2020

Small Diameter Vascular Graft Packaging Assembly Manual

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Contents

Machine Overview

General Machine Description

The assembly machine is a multi-station system for assembling small diameter vascular graft packaging. The packaging consists of a glass test tube, a steel mandrel and a silicon test tube cap. The mandrel sits in on the inside of the cap, so that it is protected within the test tube. This machine utilizes pneumatics and stepper motors to feed and assemble parts in three stations around a pneumatic indexing turret. These three stations will be discussed more later.

Starting the machine

When starting the Assembly machine,

1. First you must make sure that power and air is applied to the system.
2. Ensure that the machine is properly loaded
    a. Place a cap in the fixture under the cap dispenser
    b. Place a cap and mandrel in the fixture under the mandrel dispenser.
3. Once the machine is prepped, you may flip the switch on the PLC to the run position and hit the “Magic” button. This starts the cycle and must be pressed for every cycle to run. Additionally, this will allow you time to fix any jams or mistakes that happen, so you end up with completed products and reduces damage to the machine.

Overview of components

System Overview:

Three stations are set up around a pneumatic indexing turret and they function simultaneously. At each station a process is completed. The first station is the cap dispenser, which drops a cap onto a fixture. From here the cap rotates underneath the mandrel dispenser. The mandrel dispenser drops and presses a mandrel into place in the cap. After this process, a glass tube is pushed out of the tube feeder, grabbed, and brought into place. This completes the assembly, and the product can be removed from the turret.

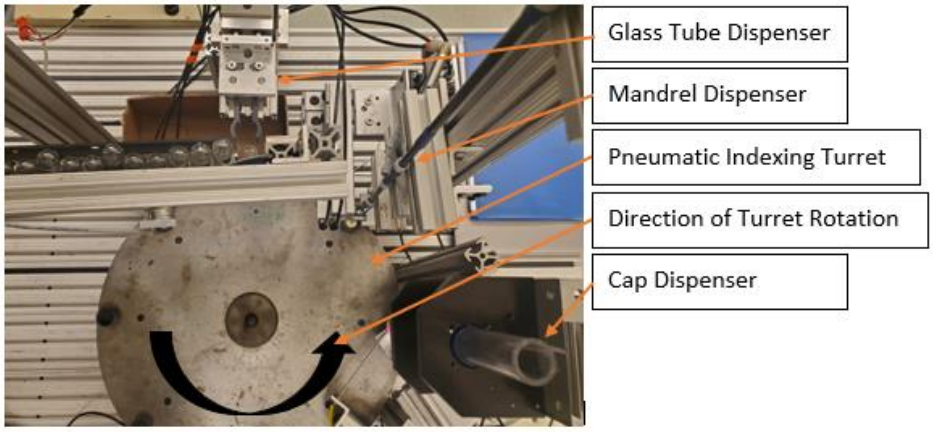


FIGURE 1: TOP VIEW OF THE SYSTEM

Cap Dispenser

How it works

The cap dispenser works through a series of pneumatic actuators separating the caps in a long plastic tube and an optical sensor. The sensor needs to first see that there is a cap in place. Once there is a cap in place in the tube the separator will close and stop the next cap in line from falling through. Then a sliding plate will open, allowing the cap to fall into the cup, with the thinner side up, on the turret below.

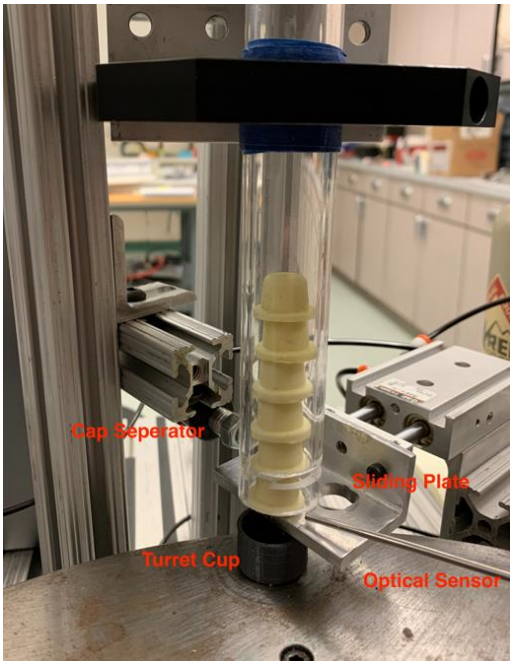


FIGURE 2: CAP DISPENSER

Loading

The caps are easily loaded by dropping the caps, flat side down, one by one into the top of the clear tube. They fall on top of the sliding plate and wait for the program to be run. If there are no caps sensed by the sensor the system will not complete. At this point more caps will have to be loaded for the entire cycle to complete.

Clearing Jams

Due to the caps being silicon material, this causes lots of opportunities for the system to jam. The caps sometimes are a little sticky and occasionally have issues falling all the way down the plastic tube. This can be solved by pushing them down with a long metal rod. The next most common issue is that the caps do not slide easily on the slider and then do not land in the cup with the flat part down. Many times, the caps need to be readjusted to be in the correct position for the mandrels in the next station.

Mandrel Dispenser

How it works

The mandrels are placed in a gravity feeder with two pneumatic separators, a pneumatic vertical slider and a pneumatic gripper. When the turret fixture rotates to be under the dispenser, the first separator will drop a mandrel down the second tube. The mandrel stops at the second separator and the gripper grabs the mandrel. The second separator slides out of position and the vertical slider pushes the mandrel into the cap. This process repeats each time the magic button is pressed.

