HEADLAMP ASSEMBLY

An overview of an assembly process for headlamps using an IAI slide, and pneumatic cylinders.

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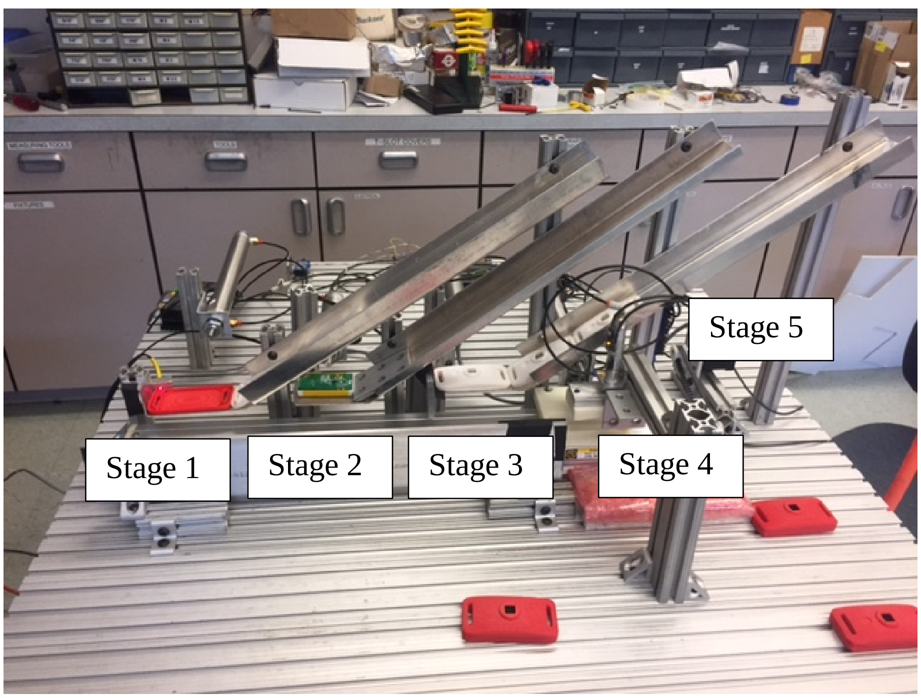
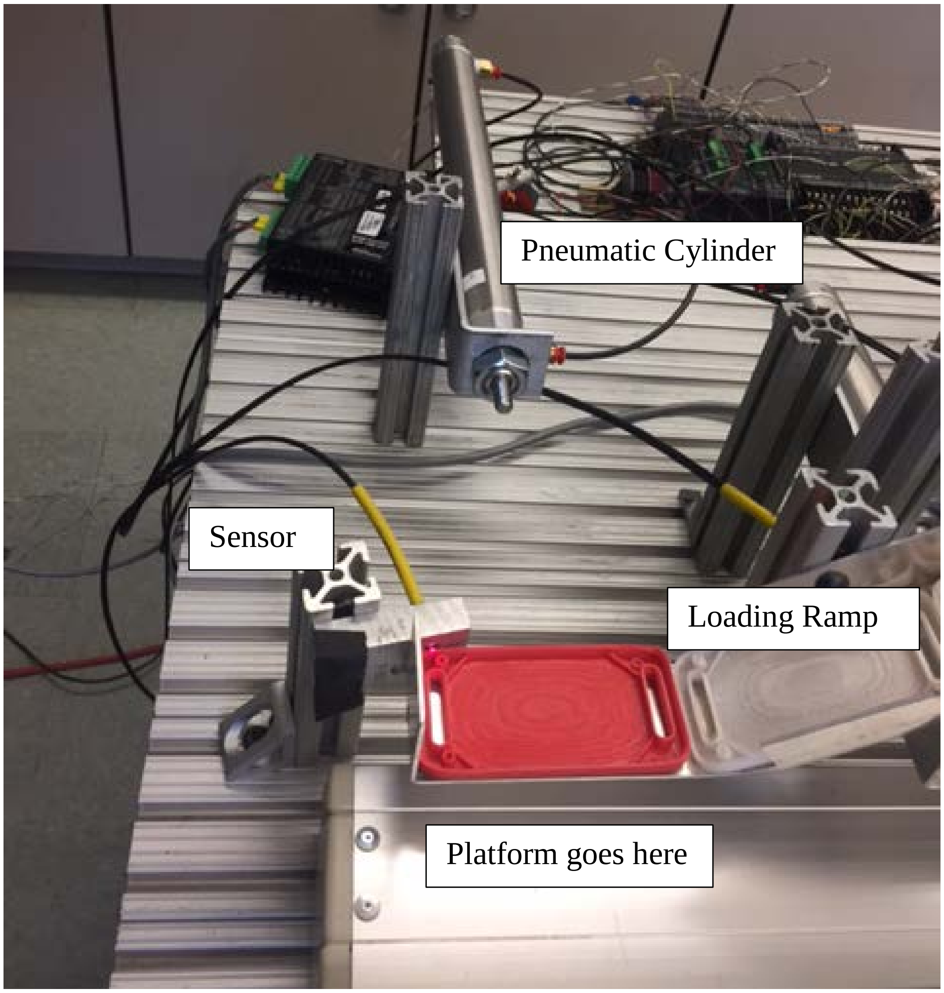
Introduction

The purpose of this document is to provide background information and describe how to run and troubleshoot the manufacturing process developed to put together a headlamp case. The process for putting the headlamp together takes place in 5 different stages. The first three stages assemble the three components of the headlamp and the fourth and fifth stages snap the parts together and then offload the part from the conveyor belt. These stages are described in more detail below.

If this process were to be implemented in a commercial setting there are a few adjustments that would be made. Instead of using a slide, a conveyor belt with the ability to wrap underneath or a racetrack would be used to decrease the cycle time. This way, instead of only producing one part for every 5 stage rotation, the process would be able to produce one part for every stage advancement. This change alone would decrease production time from one every 30 seconds to one every 10 seconds.

