Walla Walla University
ENGR 480
Manufacturing

Manufacturing Lab Project

Automated Flashlight Assembly Manual

Turret Team

Daniel Biesenthal
Nathan Reeves
Jonathan Schreven
Brielle Starr

2011

Table of Contents

Table of Figures

1 – Introduction

This document is a compilation of the instructions, diagrams, descriptions, and codes necessary to operate and understand the workings of the automated flashlight assembly machine.

2 – Running the Machine

To start the machine:

1. Check to see that all parts of the machine are in proper working order. Remove any obstructions or foreign objects from the machine.
2. Load the machine fully with parts.
3. Make sure power is on.
4. Make sure both PLCs are set to "Stop."
5. Turn on the air (by clearing the E-Stop).
6. Place switches in proper orientation.
    a. Switch 0 on the PLC is a safety switch for the outer o-ring station. With this switch off, the station will not place the o-ring.
    b. Switch 1 on the PLC is a safety switch for the indexing table. With this switch off, the table will not turn automatically.
    c. Switches 4, 5, and 6 on the PLC toggle the outer o-ring station, the snap disc station, and the assembly station. With these switches off, their respective stations will not operate.
    d. Switch 7 on the PLC toggles between the startup cycle and the normal steady-state cycle. With this switch off, each time the machine starts up it will perform the startup cycle and then run normally. With the switch on, it will run only the steady-state system, with each station working every time from the beginning.
7. Set both PLCs to "Run."
8. Press the start button.

To stop the machine:

1. Press the E-stop.
2. Set both PLCs to "Stop."

3. Disconnect power.

While the machine is in operation, the warning light panel will function. Any problem with a station will cause the corresponding warning light to illuminate. Fix the problem, and the light will go off.

3 – Description of Operations

3.1 – Station #1: Nose Drop

3.1.1 – Function

The purpose of the nose drop station is to deposit a single nose cone into one of the eight nose cone holders on the index table. To complete this task, the station requires a feeder tube to hold the nose cones, two dual-action pistons to perform singulation, a slide system to move the feeder tube down over the nose cone holder, and sensors to tell us when a part is present and when the system is extended (interfering) or retracted (not interfering).

3.1.2 – Loading

To load this station, drop one or more nose cones (must be face down) into the top of the feeder tube. This may be accomplished by hand or with the use of an automated feeder.

3.1.3 - Clearing

If the station jams, press the E-stop button, manually slide the feeder tube up out of the way, and remove the nose cone by hand. If nothing is damaged then replace the nose cone and continue to run the program. If there is any damage, fix or replace the affected parts, reload the system, and continue system production.

3.2 – Station #2: Inner O-ring & Heat Sink w/Lens

3.2.1 – Function

The purpose of this station is to singulate and install the inner o-ring and the heat sink (with the lens pre-installed), respectively. The o-rings are set up on edge in a narrow slot-ramp with two pistons that move horizontally. The first piston extends in front of the first o-ring. The second piston extends through the center of the second o-ring. A sensor is installed to recognize that there is an o-ring in position, ready for the next round.

The heat sinks are stacked in a tube, with a platform stopping them from falling into the nose cone. The platform is attached to the end of a piston. There is a second piston with a semi-circular stopper on the end of it that holds the second heat sink in place by pushing it against the side of the tube. A sensor is installed to recognize that the heat sink is in position, and signals the first piston to begin.

3.2.2 – Loading

The o-rings are loaded on their rolling sides, one right after another in the ramp. The heat sinks stack on top of each other in the tube.

3.2.3 - Clearing

To clear a jam, immediately push the emergency stop and wait for the system to power down. The o-rings can be removed by hand or by grabbing with a tool, such as needle nose pliers. To remove heat sinks, the pistons must be pulled back so the heat sinks can fall through the tube without any obstructions. Someone should be ready to catch the heat sinks as they fall out of the tube in order to prevent damage to the lens.

3.3 – Station #3: First Outer O-ring

3.3.1 – Function

The purpose of the outer o-ring station is to singulate and install the outer o-ring. The o-ring singulation system for stations 3 and 5 uses a single pneumatic piston to singulate the o-rings for placement. It is built by taking two pieces of aluminum bar stock and cutting a relief in one side to allow the o-ring to slide down. Another relief is cut for a rotating disc that is used as the singulation mechanism. A pivot hole is drilled on either side to allow the rotating disc's shaft to extend out to either side. This disc has a section notched out the top side that allows an o-ring to sit in its place. The extend shaft off the disc is attached to a lever, which is then attached to a clevis on an air cylinder.

3.3.2 – Loading

O-rings are loaded on edge, one right after another in the ramp.

3.3.3 - Clearing

To clear a jam, immediately push the emergency stop and wait for the system to power down. The jammed o-rings can be removed by using your hands or a device such as needle nose pliers.

3.4 – Station #4: Magnet Ring

3.4.1 – Function

The magnet ring station performs the function of placing the magnet ring (with magnet pre-attached) over the flashlight nose piece. The station utilizes two dual-action pistons to control ring singulation, an aluminum feeder tray, two pneumatic slides, an inductive sensor, and a pneumatic gripper for grabbing the magnet ring.

3.4.2 – Loading

To load this station, simply slide the magnet rings down the aluminum delivery chute. Rings are not directional and may also be added by attaching another automated system such as a vibratory bowl.

3.4.3 - Clearing

If the station jams for any reason, press the E-stop button and remove the magnet ring by hand. If nothing has been damaged the system may be started up again immediately. If any of the parts has been damaged, fix or replace the part, re-align the system, and then continue operation.

3.5 – Station #5: Second Outer O-ring

3.5.1 – Function

See information in Section 3.3.1.

3.5.2 – Loading

See information in Section 3.3.2.

3.5.3 - Clearing

See information in Section 3.3.3.

3.6 – Station #6: Snap Disc

3.6.1 – Function

The function of Station 6 is to place a keeper disc in the flashlight to prevent the internals from falling out if the nose cone is turned over. A vacuum system is used on the end of a cylinder to pick and place the part. A rotational air cylinder is used for the motion between grabbing the disc, and placing it in the nose cone. The discs are located on a centering rod, with a sprung base that allows compression when the vacuum head is lowered on to it. This station houses two sensors, the first located on the cylinder to indicate when it is in the down position. The second sensor is placed above nose holder region and is used to indicate when the sensor is up.

3.6.2 – Loading

Loading this station is done by placing the discs on to the holder while the vacuum head is out of the way.

3.6.3 - Clearing

If a jam occurs immediately press the emergency stop and wait for the system to power down. Then proceed to remove jammed part manually with hand. Due to the simplicity of this station a jam is unlikely. If the machine stops in the middle of the procedure, check to see if the sensors are reading the position of the cylinder.

3.7 – Station #7: Final Assembly

3.7.1 – Function

Station #7 is used to thread together the assembled nose cone and the body. The station has a four-inch remote controlled aircraft wheel mounted to a stepper motor. When the table is indexed the wheel comes in contact with the nose cone and turns, spinning the holder.

3.7.2 – Loading

There is no loading required for this station, because the nose cone is preloaded from the previous station.

3.7.3 - Clearing

To clear a jam press the emergency stop and wait for the system to power down. Manually rotate the table to free the nose cone holder from the wheel. Proceed to clear the jam.

3.8 – Station #8: Check for Empty

3.8.1 – Function

The purpose of this station is to make sure there is nothing in the nose cone holder before the turret starts a new cycle. There is a sensor that will stop the turret from turning if it senses anything in front of it.

3.8.2 – Loading

No loading takes place at this station.

3.8.3 - Clearing

In the event of something being in the holder, the E-stop button should be pressed and the flashlight should be removed by hand.

3.9 – Index Table

3.9.1 – Function

The index table is the main parts handler for the flashlight assembly. Its purpose is to transfer the parts between stations and give a solid location for parts assembly. The index table is fitted with eight nose cone holders that sit on bearings to allow the flashlight to be assembled in the holder, and then removed. Inside the holders is a small piston that when it reaches the inner o-ring station it is plunged up centering the o-ring inside the nose cone.