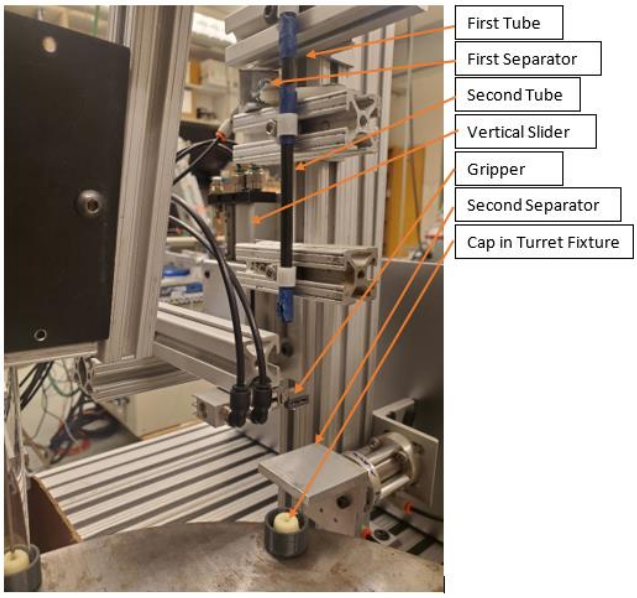


FIGURE 3: TURRET-SIDE VIEW OF THE MANDREL DISPENSER

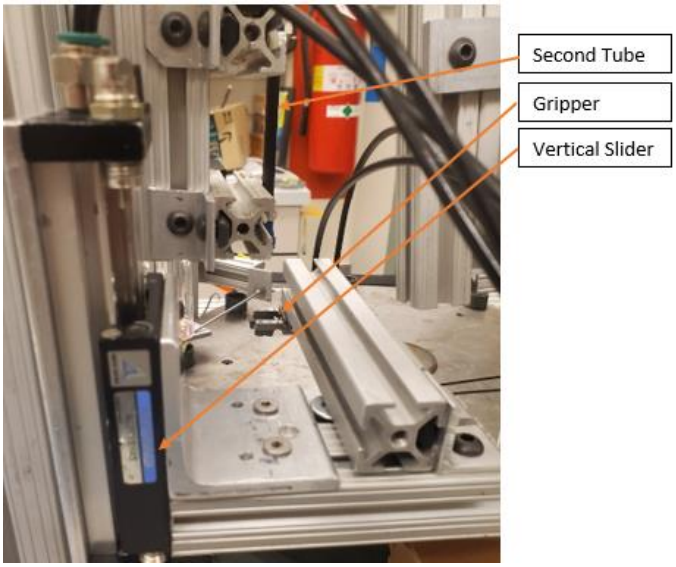


FIGURE 4: ALTERNATIVE VIEW OF MANDREL DISPENSER

Loading

To load the mandrel dispenser, drop mandrels into the upper black tube on the mandrel dispenser. It will automatically drop the mandrels into place during the dispensing process.

Clearing Jams

This station does not have issues with jamming, but from time to time some failures may occur that will cause jams if not corrected. If an extra mandrel falls or if a mandrel is not placed correctly, it is best to remove any mandrels and caps from the area around the station before starting the next cycle.

Glass tube Dispenser

How it works

The glass tube dispenser works in two operations. The first, is moving the tube from the loader to the pickup position with a stepper motor. Next the pneumatic slide extends the open grippers out to wrap around the tube before the grippers clamp shut to hold the tube as it is pushed onto the cap. After the grippers clamp down and the slide retracts, a stepper motor, on a threaded shaft, lowers the assembly holding the glass onto the cap and mandrel assembly. Once it reaches the bottom of its travel, it releases the tube and returns to the top of its travel.

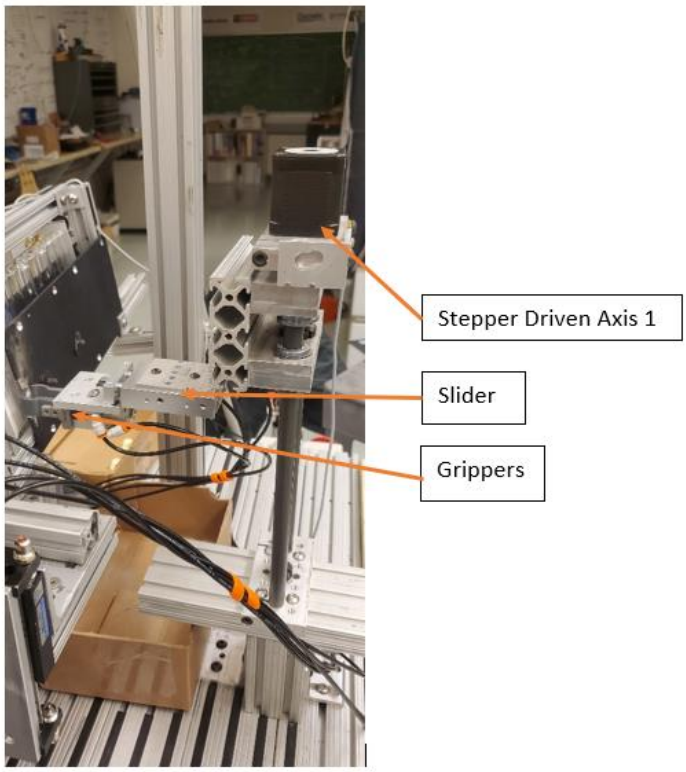


FIGURE 5: TUBE DISPENSER

Loading

To load the Glass tubes, once the tube advancer reaches the end of its run and trips the induction sensor, it backs out to its starting place, then advances one position to push a tube out to assemble the SDVG. Because of this, the operator needs to be quick to reload the tubes as it backs out and makes space.

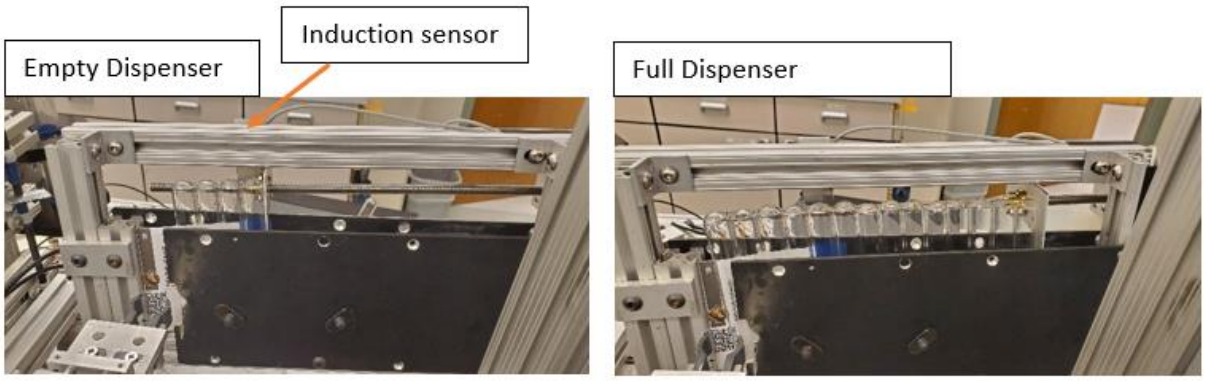


FIGURE 6:TUBE LOADING

Clearing Jams

This machine as the occasional double feed of tubes and the extra tube will need to be removed. This might be fixed by adjusting the distance the stepper motor travels.

Maintenance Instructions

To ensure that this machine continues to function, several maintenance items are necessary.

1. Check alignment regularly. If the dispensers become misaligned from the turret fixtures, catastrophic failure might occur.
2. Follow the maintenance instructions included with the pneumatic indexing turret.
3. Regularly inspect parts for wear, replacing if necessary.

