ENGR 480

Final Project Manual

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12/14/2018

Contents

Machine Instructions

Loading and Starting the Machine

Tiles are loaded by hand one-by-one – each color in its respective magazine – which is then inserted into the loading channel. Using LinuxCNC, the “grid plate” (the plate that the tiles are to fall onto) is “homed” (brought to its starting position). The air is turned on by rotating the “big red button”. The program is run by pressing the “MAGIC” button.

Clearing Jams

Jams may occur in the “chute” (opening of the baseplate). The fiber optic sensor detects when this happens and the program pauses until the jam is removed. A jam occurs because the tile is not properly seated in the chute. To fix this, gently push the tile into the chute so that it is in a proper, upright position. Once done, the program will resume.

Machine Operations

Component Diagrams

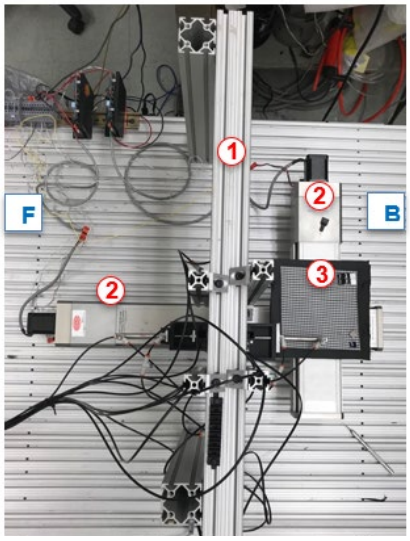


Figure 2 - Top View

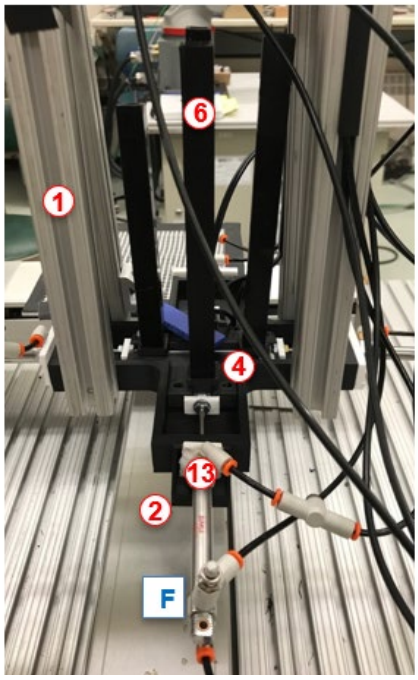


Figure 1 - Front View

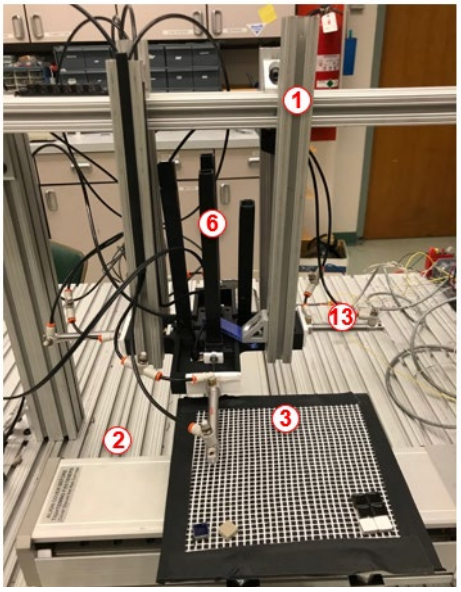


Figure 3 - Back View

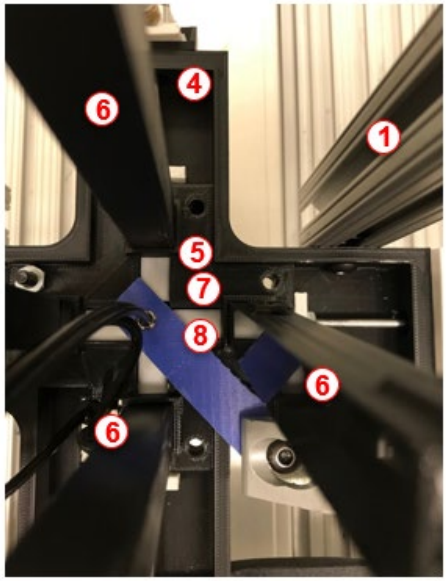


Figure 4 – Bottom View

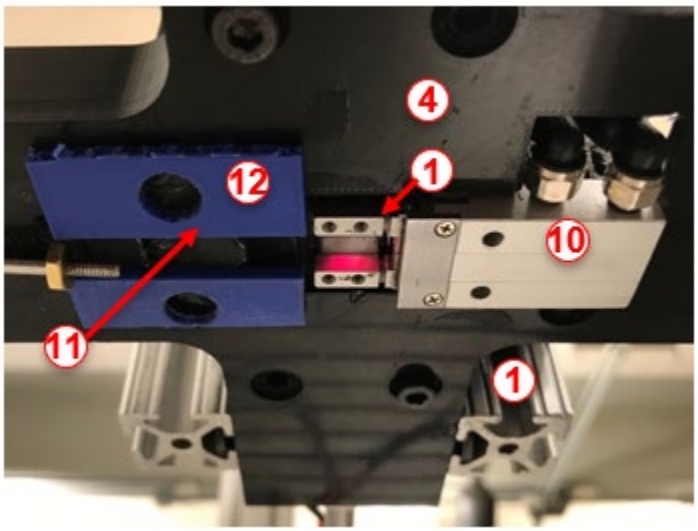


Figure 5 – Bottom View

Part #	Part Name
1	Frame
2	Stepper Motor
3	Grid Plate
4	Baseplate
5	Magazine Channel
6	Magazine
7	Pusher
8	Sensor
9	Chute
10	Gate
11	Safety
12	Guide
13	Cylinder

Magazine: Each magazine is designed to hold 36 tiles, which allows for the full 12x12 tile array to be populated. These magazines may be removed from the loading channel and easily loaded separately, to be replaced into their respective slots.

