010T5M06
S1800M03
G00X1.916Y.7388
G43Z.5H05
Z.05
G01Z-.06F8.
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z-.12
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z-.18
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z-.24
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z-.3
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z-.36
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```
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z-.42
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z-.435
G02X1.9768Y.6777I-.0287J-.0892
G03X2.0232Y.6777I.0232J.0073
G02X2.084Y.7388I.0895J-.0281
G03X1.916Y.7388I-.084J.2612
G01Z.5
N0020T6M06
S1800M03
G00X1.9721Y.6369
G43Z.5H06
Z-.3231
G01Z-.4331F10.
X2.0279
G03X2.053Y.6683I-.0279J.0481
G02X2.0713Y.6964I.0597J-.0187
G01X1.9287
G03X1.9065Y.709I-.0414J-.0468
G02X1.8162Y.7558I.0935J.291
G01X2.1838
G03X2.2435Y.8153I-.1838J.2442
G01X1.7565
G02X1.7212Y.8748I.2435J.1847
G01X2.2788
G03X2.2984Y.9342I-.2788J.1252
G01X1.7016
G02X1.6945Y.9937I.2984J.0658
G01X2.3055
G03X2.301Y1.0531I-.3055J.0063
G01X1.699
G02X1.7159Y1.1126I.301J-.0531
G01X2.2841
G03X2.2526Y1.172I-.2841J-.1126
G01X1.7474
G02X1.8005Y1.2315I.2526J-.172
G01X2.1995
G03X2.0935Y1.291I-.1995J-.2315
G01X1.9065
```

```
G03X1.9065Y.709I.0935J-.291
G02X1.947Y.6683I-.0192J-.0594
G03X2.053Y.6683I.053J.0167
G02X2.0935Y.7091I.0597J-.0187
G03X1.9201Y1.295I-.0935J.2909
G01X1.9065Y1.291
X2.2435Y.8153
Z-.435
X2.1347
G03X2.1557Y.8299I-.0245J.0575
G01X2.1667Y.8461
X2.1722Y.8656
X2.1727Y.8728
Y.8748
X2.2788
G03X2.2984Y.9342I-.2788J.1252
G01X2.1727
Y.9937
X2.3055
G03X2.301Y1.0531I-.3055J.0063
G01X2.1727
Y1.1126
X2.2841
G03X2.2526Y1.172I-.2841J-.1126
G01X2.1536
X2.137Y1.1836
X2.1189Y1.1888
X1.9065Y1.291
X2.0935
G02X2.1995Y1.2315I-.0935J-.291
G01X1.8005
G03X1.7474Y1.172I.1995J-.2315
G01X1.8463
X1.7474
G03X1.7159Y1.1126I.2526J-.172
G01X1.8273
Y1.0531
X1.699
G03X1.6945Y.9937I.301J-.0531
G01X1.8273
Y.9342
X1.7016
G03X1.7212Y.8748I.2984J.0658
G01X1.8273
Y.8728
X1.8283Y.8622
```

```
X1.8286Y.8606
G03X1.8464Y.828I.0534J.008
G01X1.863Y.8164
X1.8667Y.8153
X1.7565
G03X1.8162Y.7558I.2435J.1847
G01X2.1838
X1.8162
G03X1.9065Y.7091I.1838J.2442
G01X1.9137Y.7062
X1.9278Y.6964
X2.0711
X2.0678Y.6929
X2.056Y.6759
X2.053Y.6683
G02X2.0279Y.6369I-.053J.0167
G01X1.9721
X2.0309Y.8103
X2.1102
X2.1209Y.8114
X2.1218
G03X2.1557Y.8299I-.0116J.0614
G01X2.1667Y.8461
X2.1722Y.8656
X2.1727Y.8728
Y1.1272
X2.1717Y1.1378
X2.1714Y1.1394
G03X2.1536Y1.172I-.0534J-.008
G02X2.1714Y1.1394I-.0356J-.0406
G01X2.1716Y1.1388
X2.1717Y1.1378
X2.1727Y1.1272
Y.8728
X2.1722Y.8656
X2.1667Y.8461
X2.1557Y.8299
G02X2.1218Y.8114I-.0455J.0429
G01X2.1209
X2.1102Y.8103
X1.8898
X1.8825Y.8109
X1.863Y.8164
X1.8464Y.828
G02X1.8286Y.8606I.0356J.0406
G01X1.8284Y.8612
```

```
X1.8283Y.8622
X1.8273Y.8728
Y1.1272
X1.8278Y1.1344
X1.8333Y1.1539
X1.8443Y1.1701
G02X1.8782Y1.1886I.0455J-.0429
G01X1.8791
X1.8898Y1.1897
X2.1102
X2.1175Y1.1891
X2.137Y1.1836
X2.1536Y1.172
Z.5
G00X2.0678Y.6929
Z-.3831
G01Z-.435
G02X2.0935Y.7091I.0398J-.0349
G03X1.9065Y.7091I-.0935J.2909
G01X1.9137Y.7062
X1.9307Y.6944
G02X1.947Y.6683I-.0349J-.0399
G03X2.053Y.6683I.053J.0167
G01X2.056Y.6759
X2.0678Y.6929
Z.5
G00X1.9818Y.685
Z-.385
G01Z-.475F8.
G03X1.9818Y.685I.0182J0.
G01Z.5
M30
%
```

Magnetic Ring G-Code

```
%
O0510
; (FLASHLIGHT MAGNET RING)
; (ERIK BIESENTHAL)
; (1.5" x 14MM + 10MM)
; (ALUM CUTTING SPEED: 75M/MIN ROUGH)
;
; (VARIABLES)
#500=38.1            (STOCK DIAMETER)
#501=13.25           (STOCK LENGTH)
#502=75.0            (SURFACE M/MIN)
```

```
#503=0.4              (ROUGHING FEED: MM/REV)
#504=0.4       (NOSE RADIUS VALUE - mm)
;
N1
G54                   (WORK OFFSET)
G21                   (METRIC)
G28 U0 W0             (GO HOME)
;
; (FACING WITH PARTING TOOL AND SPEED LIMITING)
;
G00 T1010             (CUTOFF TOOL)
G50 S1000             (CLAMP SPEED AT 1000RPM)
G96 S#502             (CONST SURFACE SPEED)
G99                   (FEED PER REV)
M03                   (SPINDLE ON, NORMAL DIR)
G00 Z#501             (INITIAL Z POSITION)
G00 X[#500+1]         (INITIAL X POSITION)
M08                   (COOLANT ON)
G01 X-0.01 F#503      (FACE FROM OUTSIDE DOWN TO -0.01)
G01 Z[#501+1.0] F1.0 (MOVE OFF FROM FACE)
M09                   (TURN OFF COOLANT)
M05                   (TURN OFF SPINDLE)
G28 U0 W0             (GO HOME)
M01                   (OPTIONAL STOP)
;
; (CONTOURING - O.D. PROFILING)
;
N2
G00 T0202             (FINISHING TOOL FOR OD PROFILE)
G50 S2000             (CLAMP SPEED AT 2000RPM)
G96 S#502             (CONST SURFACE SPEED)
G99                   (FEED PER REV)
G00 X#500 Z13.02      (INITIAL POINT FOR PROFILING PASS)
M03                   (SPINDLE ON)
M08                   (COOLANT ON)
G71 U1.0 R1.5         (ROUGHING CYCLE)
G71 P21 Q22 U0.5 W0.0 F#503
N21      G42 X33.1  Z15.77 D#504
   G01 X36.4  Z11.25 D#504
   G01 X36.4  Z2.0   D#504
   G01 X34.94 Z0.0   D#504
   G01 X34.94 Z-3.0  D#504
N22      G01 X#500  Z-3.0  D#504
G00 X#500 Z#501             (SP)
G70 P21 Q22 F0.1      (FINISHING CYCLE)
G40 G00 X#500 Z#501   (SP - NOSE RADIUS OFFSET CANCEL)
M09                   (COOLANT OFF)
M05                   (SPINDLE STOP)
G28 U0 W0             (RETURN HOME)
M01                   (OPTIONAL STOP
;
; (CENTER DRILLING)
```

```
;
N3
G00 T0505            (CENTER DRILLING TOOL)
G97 S1500            (DRILL AT 1400RPM)
G99                  (FEED PER REV)
G00 X0.0 Z[#501+1.0] (START POINT)
M03                  (SPINDLE ON)
M08                  (COOLANT ON)
G01 Z[#501-3.0]      F0.1  (FEED DRILL)
G01 Z[#501+1.0]      F1.0  (RETRACT DRILL)
M09                  (COOLANT OFF)
M05                  (SPINDLE STOP)
G28 U0 W0            (RETURN HOME)
M01                  (OPTIONAL STOP)
;
; (DRILLING - 19/32" DRILL)
;
N4
G00 T1212            (19/32" DRILL)
G97 S1000            (DRILL AT 1000RPM)
G99                  (FEED PER REV)
G00 X0.0 Z[#501+1.0] (DRILL START POINT)
M03                  (SPINDLE ON)
M08                  (COOLANT ON)
G01 Z8.0 F0.1        (DRILL FEED)
G01 Z[#501+1.0] F1.0 (DRILL RETRACT)
G01 Z3.0 F0.1        (DRILL FEED)
G01 Z[#501+3.0] F1.0 (DRILL RETRACT)
G01 Z-1.5 F0.1       (DRILL FEED)
G01 Z[#501+3.0] F1.0 (DRILL RETRACT)
M09                  (COOLANT OFF)
M05                  (SPINDLE STOP)
G28 U0 W0            (RETURN HOME)
M01                  (OPTIONAL STOP)
;
;(BORING WITH END MILL - ROUGHING)
;
N5
G00 T0707            (18.0MM OD END MILL)
G50 S1000            (CLAMP SPEED AT 1000RPM)
G96 S#502            (CONST SURFACE SPEED)
G99                  (FEED PER REV)
G00 X19.0 Z[#501+1.0]      (BORING START POINT)
M03                  (COOLANT ON)
M08                  (SPINDLE ON)
G01 Z8.0 F0.1        (FIRST PASS)
G01 Z[#501+0.5] F1.0
G01 Z3.0 F0.1
G01 Z[#501+3.0] F1.0
G01 Z-1.5 F0.1
G01 Z[#501+0.5] F1.0
G00 X22.0            (SECOND PASS)
```

```
G01 Z8.0 F0.1
G01 Z[#501+0.5] F1.0
G01 Z3.0 F0.1
G01 Z[#501+3.0] F1.0
G01 Z-1.5 F0.1
G01 Z[#501+0.5] F1.0
G00 X25.0            (THIRD PASS)
G01 Z8.0 F0.1
G01 Z[#501+0.5] F1.0
G01 Z3.0 F0.1
G01 Z[#501+3.0] F1.0
G01 Z-1.5 F0.1
G01 Z[#501+0.5] F1.0
G00 X28.0            (FOURTH PASS)
G01 Z8.0 F0.1
G01 Z[#501+0.5] F1.0
G01 Z3.0 F0.1
G01 Z[#501+3.0] F1.0
G01 Z-1.5 F0.1
G01 Z[#501+0.5] F1.0
G00 X31.0            (FIFTH PASS)
G01 Z8.0 F0.1
G01 Z[#501+0.5] F1.0
G01 Z3.0 F0.1
G01 Z[#501+3.0] F1.0
G01 Z-1.5 F0.1
G01 Z[#501+1.0] F1.0
M09                  (COOLANT OFF)
M05                  (SPINDLE OFF)
G28 U0 W0            (RETURN HOME)
M01                  (OP STOP)
;
;(BORING WITH BORING BAR - ROUGHING AND FINISHING)
;
N6
G00 T0909            (14.4MM MIN DIAM BORING BAR)
G50 S1200            (CLAMP SPEED AT 1200RPM)
G96 S#502            (CSS)
G99                  (FEED PER REV)
G00 X32.0 Z[#501+1.0]      (BORING START POINT)
M03
M08
G01 Z-1.5 F0.1       (PASS 1- FEED Z)
G01 X30.5 F0.5       (RETRACT X)
G00 Z[#501+0.5]            (RETRACT Z)
G00 X33.1            (POSITION X FOR PASS 2)
G01 Z-1.5 F0.1       (PASS 2 - FEED Z)
G01 X31.0 F0.5       (RETRACT X)
G00 Z[#501+1.0]            (RETRACT Z)
M09                  (COOLANT OFF)
M05                  (SPINDLE STOP)
G28 U0 W0            (RETURN HOME)
```

```
M01                  (OP STOP)
;
;(CUTTING THE MAGNET GROOVE)
;
N7
G00 T0808            (ID THREADING TOOL)
G50 S1200            (CLAMP SPEED AT 1200RPM)
G96 S#502            (CSS)
G99                  (FEED PER REV)
G00 X33.0 Z[#501+0.5]      (SP)
M03                  (SPINDLE ON)
M08                  (COOLANT ON)
G01 Z5.75 F1.0       (POSITION IN Z)
G01 X34.0 F0.3       (FEED X)
G01 Z0.75 F0.1       (FEED Z)
G01 X33.0 F0.5       (RETRACT X)
G01 Z5.75 F0.5       (RETRACT Z)
G01 X35.0 F0.3       (FEED X)
G01 Z0.75 F0.1       (FEED Z)
G01 X33.0 F0.5       (RETRACT X)
G01 Z[#501+1.0] F1.0 (RETRACT Z)
M09                  (COOLANT OFF)
M05                  (SPINDLE STOP)
G28 U0 W0            (RETURN HOME)
M01                  (OP STOP)
;
; (PARTING)
;
N8
G00 T1010            (PARTING TOOL)
G97 S1000            (SPINDLE SPEED OF 1000RPM)
G00 X#500 Z-3.0            (CUTOFF BLADE IS 3.0MM WIDE)
M03                  (SPINDLE ON)
M08                  (COOLANT ON)
G01 X-0.1 F0.05            (CUTOFF)
G00 Z#501            (RETRACT OFF OF FACE)
M09                  (COOLANT OFF)
M05                  (SPINDLE STOP)
G28 U0 W0            (RETURN HOME)
M30                  (IT IS FINISHED!!!!!)
%
```

Body G Code

```
%
O2 (FLASHLIGHT BODY)
; (FLASHLIGHT BODY 2010-5-31)
; (STOCK: ALUM 1.5" X 88MM + 10MM)
; (ALUM CUTTING SPEED: 75M/MIN ROUGH, 185M/MIN FINISH)
;
; (VARIABLES)
#500=38.1    (STOCK DIAMETER)
#501=88.0    (STOCK LENGTH)
```

```
#502=75.0    (SURFACE M/MIN)
#503=0.4     (ROUGHING FEED: MM/REV)
#504=0.1     (FINISH FEED: MM/REV)
#505=18.13   (DIAMETER OF END MILL FOR BORING)
#506=35.0   (MAX OD OF FINISHED PART)