3.9.2 - Loading

The index table is loaded by the stations around its path. Starting with the nose cone a different part is loaded at each station as it makes a complete revolution.

3.9.3 - Clearing

If a jam occurs on the index table immediately press the emergency stop and wait for system to power down. Once powered down the jam can be cleared manually by hand. If the jam has occurred under a station, rotating the index table can be done to assist in clearing the jam.

4 – Station Design

4.1 – Station #1: Nose Cone Drop

This process begins when the inductive sensor in the feeder tube shows a part as present. After the table has indexed a nose cone holder into place the feeder tube will drop down over the nose cone holder and the bottom piston will pull out. Our program is written for the piston to fire in and then out a second time to ensure that the nose piece does not hang up on the cutout which allows the piston to enter the feeder tube. Once the bottom piston has fired a second time it extends and the upper piston releases the next nose piece. The feeder tube then retracts away from the nose cone holder. When the position sensor shows that the tube is fully retracted the table indexes the nose piece to the second station.

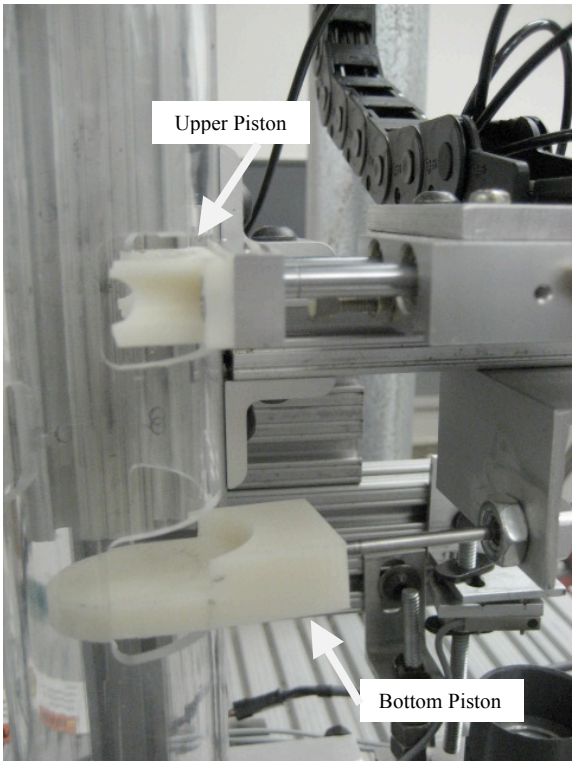


Figure 1: Nose Cone Singulation & Feeder Tube

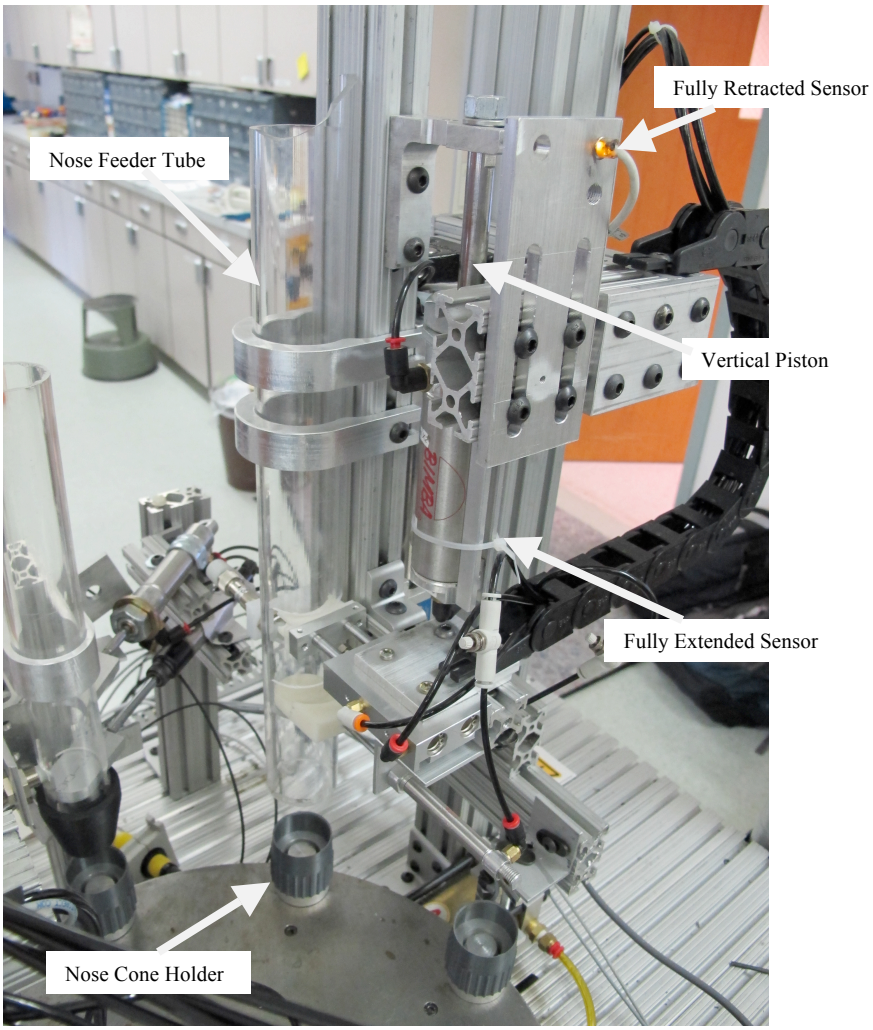


Figure 2: Complete Nose Drop Assembly

4.2 – Station #2: Inner O-ring & Heat Sink w/Lens

When the o-ring is ready, the first piston releases to let the first o-ring roll into the flashlight nose while the second piston prevents the next o-ring from rolling. The first piston extends again and the second piston releases to allow the entire row of o-rings to roll into the starting position.

The platform slides out from under the first heat sink, and after the heat sink has dropped into the nose, the platform returns to its position. The stopper then releases to allow the line of heat sinks to drop into the starting position.