Loading Bar Assembly: This portion of the machine consists of a linear pusher which moves under a stack of ceramic tiles loaded into a magazine. This pusher moves back to its farthest retracted state which allows one of the tiles to drop into the loading channel for transport to the chute. The pusher moves forward through this channel and pushes the tile into the chute with closed safety plate and gate.

Chute Assembly: This portion of the machine controls the drop of the tiles. Two pneumatically controlled gripper arms (serving as a gate) and a center safety plate come together to fully

close the exit of the chute while a tile is positioned for dropping. Once the diffusion sensor detects that a tile is present, the safety is first fully retracted, leaving the tile only supported by the arms coming from the gate. At this point the gate is opened and the tile free falls to the baseplate.

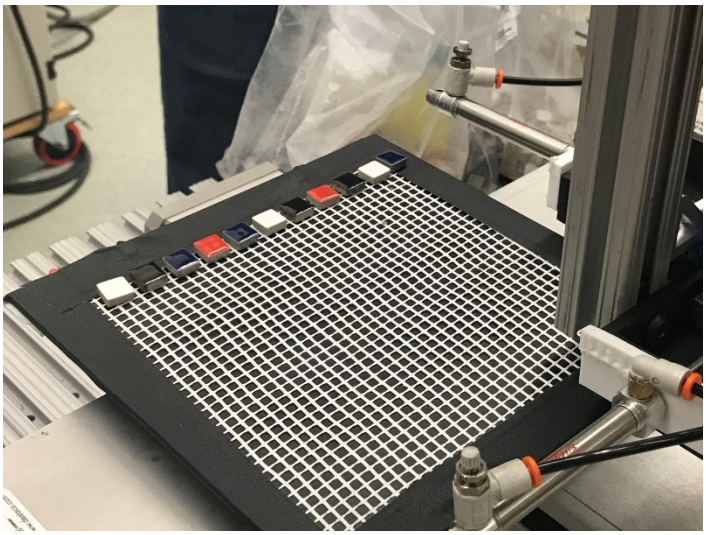
Maintenance Instructions

1. The completed assembly is reasonably robust, with exception of the safety plate module. This element utilizes a single acting cylinder which does not allow for the same flow control as a double acting cylinder. As such, each completed cycle results in the tongue cylinder rapidly extending which can cause wear or breakage of the tongue plate itself. Because of this, it is recommended that this part be frequently checked to ensure that the alignment is still acceptable as it interfaces with the door.

2. Due to the jarring actuation of the tongue plate actuator, some fasteners can loosen over time, particularly the nuts fastening the loading bar cylinders to the loading bar. These may simply be monitored and tightened on an as-needed basis.
3. Given the free-fall methodology used to place tiles on the baseplate, the backing adhesive on the mat must be sticky enough to ensure that tiles are adequately secure to the baseplate. Check this component often to ensure that the adhesive is still active.