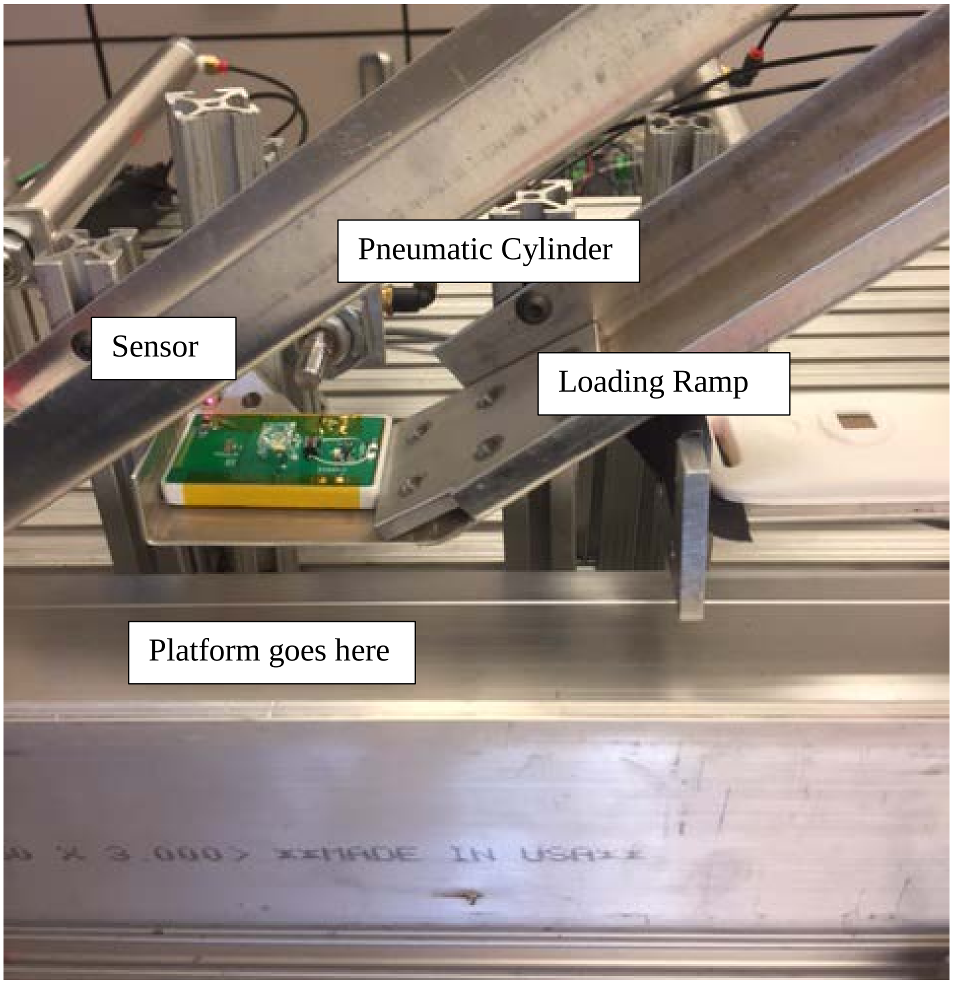


Stage 1



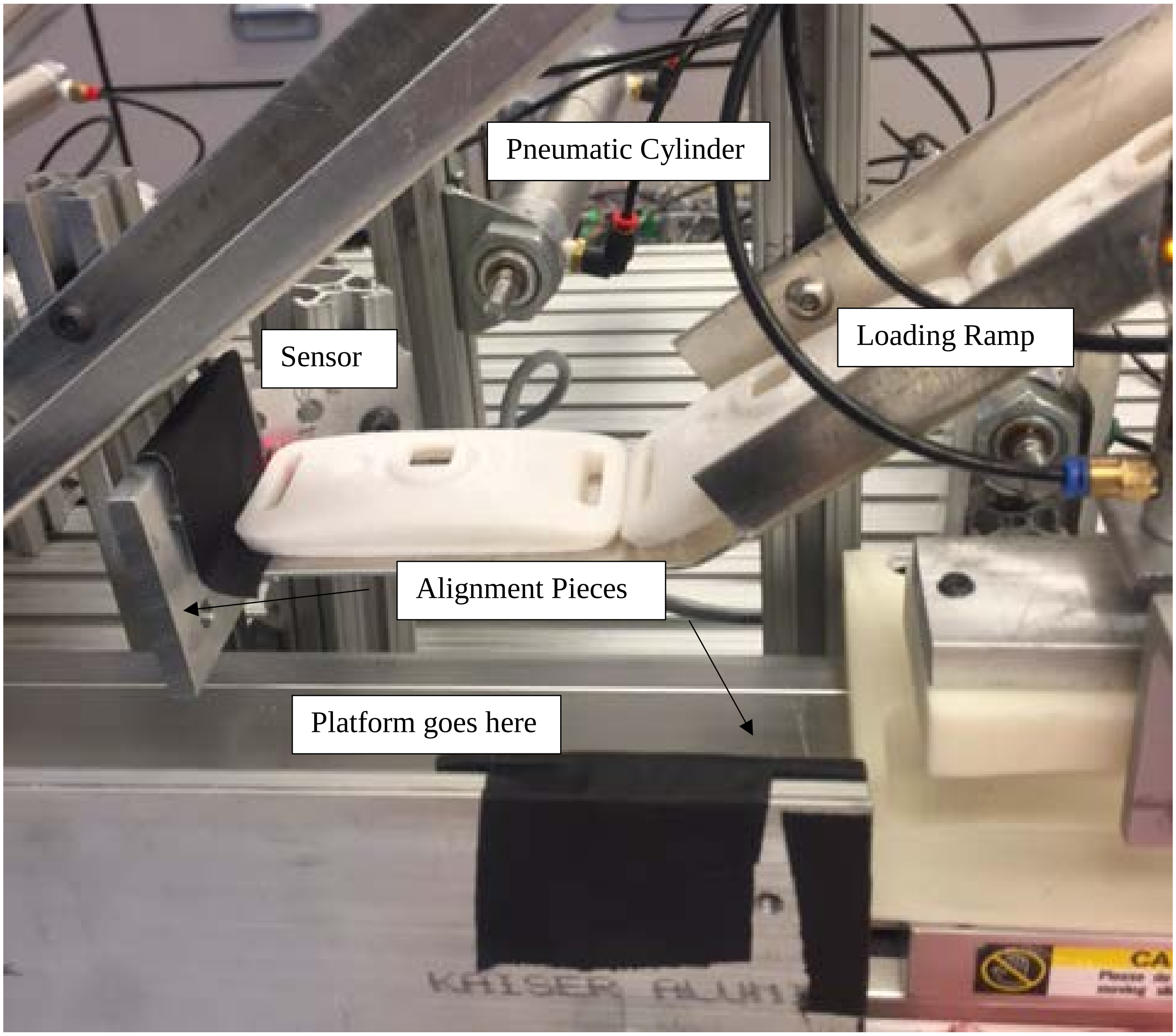
The first stage in the assembly places the bottom half of the headlamp case onto the platform located on the slide. A loading ramp slides the parts down to the level of the assembly line and then a pneumatic cylinder pushes the part from the bottom of the ramp onto the platform. An optical sensor senses when the part has been removed from the assembly line and after a time delay, the slide moves to stage 2.