;
; (FACING CUTOFF)
;
N1 (FACING CUTOFF)
G54                    (WORK OFFSET)
G21                    (METRIC)
;
G28 U0 W0              (GO HOME)
G50 S1000              (MAX SPINDLE SPEED)
G00 T1010              (CUTOFF TOOL)
G50 S1000              (CLAMP SPEED AT 1000RPM)
G96 S#502              (CONST SURF SPEED)
G99                    (FEED PER REV)
M03                    (SPINDLE ON, NORMAL DIR)
G00 X[#500+1.0]  Z#501       (INITIAL POSITION)
M08                          (TURN ON COOLANT)
G01 X-0.4 F#503              (FACE FROM OUTSIDE DOWN TO -0.4)
M09                          (TURN OFF COOLANT)
G00 X[#500+2.0]              (RETRACT)
M05                          (TURN OFF SPINDLE)
G28 U0 W0      (RETURN TO HOME)
M01            (OPTIONAL STOP)
;
; (CENTER DRILLING)
;
N2                 (CENTER DRILL)
G00 T0505          (CENTER DRILL, TOOL 5)
G97 S1000          (1000RPM)
G99
M03       (SPINDLE ON)
G00 X0 Z[#501 + 2.0]
M08       (COOLANT ON)
G01 X0 Z[#501 - 2.0] F0.5
G01 X0 Z[#501 + 2.0] F2.0
M09
M05
G28 U0 W0
M01
;
(DRILLING OPPERATION)
N3                 (DRILLING)
G00 T1212          (0.5IN DRILL, TOOL 12)
G97 S1000          (1000RPM)
G99
M03       (SPINDLE ON)
G00 X0.0 Z[#501 + 2.0]
```

```
M08       (COOLANT ON)
G01 X0.0 Z[#501-5.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-10.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-15.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-20.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-25.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-30.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-35.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-40.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-45.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-50.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-55.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-60.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-65.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-70.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
G01 X0.0 Z[#501-73.0] F0.5
G01 X0.0 Z[#501 + 2.0] F2.0
M09    (TURN COOLANT OFF)
M05    (TURN SPINDLE OFF)
G28 U0 W0         (GO HOME)
M01               (OPTIONAL STOP)
;
N4
;(BORING WITH END MILL)
G00 T0707   (TOOL CHANGE END MILL TOOL 7)
G97 S800          (800RPM)
G99
M03         (SPINDLE ON)
G00 X#505 Z[#501+2.0]
M08         (COOLANT ON)
(BORING PASS 1)
G01 X#505 Z[#501-5.0] F0.5   (THIS MAKES INNER DIAMETER 18.13)
G01 Z[#501+2.0] F2.0
G01 Z[#501-10.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-15.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-20.0] F0.5
```

```
G01 Z[#501+2.0] F2.0
G01 Z[#501-25.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-30.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-35.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-40.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-45.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-50.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-55.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-60.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-65.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-70.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-73.0] F0.5
G01 Z[#501+2.0] F2.0
(BORING PASS #2)
G01 X[#505+0.8] Z[#501+2.0] F2.0      (THIS MAKES INNER DIAMETER 18.13+0.8
= 18.93)
G01 Z[#501-10.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-15.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-20.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-25.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-30.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-35.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-40.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-45.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-50.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-55.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-60.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-65.0] F0.5
G01 Z[#501+2.0] F2.0
G01 Z[#501-70.0] F0.5
G01 Z[#501+2.0] F2.0
```

```
G01 Z[#501-73.0] F0.5
G01 Z[#501+2.0] F2.0
;
;(BORING PASS 3 - THREADED SECTION)
;
G01 X28.0 F0.5
G01 Z#501 F0.5
G01 Z77.2 F0.5
G01 X18.5 Z73.0 F0.5
G01 Z[#501+5.0] F2.0
;
M09    (TURN COOLANT OFF)
M05    (TURN SPINDLE OFF)
G28 U0 W0        (GO HOME)
M01              (OPTIONAL STOP)
;
;(BORING WITH BORING BAR)
;
N5
G28 U0 W0        (GOING HOME - JUST TO MAKE SURE)
G00 T0909        (TOOL CHANGE - BORING BAR TOOL 9)
G97 S1000        (1000RPM)
G99
M03         (SPINDLE ON)
G00 X31.5 Z[#501+5.0]
M08         (COOLANT ON)
G01 Z#501 F0.1
G01 X30.5 Z87.5 F0.1 (CHAMFER)
G01 Z86.0 F0.1
G01 X28.4 F0.1
G01 Z77.0 F0.1
G01 X19.05 Z72.33 F0.1
G01 Z15.0 F0.1
G01 X15.0 Z13.0 F0.1
G01 Z[#501+5.0] F2.0   (RETRACT AWAY FROM PART)
M09        (COOLANT OFF)
M05        (SPINDLE STOP)
G28 U0 W0        (GO HOME)
M01        (OPTIONAL STOP)
;
; (ID THREADING)
;
N6
G28 U0 W0
G00 T0808            (THREADING TOOL)
G97 S1000
G00 X28.4 Z[#501+2.0]
M03                  (SPINDLE ON FORWARD)
M08                  (COOLANT ON)
G76 P160060
G76 X30.132 Z77.0 P866 Q100 F1.0
G01 X25.0 F2.0          (RETRACT X)
```

```
G01 Z[#501+5.0]
M09                  (COOLANT OFF)
M05                  (SPINDLE OFF)
G28 U0 W0            (HOME)
M01                  (OPTIONAL STOP)