Performance Data

The machine had consistent feeds and operations. There were issues with the orientation of the tile when it would be dropped onto the plate. This is due to the tile sitting on the trap door's arms before being dropped. The tiles are currently tilted when dropped onto the plate. There are a possible few reasons why this is happening. Our tolerance could be slightly off, 3d printed part (oppose to machined part), freefall distance from our gripper to the base place, and the overall rigidity.



Performance Statistics	
Feed Success	96%
Drop Success	96%
Orient Success	76%

14mm Spacing (52 Tested Drops)

There were times where the tiles were dropping constantly with no problems occurring. Most of our tile dropping issues occurred with the first two tiles. The only feeding issues that occurred was caused by human or 3d printer error. Overall, we're very happy with our feed and drop success percentage.

Future Improvements

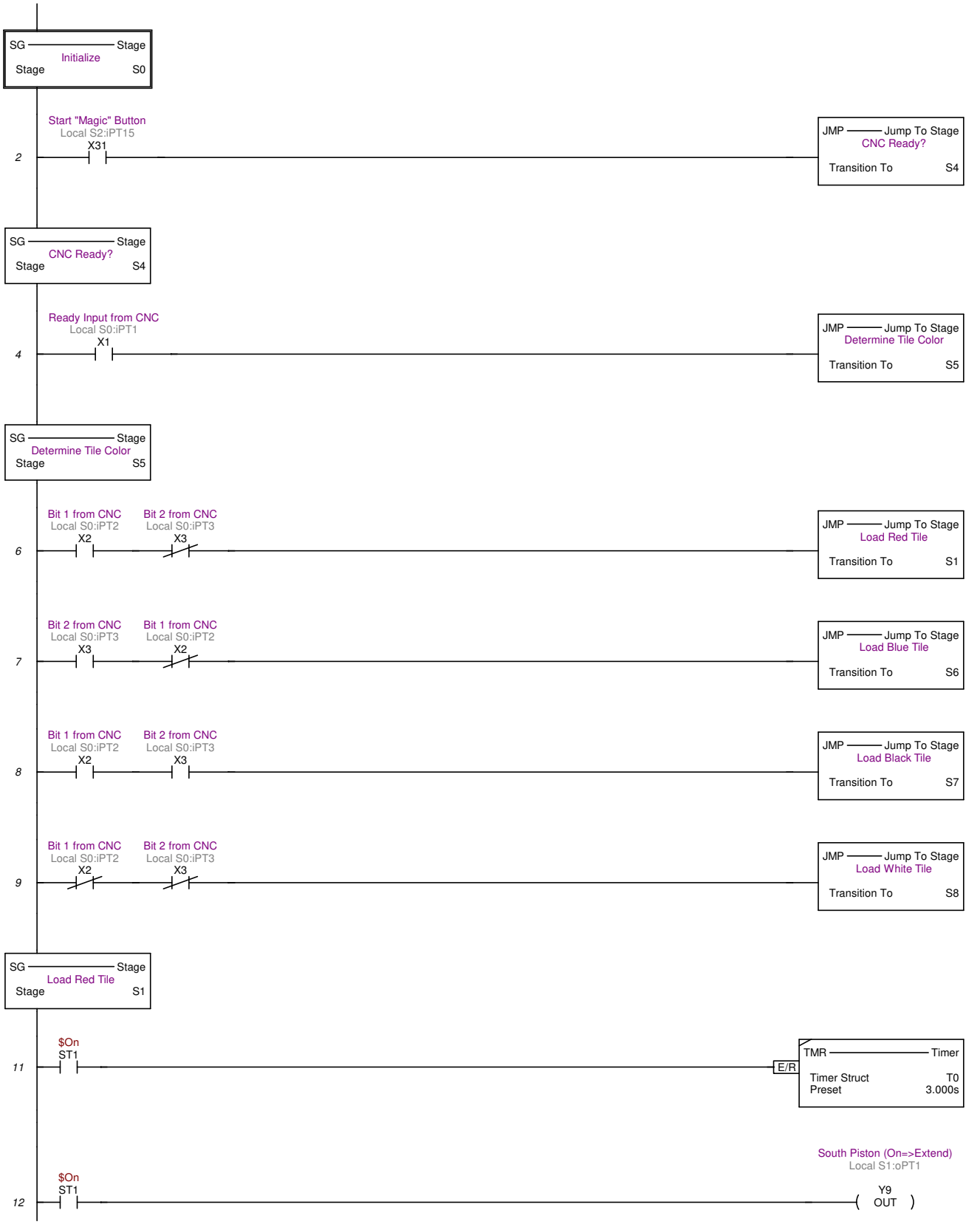
A complete redesign is out of the question. Our machine works but needs consistency. Here are a few possibilities we have discussed as a group that we did not have the time to practice or implement: suction tile placer, this would be a suction arm that is placed where our fiber optic sensor is currently located. Every other actuation would be the same, the only difference is that when the tile is slid into position before it is dropped, the suction arm would pick the tile up, let the trap door move, then place the tile down gently. This idea would solve our orientation problem.