Stage 2



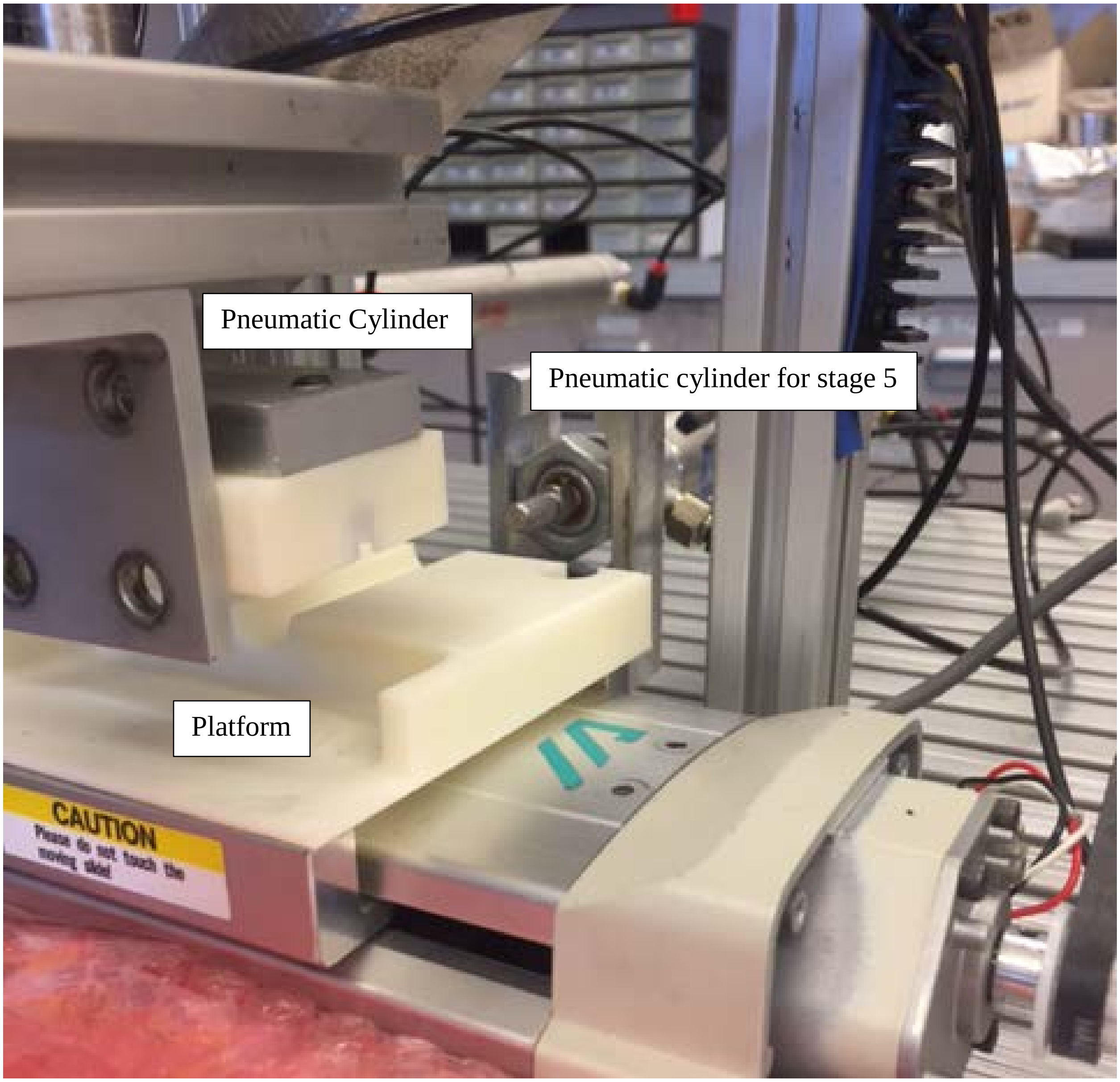
The second stage is almost identical to the first stage. This stage slides the interior electronics package from its loading ramp into the bottom half of the headlamp via a pneumatic cylinder. Just like stage 1, after the optical sensor senses that the part has been moved from the loading ramp, the IAI slide moves the platform to stage 3.

Stage 3



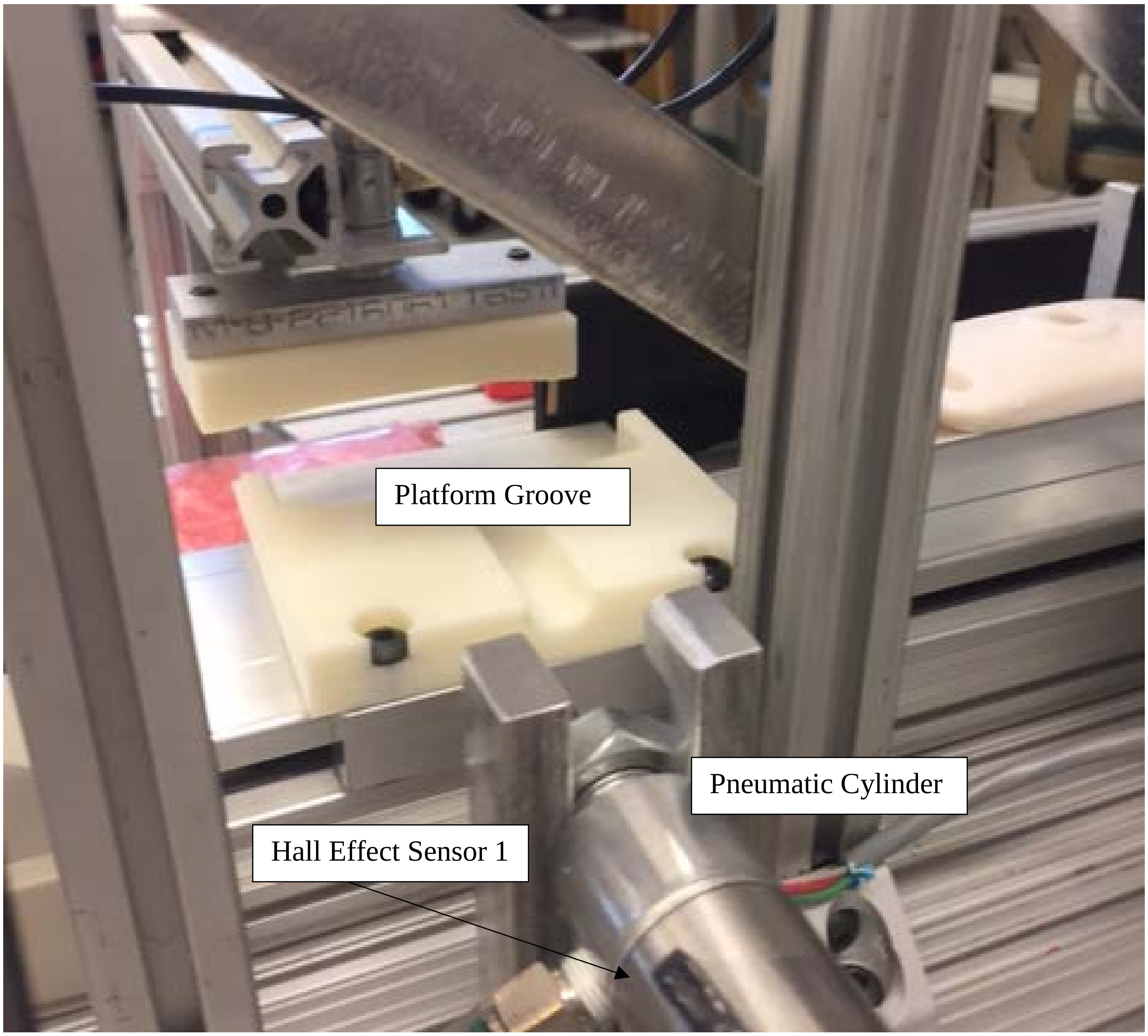
Stage three is an exact replica of stages 1 and 2 with the exception that this stage puts the top half of the headlamp on top of the electronics package. Once the sensor has activated indicating that the part has been loaded, and after a time delay to make sure it is fully in place, the platform goes through an alignment phase. The platform goes backwards to align the top from one side and then forwards to align the part from another side. Once alignment has been completed, the platform advances to the position for stage 4.