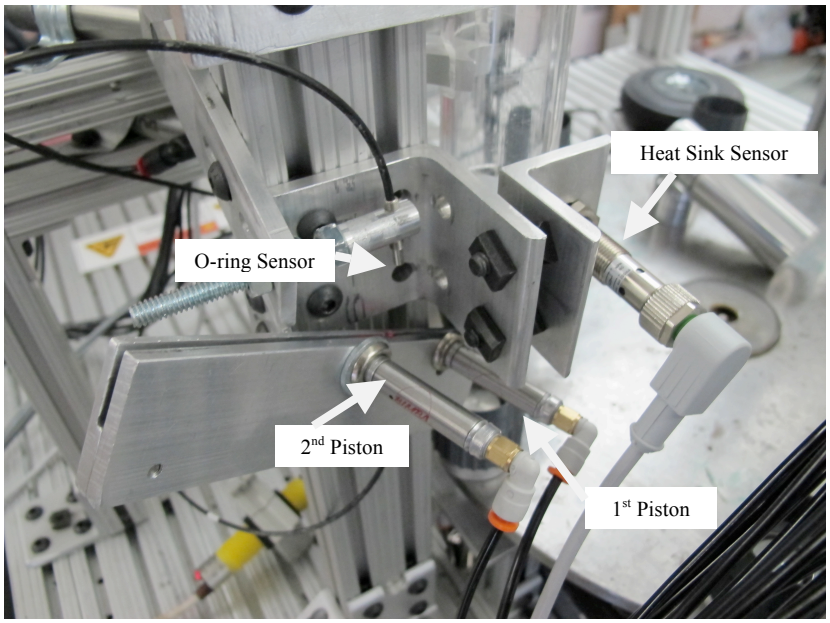


Figure 3: O-ring Singulator

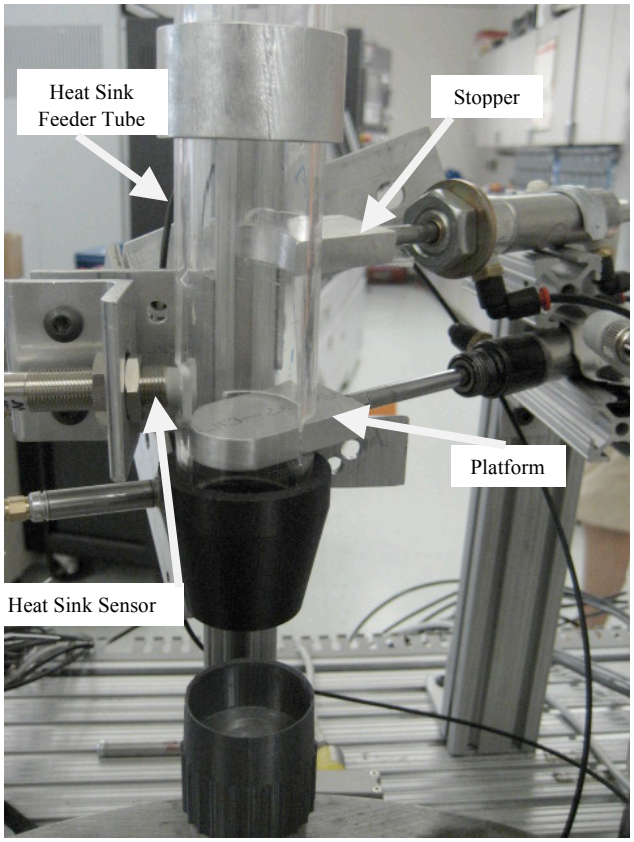


Figure 4: Heat Sink Singulator

4.3 – Station #3: First Outer O-ring

When the air cylinder is extended it rotates the disc, pushing the o-ring in the notch forward, and restraining the o-ring behind it (shown below). The o-ring to be installed rolls onto and lays flat on the gripper shown. The gripper then stretches the o-ring and rotates 180° so it is facing downward. The gripper is then lowered onto the flashlight nose where it closes to fit around the nose. A piston extends to hold the o-ring in place while the grippers lift and return to the starting position. The sequence of installing the o-ring is shown below.