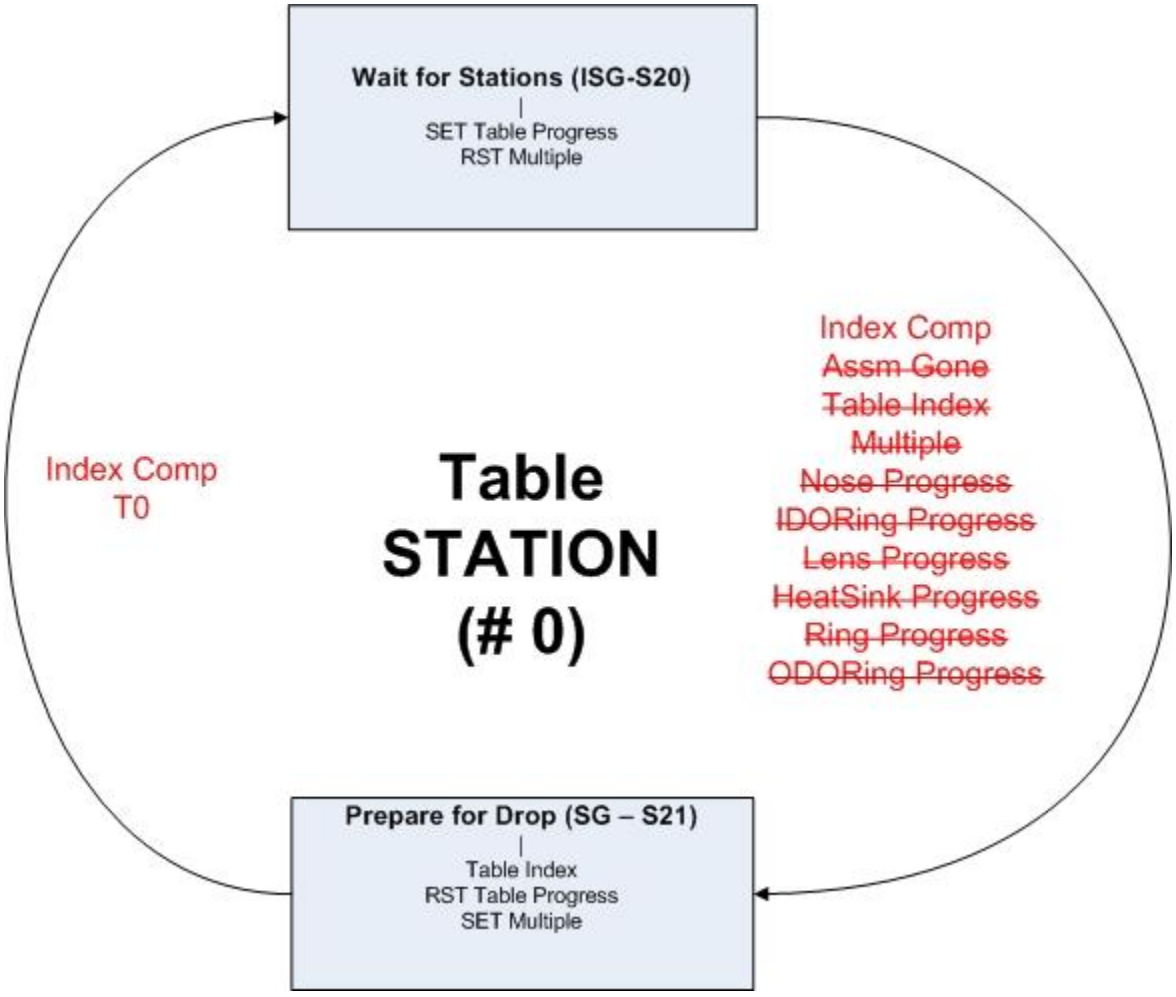
;
; (OD ROUGH TURNING)
;
N7
G28 U0 W0         (GOING HOME - JUST TO MAKE SURE)
G00 T0101           (55DEG DIAMOND TOOL, TOOL 1)
G50 S2000           (CLAMP SPEED AT 2000)
G96 S#502           (CONST SURF SPEED)
G99                 (FEED PER REV)
M03                 (SPINDLE ON)
M08                 (COOLANT ON)
G00 X[#500-2.9] Z[#501+2.0]    (GETS CLOSE)
G01 Z-0.3 F0.4       (MAKES DIAMETER = 38.1 - 2.9 = 35.2)
M09         (COOLANT OFF)
G01 X#500 F2.0             (RETRACTS FROM SURFACE)
G01 Z[#501+5.0] F2.0       (RETRACTS TO Z START)
M05         (SPINDLE STOP)
G28 U0 W0   (GO HOME)
M01         (OPTIONAL STOP)
;
; (CUTTING GROOVES WITH PARTING TOOL)
;
N8
#514=32.1         (MINOR DIAMETER OF GROOVES)
G28 U0 W0         (GOING HOME - JUST TO MAKE SURE)
G00 T1010              (CUTOFF TOOL)
G50 S1000              (CLAMP SPEED AT 1000RPM)
G96 S#502              (CONST SURF SPEED)
G99                    (FEED PER REV)
M03                    (SPINDLE ON, NORMAL DIR)
#507=66.0              (STARTING POINT OF FIRST GROOVE)
G00 Z[#507+1.5]        (GETS CLOSE IN Z)
G00 X#500              (GETS CLOSE IN X)
M08                    (COOLANT ON)
G01 X#514 F#504
G01 X#500 F2.0
G01 Z[#507+6.5-3.0] F2.0
G01 X#514 F#504
G01 X#500 F2.0
M09                    (COOLANT OFF)
#507=52.5              (START POINT OF SECOND GROOVE)
G00 Z[#507+1.5]        (GETS CLOSE IN Z)
G00 X#500              (GETS CLOSE IN X)
M08                    (COOLANT ON)
G01 X#514 F#504
G01 X#500 F2.0
```

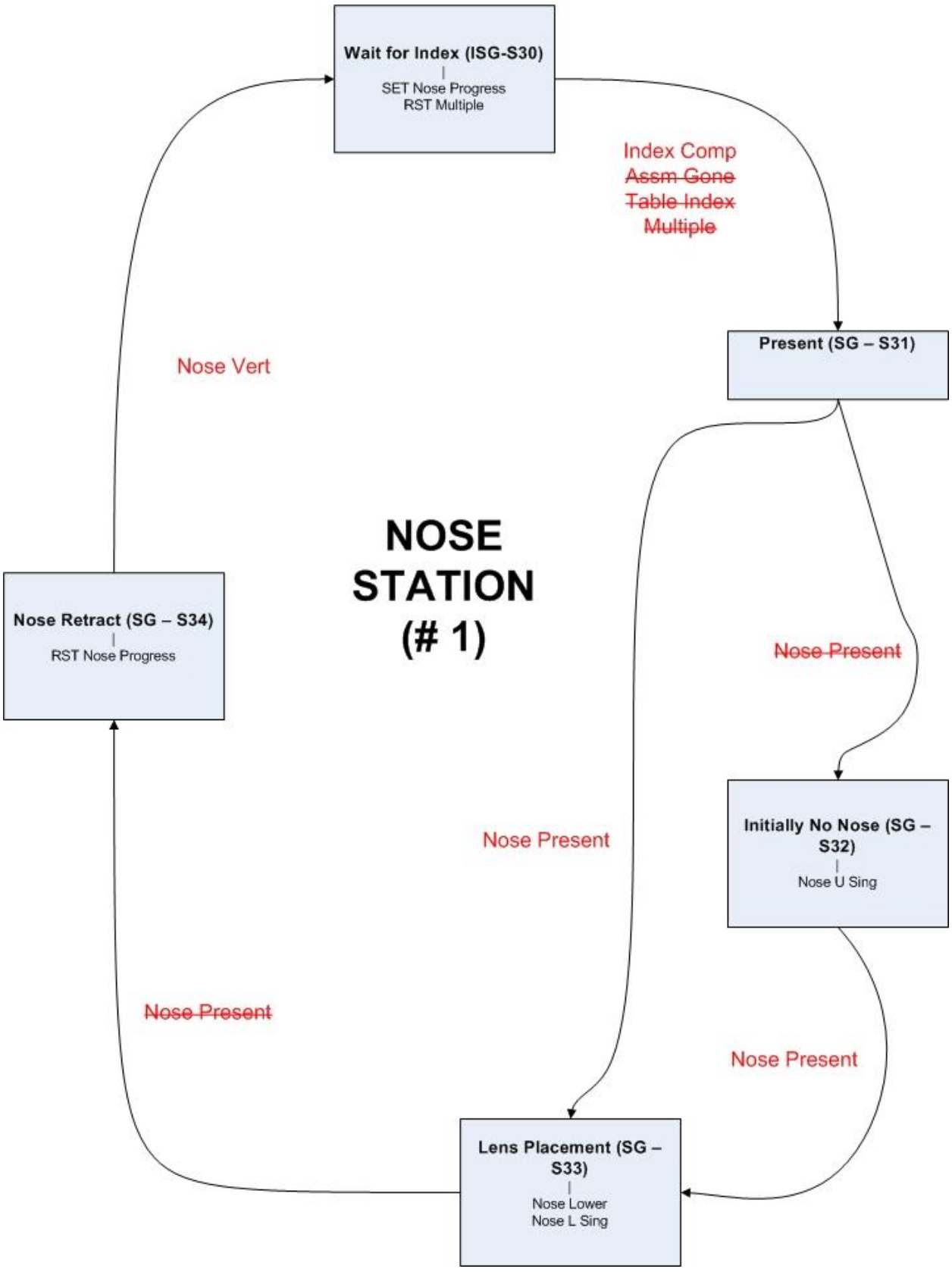
```
G01 Z[#507+6.5-3.0] F2.0
G01 X#514 F#504
G01 X#500 F2.0
M09                    (COOLANT OFF)
#507=39.0              (START POINT OF THIRD GROOVE)
G00 Z[#507+1.5]        (GETS CLOSE IN Z)
G00 X#500              (GETS CLOSE IN X)
M08                    (COOLANT ON)
G01 X#514 F#504
G01 X#500 F2.0
G01 Z[#507+6.5-3.0] F2.0
G01 X#514 F#504
G01 X#500 F2.0
M09                    (COOLANT OFF)
#507=25.5              (START POINT OF FOURTH GROOVE)
G00 Z[#507+1.5]        (GETS CLOSE IN Z)
G00 X#500              (GETS CLOSE IN X)
M08                    (COOLANT ON)
G01 X#514 F#504
G01 X#500 F2.0
G01 Z[#507+6.5-3.0] F2.0
G01 X#514 F#504
G01 X#500 F2.0
M09                    (COOLANT OFF)
#507=12.0              (START POINT OF FIFTH GROOVE)
G00 Z[#507+1.5]        (GETS CLOSE IN Z)
G00 X#500              (GETS CLOSE IN X)
M08                    (COOLANT ON)
G01 X#514 F#504
G01 X#500 F2.0
G01 Z[#507+6.5-3.0] F2.0
G01 X#514 F#504
G01 X[#500+5.0] F2.0
M09                    (COOLANT OFF)
G00 Z-3.3
M08                    (COOLANT ON)
G01 X26.0 F0.1         (PARTIAL CUTOFF FOR CHAMFER)
G01 X#500 F2.0         (RETRACT X)
G01 X35.0 Z-1.5 F0.5
G01 X31.5 Z-3.1 F0.1
G01 X[#500+5.0]        (RETRACT X)
M09                    (COOLANT OFF)
M05                    (SPINDLE OFF)
G00 Z[#501+5.0]        (RETRACT Z)
G28 U0 W0         (GO HOME)
M01               (OPTIONAL STOP)
;
; (OD FINISHING PASS)