Stage 4



The fourth stage is where the parts get snapped together. A pneumatic cylinder above the assembly line comes down and pushes the two halves of the headlamp together. To do this, the inverse of the top half of the headlamp was 3D printed and then attached to the end of the pneumatic cylinder. The sloped sides of the snapping mechanism also helps to align the parts if they are still slightly off after the alignment process. Two Hall Effect sensors detect when the pneumatic cylinder is up and down. This ensures that the cylinder has been fully retracted before the program advances to stage 5.

Stage 5



The fifth and final stage is to push the part off of the platform so that the process can repeat itself. This is done by a pneumatic cylinder which slides through a groove on the platform. Two Hall Effect sensors ensure that the platform does not start moving while the pneumatic cylinder is extended through the platform. A slight time delay is also added to ensure that there is plenty of time for the cylinder to completely retract. Once the headlamp has been ejected and the cylinder has withdrawn, the process goes back to stage one and repeats.

Electronics

The electronics of the system are driven through two handshaking systems: a PLC controller and a CNC controller. The PLC controller reads inputs from sensors placed on the pneumatic cylinders and the chutes from which the parts are loaded, as well as a ready signal from the CNC controller that signals when the platform is in position. The PLC controller actuates the pneumatic cylinders that load parts into the platform, snap the halves of the headlamp together, and eject the completed headlamp from the cart. Once the sensors indicate whatever stage the PLC actuated is completed, the PLC controller then outputs a ready signal back into the CNC controller. Upon receiving said signal, the CNC controller will then move the cart to the next position on the track.

The use of sensors to allow the PLC to move forward through its ladder logic rather than relying on hard coded delays (except in the case of the fourth pneumatic cylinder, where a delay is used to give the headlamp halves extra time to snap together) means the system will pause in the event that one chute runs out of parts or the halves are significantly misaligned when the system tries to snap them together. At this point, the technician servicing the system would then be able to come rectify the problem without the machine continually pumping out defective headlamps.

Start-up Process

The start-up process for this assembly line is fairly simple. A quick visual inspection should be done before starting any of the electronics or motors. This inspection should check to make sure that there is nothing in the way of the sensors, pneumatic cylinders, or the belt between the stepper motor and the IAI slide. If there is, this obstacle should be removed. Additionally, the loading chutes should be checked for any kind of corrosion which could increase the coefficient of friction and prevent the parts from sliding down. An inspection should also be done on the plastic parts to make sure there are no signs of bending or cracking which could cause the part to fail during operation. Once all of the inspections have been done, any parts on the platform should be removed. The power supply can then be plugged in and the air compressor can be turned on. Then the computer can be booted up and the program to run the assembly can be launched

Clearing Jams

There are multiple sensors that have been places along the manufacturing process to notify the operator of an error. There are three optical sensors on the loading chutes (one on each) which will halt the system is a problem is noticed. These sensors will detect whether or not there is a part that can be added and can sense whether or not the part was put into the assembly. If the pneumatic cylinder fails to fire and the part is not added or there are no more parts, then the assembly line will halt. There are also Hall Effect sensors on the pneumatic cylinders in stages 4 and 5. These sensors detect whether or not the pneumatic cylinder is extended or retracted. If the pneumatic cylinder fails to extend or retract, then the process will halt. If any of these sensors detect an error an operator will need to determine what problem is causing the error message. Fixing the possible errors is outlined in the next few paragraphs.

Optical Sensor Failure

The optical sensors detect whether or not a part is present in the loading chute and whether or not that part has been pushed onto the platform. If these sensors detect a problem this means that either the pneumatic cylinder has not actuated, the chute is out of parts, or the sensor itself has stopped working. To correct the first problem check to make sure that there isn't anything blocking the pneumatic cylinder. If there are not blockages, check to make sure the cylinder is working. This can be done by manually triggering the cylinder on the control panel. If the cylinder does not activate, then there is a problem with the pneumatic cylinder, or there is a problem with the air. Disconnect the hoses from the cylinder to see if there is air flowing. If air flows, then the problem is with the pneumatic cylinder. To fix this, please consult the manual for the pneumatic cylinder. If there is no air then there is either a problem with the air compressor, or an electronic component. Electronic problems can be trouble shot by using a voltage meter to check electric outputs, and by tracing wires to make sure all of the connections are strong. If it is an air compressor problem, please consult the manual for the air compressor.

The second problem that these sensors may detect is a lack of parts to add to the assembly. In this case, check to make sure there are no blockages in the loading chutes. Clear these if necessary or add more parts if there is are no more parts in the chute.

The third reason for a sensor failure notification is failure of the sensor itself. To check this, simply swipe your hand over the sensor and check the lights on the PLC to make sure that the PLC is reading the sensor turning off and on. If it is not, then the problem is with the sensor itself. Trouble shoot the sensor by using the product manual.

Hall Effect Sensor Failure

If the Hall Effect Sensors detect a failure, this means that the pneumatic cylinders in stages 4 or 5 have not actuated properly. In stage 4, this could be caused be a blockage that prevents the cylinder from either going down or coming back up. If this is the case, clear the blockage. This could also mean there is a problem with the pneumatic cylinder itself or with the air supply. If there is no blockage, trouble shoot this problem as described in the first paragraph of the "optical sensor failure" section.

Another failure mode is with the sensor itself. If one of the sensors has become detached, or moved on the cylinder then it may not be taking an accurate reading. Visually check to make sure the sensor is still attached. Also, check to see if the lights on the sensors activate and deactivate when the pneumatic cylinder is manually actuated from the control board. If the lights do not indicate that the sensors are working, check the placement of the sensors by moving the sensor up and down on the cylinder to see if the lights activate at any location. If they do not, then troubleshoot the sensor using the sensor manual.

Shut-down Process

The process for shutting down the assembly is also very simple. A command should be input into the computer to stop the process. Once this has been done, the air compressor can be turned off and the power supply can be unplugged.