Diagrams

3-D Printed Parts

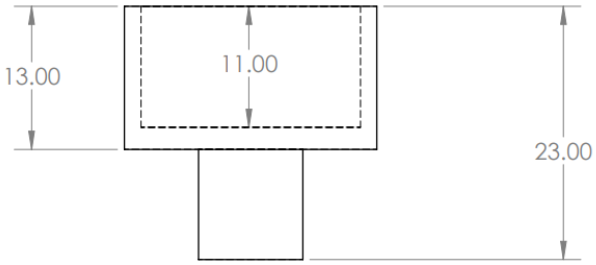


FIGURE 7: TURRET FIXTURE (SIDE)

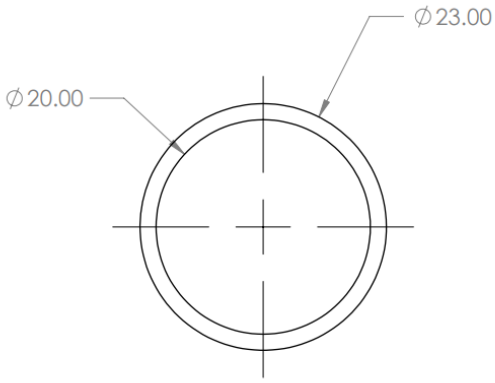


FIGURE 8: TURRET FIXTURE (TOP)

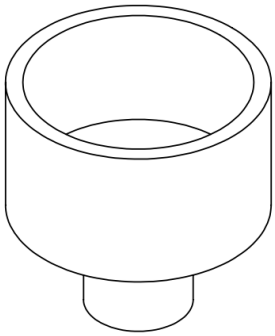


FIGURE 9: TURRET FIXTURE (ISOMETRIC)

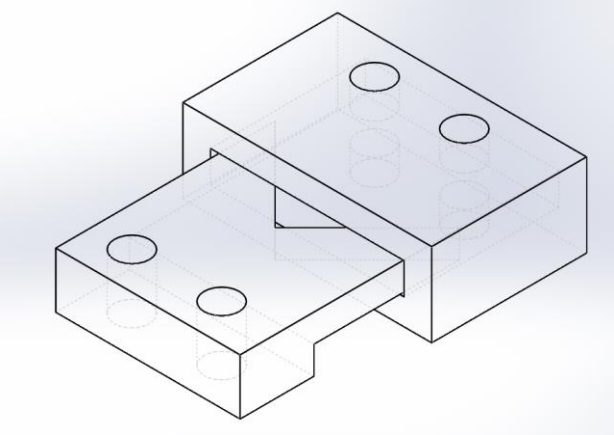


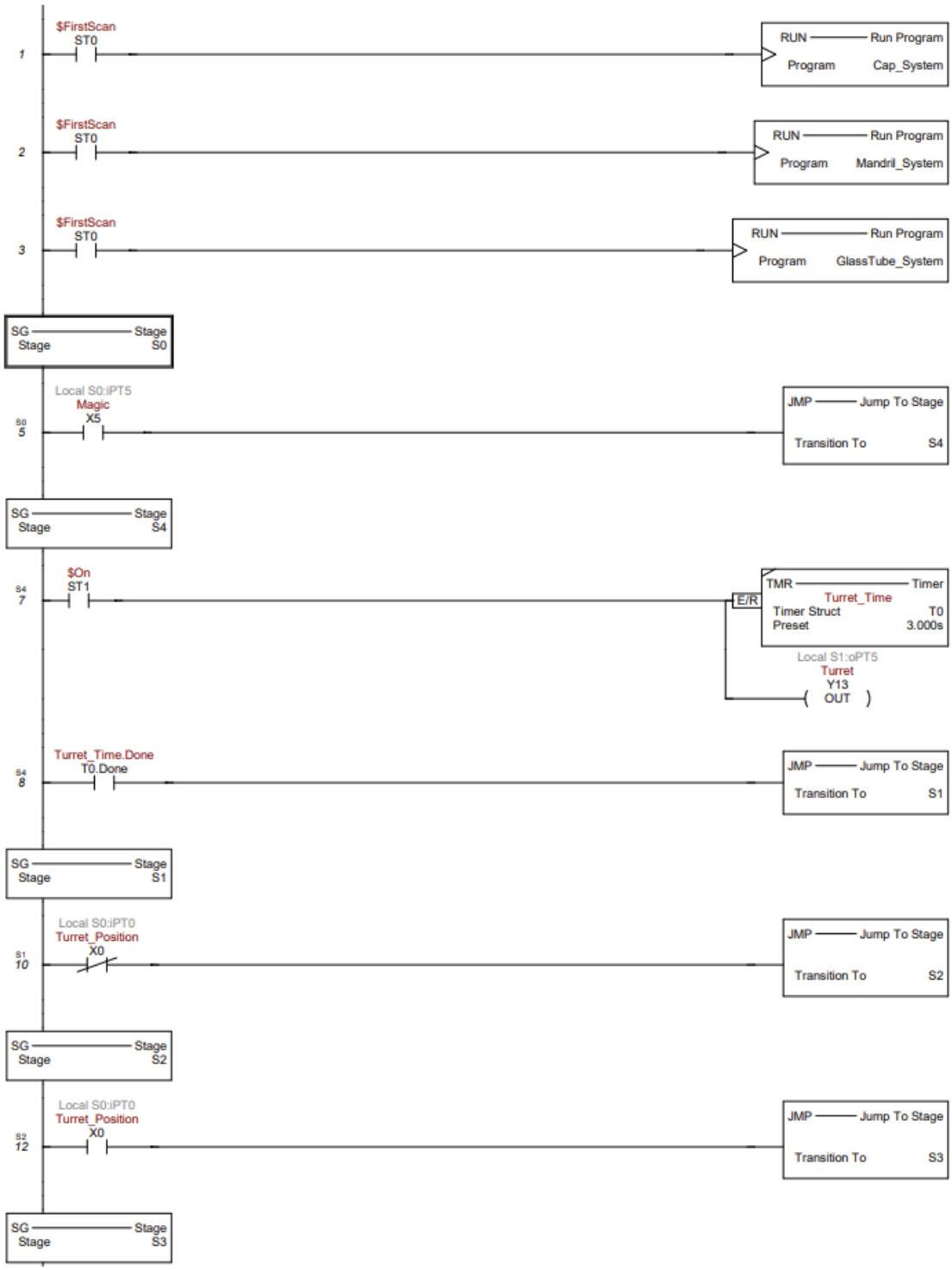
FIGURE 10: MANDREL GRIPPER

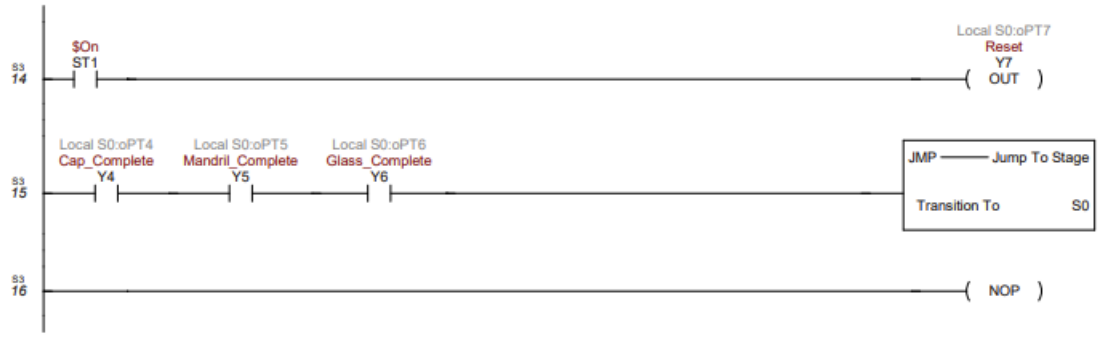
Annotated Photos of the Assembly:

These photos are included in the overview of components section as figures 1-7.