;
N9
G28 U0 W0           (GOING HOME - JUST TO MAKE SURE)
G00 T0202           (FINISHING TOOL)
```

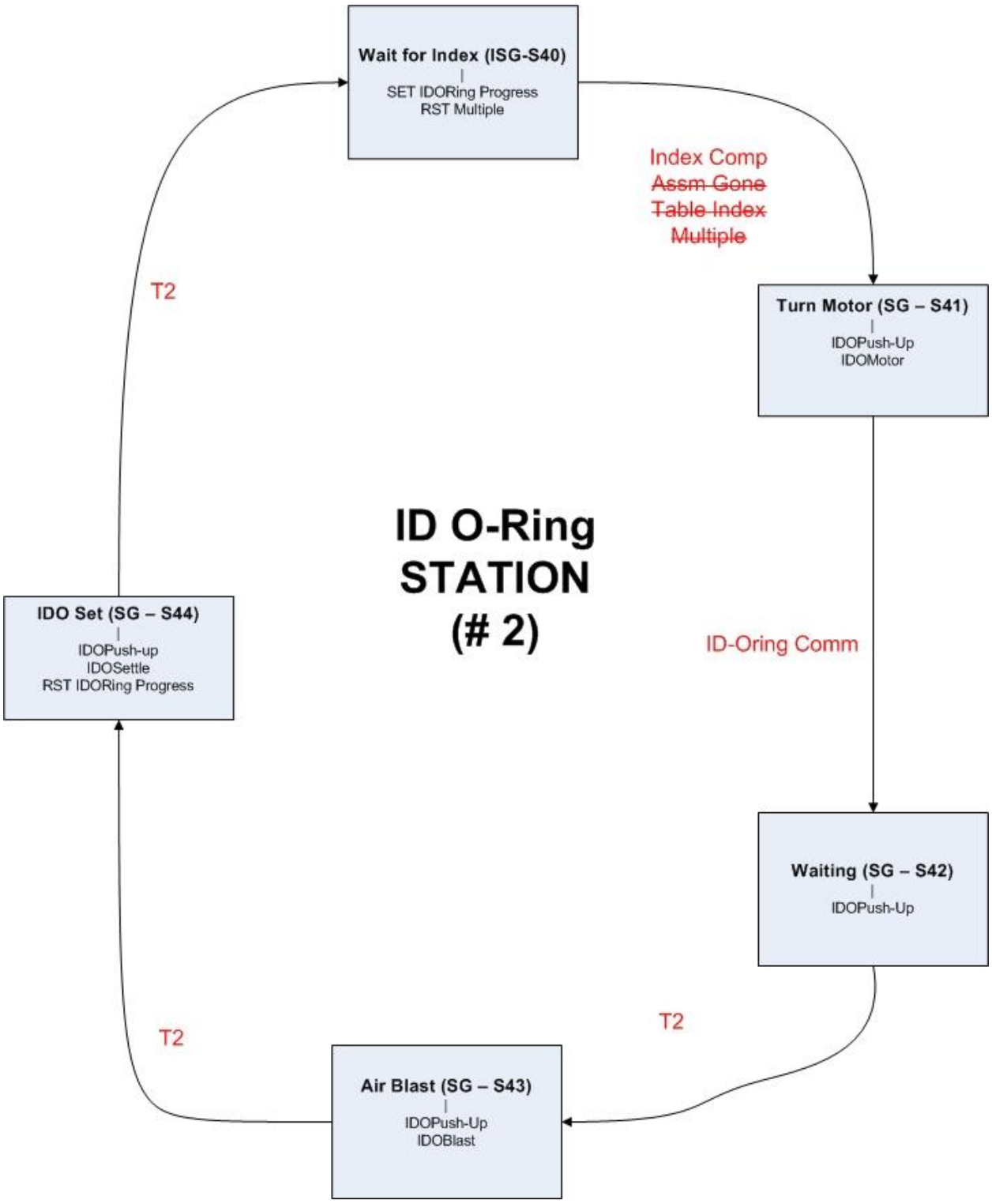
```
G50 S2000          (CLAMP SPEED AT 2000)
G96 S#502          (CONST SURF SPEED)
M03                (SPINDLE ON)
G00 X33.0 Z[#501+2.0]
M08                (COOLANT ON)
G01 Z83.5 F0.1     (NOTCH FOR RING)
G01 X35.0 F0.1
#507=66.0             (START POINT OF FIRST GROOVE)
G01 Z[#507+8.0] F0.1
G01 X#514 Z[#507+6.5] F0.1
G01 Z[#507+1.5] F0.1
G01 X35.0 Z#507 F0.1
#507=52.5              (START POINT OF SECOND GROOVE)
G01 Z[#507+8.0] F0.1
G01 X#514 Z[#507+6.5] F0.1
G01 Z[#507+1.5] F0.1
G01 X35.0 Z#507 F0.1
#507=39.0            (START POINT OF THIRD GROOVE)
G01 Z[#507+8.0] F0.1
G01 X#514 Z[#507+6.5] F0.1
G01 Z[#507+1.5] F0.1
G01 X35.0 Z#507 F0.1
#507=25.5          (START POINT OF FOURTH GROOVE)
G01 Z[#507+8.0] F0.1
G01 X#514 Z[#507+6.5] F0.1
G01 Z[#507+1.5] F0.1
G01 X35.0 Z#507 F0.1
#507=12.0            (START POINT OF FIFTH GROOVE)
G01 Z[#507+8.0] F0.1
G01 X#514 Z[#507+6.5] F0.1
G01 Z[#507+1.5] F0.1
G01 X35.0 Z#507 F0.1
;
G01 Z1.75 F0.1       (BACK CHAMFER)
G01 X31.3 Z-0.7 F0.1
G01 Z-3.0 F0.1
G01 X[#500+5.0] F2.0
M09              (COOLANT OFF)
M05              (SPINDLE OFF)
G28 U0 W0        (GO HOME)
M01              (OPTIONAL STOP)
;
;(CUTOFF)
;
N10
G28 U0 W0          (GOING HOME - JUST TO MAKE SURE)
G00 T1010
G00 X[#500 + 2.0] Z-3.0
G50 S1000
G96 S#502
M03                (SPINDLE ON)
M08                (COOLANT ON)
```

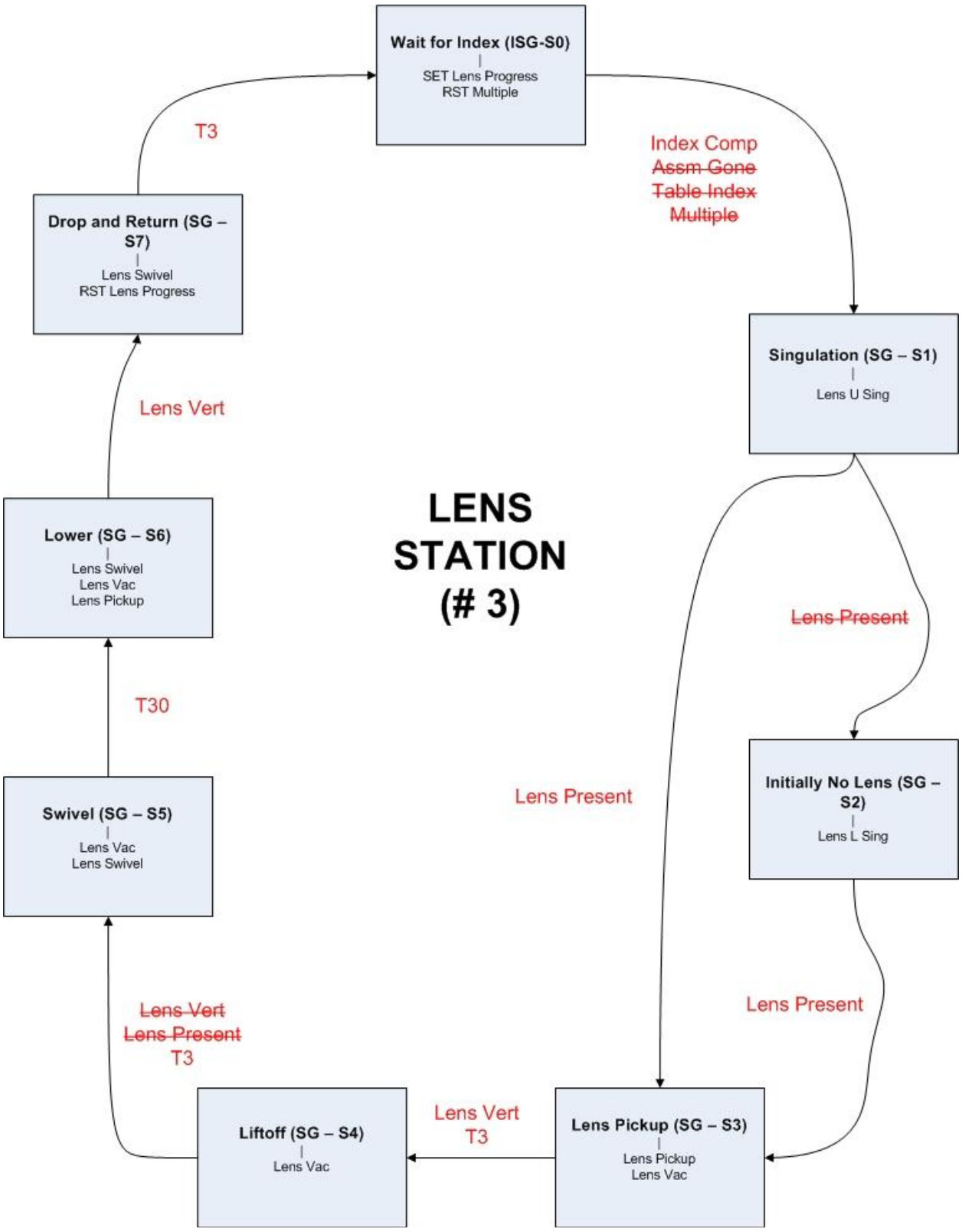
```
G01 X-0.4 F.05      (CUTOFF)
G01 X[#500 + 2] F4.0  (RETRACT)
M09                 (COOLANT OFF)
M05                 (SPINDLE OFF)
G28 U0 W0           (GO HOME)
M30                 (FINISH)
%
```

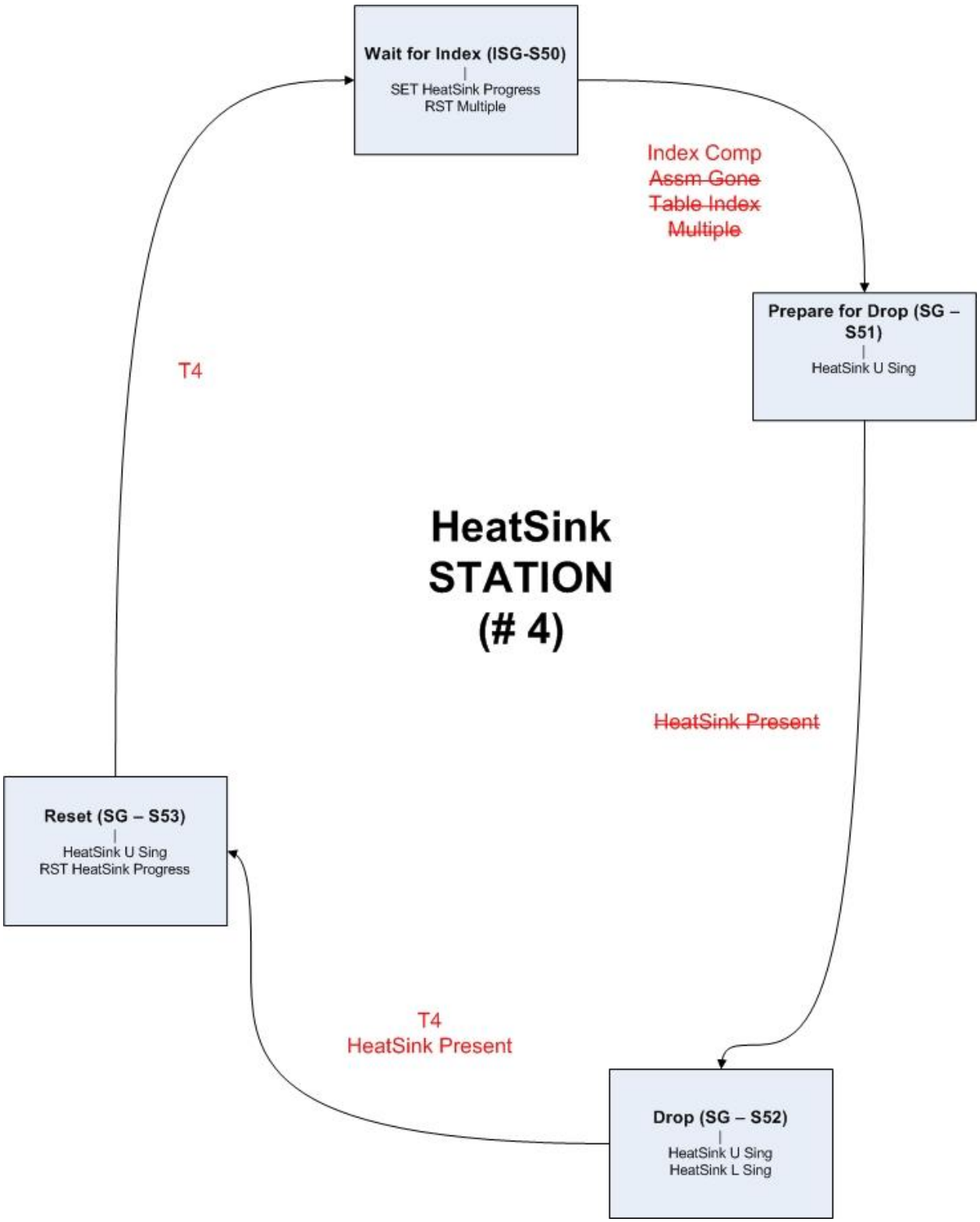
State Machine Diagrams

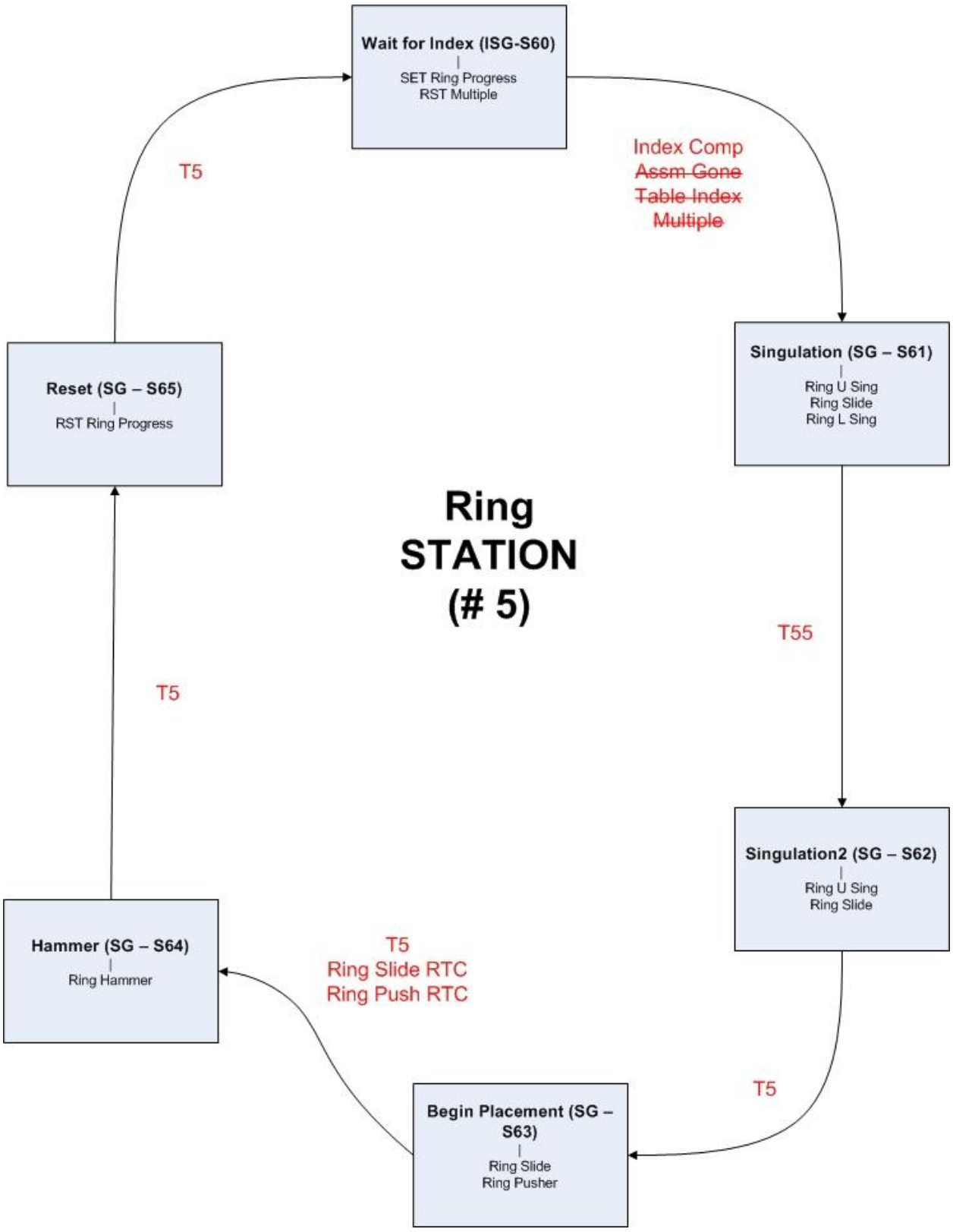


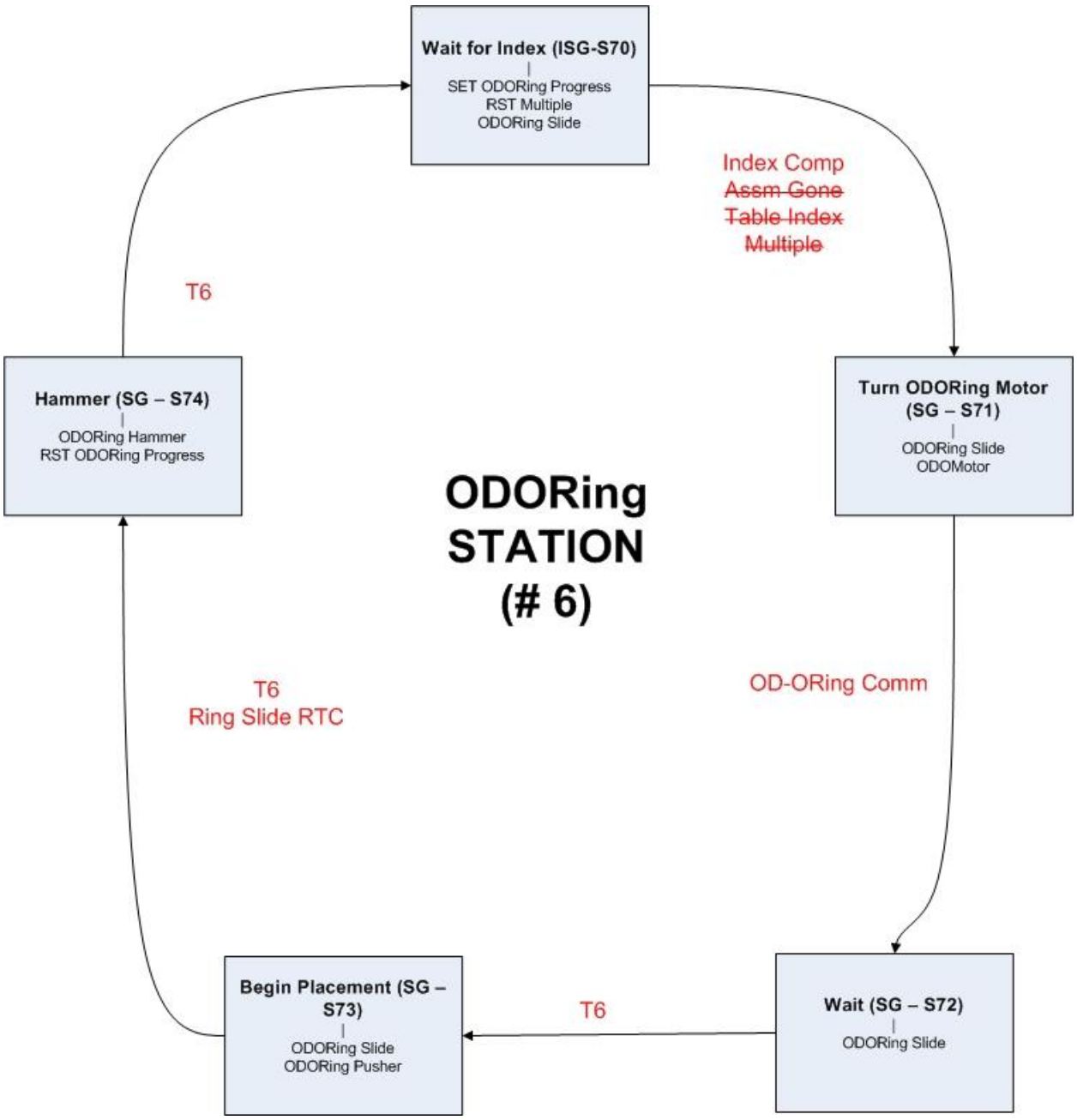

Wait for Index (ISG-S30)
SET Nose Progress
RST Multiple
Index Comp
~~Assm Gone~~
~~Table Index~~
~~Multiple~~
Present (SG – S31)
Nose Vert
NOSE STATION (# 1)
Nose Retract (SG – S34)
RST Nose Progress
~~Nose Present~~
Initially No Nose (SG – S32)
Nose U Sing
Nose Present
~~Nose Present~~
Nose Present
Lens Placement (SG – S33)
Nose Lower
Nose L Sing


Wait for Index (ISG-S40)
SET IDORing Progress
RST Multiple
Index Comp
~~Assm Gone~~
~~Table Index~~
~~Multiple~~
Turn Motor (SG – S41)
IDOPush-Up
IDOMotor
ID O-Ring
STATION
(# 2)
ID-Oring Comm
Waiting (SG – S42)
IDOPush-Up
T2
Air Blast (SG – S43)
IDOPush-Up
IDOBlast
T2
IDO Set (SG – S44)
IDOPush-up
IDOSettle
RST IDORing Progress
T2

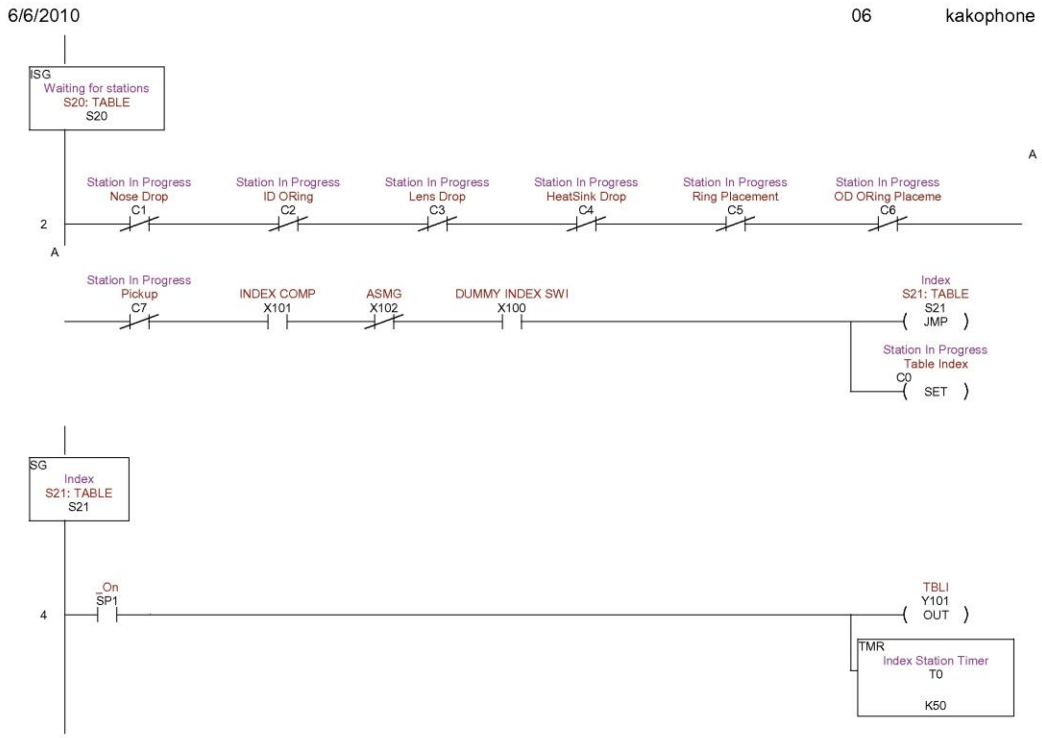

Wait for Index (ISG-S0)
SET Lens Progress
RST Multiple
T3
Index Comp
~~Assm Gone~~
~~Table Index~~
~~Multiple~~
Drop and Return (SG – S7)
Lens Swivel
RST Lens Progress
Singulation (SG – S1)
Lens U Sing
Lens Vert
LENS STATION (# 3)
Lower (SG – S6)
Lens Swivel
Lens Vac
Lens Pickup
~~Lens Present~~
T30
Initially No Lens (SG – S2)
Lens L Sing