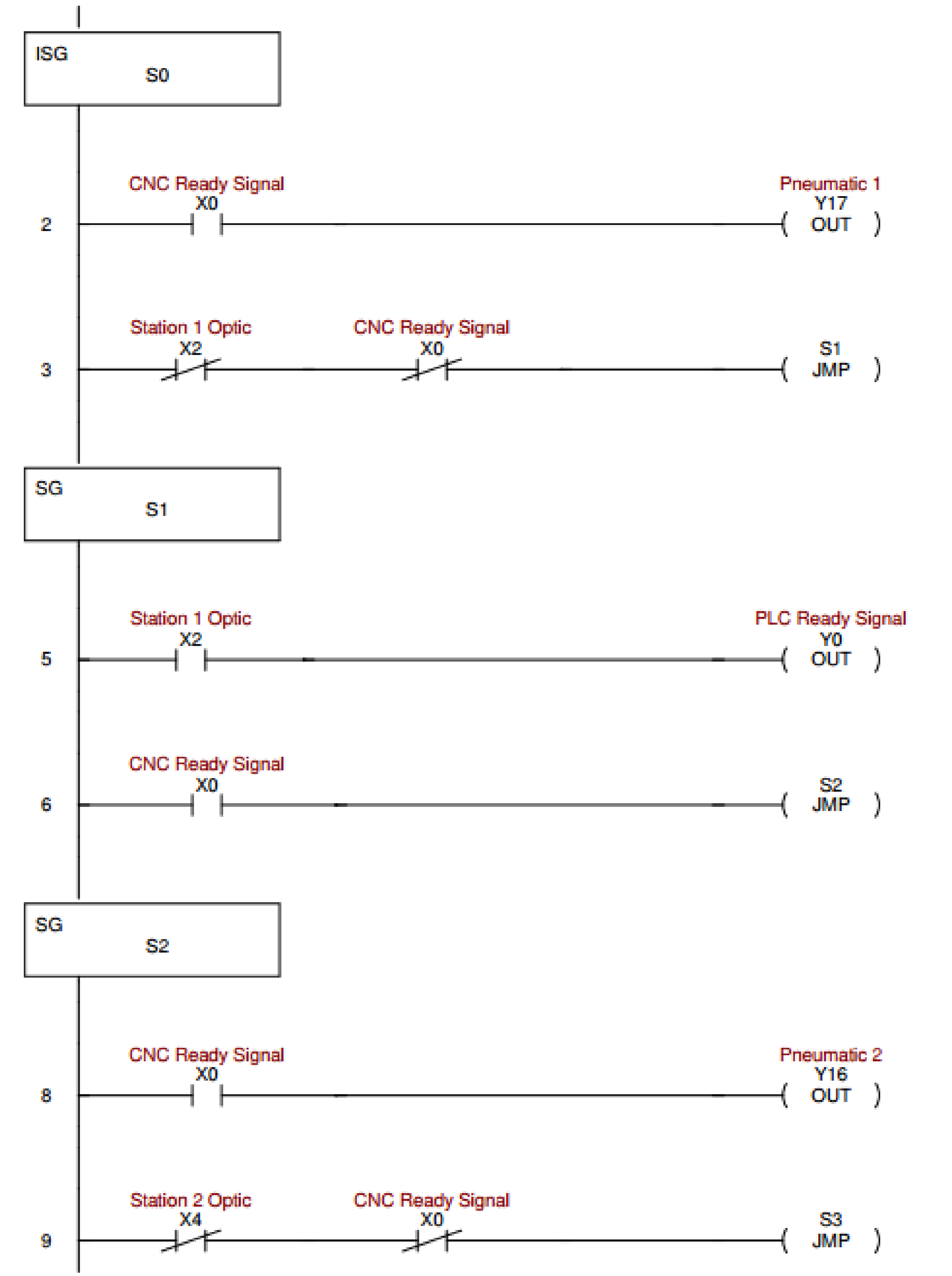
Maintenance

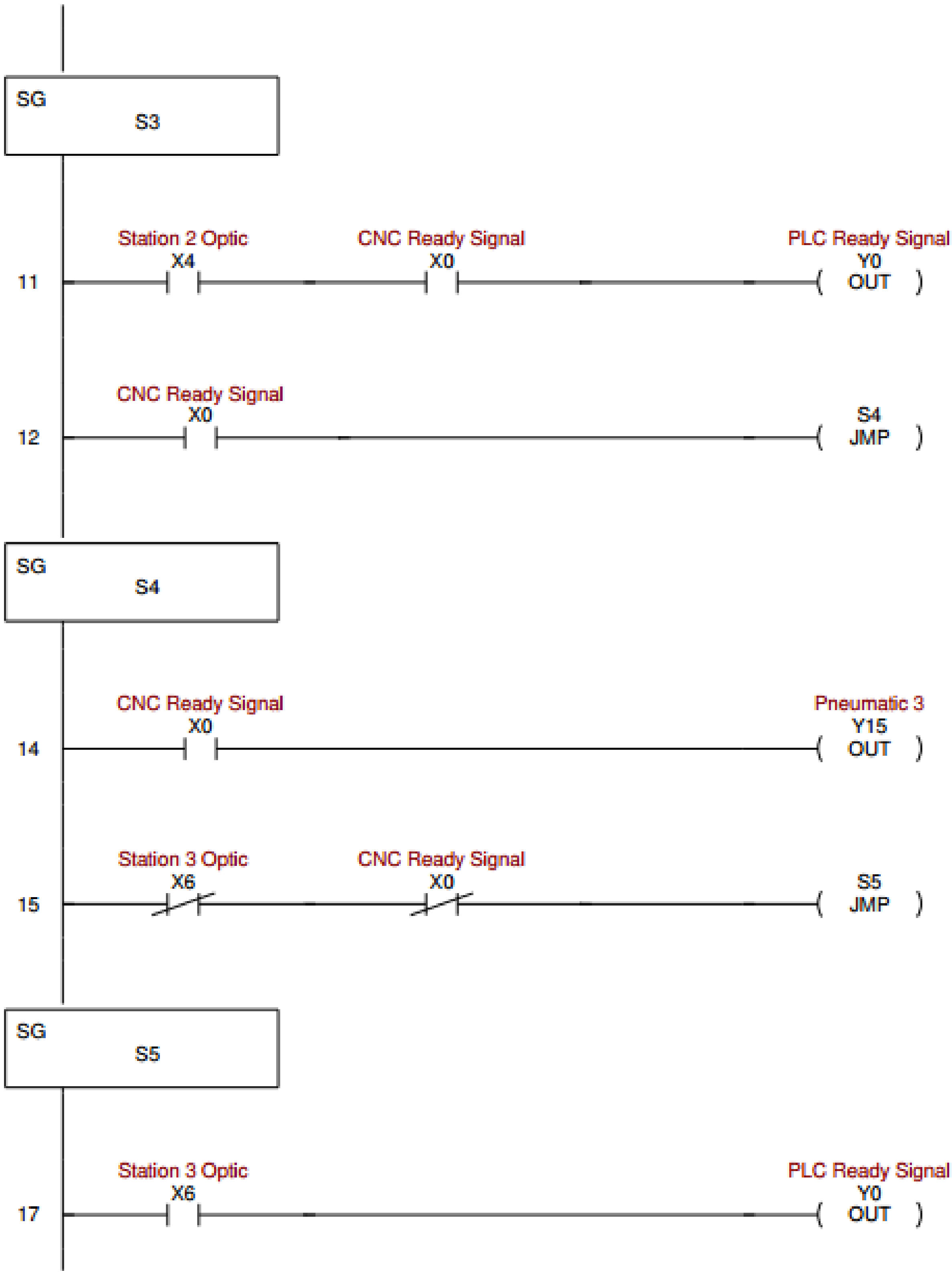
Maintenance on this assembly is not complicated. Visual inspections are done every time the assembly line is turned on. Any corrosion noted should be addressed by taking steps to remove the corrosion, and prevent it from recurring. If any cracks are found in the plastic, this part should be removed and replaced with a new one. Any maintenance required by the pneumatic cylinders, stepper motor, slide, or sensors should be completed as outlined in the manuals for each part.