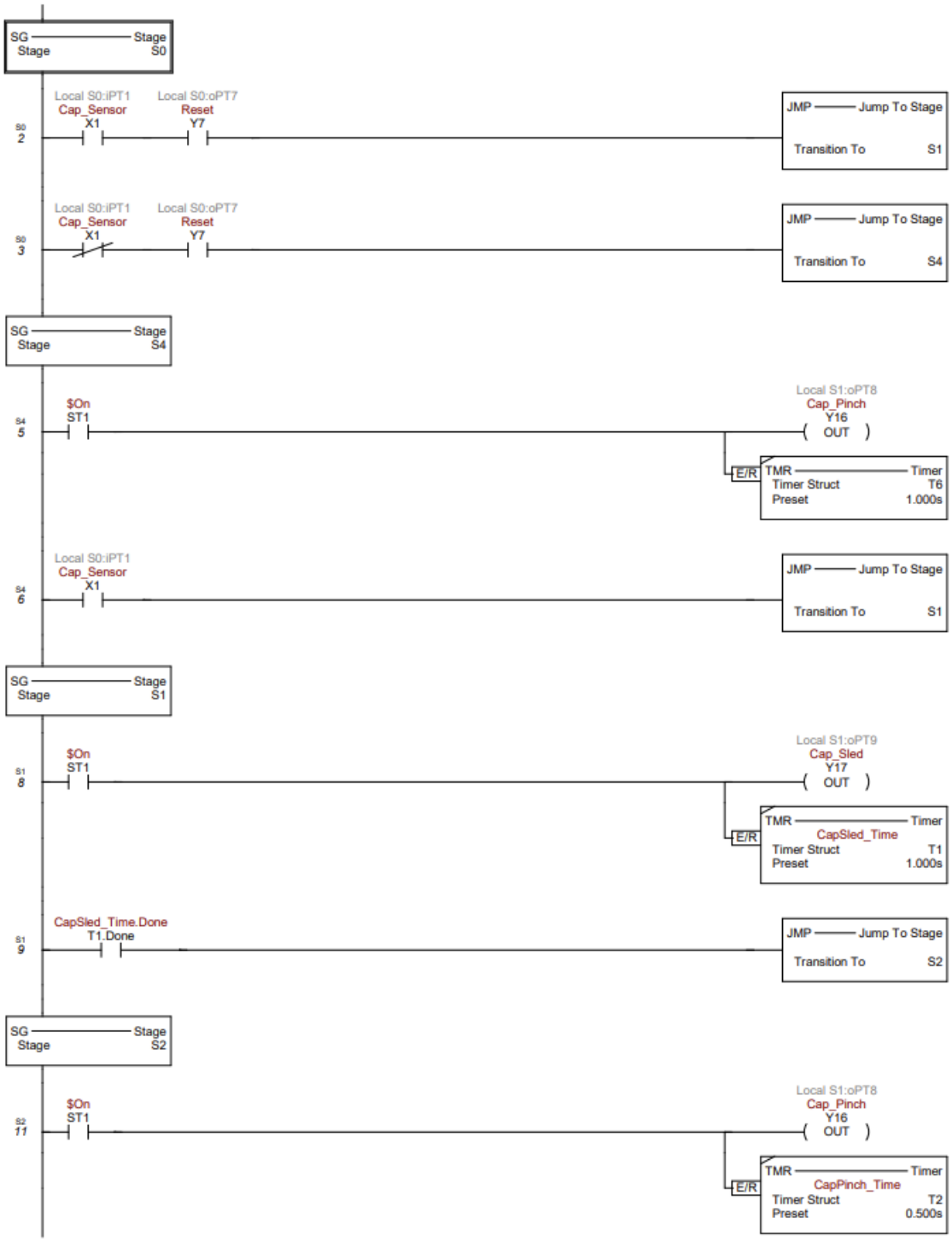
PLC Ladder Logic

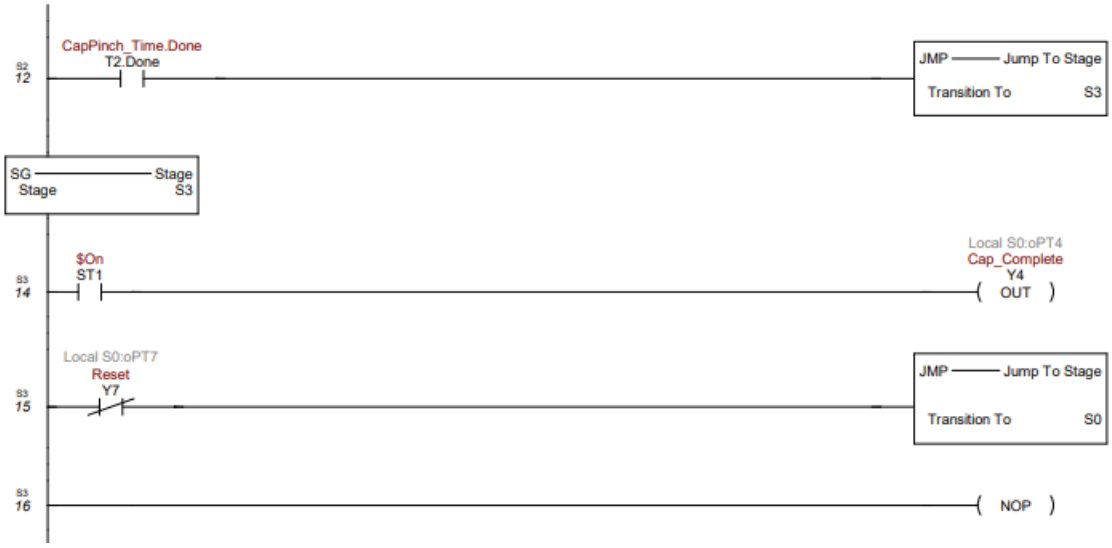
$MAIN



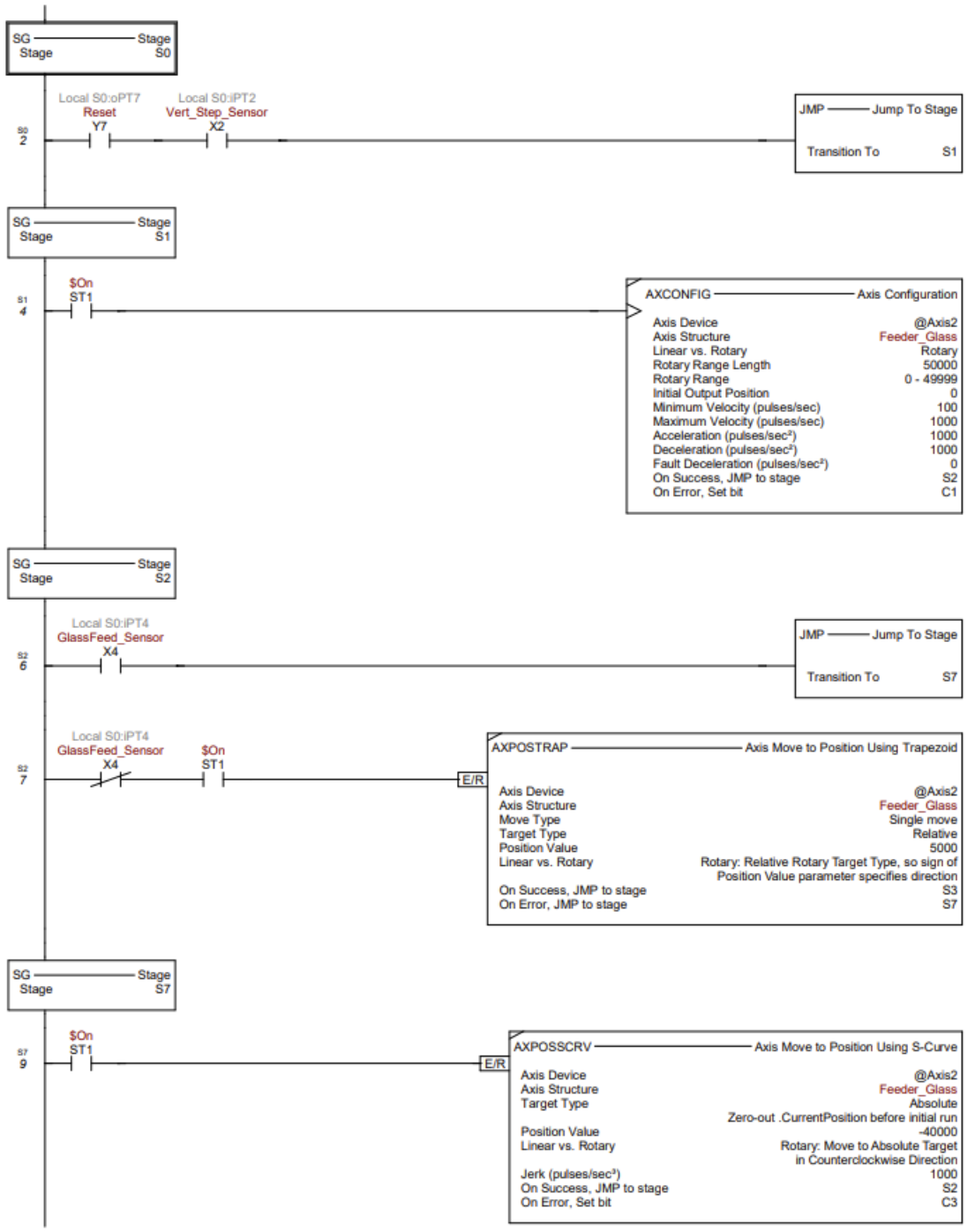

S3
14
$On
ST1
Local S0:oPT7
Reset
Y7
OUT
S3
15
Local S0:oPT4
Cap_Complete
Y4
Local S0:oPT5
Mandril_Complete
Y5
Local S0:oPT6
Glass_Complete
Y6
JMP
Jump To Stage
Transition To
S0
S3
16
NOP