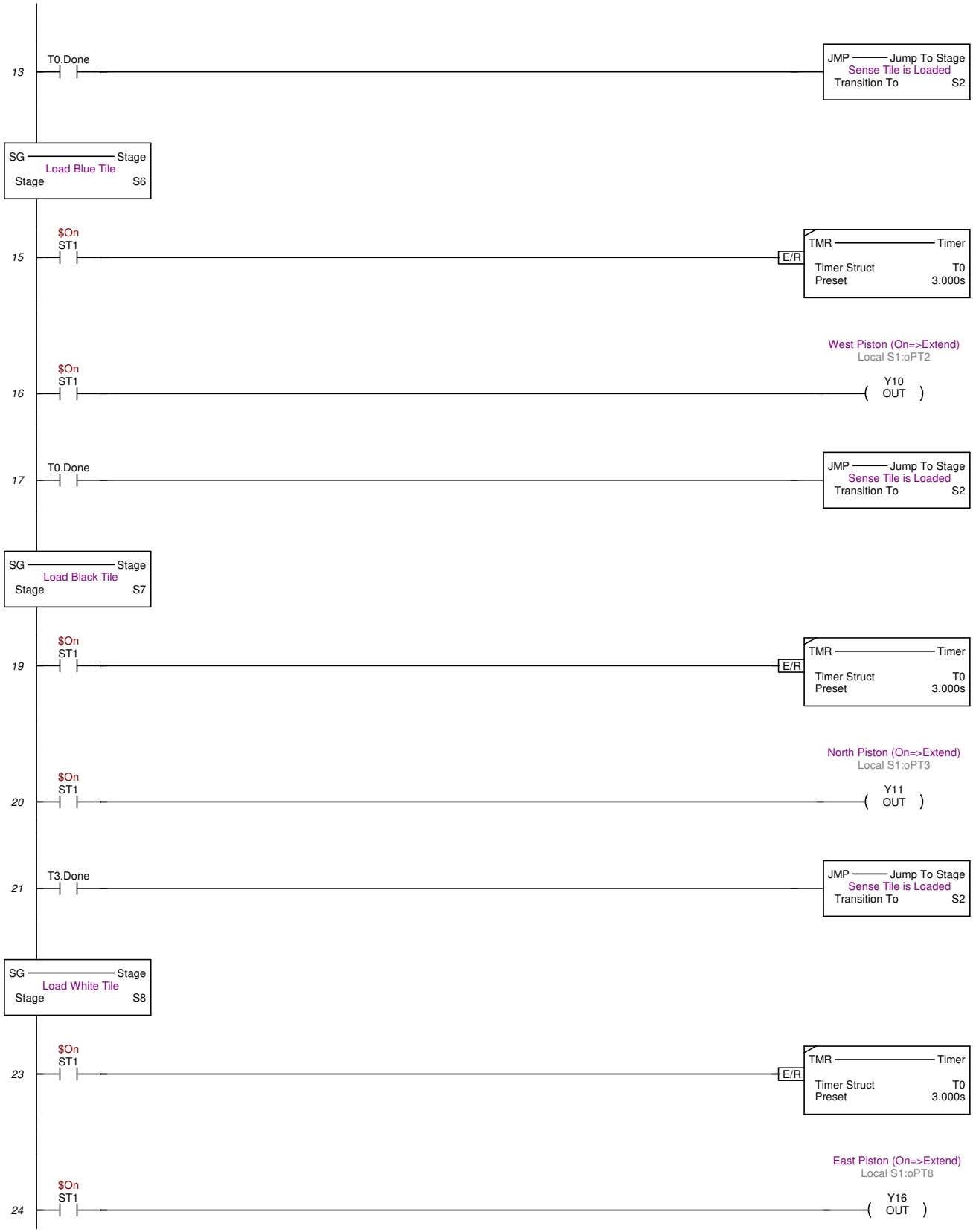
If we were to experiment with any changes to the current mechanisms, we would slightly modify the trap door safety to hold a tile. Once the tile is properly seated in the safety -> the trap door would then pinch the tile -> safety retracts -> tile is dropped. Theoretically this way will drop the tiles without having any rotational issues. The current design with the tile sitting on the trap door allows rotating or tilting to occur when the tile is dropped from the extruder. This is our preferred solution to our orientation issues.