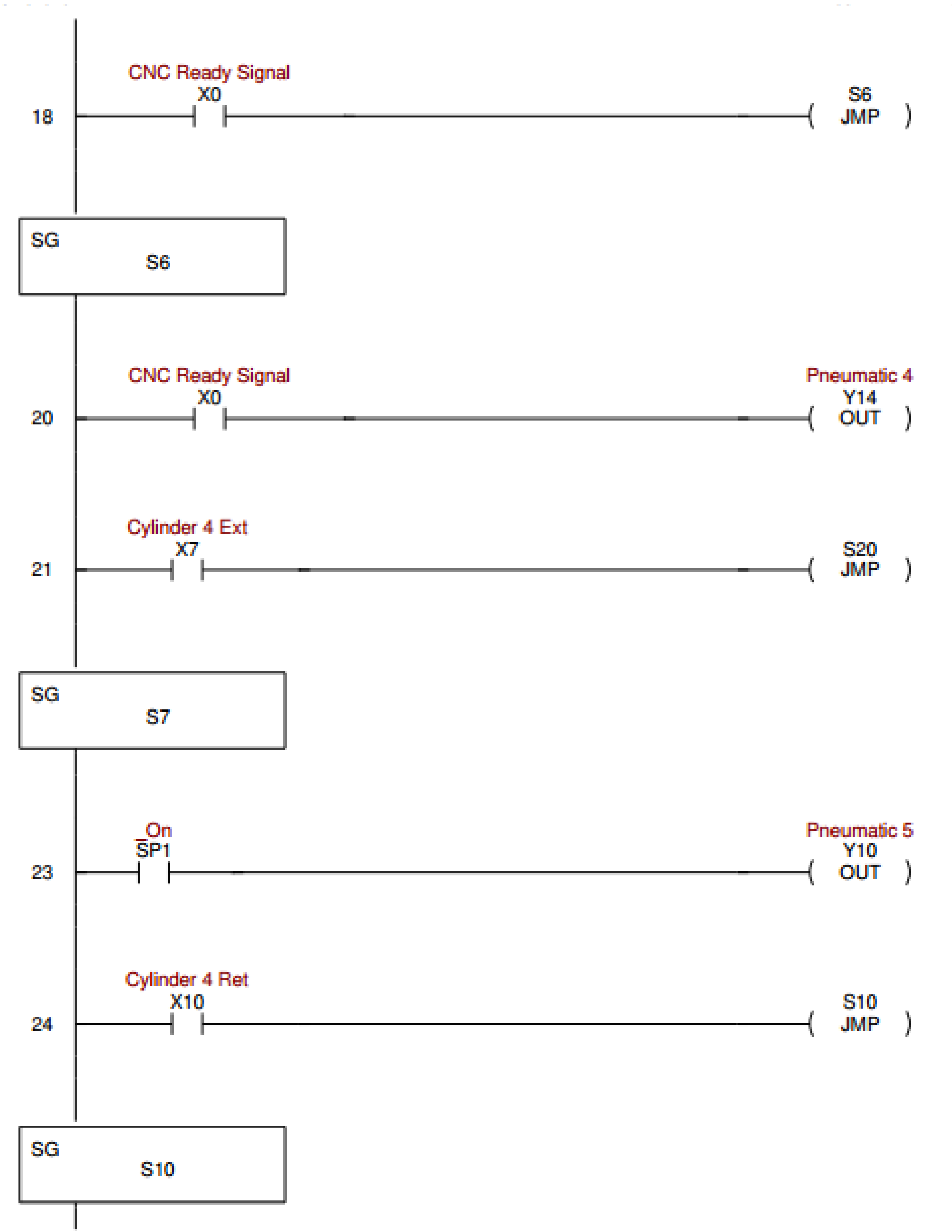
APPENDIX A: G-Code

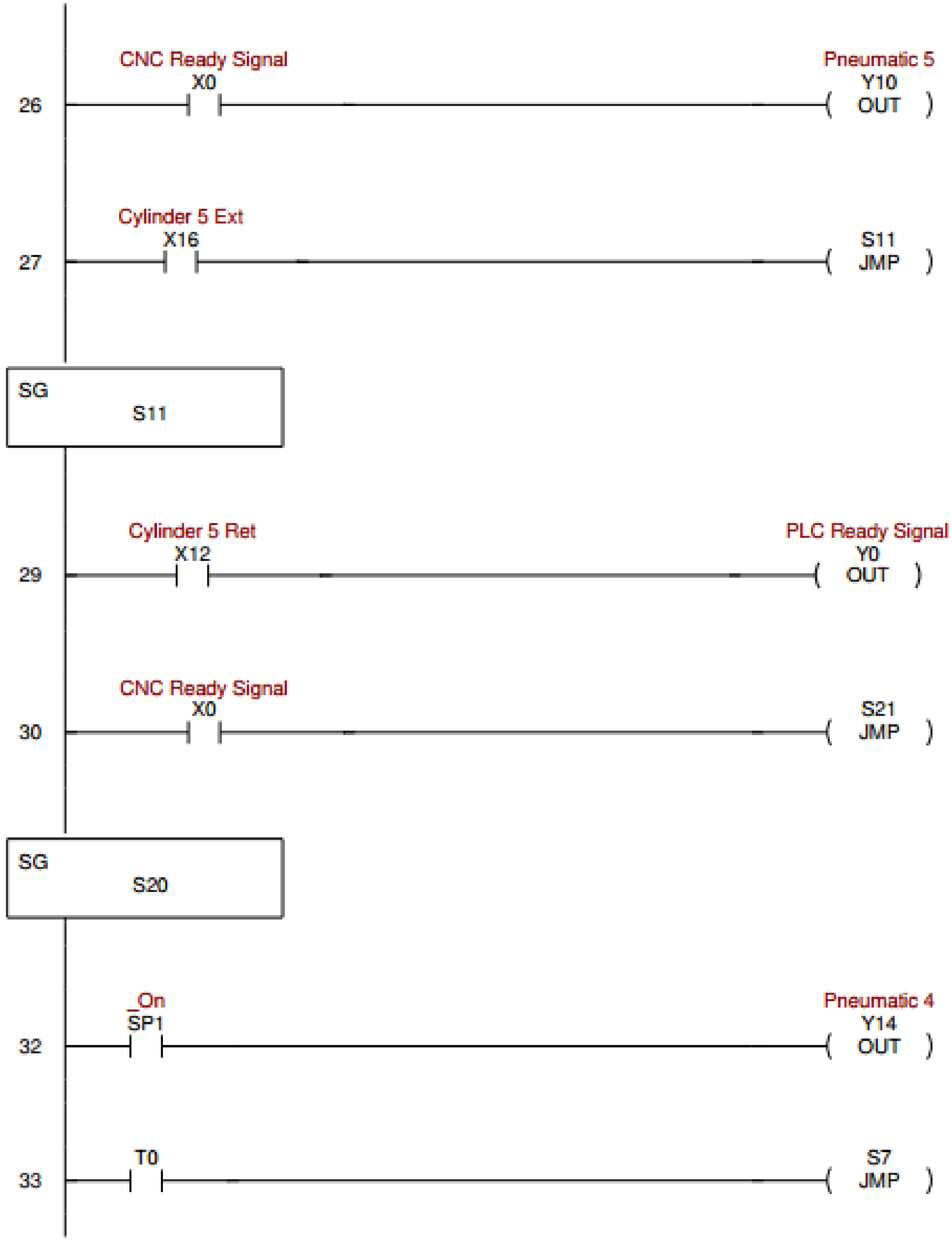
```
(AXIS,stop)

        G1 X460.0 Y0.0 F5000          (move to position 460)

O100 WHILE[1]                         (loop the following section
indefinitely)

        M64 P0                        (activate cnc ready signal)
        G4 P3.0                       (pause 3 seconds)
        M65 P0                        (clear cnc ready signal)
        M66 P0 L3 Q100                (wait for plc ready signal)
        G1 X314.0 Y0.0                (move to position 314)
        G4 P1.0                       (pause 1 second)

        M66 P0 L3 Q100                (wait for plc ready signal)
        M64 P0                        (activate cnc ready signal
        G4 P1.0                       (pause 1 second)
        G1 X143.0 Y0.0 F5000          (move to position 143)
        G4 P1.0                       (pause 1 second)
        M65 P0                        (clear cnc ready signal)
        G4 P1.0                       (pause 1 second)
        M64 P0                        (activate cnc ready signal

        G4 P1.0                       (pause for 1 second)
        M65 P0                        (clear cnc ready signal)
        G4 P3.0                       (pause 3 seconds)
        M65 P0                        (activate cnc ready signal)
        G4 P1.0                       (pause 1 second)
        G1 X300.0 Y0.0 F5000          (move to position 300)
        G1 X0.0 Y0.0 F5000            (move to position 0)
        G4 P1.0                       (pause for 1 second)
        M64 P0                        (clear cnc ready signal)

        M66 P0 L3 Q100                (wait for plc ready signal)
        M65 P0                        (clear cnc ready signal)
        G4 P2.0                       (pause for 2 seconds)
        G1 X460.0 Y0.0                (move to position 460)
        M64 P0                        (activate cnc ready signal)
        G4 P1.0                       (pause 1 second)
O100 ENDWHILE
```