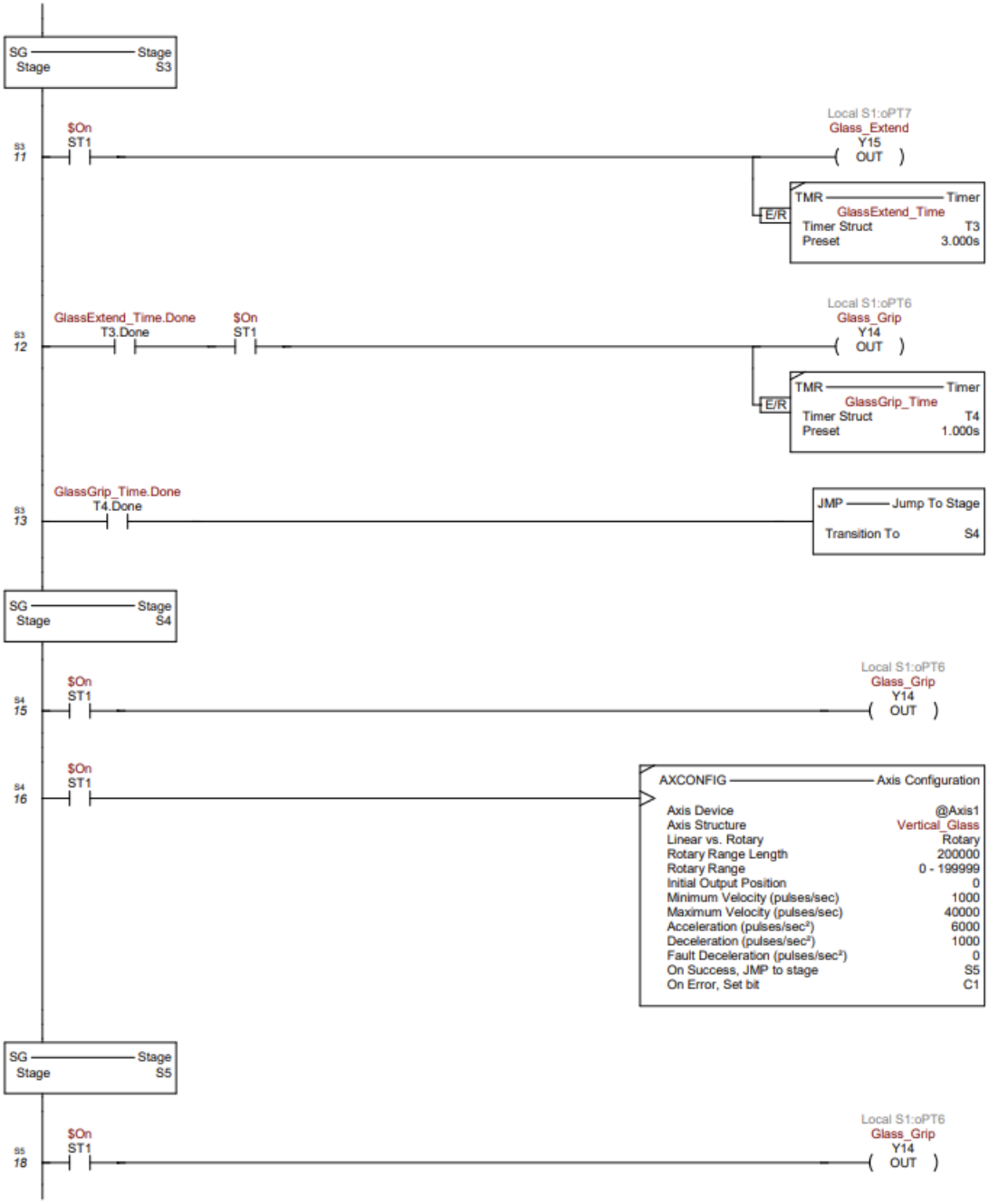
$CAP_SYSTEM

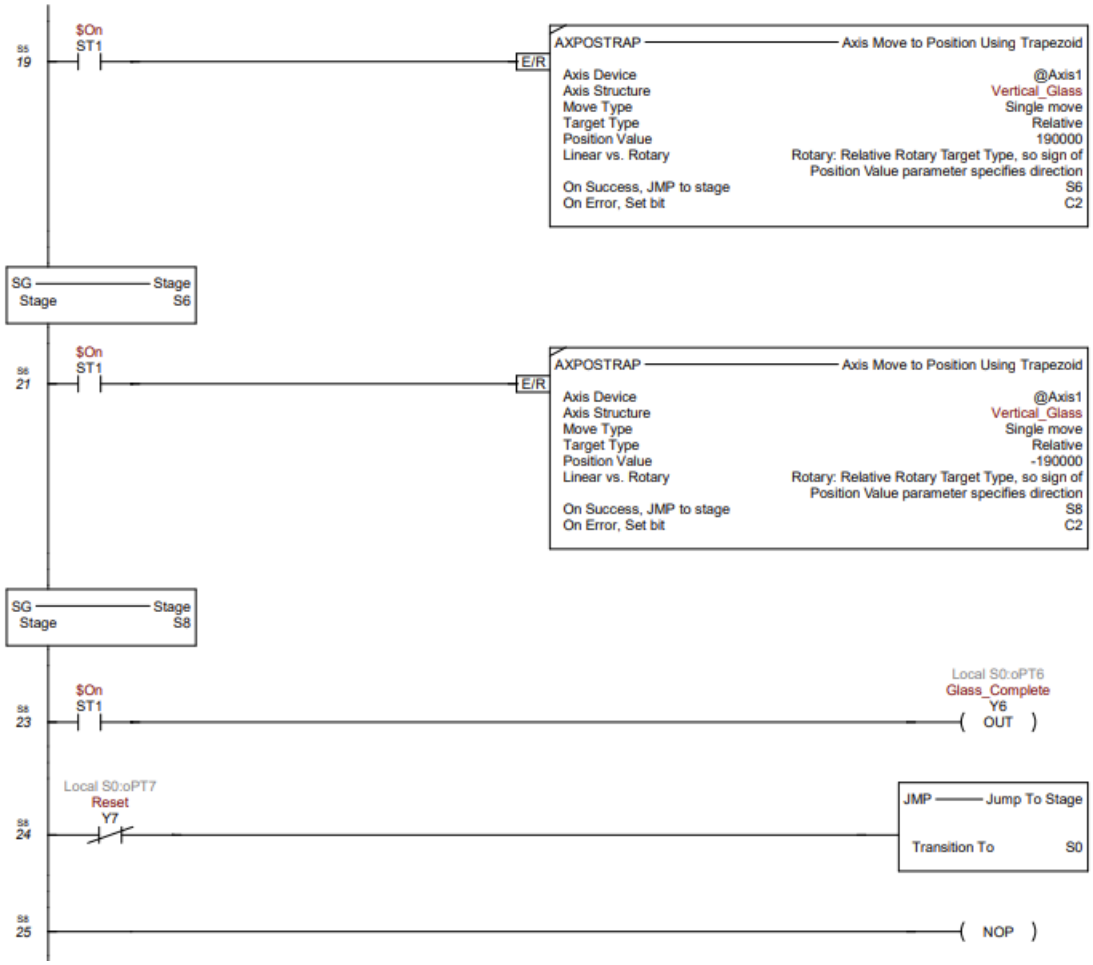

SG
Stage
Stage
S0
Local S0:iPT1
Cap_Sensor
X1
Local S0:oPT7
Reset
Y7
S0
2
JMP
Jump To Stage
Transition To
S1
Local S0:iPT1
Cap_Sensor
X1
Local S0:oPT7
Reset
Y7
S0
3
JMP
Jump To Stage
Transition To
S4
SG
Stage
Stage
S4
$On
ST1
S4
5
Local S1:oPT8
Cap_Pinch
Y16
OUT
E/R
TMR
Timer
Timer Struct
T6
Preset
1.000s
Local S0:iPT1
Cap_Sensor
X1
S4
6
JMP
Jump To Stage
Transition To
S1
SG
Stage
Stage
S1
$On
ST1
S1
8
Local S1:oPT9
Cap_Sled
Y17
OUT
E/R
TMR
Timer
CapSled_Time
Timer Struct
T1
Preset
1.000s
CapSled_Time.Done
T1.Done
S1
9
JMP
Jump To Stage
Transition To
S2
SG
Stage
Stage
S2
$On
ST1
S2
11
Local S1:oPT8
Cap_Pinch
Y16
OUT
E/R
TMR
Timer
CapPinch_Time
Timer Struct
T2
Preset
0.500s


S2
12
CapPinch_Time.Done
T2.Done
JMP
Jump To Stage
Transition To
S3
SG
Stage
Stage
S3
S3
14
$On
ST1
Local S0:oPT4
Cap_Complete
Y4
OUT
S3
15
Local S0:oPT7
Reset
Y7
JMP
Jump To Stage
Transition To
S0
S3
16
NOP