Lens Present
Swivel (SG – S5)
Lens Vac
Lens Swivel
Lens Present
~~Lens Vert~~
~~Lens Present~~
T3
Liftoff (SG – S4)
Lens Vac
Lens Vert
T3
Lens Pickup (SG – S3)
Lens Pickup
Lens Vac

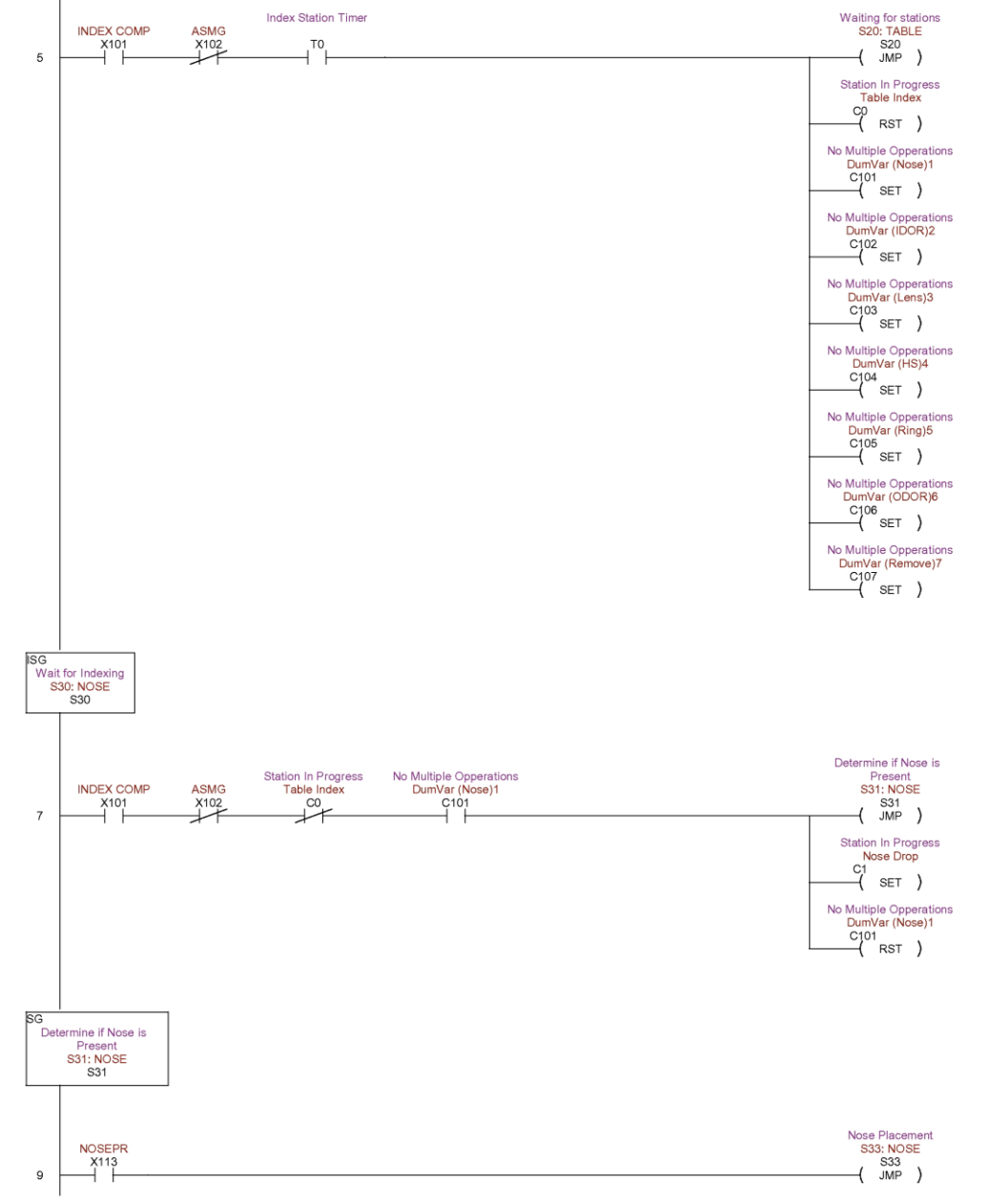

Wait for Index (ISG-S50)
SET HeatSink Progress
RST Multiple
Index Comp
~~Assm Gone~~
~~Table Index~~
~~Multiple~~
Prepare for Drop (SG – S51)
HeatSink U Sing
T4
HeatSink STATION (# 4)
~~HeatSink Present~~
Reset (SG – S53)
HeatSink U Sing
RST HeatSink Progress
T4
HeatSink Present
Drop (SG – S52)
HeatSink U Sing
HeatSink L Sing

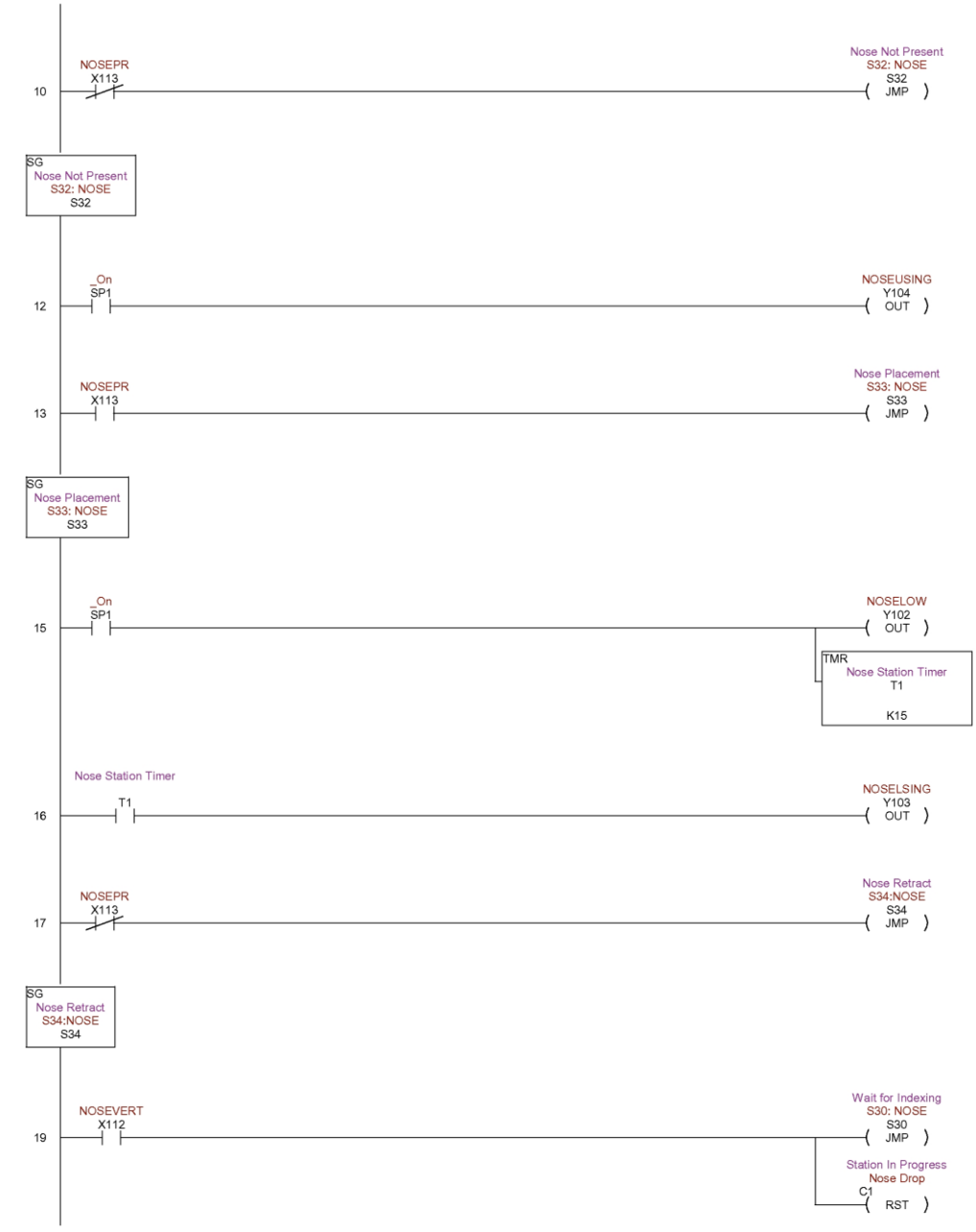

Wait for Index (ISG-S60)
SET Ring Progress
RST Multiple
Index Comp
~~Assm Gone~~
~~Table Index~~
~~Multiple~~
T5
Singulation (SG – S61)
Ring U Sing
Ring Slide
Ring L Sing
Reset (SG – S65)
RST Ring Progress
Ring
STATION
(# 5)
T55
T5
Singulation2 (SG – S62)
Ring U Sing
Ring Slide
Hammer (SG – S64)
Ring Hammer
T5
Ring Slide RTC
Ring Push RTC
T5
Begin Placement (SG – S63)
Ring Slide
Ring Pusher

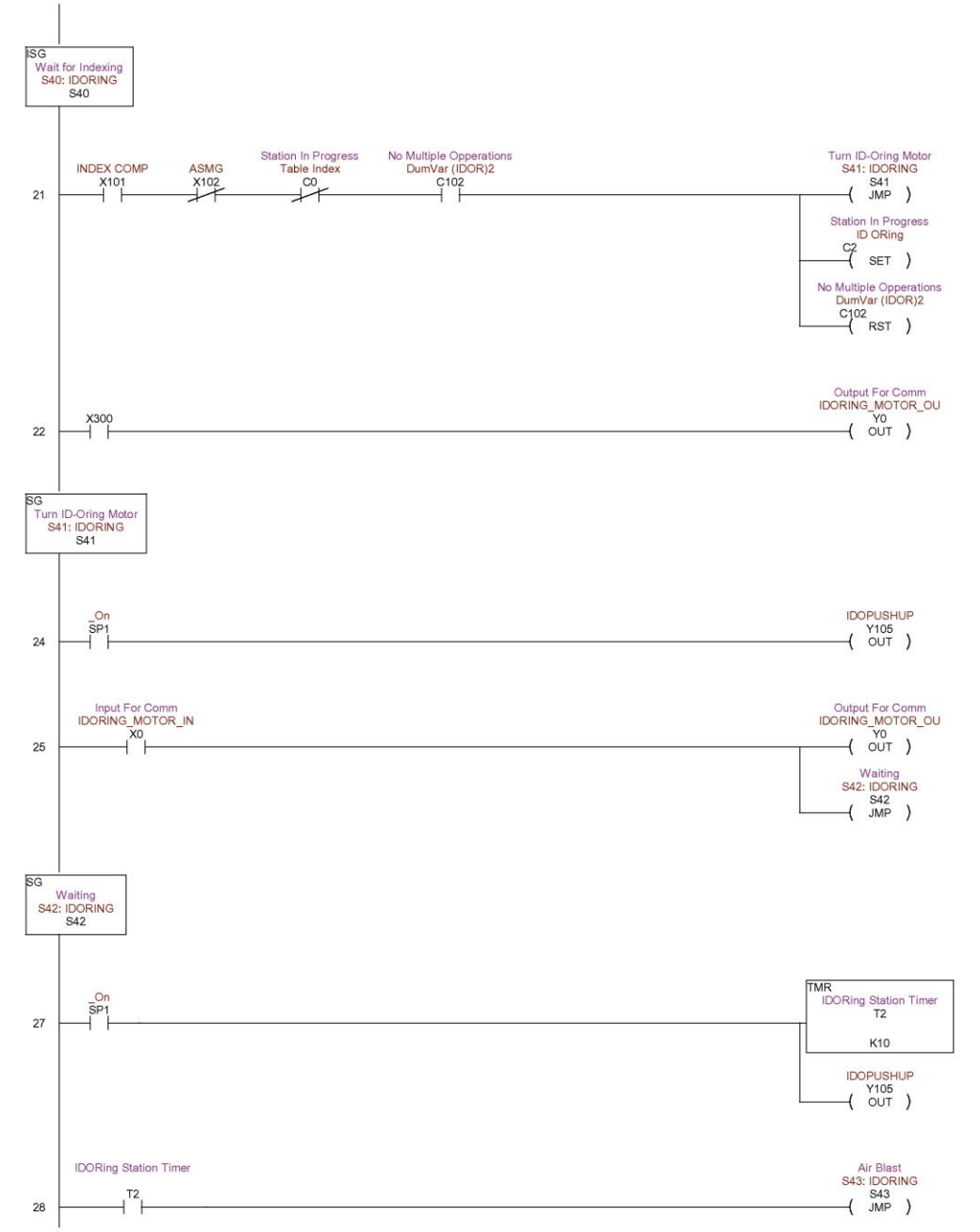

Wait for Index (ISG-S70)
SET ODORing Progress
RST Multiple
ODORing Slide
Index Comp
~~Assm Gone~~
~~Table Index~~
~~Multiple~~
Turn ODORing Motor (SG – S71)
ODORing Slide
ODOMotor
OD-ORing Comm
Wait (SG – S72)
ODORing Slide
T6
Begin Placement (SG – S73)
ODORing Slide
ODORing Pusher
T6
Ring Slide RTC
Hammer (SG – S74)
ODORing Hammer
RST ODORing Progress
T6
ODORing STATION (# 6)

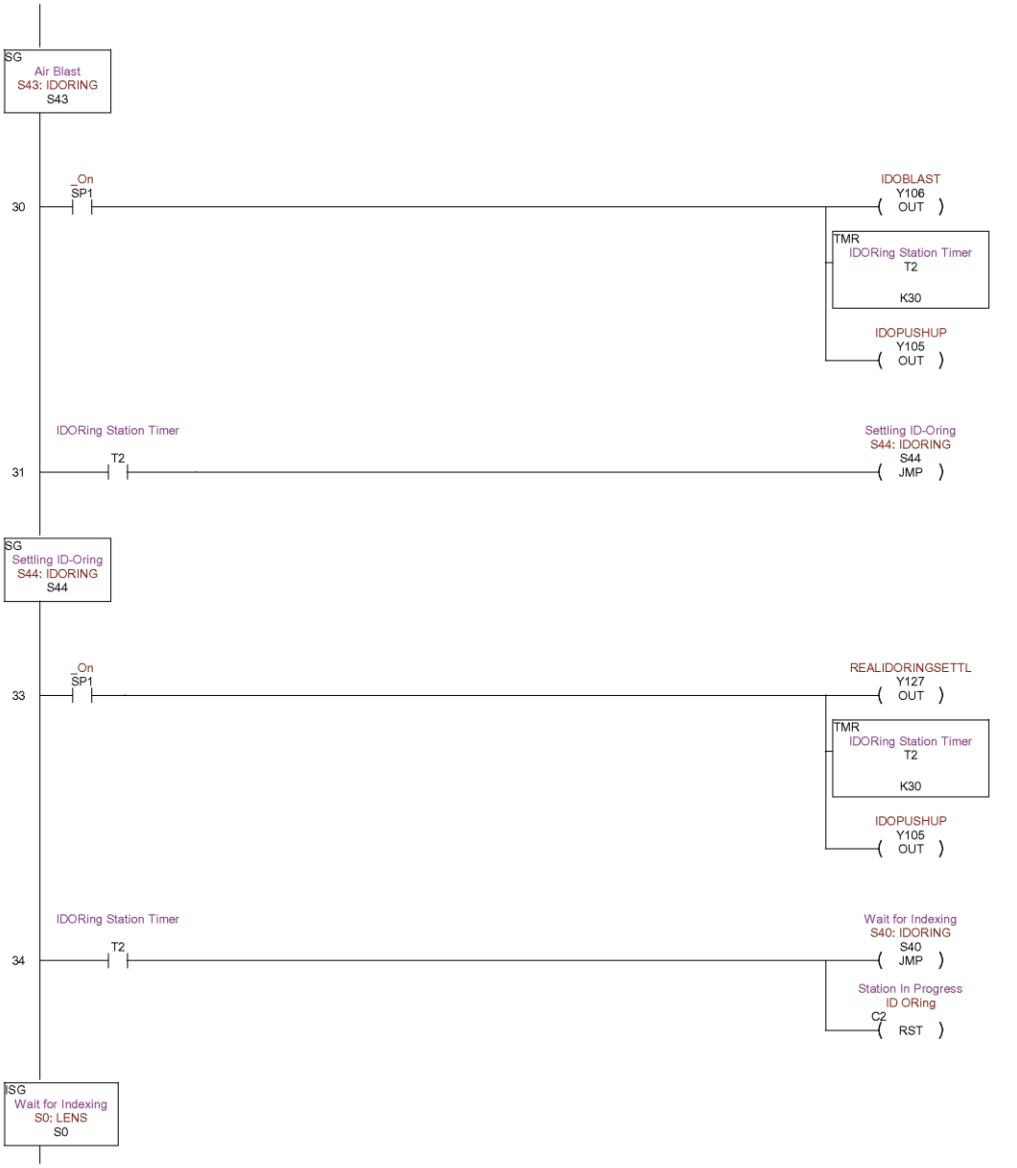
PLC Ladder Logic

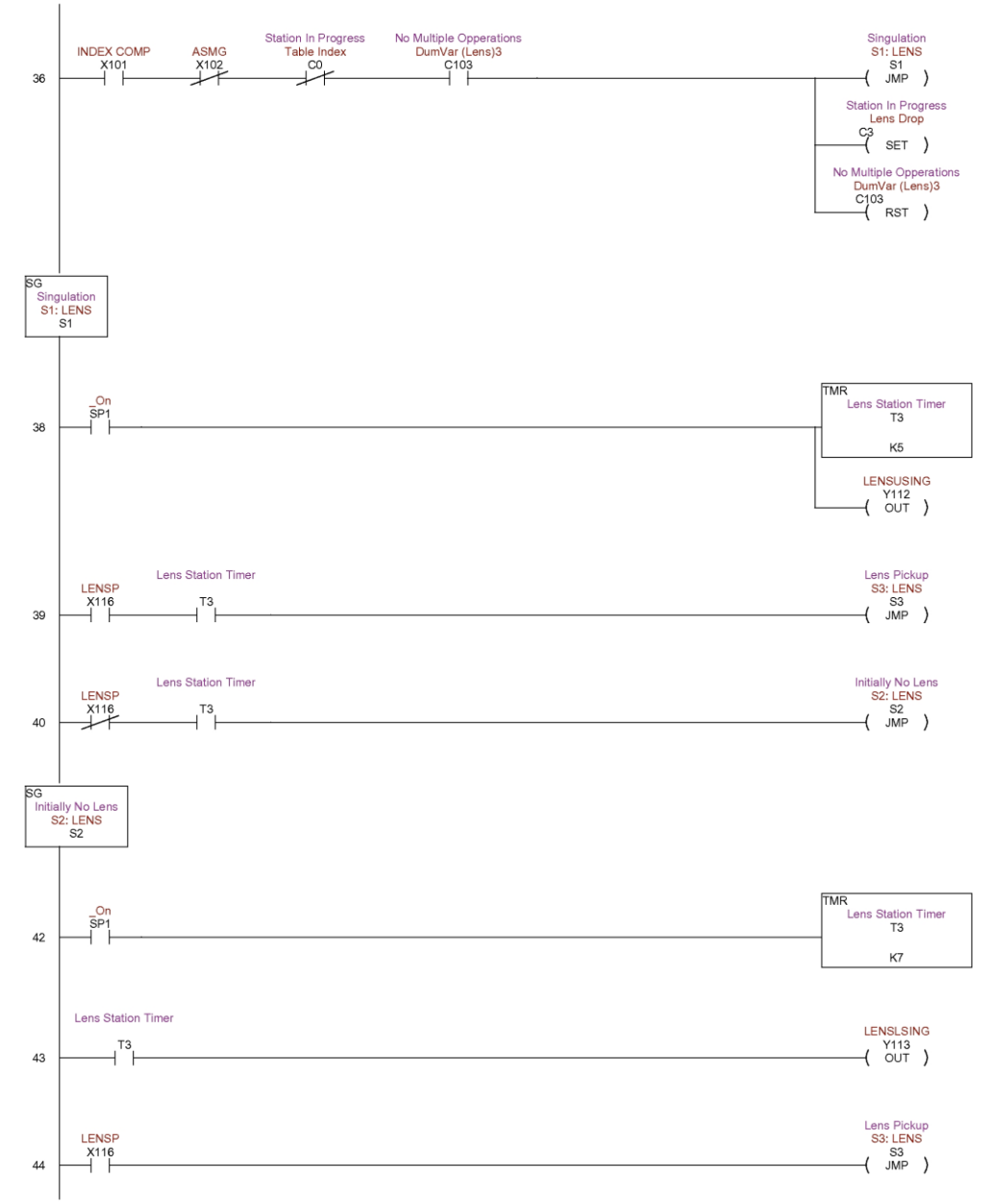


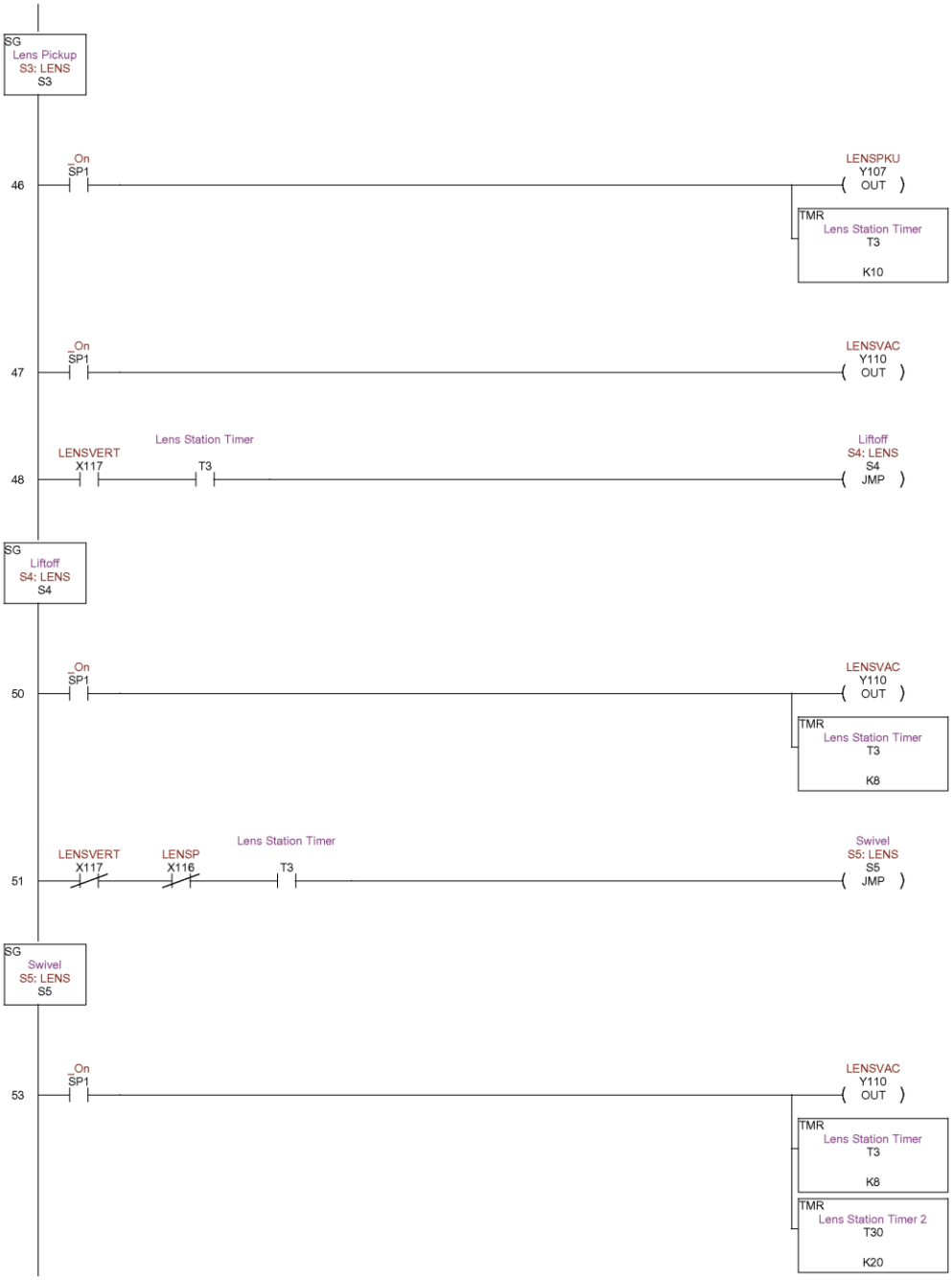

Index Station Timer
INDEX COMP
X101
ASMG
X102
T0
5
Waiting for stations
S20: TABLE
S20
JMP
Station In Progress
Table Index
C0
RST
No Multiple Opperations
DumVar (Nose)1
C101
SET
No Multiple Opperations
DumVar (IDOR)2
C102
SET
No Multiple Opperations
DumVar (Lens)3
C103
SET
No Multiple Opperations
DumVar (HS)4
C104
SET
No Multiple Opperations
DumVar (Ring)5
C105
SET
No Multiple Opperations
DumVar (ODOR)6
C106
SET
No Multiple Opperations
DumVar (Remove)7
C107
SET
ISG
Wait for Indexing
S30: NOSE
S30
Station In Progress
Table Index
No Multiple Opperations
DumVar (Nose)1
INDEX COMP
X101
ASMG
X102
C0
C101
7
Determine if Nose is
Present
S31: NOSE
S31
JMP
Station In Progress
Nose Drop
C1
SET
No Multiple Opperations
DumVar (Nose)1
C101
RST
SG
Determine if Nose is
Present
S31: NOSE
S31
NOSEPR
X113
9
Nose Placement
S33: NOSE
S33
JMP

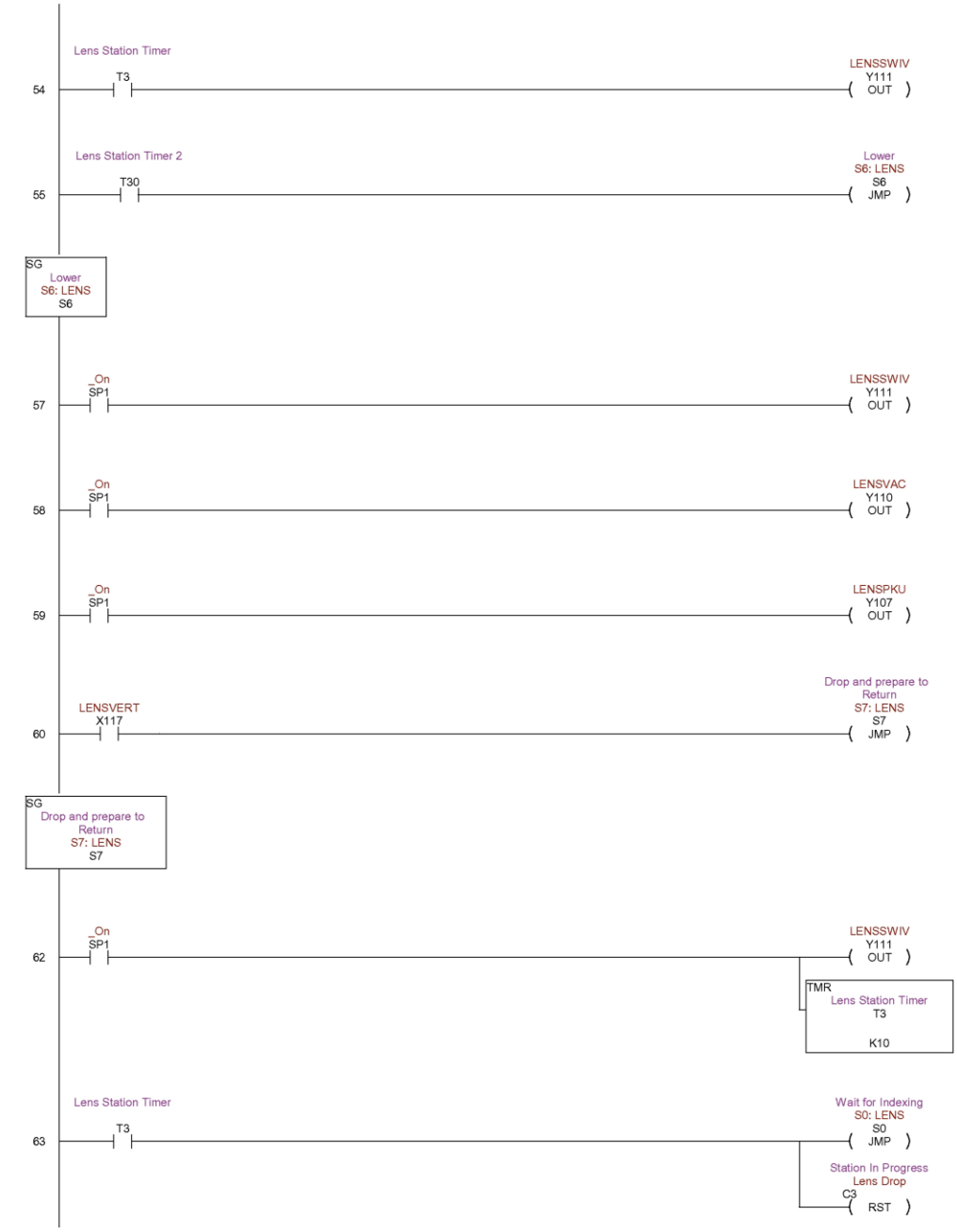

10
NOSEPR
X113
Nose Not Present
S32: NOSE
S32
JMP
SG
Nose Not Present
S32: NOSE
S32
12
_On
SP1
NOSEUSING
Y104
OUT
13
NOSEPR
X113
Nose Placement
S33: NOSE
S33
JMP
SG
Nose Placement
S33: NOSE
S33
15
_On
SP1
NOSELOW
Y102
OUT
TMR
Nose Station Timer
T1
K15
16
Nose Station Timer
T1
NOSELSING
Y103
OUT
17
NOSEPR
X113
Nose Retract
S34:NOSE
S34
JMP
SG
Nose Retract
S34:NOSE
S34
19
NOSEVERT
X112
Wait for Indexing
S30: NOSE
S30
JMP
Station In Progress
Nose Drop
C1
RST

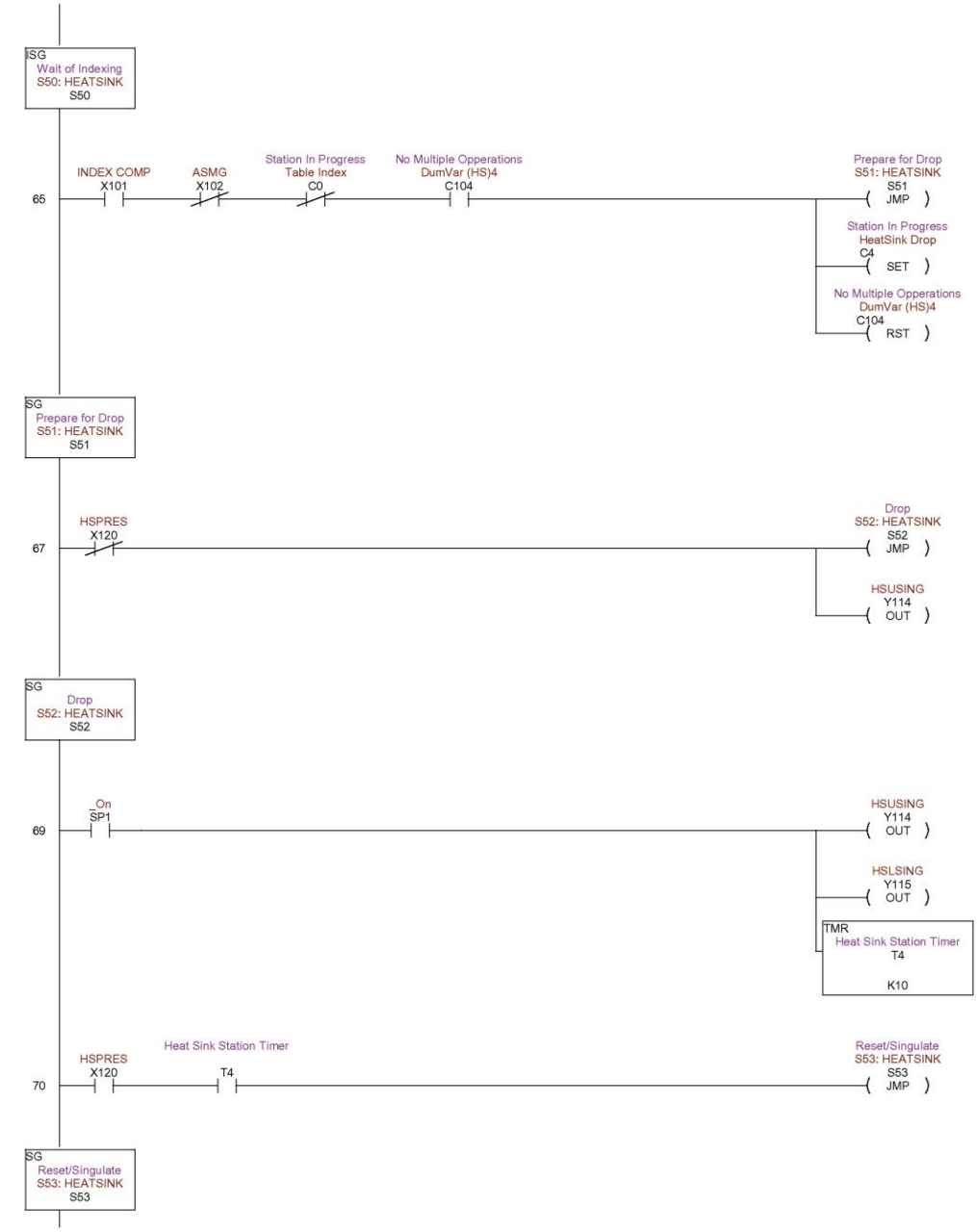