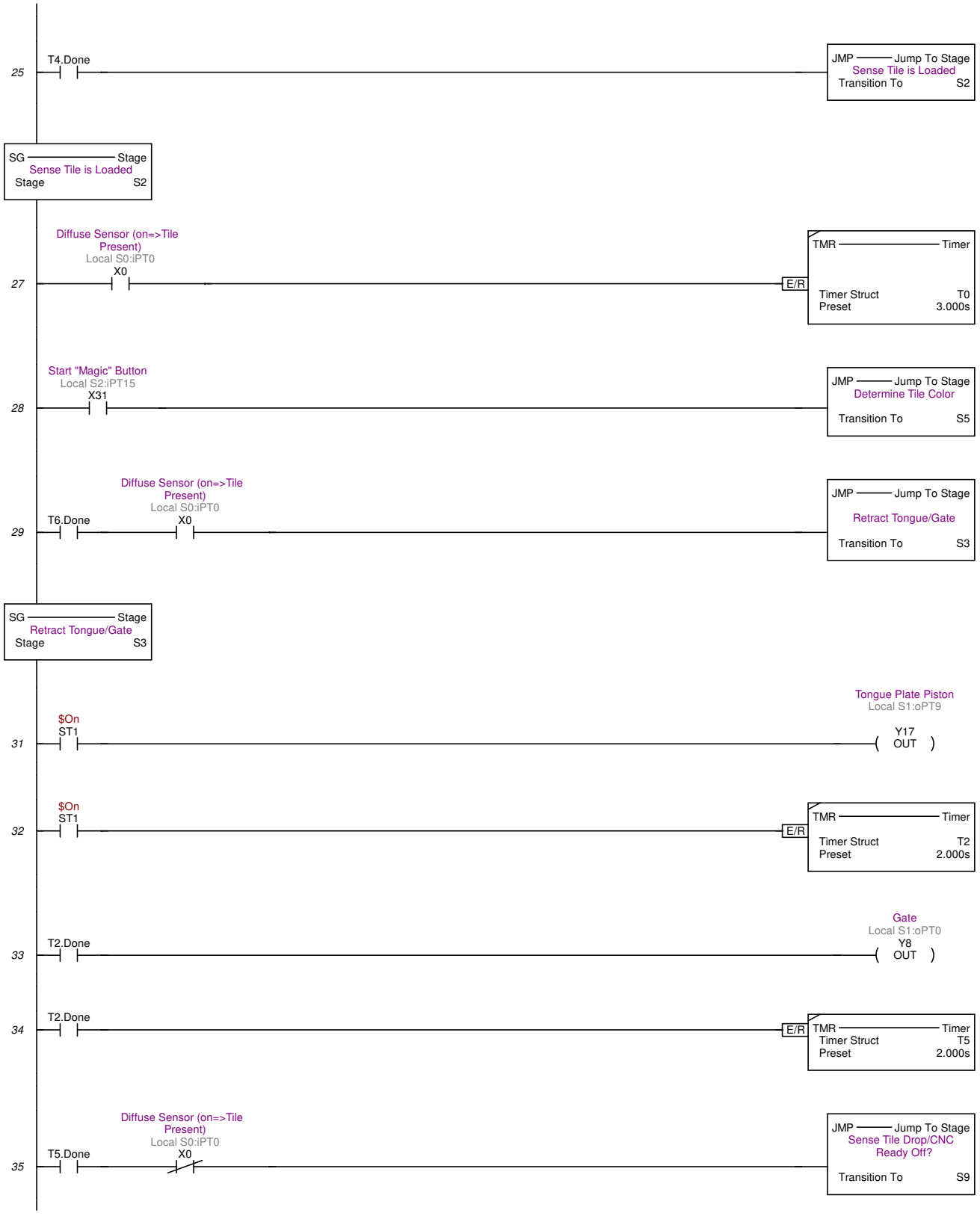
Some of our biggest issues were caused by tolerance and rigidity. Our mechanism would break parts frequently or loosen up during actuation. All these issues could be solved by machining our parts out of aluminum. The overall system would operate much better. If we were able to machine our mechanism out of aluminum, that would decrease operational error.

If we used 'z' axis movement, we could have implemented a barrel to the extruder below the trap door all the way to the baseplate. This would force the tile to drop and land in the orientation desired if the tolerance is tight enough. This idea would fix orientation issues at the cost of complexity and speed.