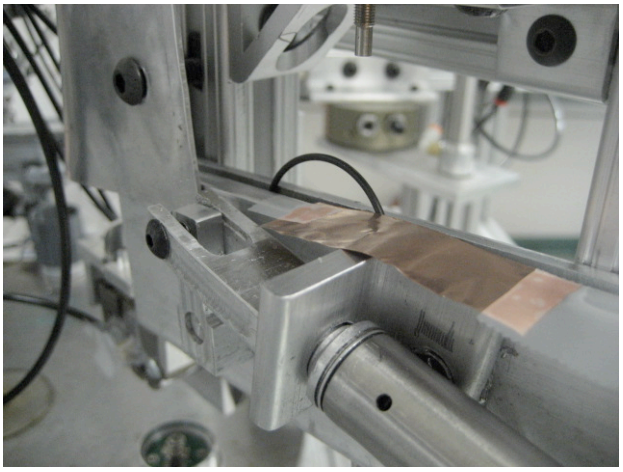


Figure 5: O-ring Ramp

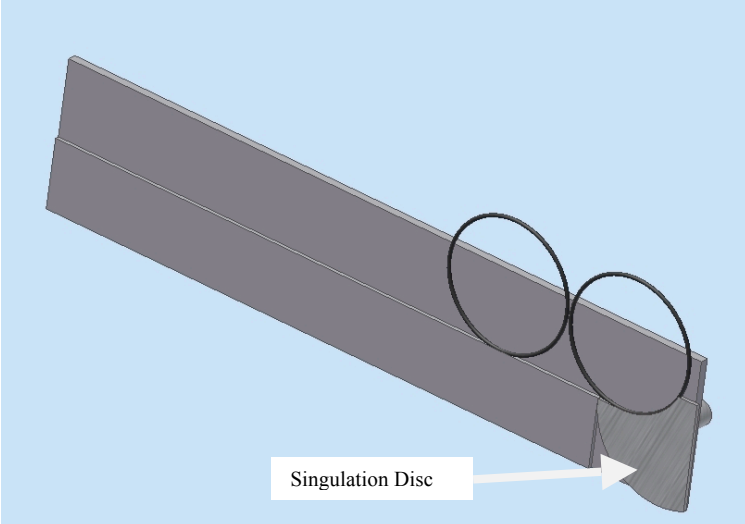


Figure 6: O-ring Singulation Ready

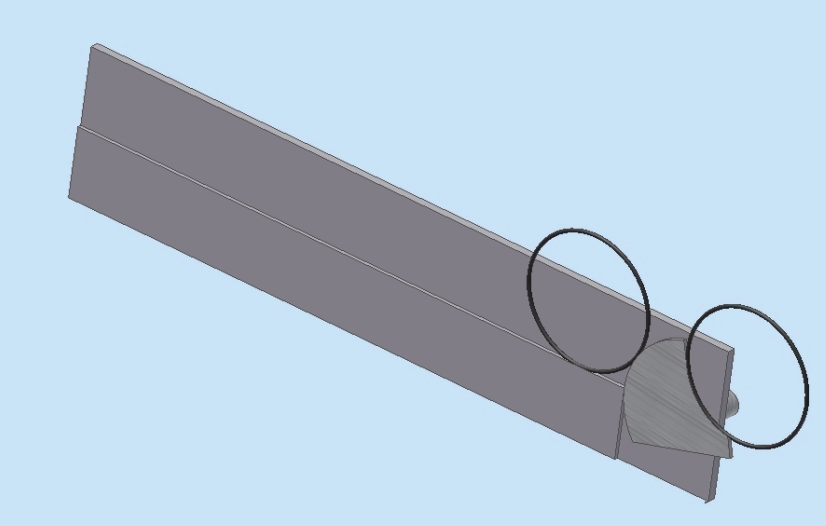


Figure 7: O-ring Singulation in Action

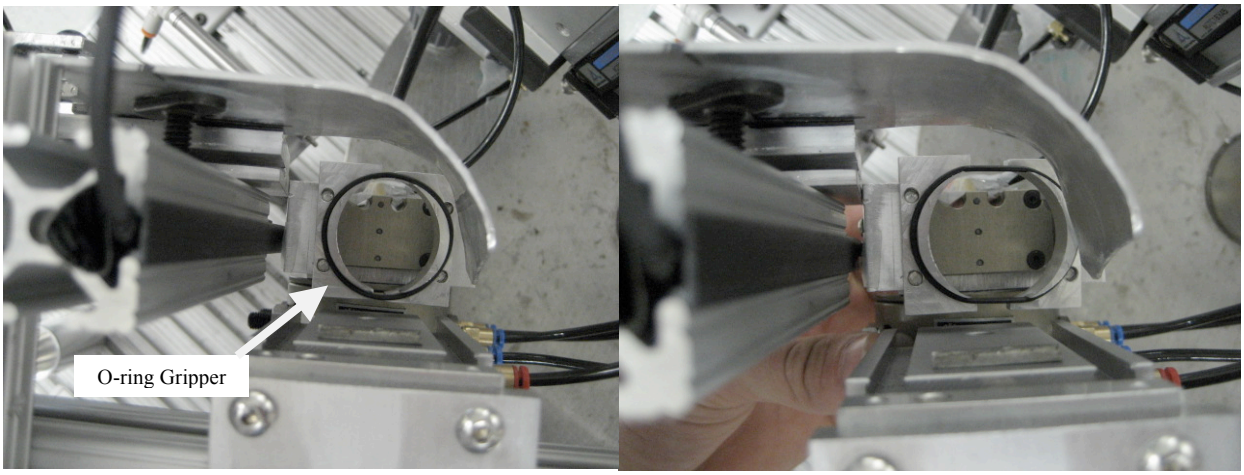


Figure 8: O-ring Gripper Stretched

Figure 9: O-ring Gripper 180^{o} Turn

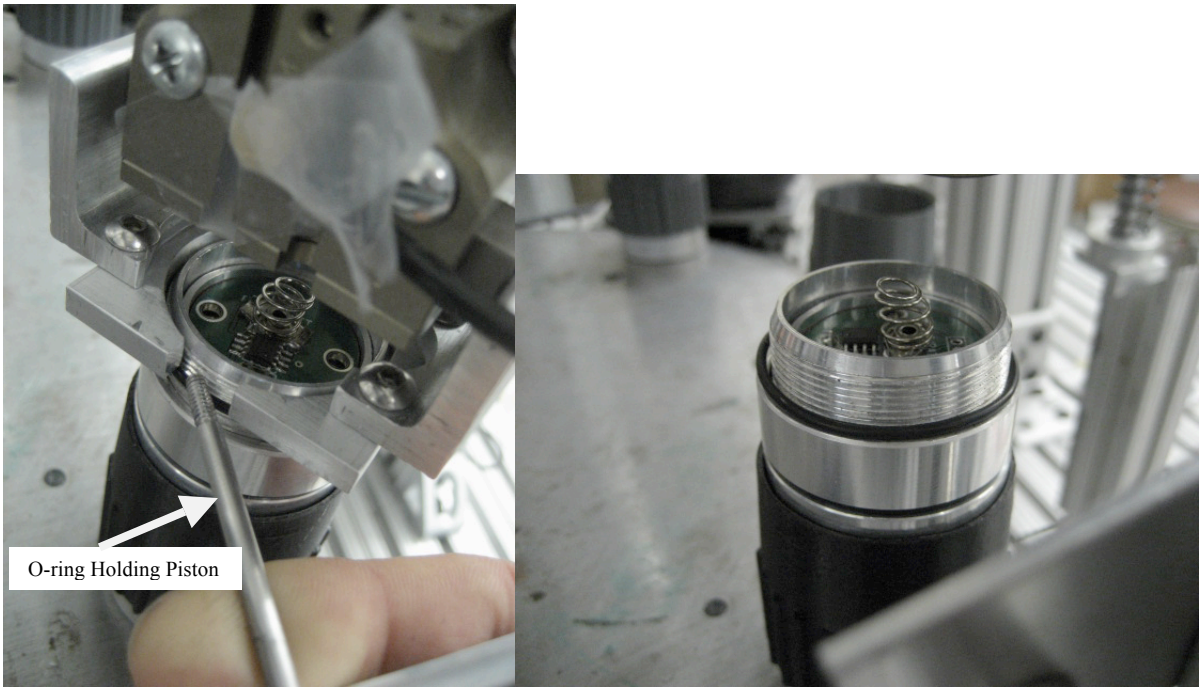


Figure 10: Piston Holds O-ring On Nose

4.4 – Station #4: Magnet Ring

The process starts with several rings loaded in the feeder tray next to the index table. There are two dual-action pistons that singulate the rings down to a shelf which is mounted on one of the pneumatic slides. When the gripper jaws are up and the inductive sensor sees a part, the sliding shelf will extend and a single ring will be released. The ring slides down the delivery chute and lands on the shelf between the gripper jaws. The jaws then close and the shelf slides back out of the way. The gripper mechanism is mounted on a vertically actuating pneumatic slide that then delivers the gripped ring down over the nose piece. Finally, the gripper releases the ring and returns up to its start position and the process can be repeated as long as there are parts in the delivery chute. The pictures below show the various devices involved in this operation.

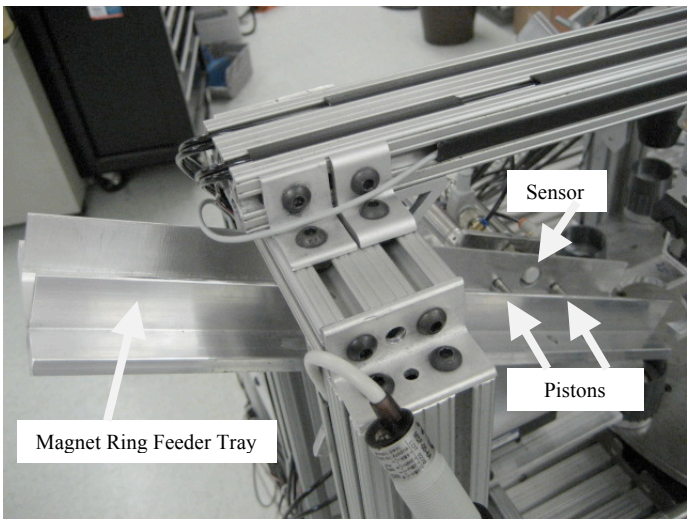


Figure 11: Magnet Ring Feeder Tray

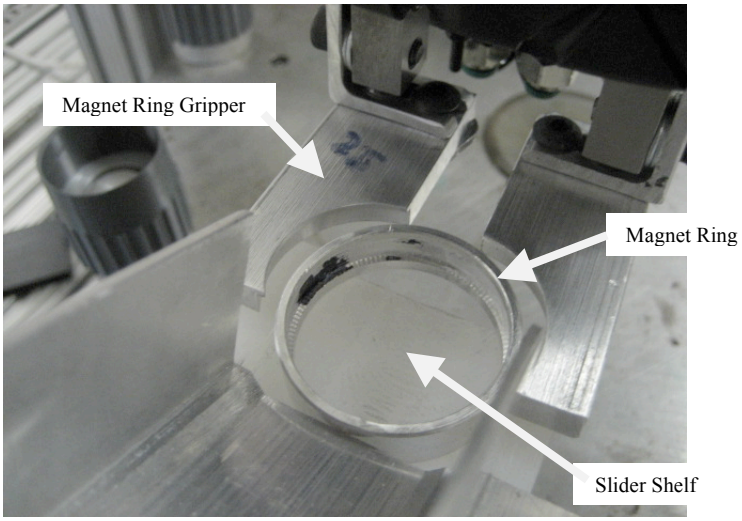


Figure 12: Magnet Ring Gripper

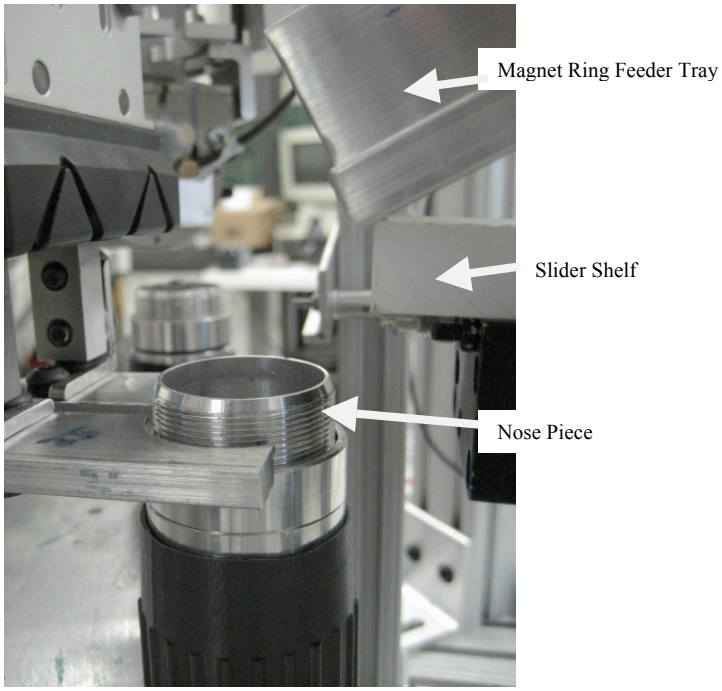


Figure 13: Final Magnet Ring Placement

4.5 – Station #5: Second Outer O-ring

Refer to Section 4.3.

4.6 – Station #6: Snap Disk

The station has an overhead gantry design. A rotating air cylinder is mounted on the gantry to allow movement from the disc holder to the nose cone holder. An arm connects the rotating air cylinder to an air piston which has a vacuum head mounted on it. The piston is used

as a vertical action to pick and place the part. The vacuum head is a piece of aluminum round stock that has a center recess, and a side recess. The center is recessed to allow fitment over the heat sink spring and the disc holder. The side recess has a vacuum nozzle fitted in it, and connected to a fitting on the other side. The disc holder is a single one by one 8020 stock with rod mounted to one side. On the upper portion of this rod are two aluminum pucks, with a spring in between them, which absorbs any over-compression from the placement cylinder.