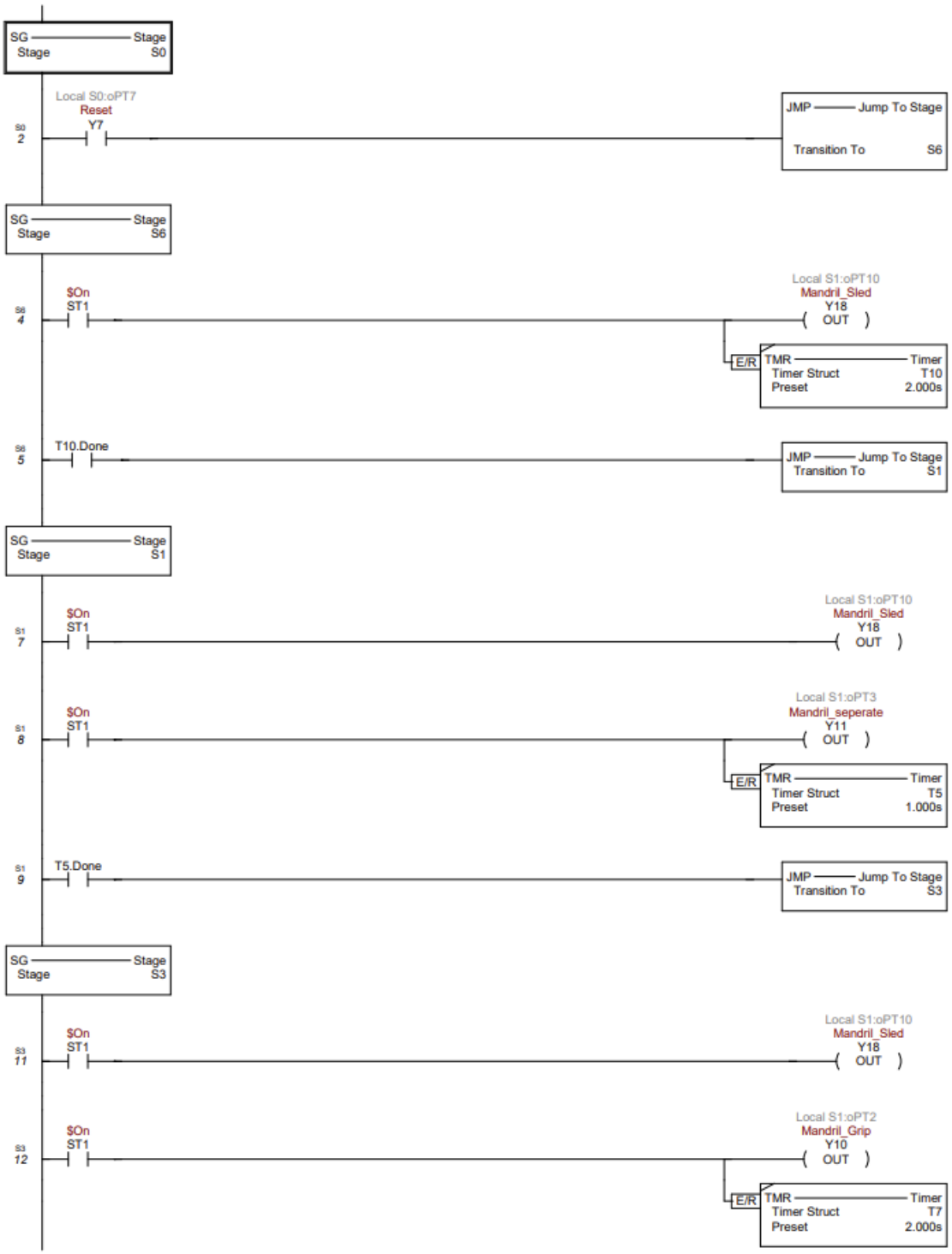
$GlassTube_System

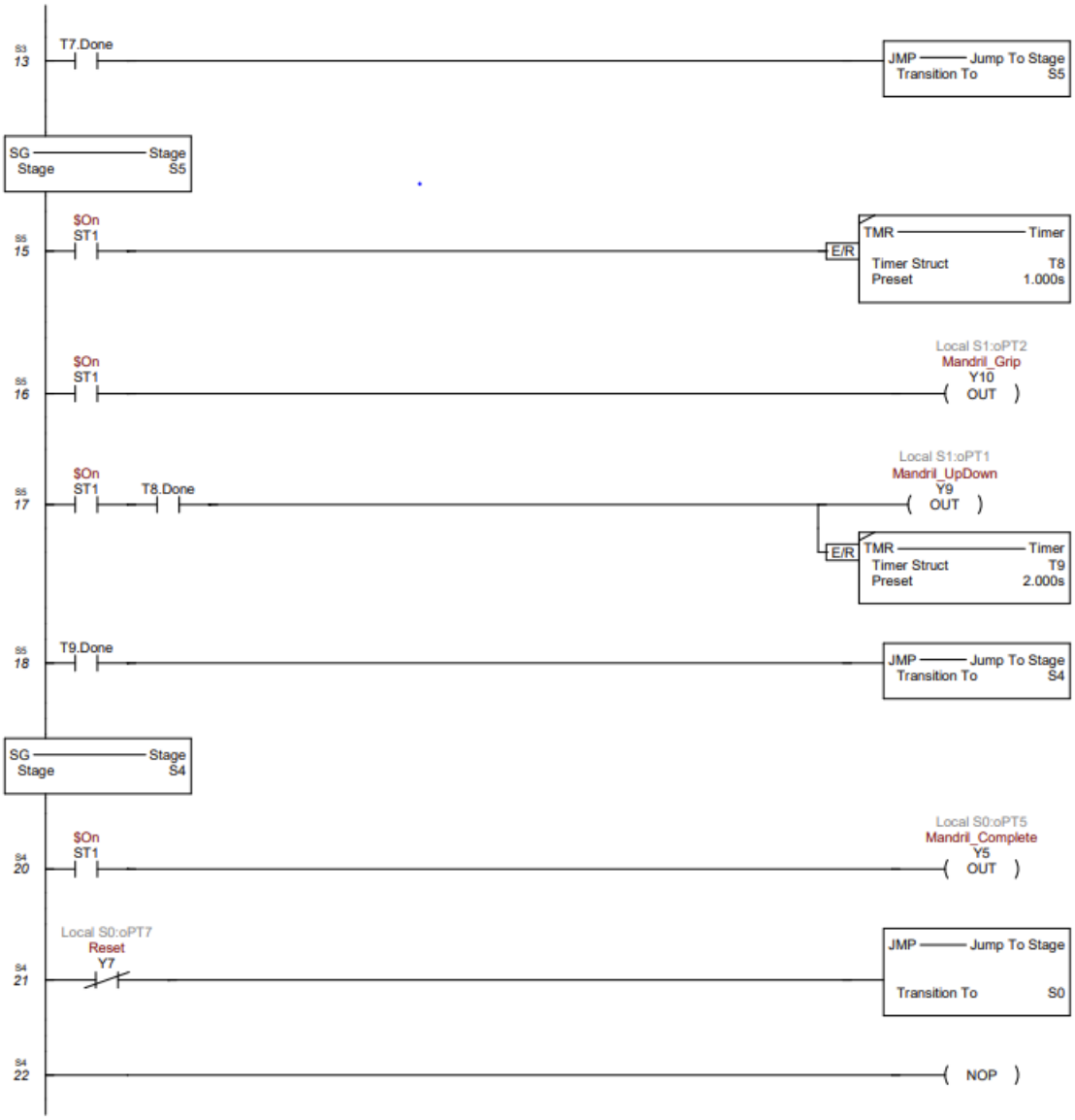



SG
Stage
Stage
S3
$On
ST1
S3
11
Local S1:oPT7
Glass_Extend
Y15
OUT
TMR
Timer
GlassExtend_Time
E/R
Timer Struct
T3
Preset
3.000s
GlassExtend_Time.Done
T3.Done
$On
ST1
S3
12
Local S1:oPT6
Glass_Grip
Y14
OUT
TMR
Timer
GlassGrip_Time
E/R
Timer Struct
T4
Preset
1.000s
GlassGrip_Time.Done
T4.Done
S3
13
JMP
Jump To Stage
Transition To
S4
SG
Stage
Stage
S4
$On
ST1
S4
15
Local S1:oPT6
Glass_Grip
Y14
OUT
$On
ST1
S4
16
AXCONFIG
Axis Configuration
Axis Device
@Axis1
Axis Structure
Vertical_Glass
Linear vs. Rotary
Rotary
Rotary Range Length
200000
Rotary Range
0 - 199999
Initial Output Position
0
Minimum Velocity (pulses/sec)
1000
Maximum Velocity (pulses/sec)
40000
Acceleration (pulses/sec²)
6000
Deceleration (pulses/sec²)
1000
Fault Deceleration (pulses/sec²)
0
On Success, JMP to stage
S5
On Error, Set bit
C1
SG
Stage
Stage
S5
$On
ST1
S5
18
Local S1:oPT6
Glass_Grip
Y14
OUT