APPENDICES


SG Stage
Initialize
Stage S0
Start "Magic" Button
Local S2:iPT15
X31
2
JMP Jump To Stage
CNC Ready?
Transition To S4
SG Stage
CNC Ready?
Stage S4
Ready Input from CNC
Local S0:iPT1
X1
4
JMP Jump To Stage
Determine Tile Color
Transition To S5
SG Stage
Determine Tile Color
Stage S5
Bit 1 from CNC
Local S0:iPT2
X2
Bit 2 from CNC
Local S0:iPT3
X3
6
JMP Jump To Stage
Load Red Tile
Transition To S1
Bit 2 from CNC
Local S0:iPT3
X3
Bit 1 from CNC
Local S0:iPT2
X2
7
JMP Jump To Stage
Load Blue Tile
Transition To S6
Bit 1 from CNC
Local S0:iPT2
X2
Bit 2 from CNC
Local S0:iPT3
X3
8
JMP Jump To Stage
Load Black Tile
Transition To S7
Bit 1 from CNC
Local S0:iPT2
X2
Bit 2 from CNC
Local S0:iPT3
X3
9
JMP Jump To Stage
Load White Tile
Transition To S8
SG Stage
Load Red Tile
Stage S1
$On
ST1
11
TMR Timer
E/R
Timer Struct T0
Preset 3.000s
South Piston (On=>Extend)
Local S1:oPT1
$On
ST1
12
Y9
OUT