APPENDIX B: Ladder Logic

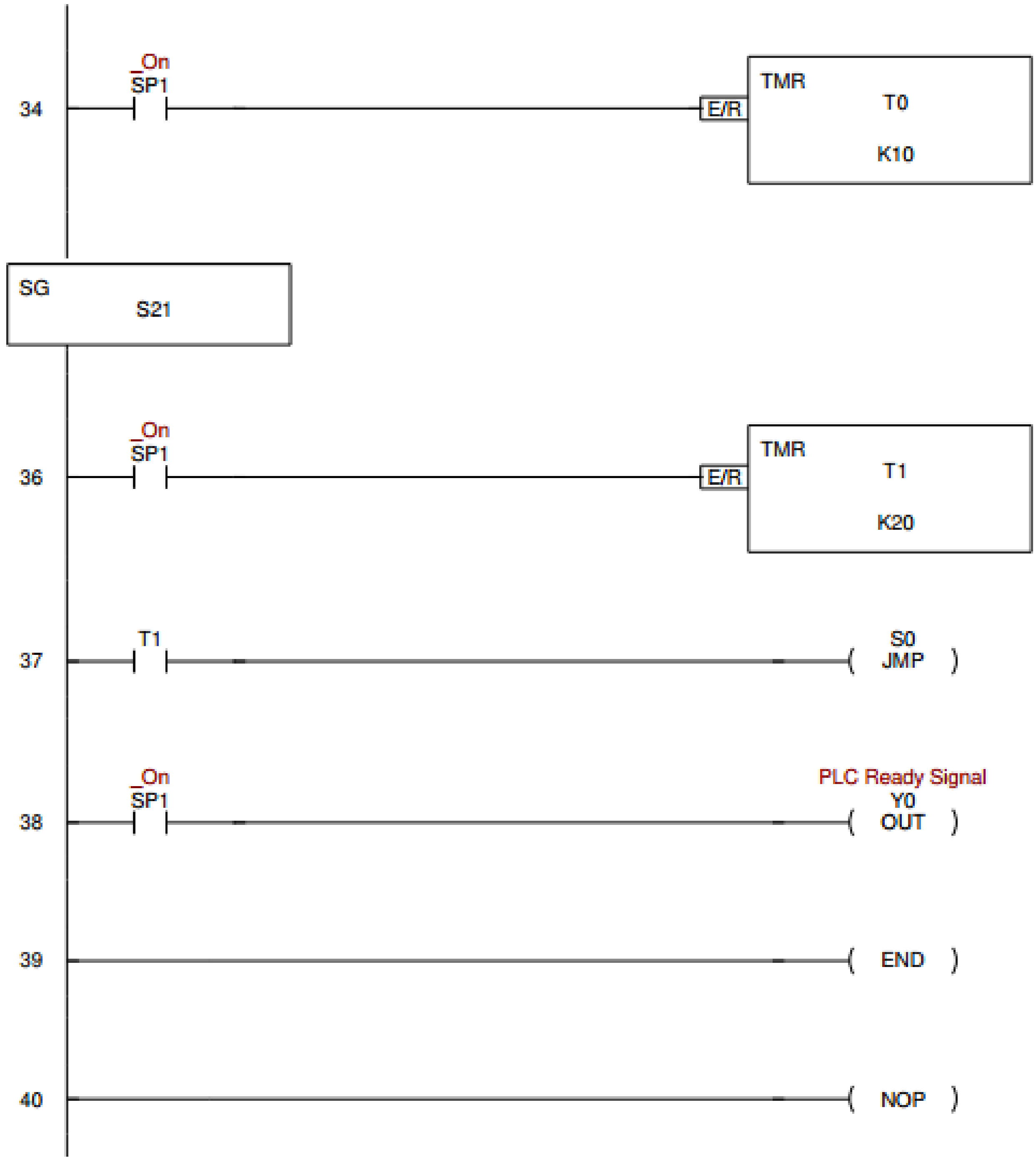



SG
S3
11
Station 2 Optic
X4
CNC Ready Signal
X0
PLC Ready Signal
Y0
OUT
12
CNC Ready Signal
X0
S4
JMP
SG
S4
14
CNC Ready Signal
X0
Pneumatic 3
Y15
OUT
15
Station 3 Optic
X6
CNC Ready Signal
X0
S5
JMP
SG
S5
17
Station 3 Optic
X6
PLC Ready Signal
Y0
OUT


18
CNC Ready Signal
X0
S6
JMP
SG
S6
20
CNC Ready Signal
X0
Pneumatic 4
Y14
OUT
21
Cylinder 4 Ext
X7
S20
JMP
SG
S7
23
_On
SP1
Pneumatic 5
Y10
OUT
24
Cylinder 4 Ret
X10
S10
JMP
SG
S10

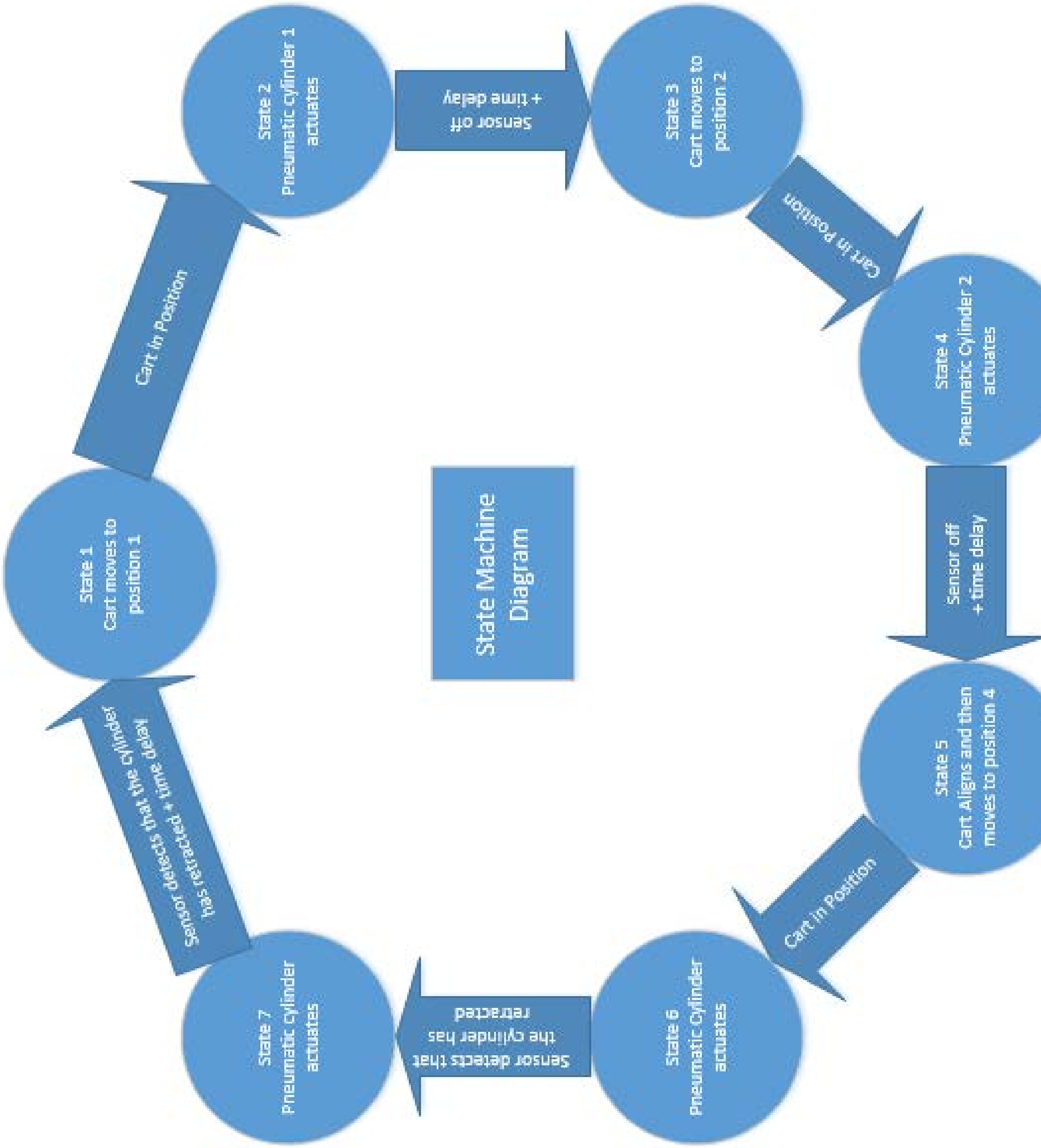


CNC Ready Signal
X0
26
Pneumatic 5
Y10
OUT
Cylinder 5 Ext
X16
27
S11
JMP
SG
S11
Cylinder 5 Ret
X12
29
PLC Ready Signal
Y0
OUT
CNC Ready Signal
X0
30
S21
JMP
SG
S20
_On
SP1
32
Pneumatic 4
Y14
OUT
T0
33
S7
JMP



34
_On
SP1
E/R
TMR
T0
K10
SG
S21
36
_On
SP1
E/R
TMR
T1
K20
37
T1
S0
JMP
38
_On
SP1
PLC Ready Signal
Y0
OUT
39
END
40
NOP

APPENDIX C: State Machines



APPENDIX D: Stepper Motor Configuration

For ease of analysis and system setup, it is desirable that positions defined in the LinuxCNC program correspond to equivalent positions on the linear actuator. This system is configured such that a position of 100 in LinuxCNC corresponds to a position approximately 100 mm from the origin of the physical linear actuator. The stepper motor used in our system has a resolution of 1.8 degrees per step. With this in mind, switches 3, 4, 5, and 6 on the back of the stepper drive must all be in the on (down) position and the 16-position rotary dial must be set to position 8. Additionally, the configuration file for LinuxCNC must have the scale factor for the axis of motion set to -250. Note that the axis must also be homed on LinuxCNC while the cart is in its 0 position (as close as possible to the end that holds the stepper motor) before coordinate inputs will be accurate.