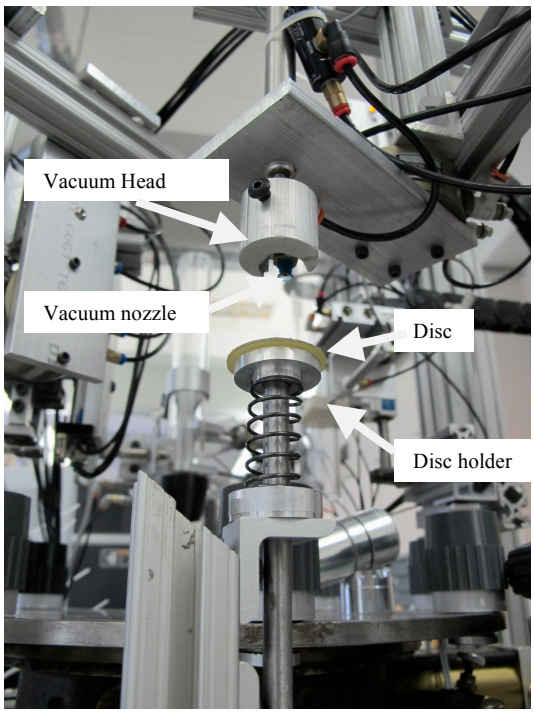


Figure 14: Snap Disc Placement Station

4.7 – Station #7: Final Body Assembly

A stepper motor is mounted to the table, and placed near the indexing table so it makes contact with the nose cone holder every time the table is indexed. An RC aircraft wheel is used to connect the nose cone holder to the stepper motor. This was chosen due to the soft rubber of the wheel. When the table is indexed the stepper motor receives a ready signal that causes it to start running its operation. Due time constraints, this station was never completed. It was intended to have a Cartesian robot or other system to pick up a battery and body and then place it on the nose cone, for when the stepper motor starts. It would then pick up the completed flash light and place it at a location for the finished flashlights.

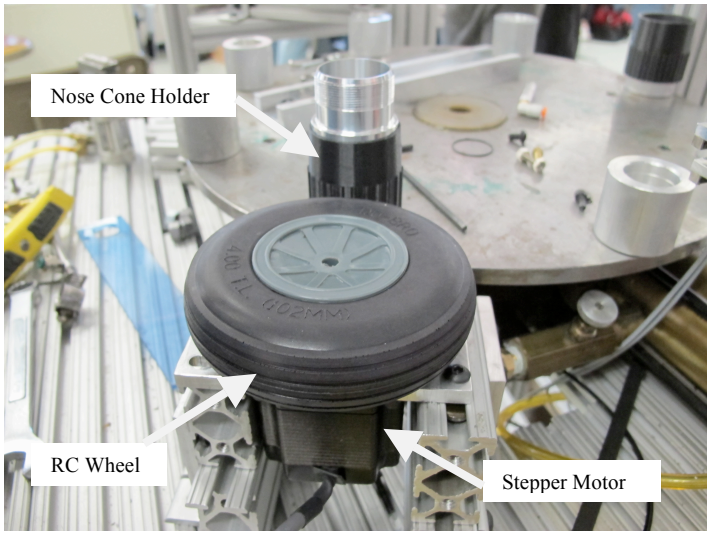


Figure 15: Stepper Motor Assembly

4.8 – Index Table

The index table is a complete unit with eight holes drilled in it for each of the eight spots it stops at in its rotational path. This was mounted to the 8020 table. Each of the spots was fitted with a nose cone holder. These were made with aluminum stock, and jacketed with a rapid prototyped shell. The aluminum bases have a threaded end that sticks below the base of the table, a bored out upper end, and a hole that passes through the center for inner o-ring locator air cylinder. This air cylinder was fitted beneath station two where the heat sink and inner o-ring station is located. The hole on the top side of the aluminum holder sits an aluminum piston that is used to center the o-ring. On the top and bottom side of the contact areas with the table a bearing recess is there to allow the free rotation of the nose cone holders. The bottom side is held on with a custom made nut that centers the bottom bearing in place. The rapid prototyped jacket is used to hold the nose cone in a centered position on the aluminum. It has ridges on the outside to allow a rubber wheel to spin the nose cone holder at station 7, which assembles the flashlight.

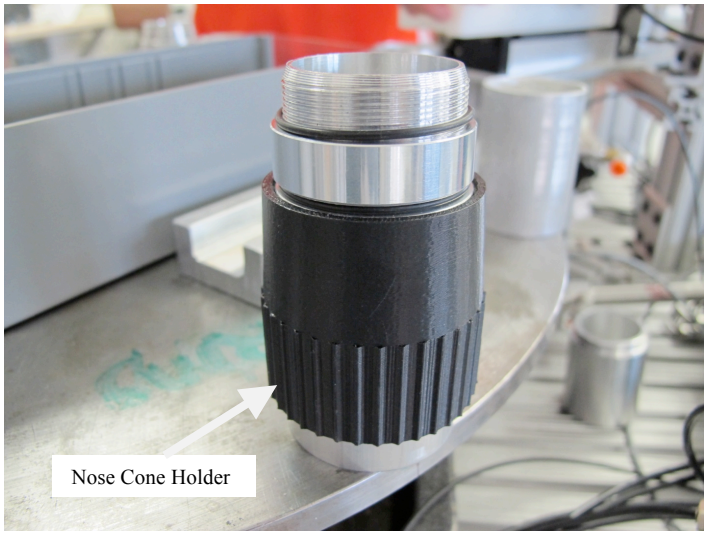


Figure 16: Nose Cone Assembly

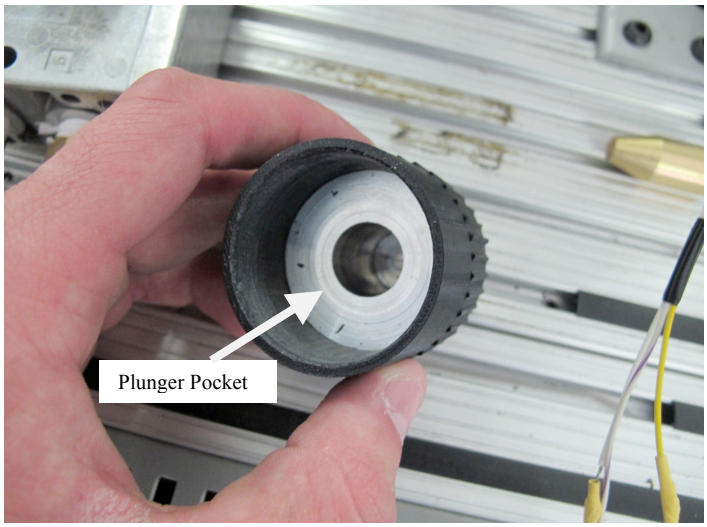


Figure 17: O-ring Piston Pocket

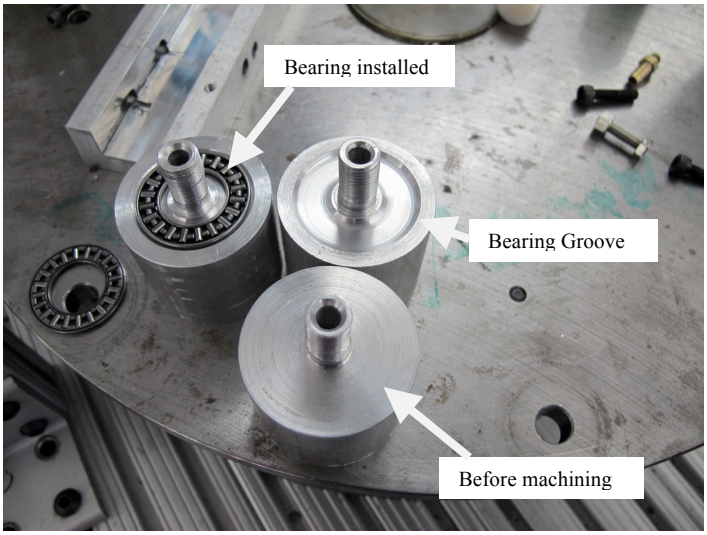


Figure 18: Bearing Location

5 – Suggestions

Complete second o-ring station (need more parts)