ISG
Wait for Indexing
S40: IDORING
S40
INDEX COMP
X101
ASMG
X102
Station In Progress
Table Index
C0
No Multiple Opperations
DumVar (IDOR)2
C102
21
Turn ID-Oring Motor
S41: IDORING
S41
JMP
Station In Progress
ID ORing
C2
SET
No Multiple Opperations
DumVar (IDOR)2
C102
RST
Output For Comm
IDORING_MOTOR_OU
Y0
OUT
X300
22
SG
Turn ID-Oring Motor
S41: IDORING
S41
_On
SP1
24
IDOPUSHUP
Y105
OUT
Input For Comm
IDORING_MOTOR_IN
X0
25
Output For Comm
IDORING_MOTOR_OU
Y0
OUT
Waiting
S42: IDORING
S42
JMP
SG
Waiting
S42: IDORING
S42
_On
SP1
27
TMR
IDORing Station Timer
T2
K10
IDOPUSHUP
Y105
OUT
IDORing Station Timer
T2
28
Air Blast
S43: IDORING
S43
JMP

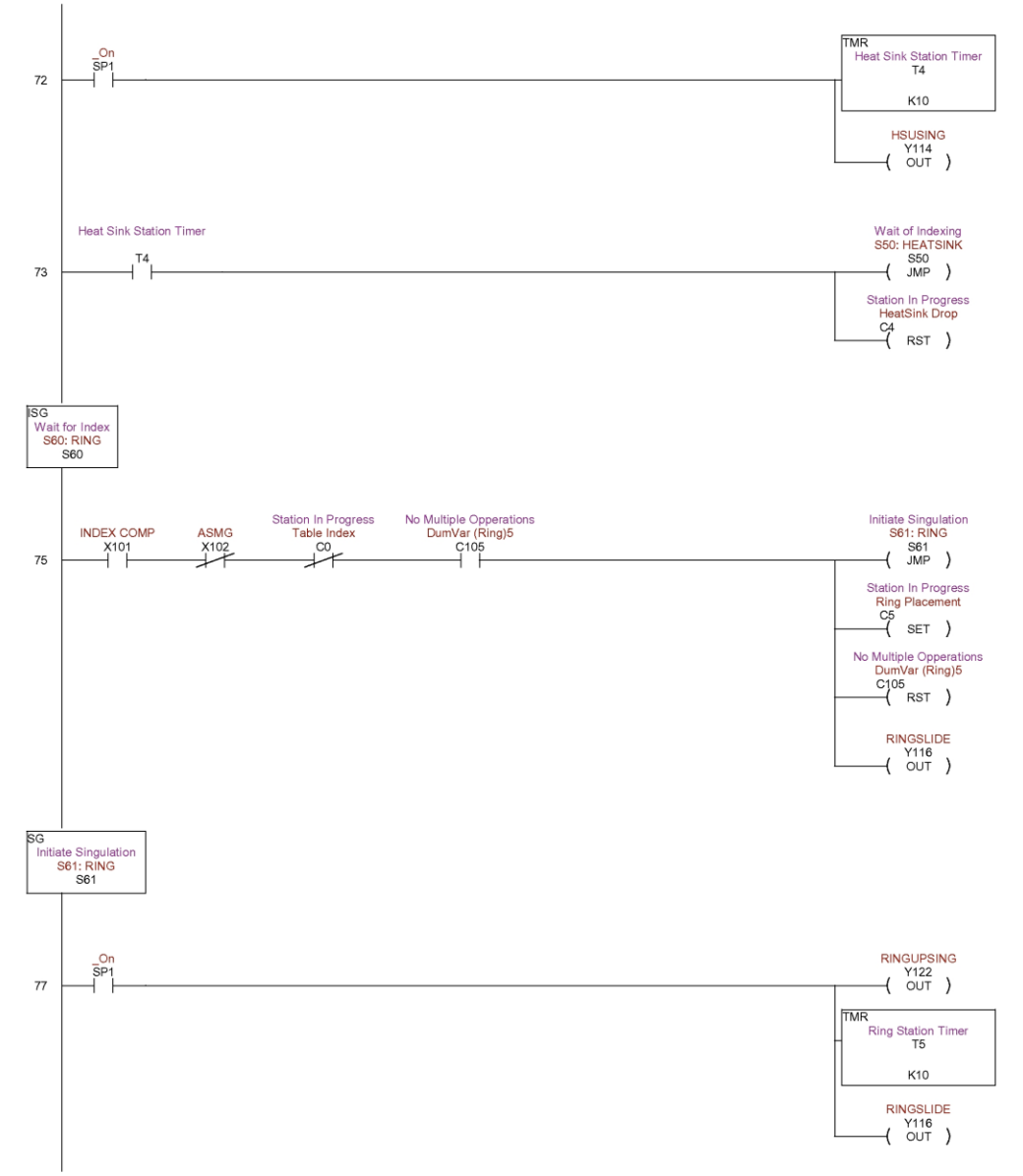

SG
Air Blast
S43: IDORING
S43
30
_On
SP1
IDOBLAST
Y106
OUT
TMR
IDORing Station Timer
T2
K30
IDOPUSHUP
Y105
OUT
IDORing Station Timer
T2
31
Settling ID-Oring
S44: IDORING
S44
JMP
SG
Settling ID-Oring
S44: IDORING
S44
33
_On
SP1
REALIDORINGSETTL
Y127
OUT
TMR
IDORing Station Timer
T2
K30
IDOPUSHUP
Y105
OUT
IDORing Station Timer
T2
34
Wait for Indexing
S40: IDORING
S40
JMP
Station In Progress
ID ORing
C2
RST
ISG
Wait for Indexing
S0: LENS
S0

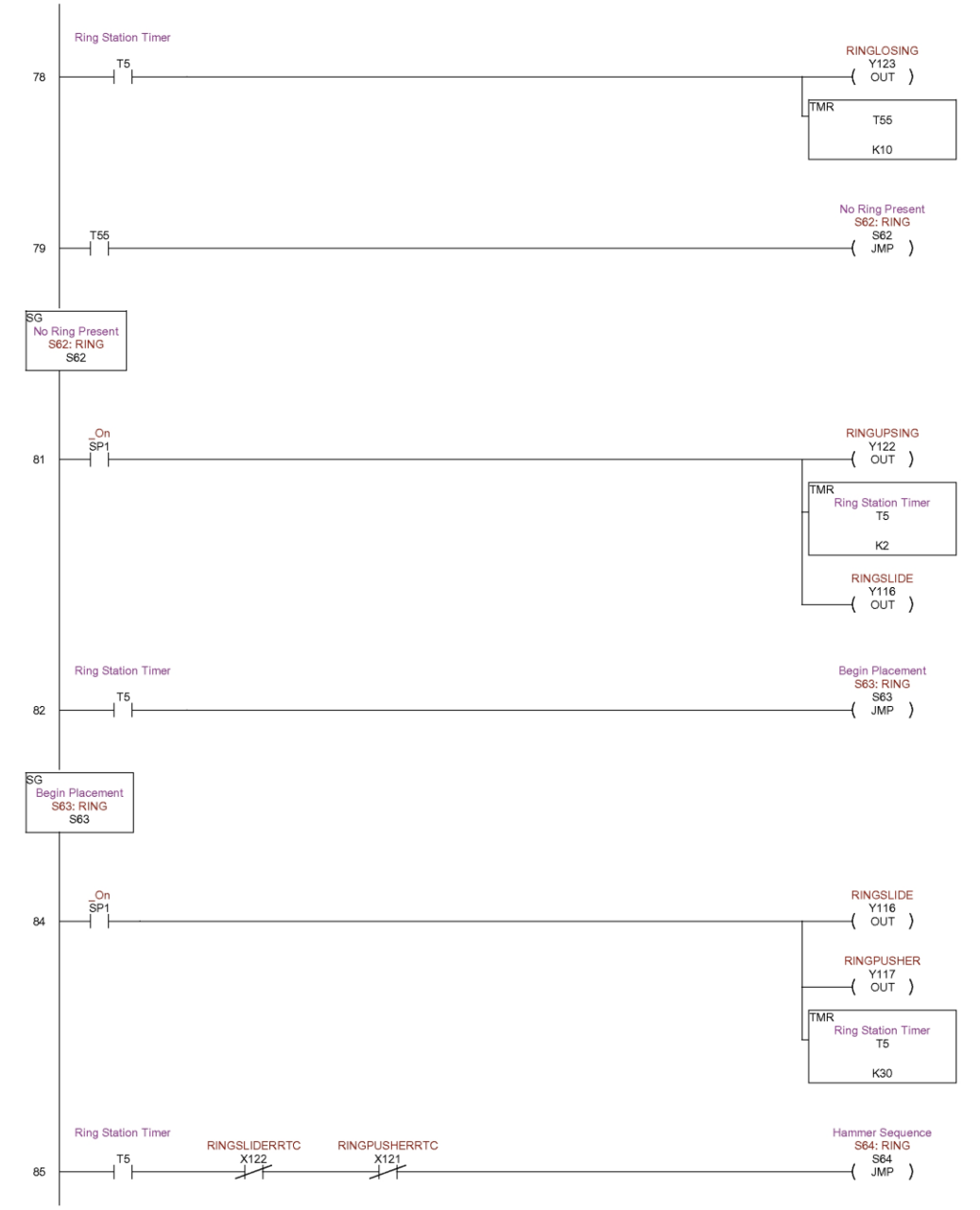

36
INDEX COMP
X101
ASMG
X102
Station In Progress
Table Index
C0
No Multiple Opperations
DumVar (Lens)3
C103
Singulation
S1: LENS
S1
JMP
Station In Progress
Lens Drop
C3
SET
No Multiple Opperations
DumVar (Lens)3
C103
RST
SG
Singulation
S1: LENS
S1
38
_On
SP1
TMR
Lens Station Timer
T3
K5
LENSUSING
Y112
OUT
39
LENSP
X116
Lens Station Timer
T3
Lens Pickup
S3: LENS
S3
JMP
40
LENSP
X116
Lens Station Timer
T3
Initially No Lens
S2: LENS
S2
JMP
SG
Initially No Lens
S2: LENS
S2
42
_On
SP1
TMR
Lens Station Timer
T3
K7
43
Lens Station Timer
T3
LENSLSING
Y113
OUT
44
LENSP
X116
Lens Pickup
S3: LENS
S3
JMP

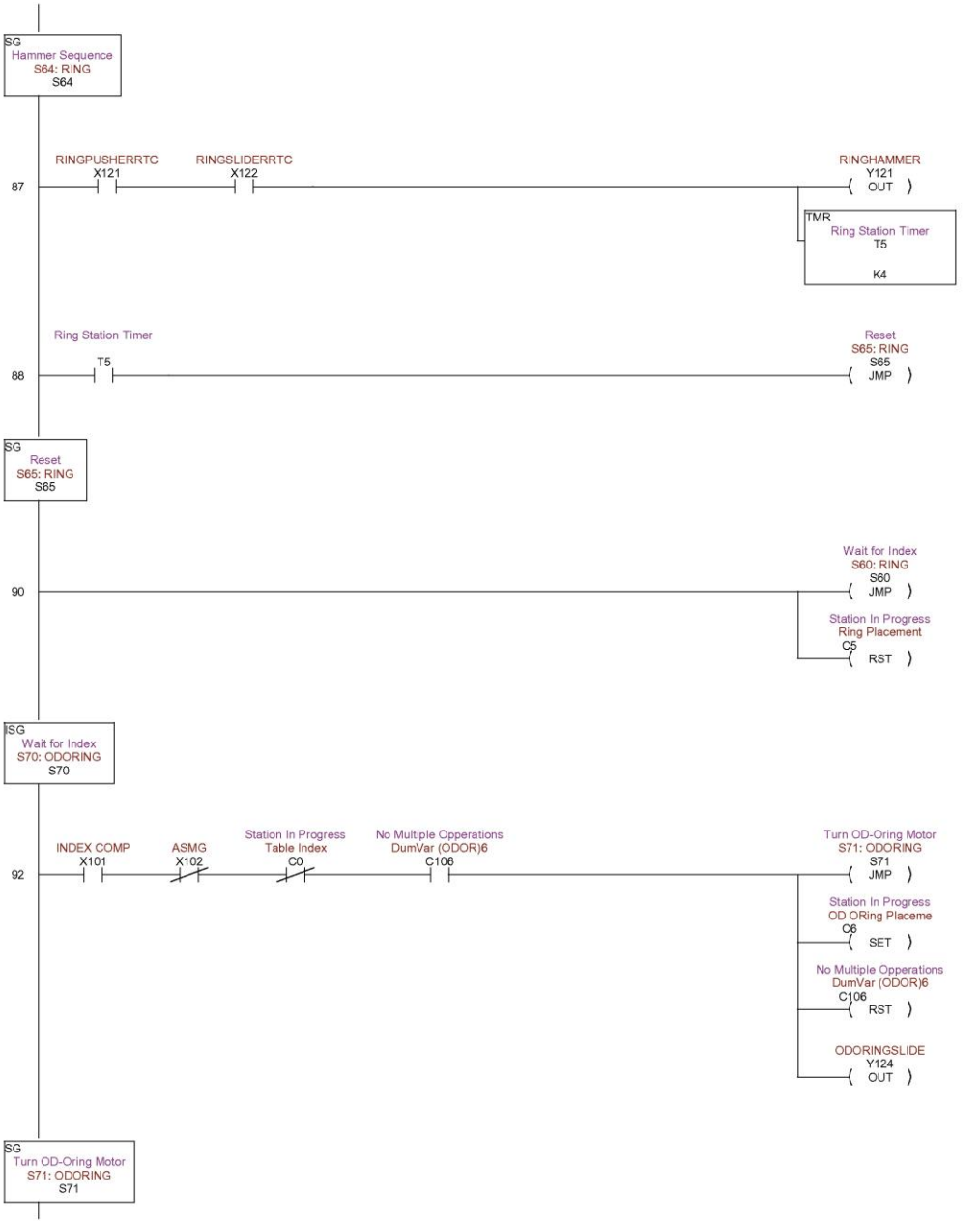

SG
Lens Pickup
S3: LENS
S3
46
On
SP1
LENSPKU
Y107
OUT
TMR
Lens Station Timer
T3
K10
47
On
SP1
LENSVAC
Y110
OUT
48
LENSVERT
X117
Lens Station Timer
T3
Liftoff
S4: LENS
S4
JMP
SG
Liftoff
S4: LENS
S4
50
On
SP1
LENSVAC
Y110
OUT
TMR
Lens Station Timer
T3
K8
51
LENSVERT
X117
LENSP
X116
Lens Station Timer
T3
Swivel
S5: LENS
S5
JMP
SG
Swivel
S5: LENS
S5
53
On
SP1
LENSVAC
Y110
OUT
TMR
Lens Station Timer
T3
K8
TMR
Lens Station Timer 2
T30
K20

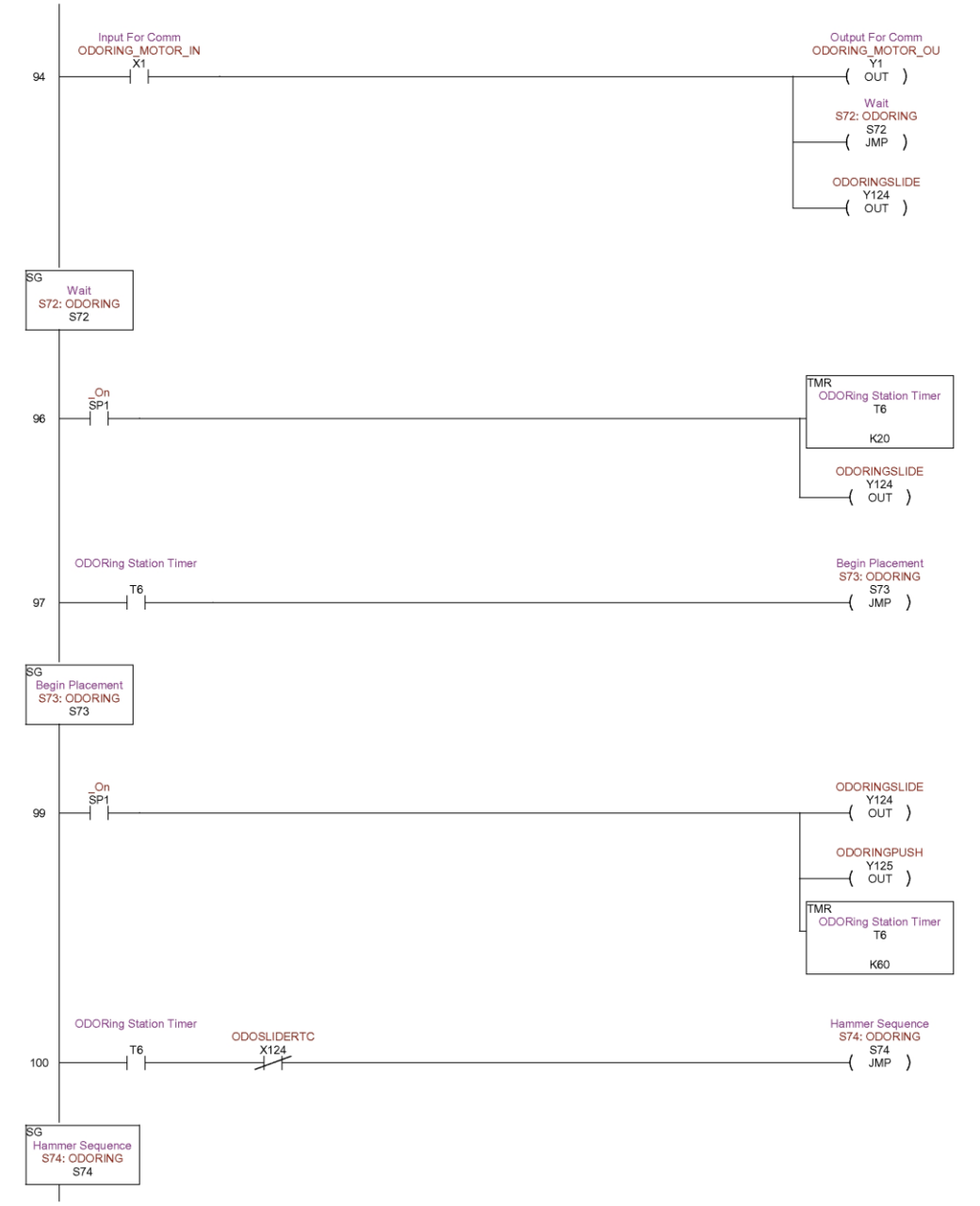

Lens Station Timer
T3
54
LENSSWIV
Y111
OUT
Lens Station Timer 2
T30
55
Lower
S6: LENS
S6
JMP
SG
Lower
S6: LENS
S6
On
SP1
57
LENSSWIV
Y111
OUT
On
SP1
58
LENSVAC
Y110
OUT
On
SP1
59
LENSPKU
Y107
OUT
LENSVERT
X117
60
Drop and prepare to
Return
S7: LENS
S7
JMP
SG
Drop and prepare to
Return
S7: LENS
S7
On
SP1
62
LENSSWIV
Y111
OUT
TMR
Lens Station Timer
T3
K10
Lens Station Timer
T3
63
Wait for Indexing
S0: LENS
S0
JMP
Station In Progress
Lens Drop
C3
RST


SG
Wait of Indexing
S50: HEATSINK
S50
65
INDEX COMP
X101
ASMG
X102
Station In Progress
Table Index
C0
No Multiple Opperations
DumVar (HS)4
C104
Prepare for Drop
S51: HEATSINK
S51
JMP