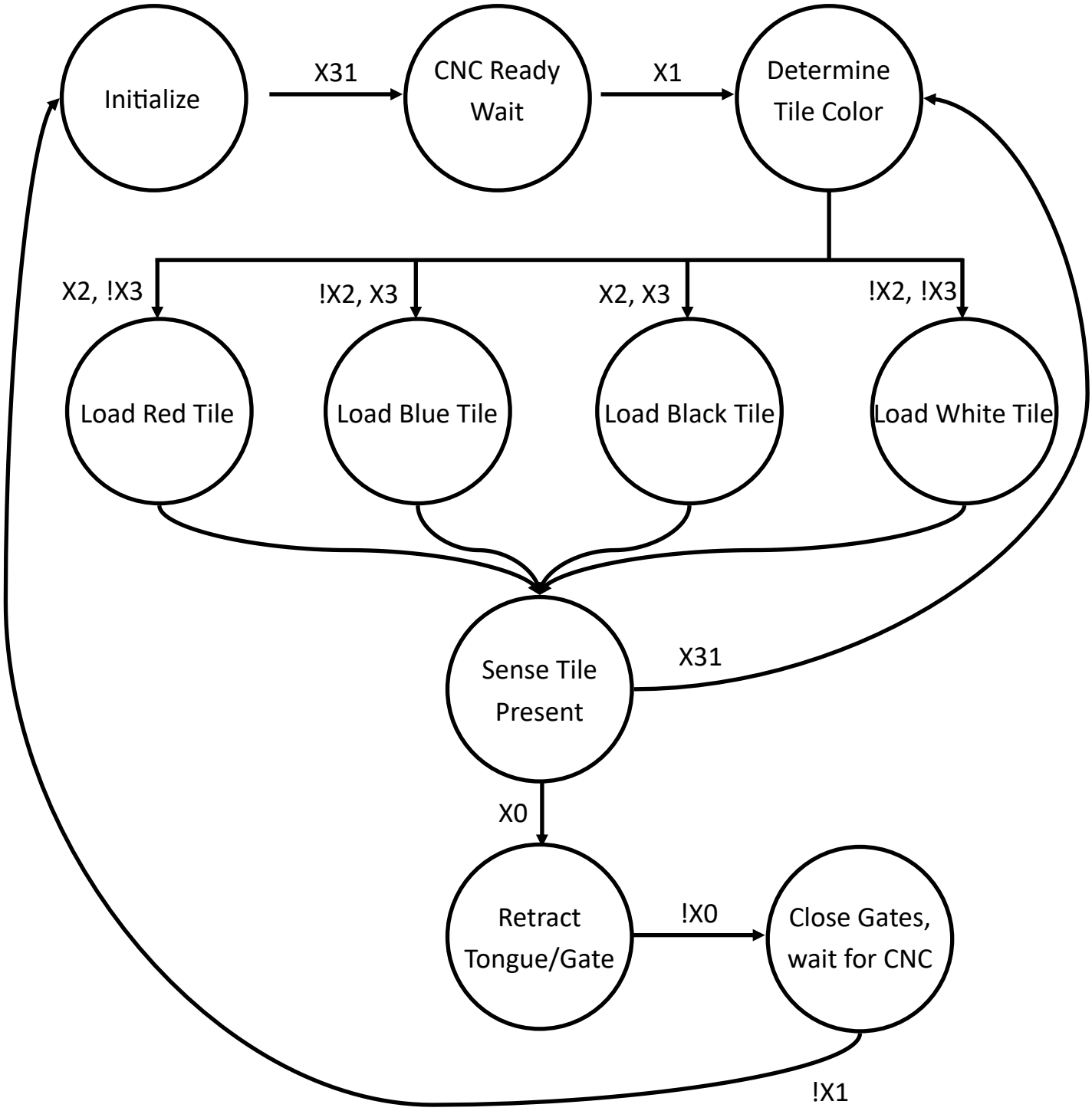

13
T0.Done
JMP Jump To Stage
Sense Tile is Loaded
Transition To S2
SG Stage
Load Blue Tile
Stage S6
15
$On
ST1
E/R
TMR Timer
Timer Struct T0
Preset 3.000s
West Piston (On=>Extend)
Local S1:oPT2
16
$On
ST1
Y10
OUT
17
T0.Done
JMP Jump To Stage
Sense Tile is Loaded
Transition To S2
SG Stage
Load Black Tile
Stage S7
19
$On
ST1
E/R
TMR Timer
Timer Struct T0
Preset 3.000s
North Piston (On=>Extend)
Local S1:oPT3
20
$On
ST1
Y11
OUT
21
T3.Done
JMP Jump To Stage
Sense Tile is Loaded
Transition To S2
SG Stage
Load White Tile
Stage S8
23
$On
ST1
E/R
TMR Timer
Timer Struct T0
Preset 3.000s
East Piston (On=>Extend)
Local S1:oPT8
24
$On
ST1
Y16
OUT


25
T4.Done
JMP
Jump To Stage
Sense Tile is Loaded
Transition To
S2
SG
Stage
Sense Tile is Loaded
Stage
S2
Diffuse Sensor (on=>Tile Present)
Local S0:iPT0
X0
27
E/R
TMR
Timer
Timer Struct
T0
Preset
3.000s
Start "Magic" Button
Local S2:iPT15
X31
28
JMP
Jump To Stage
Determine Tile Color
Transition To
S5
Diffuse Sensor (on=>Tile Present)
Local S0:iPT0
T6.Done
X0
29
JMP
Jump To Stage
Retract Tongue/Gate
Transition To
S3
SG
Stage
Retract Tongue/Gate
Stage
S3
Tongue Plate Piston
Local S1:oPT9
$On
ST1
31
Y17
OUT
$On
ST1
32
E/R
TMR
Timer
Timer Struct
T2
Preset
2.000s
Gate
Local S1:oPT0
T2.Done
33
Y8
OUT
T2.Done
34
E/R
TMR
Timer
Timer Struct
T5
Preset
2.000s
Diffuse Sensor (on=>Tile Present)
Local S0:iPT0
T5.Done
X0
35
JMP
Jump To Stage
Sense Tile Drop/CNC Ready Off?
Transition To
S9


SG
Stage
Sense Tile Drop/CNC Ready Off?
Stage
S9
Ready Input from CNC
Local S0:iPT1
X1
37
JMP
Jump To Stage
CNC Ready?
Transition To
S4
Ready Output to CNC
Local S0:oPT0
$On
ST1
38
Y0
OUT
39
NOP

```
(AXIS,stop)
G54
G90
G0 x0 y0 F3000

#<row>=0

o99 while [#<row> LT 10]

#<col>=0

o100 while [#<col> LT 10]

#<tile_addr> = [1000+#<row>*12+#<col>]
#<tile_num> = #[#<tile_addr>]
(debug,"tile_addr=",#<tile_addr>)

o102 if [#<tile_num> EQ 0]
        M65 P2
        M65 P3
o102 elseif[#<tile_num> EQ 1]
        M64 P2
        M65 P3
o102 elseif[#<tile_num> EQ 2]
        M65 P2
        M64 P3
o102 elseif[#<tile_num> EQ 3]
        M64 P2
        M64 P3
o102 endif


    M66 P0 L3 Q100
    M64 P1

    (debug,"row val= ",#<row>)
    (debug,"col val= ",#<col>)
    (debug,"tile num= ",#<tile_num>)

    M66 P0 L4 Q100
    M65 P1


    #<col> = [#<col> + 1]
G91
G1 X14.0 F1500

o100 endwhile
    #<row> = [#<row> + 1]
G91
G1 Y14.0 X-140.0 F3000

o99 endwhile
```