Complete body assembly

Improve o-ring sensing (currently unreliable)

Tune o-ring placement stations

Replace dual action o-ring singulator with single action

Add sensors to keeper disc station

Sensor to sense nose cone is properly seated

More testing

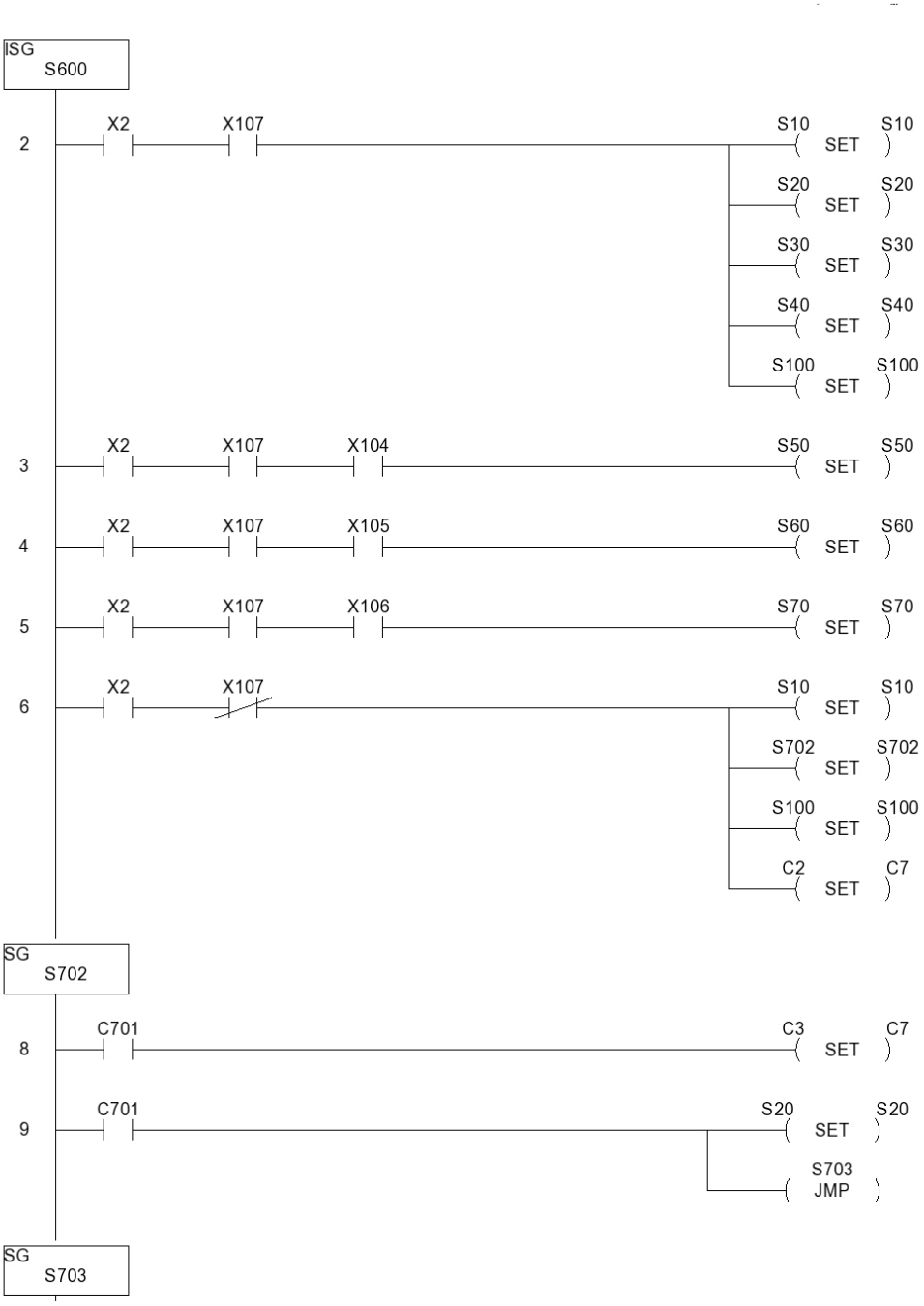
Better nose cone holders with more friction

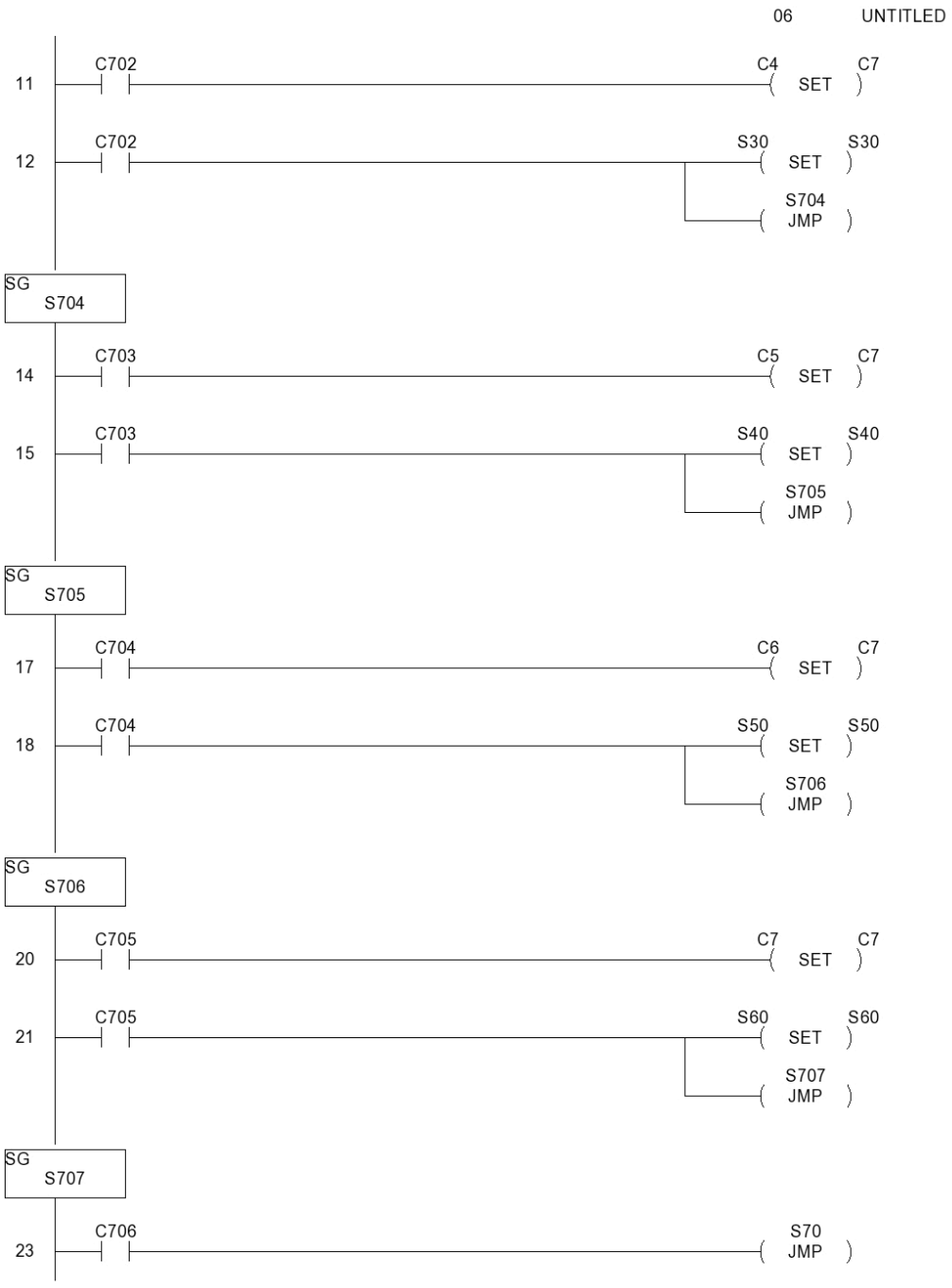
Reprint Nose cone cups for better fitment