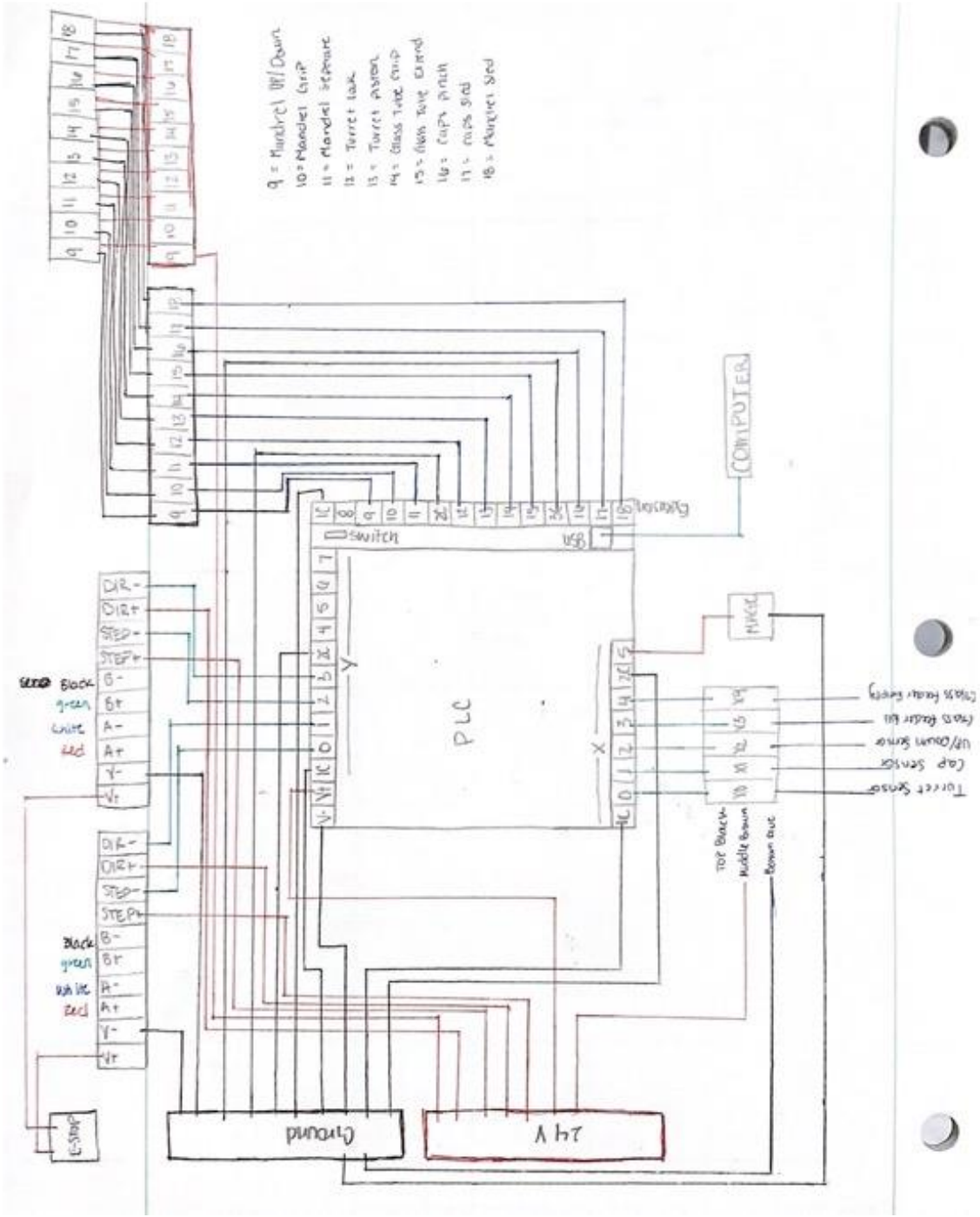

S5
19
$On
ST1
E/R
AXPOSTRAP
Axis Move to Position Using Trapezoid
Axis Device
@Axis1
Axis Structure
Vertical_Glass
Move Type
Single move
Target Type
Relative
Position Value
190000
Linear vs. Rotary
Rotary: Relative Rotary Target Type, so sign of Position Value parameter specifies direction
On Success, JMP to stage
S6
On Error, Set bit
C2
SG
Stage
Stage
S6
S6
21
$On
ST1
E/R
AXPOSTRAP
Axis Move to Position Using Trapezoid
Axis Device
@Axis1
Axis Structure
Vertical_Glass
Move Type
Single move
Target Type
Relative
Position Value
-190000
Linear vs. Rotary
Rotary: Relative Rotary Target Type, so sign of Position Value parameter specifies direction
On Success, JMP to stage
S8
On Error, Set bit
C2
SG
Stage
Stage
S8
S8
23
$On
ST1
Local S0:oPT6
Glass_Complete
Y6
OUT
S8
24
Local S0:oPT7
Reset
Y7
JMP
Jump To Stage
Transition To
S0
S8
25
NOP

$Mandril_System




S3
13
T7.Done
JMP
Jump To Stage
Transition To
S5
SG
Stage
Stage
S5
S5
15
$On
ST1
E/R
TMR
Timer
Timer Struct
T8
Preset
1.000s
S5
16
$On
ST1
Local S1:oPT2
Mandril_Grip
Y10
OUT
S5
17
$On
ST1
T8.Done
Local S1:oPT1
Mandril_UpDown
Y9
OUT
E/R
TMR
Timer
Timer Struct
T9
Preset
2.000s
S5
18
T9.Done
JMP
Jump To Stage
Transition To
S4
SG
Stage
Stage
S4
S4
20
$On
ST1
Local S0:oPT5
Mandril_Complete
Y5
OUT
S4
21
Local S0:oPT7
Reset
Y7
JMP
Jump To Stage
Transition To
S0
S4
22
NOP

Wiring Diagram



Performance and Improvements

Rotary Machine

This part of our system is quite reliable. The only issue we have is with a spot that has more friction on the brake than other positions, so it caused it to not complete its rotation. This could be fixed by performing restorative maintenance on the pneumatic rotary mechanism.

Cap Dispenser

Overall, our cap dispenser system was good. Most of the issues that we had with the caps came with the caps themselves. The material was too sticky, and the molds that we made were not consistent enough. Each cap needs to be extremely similar to the next so that the glass tubes and the mandrels can have higher accuracy and precision. The other thing we would like to improve is having the mandrel hole be deeper in the caps so that would mean that the lip over the edge of the glass tube is thicker. What was good about the cap design was it having an auto center feature for the mandrels.

Mandrel Dispenser

The mandrel dispenser works much better than our previous iterations, but it's not perfect. Most issues seen with it are from inconsistencies in mandrel form and alignment. Almost all of the mandrels are at least a little bent, which makes placing them in a very small hole in the cap difficult. Sometimes these irregularities also make it hard for the gripper to catch. Additionally, the gripper is attached to an arm that slides up and down violently, which causes the gripper to become misaligned quickly. When the gripper is misaligned, there are more issues with the mandrel not going into place.

Glass Tube Dispenser

The Glass Tube dispenser works well but suffers from alignment issues. It needs more support on the backet that holds the tubes and stepper motor for dispensing. Occasionally, when a tube is double fed or not fully dispensed to the spot where it can be picked up, the grippers will catch on the assembly and push it out of alignment, causing glass tubes to not be able to be picked up by the grippers.

Additionally, the length that the stepper motor moves to push out a tube needs to be adjusted to match the tubes better. Right now, it is slightly off and causes double feeding closer to the end of the run.

Performance Data

Our team was not able to gather definitive performance data, but observationally we have determined the following approximate performance trends:

- The cap dispenser fails about 25% of the time due to uneven cap construction
- The mandrel dispenser fails more as it goes further out of alignment.
- The glass tube dispenser fails about 12.5% of the time

- The indexing turret fails to rotate fully about 12.5% of the time.