APPENDIX C - State Diagram



APPENDIX D - Wiring Table

STP-DRV-4035
X Axis Motor

Pin #	Pin Output
X-STEP+	P-14
X-STEP-	P-19
X-DIR+	P-1
X-DIR-	P-18
X-VDC+	24V
X-VDC-	GND
X-A+	X-Red
X-A-	X-White
X-B+	X-Green
X-B-	X-Black

STP-DRV-4035
Y Axis Motor

Pin #	Pin Output
Y-STEP+	P-15
Y-STEP-	P-21
Y-DIR+	P-2
Y-DIR-	P-20
Y-VDC+	24V
Y-VDC-	GND
Y-A+	Y-Red
Y-A-	Y-White
Y-B+	Y-Green
Y-B-	Y-Black

DR - ODC24

Pin #	Pin Output
DR-1	P-4
DR-2	GND
DR-3	24V
DR-4	Y0

BX-DM1E-18ED13-D

Pin #	Pin Output
V-	GND
V+	24V
1C	GND
Y0	DR-4
Y1	
Y2	
Y3	
2C	GND
Y4	
Y5	
Y6	
Y7	
1C	GND
X0	DFT-Brown
X1	L-RCK-2
X2	L-RCK-4
X3	L-RCK-6
X4	
2C	GND
X5	
X6	
X7	
X8	
X9	
USB	Computer 1

BX-16TD1

Pin #	Pin Output
1C	GND
BX-X0	V1
BX-X1	V2
BX-X2	V3
BX-X3	V4
2C	GND
BX-X4	V5
BX-X5	V6
BX-X6	V7
BX-X7	V8
3C	GND
BX-X8	V9
BX-X9	V10
BX-X10	V11
BX-X11	V12
4C	GND
BX-X12	
BX-X13	
BX-X14	
BX-X15	

BX-16ND3

Pin #	Pin Output
1C	24V
BX-Y0	
BX-Y1	
BX-Y2	
BX-Y3	
2C	24V
BX-Y4	
BX-Y5	
BX-Y6	
BX-Y7	
3C	
BX-Y8	
BX-Y9	
BX-Y10	
BX-Y11	
4C	GND
BX-Y12	
BX-Y13	
BX-Y14	
BX-Y15	Button-2

Start Button

Pin #1	Pin Output
Button-1	GND

70RCK4

Pin #	Pin Output
L-RCK-1	

ZL-RTB-DB25

Pin #	Pin Output
P-1	X-DIR+

Button-2	BX-Y15

L-RCK-2	X1
L-RCK-3	GND
L-RCK-4	X2
L-RCK-5	GND
L-RCK-6	X3
L-RCK-7	GND
L-RCK-8	
L-RCK-9	
R-RCK-1	
R-RCK-2	
R-RCK-3	P-8
R-RCK-4	
R-RCK-5	P-9
R-RCK-6	
R-RCK-7	P-10
R-RCK-8	
R-RCK-9	

P-2	Y-DIR+
P-3	
P-4	DR-1
P-5	
P-6	YM-Green
P-7	
P-8	R-RCK-3
P-9	R-RCK-5
P-10	R-RCK-7
P-11	
P-12	
P-13	
P-14	X-STEP+
P-15	Y-STEP+
P-16	
P-17	XM-Green
P-18	X-DIR-
P-19	X-STEP-
P-20	Y-DIR-
P-21	Y-STEP-
P-22	
P-23	XM/YM-Black
P-24	
P-25	
USB	Computer 2

Pneumatic Manifold

Pin #	Pin Output
V1	BX-X0
V2	BX-X1
V3	BX-X2
V4	BX-X3
V5	BX-X4
V6	BX-X5
V7	BX-X6
V8	BX-X7
V9	BX-X8
V10	BX-X9
V11	BX-X10
V12	BX-X11
V13	
V14	
V15	
V16	

Stepper Motor X-Axis

Wire Color	Wire Connect
X-Black	X-B-
X-Green	X-B+
X-White	X-A-
X-Red	X-A+

Stepper Motor Y-Axis

Wire Color	Wire Connect
Y-Black	Y-B-
Y-Green	Y-B+
Y-White	Y-A-
Y-Red	Y-A+

Motor Sensor X-Axis

Wire Color	Wire Connect
XM-Black	P-23
XM-Green	P-17
XM-Red	5V

Motor Sensor Y-Axis

Wire Color	Wire Connect
YM-Black	P-23
YM-Green	P-6
YM-Red	5V

DFT-AN-1A

Wire Color	Wire Connect
DFT-Black	24V
DFT-Brown	X0
DFT-Pink	
DFT-Blue	GND