Station In Progress
HeatSink Drop
C4
SET
No Multiple Opperations
DumVar (HS)4
C104
RST
SG
Prepare for Drop
S51: HEATSINK
S51
67
HSPRES
X120
Drop
S52: HEATSINK
S52
JMP
HSUSING
Y114
OUT
SG
Drop
S52: HEATSINK
S52
69
On
SP1
HSUSING
Y114
OUT
HSLSING
Y115
OUT
TMR
Heat Sink Station Timer
T4
K10
70
HSPRES
X120
Heat Sink Station Timer
T4
Reset/Singulate
S53: HEATSINK
S53
JMP
SG
Reset/Singulate
S53: HEATSINK
S53


_On
SP1
72
TMR
Heat Sink Station Timer
T4
K10
HSUSING
Y114
OUT
Heat Sink Station Timer
T4
73
Wait of Indexing
S50: HEATSINK
S50
JMP
Station In Progress
HeatSink Drop
C4
RST
ISG
Wait for Index
S60: RING
S60
INDEX COMP
X101
ASMG
X102
Station In Progress
Table Index
C0
No Multiple Opperations
DumVar (Ring)5
C105
75
Initiate Singulation
S61: RING
S61
JMP
Station In Progress
Ring Placement
C5
SET
No Multiple Opperations
DumVar (Ring)5
C105
RST
RINGSLIDE
Y116
OUT
SG
Initiate Singulation
S61: RING
S61
_On
SP1
77
RINGUPSING
Y122
OUT
TMR
Ring Station Timer
T5
K10
RINGSLIDE
Y116
OUT


Ring Station Timer
T5
78
RINGLOSING
Y123
OUT
TMR
T55
K10
No Ring Present
S62: RING
S62
JMP
T55
79
SG
No Ring Present
S62: RING
S62
_On
SP1
81
RINGUPSING
Y122
OUT
TMR
Ring Station Timer
T5
K2
RINGSLIDE
Y116
OUT
Ring Station Timer
T5
Begin Placement
S63: RING
S63
JMP
82
SG
Begin Placement
S63: RING
S63
_On
SP1
84
RINGSLIDE
Y116
OUT
RINGPUSHER
Y117
OUT
TMR
Ring Station Timer
T5
K30
Ring Station Timer
T5
RINGSLIDERRTC
X122
RINGPUSHERRTC
X121
Hammer Sequence
S64: RING
S64
JMP
85


SG
Hammer Sequence
S64: RING
S64
87
RINGPUSHERRTC
X121
RINGSLIDERRTC
X122
RINGHAMMER
Y121
OUT
TMR
Ring Station Timer
T5
K4
88
Ring Station Timer
T5
Reset
S65: RING
S65
JMP
SG
Reset
S65: RING
S65
90
Wait for Index
S60: RING
S60
JMP
Station In Progress
Ring Placement
C5
RST
SG
Wait for Index
S70: ODORING
S70
92
INDEX COMP
X101
ASMG
X102
Station In Progress
Table Index
C0
No Multiple Opperations
DumVar (ODOR)6
C106
Turn OD-Oring Motor
S71: ODORING
S71
JMP
Station In Progress
OD ORing Placeme
C6
SET
No Multiple Opperations
DumVar (ODOR)6
C106
RST
ODORINGSLIDE
Y124
OUT
SG
Turn OD-Oring Motor
S71: ODORING
S71


Input For Comm
ODORING_MOTOR_IN
X1
94
Output For Comm
ODORING_MOTOR_OU
Y1
OUT
Wait
S72: ODORING
S72
JMP
ODORINGSLIDE
Y124
OUT
SG
Wait
S72: ODORING
S72
_On
SP1
96
TMR
ODORing Station Timer
T6
K20
ODORINGSLIDE
Y124
OUT
ODORing Station Timer
T6
97
Begin Placement
S73: ODORING
S73
JMP
SG
Begin Placement
S73: ODORING
S73
_On
SP1
99
ODORINGSLIDE
Y124
OUT
ODORINGPUSH
Y125
OUT
TMR
ODORing Station Timer
T6
K60
ODORing Station Timer
T6
ODOSLIDERTC
X124
100
Hammer Sequence
S74: ODORING
S74
JMP
SG
Hammer Sequence
S74: ODORING
S74

ODOSLIDERTC
X124
102
ODOHAMMER
Y126
OUT
TMR
ODORing Station Timer
T6
K20
ODORing Station Timer
T6
103
Wait for Index
S70: ODORING
S70
JMP
Station In Progress
OD ORing Placeme
C6
RST
104
END
105
NOP

Smartmotor Program

The program below runs on both Smartmotors that control the singulation for the internal O-ring and the external O-ring.

```
UAI
UBO

ZS

C1

        UB=1
        WHILE UAI==0 LOOP

        UB=0
        WHILE UAI==1 LOOP

        V=32212/1
        A=40

        D=1*2000
        G
        TWAIT

GOTO1
```

Wiring Table

The table below lists all of the connections for the assembly machine. PLC elements are listed on in column 1 with the source or destination information listed in the subsequent columns.

Element	Nickname	Wiring Info	Description
UB0	TS1		
UB1	TS2		
X0	IDORING_MOTOR_IN	Voltage Conversion Bank	ID Oring Motor Ready Signal
X1	ODORING_MOTOR_IN	Voltage Conversion Bank	OD Oring Motor Ready Signal
X100	DUMMY INDEX SWI	Toggle Switch	Safety Switch for Table Index
X101	INDEX COMP	Toggle Switch	Safety Switch for Table Index
X102	ASMG	Toggle Switch	Completed Nose Removed
X105	IDOA	Toggle Switch	Unused
X106	IDOAA	Toggle Switch	Unused

X112	NOSEVERT	Input Bank	Nose Assembly Retracted
X113	NOSEPR	Input Bank	Nose Present
X116	LENSP	Input Bank	Lens Present
X117	LENSVERT	Input Bank	Lens Assembly Retracted
X120	HSPRES	Input Bank	Heat Sink Present
X121	RINGPUSHERRTC	Input Bank	Ring Pusher Retracted
X122	RINGSLIDERRTC	Input Bank	Ring Tray Retracted
X123	RINGPRES	Input Bank	Ring Present
X124	ODOSLIDERTC	Input Bank	OD Oring Tray Retracted
Y0	IDORING_MOTOR_OU	Voltage Conversion Bank	ID Oring Start Motor Signal
Y1	ODORING_MOTOR_OU	Voltage Conversion Bank	OD Oring Start Motor Signal
Y101	TBLI	Pneumatics Bank 1	Table Index
Y102	NOSELOW	Pneumatics Bank 1	Nose Lower
Y103	NOSELSING	Pneumatics Bank 1	Nose Lower Singulation
Y104	NOSEUSING	Pneumatics Bank 1	Nose Upper Singulation
Y105	IDOPUSHUP	Pneumatics Bank 1	ID Oring Bottom Push Up
Y106	IDOBLAST	Pneumatics Bank 1	ID Oring Ramp Air Blast
Y107	LENSPKU	Pneumatics Bank 1	Lens Pickup
Y110	LENSVAC	Pneumatics Bank 1	Lens Vacuum
Y111	LENSSWIV	Pneumatics Bank 1	Lens Swivel
Y112	LENSUSING	Pneumatics Bank 1	Lens Upper Singulation
Y113	LENSLSING	Pneumatics Bank 1	Lens Lower Singulation
Y114	HSUSING	Pneumatics Bank 1	Heat Sink Upper Singulation
Y115	HSLSING	Pneumatics Bank 1	Heat Sink Lower Singulation
Y116	RINGSLIDE	Pneumatics Bank 1	Ring Tray
Y117	RINGPUSHER	Pneumatics Bank 1	Ring Pusher
Y121	RINGHAMMER	Pneumatics Bank 2	Ring Hammer
Y122	RINGUPSING	Pneumatics Bank 2	Ring Upper Singulation
Y123	RINGLOSING	Pneumatics Bank 2	Ring Lower Singulation
Y124	ODORINGSLIDE	Pneumatics Bank 2	OD Oring Tray
Y125	ODORINGPUSH	Pneumatics Bank 2	OD Oring Pusher
Y126	ODOHAMMER	Pneumatics Bank 2	OD Oring Hammer
Y127	REALIDORINGSETTL	Pneumatics Bank 2	ID Oring Settling Air Blast
C0	Table Index		Station In Progress
C1	Nose Drop		Station In Progress
C2	ID ORing		Station In Progress
C3	Lens Drop		Station In Progress
C4	HeatSink Drop		Station In Progress
C5	Ring Placement		Station In Progress
C6	OD ORing Placeme		Station In Progress

C7	Pickup		Station In Progress
C10	Sensors		Station In Progress
C20	ID Motor Var		Switch Motor to Ground
C101	DumVar (Nose)1		No Multiple Opperations
C102	DumVar (IDOR)2		No Multiple Opperations
C103	DumVar (Lens)3		No Multiple Opperations
C104	DumVar (HS)4		No Multiple Opperations
C105	DumVar (Ring)5		No Multiple Opperations
C106	DumVar (ODOR)6		No Multiple Opperations
C107	DumVar (Remove)7		No Multiple Opperations
S0	S0: LENS		Wait for Indexing
S1	S1: LENS		Singulation
S2	S2: LENS		Initially No Lens
S3	S3: LENS		Lens Pickup
S4	S4: LENS		Liftoff
S5	S5: LENS		Swivel
S6	S6: LENS		Lower
S7	S7: LENS		Drop and prepare to Return
S20	S20: TABLE		Waiting for stations
S21	S21: TABLE		Index
S30	S30: NOSE		Wait for Indexing
S31	S31: NOSE		Determine if Nose is Present
S32	S32: NOSE		Nose Not Present
S33	S33: NOSE		Nose Placement
S34	S34:NOSE		Nose Retract
S40	S40: IDORING		Wait for Indexing
S41	S41: IDORING		Turn ID-Oring Motor
S42	S42: IDORING		Waiting
S43	S43: IDORING		Air Blast
S44	S44: IDORING		Settling ID-Oring
S50	S50: HEATSINK		Wait of Indexing
S51	S51: HEATSINK		Prepare for Drop
S52	S52: HEATSINK		Drop
S53	S53: HEATSINK		Reset/Singulate
S60	S60: RING		Wait for Index
S61	S61: RING		Initiate Singulation
S62	S62: RING		No Ring Present
S63	S63: RING		Begin Placement
S64	S64: RING		Hammer Sequence
S65	S65: RING		Reset

S70	S70: ODORING		Wait for Index
S71	S71: ODORING		Turn OD-Oring Motor
S72	S72: ODORING		Wait
S73	S73: ODORING		Begin Placement
S74	S74: ODORING		Hammer Sequence
T0			Index Station Timer
T1			Nose Station Timer
T2			IDORing Station Timer
T3			Lens Station Timer
T4			Heat Sink Station Timer
T5			Ring Station Timer
T6			ODORing Station Timer
T7			Removal Station Timer
T30			Lens Station Timer 2
T50			Ring Station Timer 2