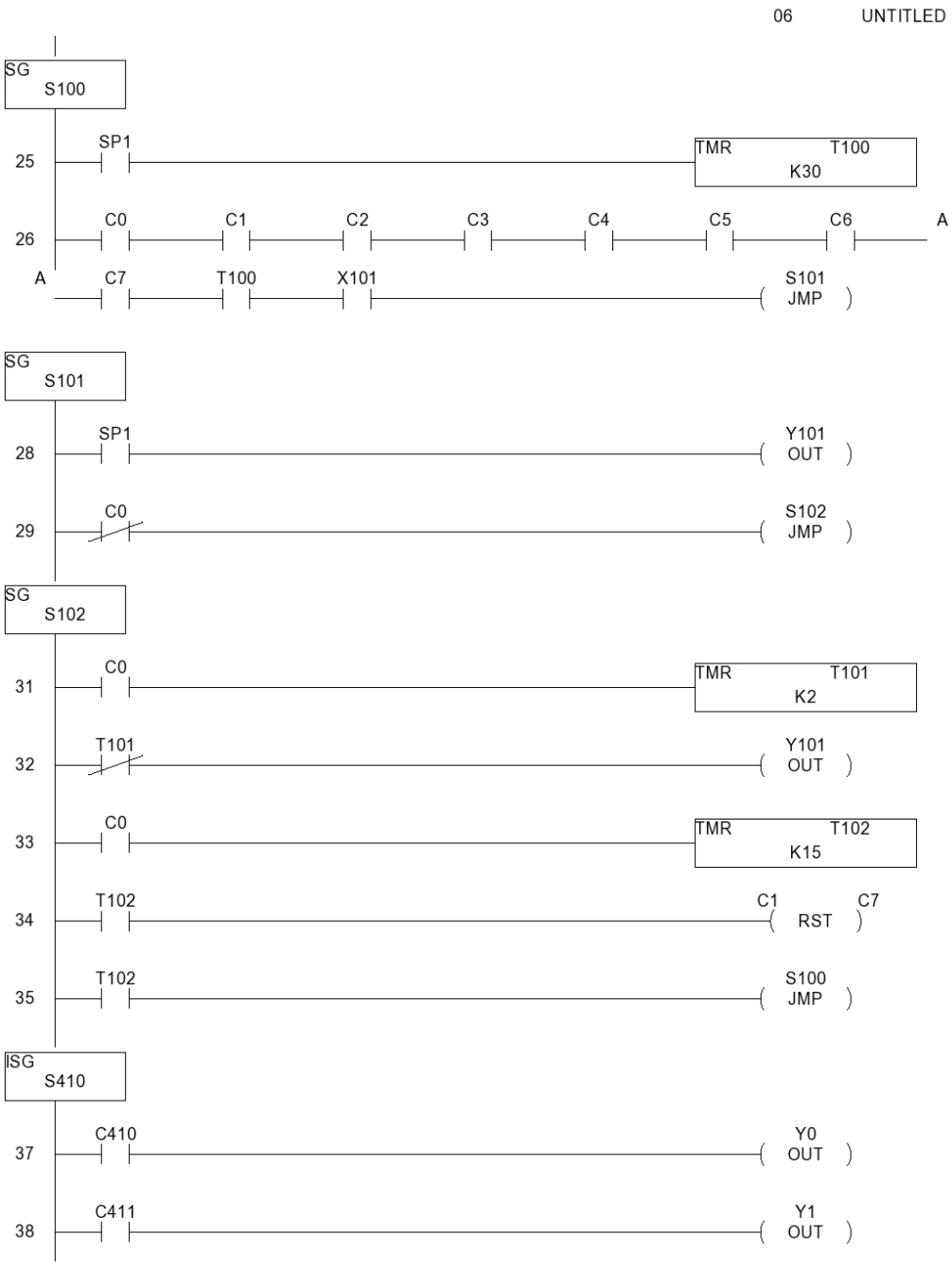
6 – Appendices

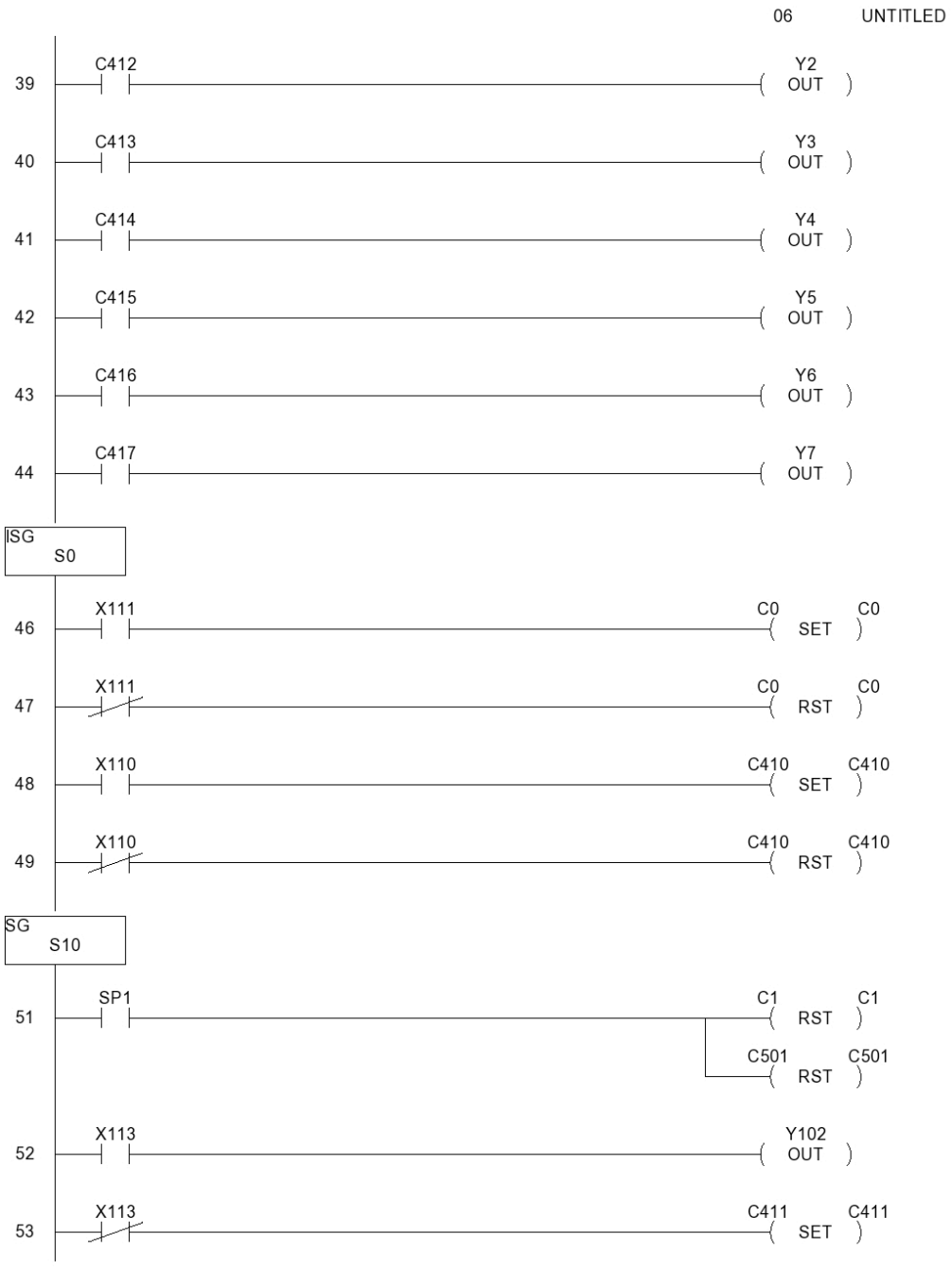
6.1 – PLC Ladder Logic

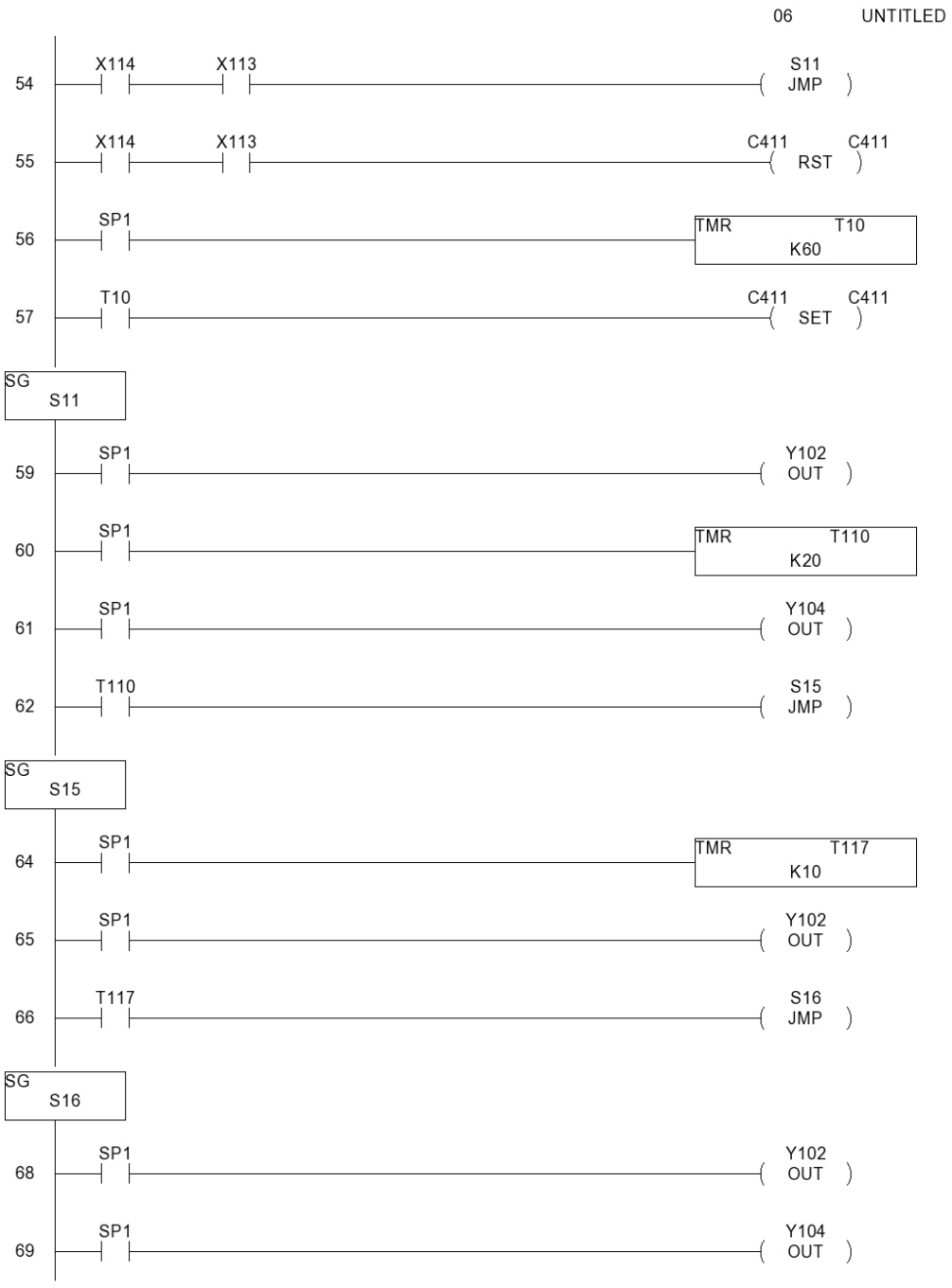
6.1.1 – PLC 1 Logic

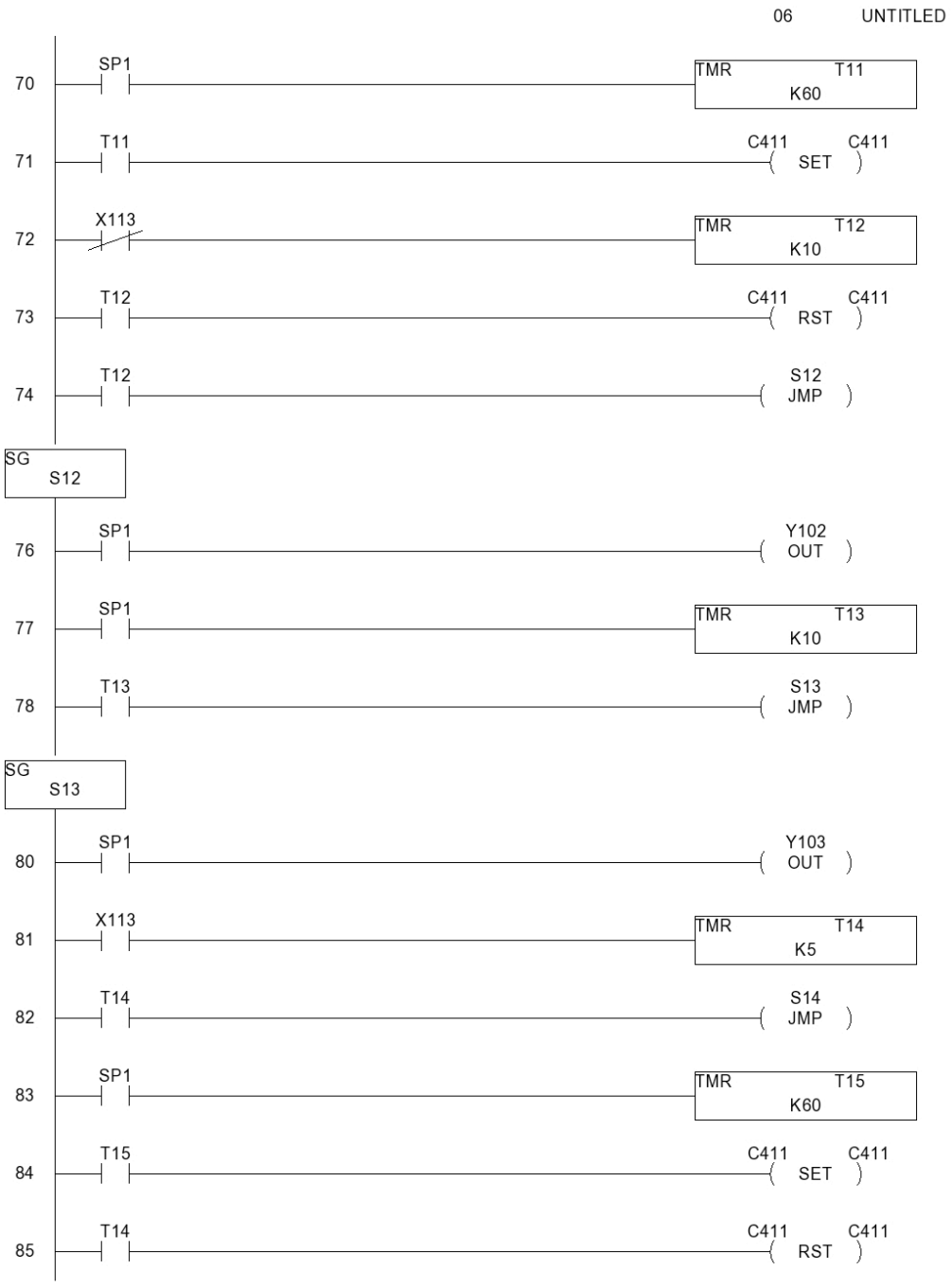

ISG
S600
2
X2
X107
S10
SET
S10
S20
SET
S20
S30
SET
S30
S40
SET
S40
S100
SET
S100
3
X2
X107
X104
S50
SET
S50
4
X2
X107
X105
S60
SET
S60
5
X2
X107
X106
S70
SET
S70
6
X2
X107
S10
SET
S10
S702
SET
S702
S100
SET
S100
C2
SET
C7
SG
S702
8
C701
C3
SET
C7
9
C701
S20
SET
S20
S703
JMP
SG
S703

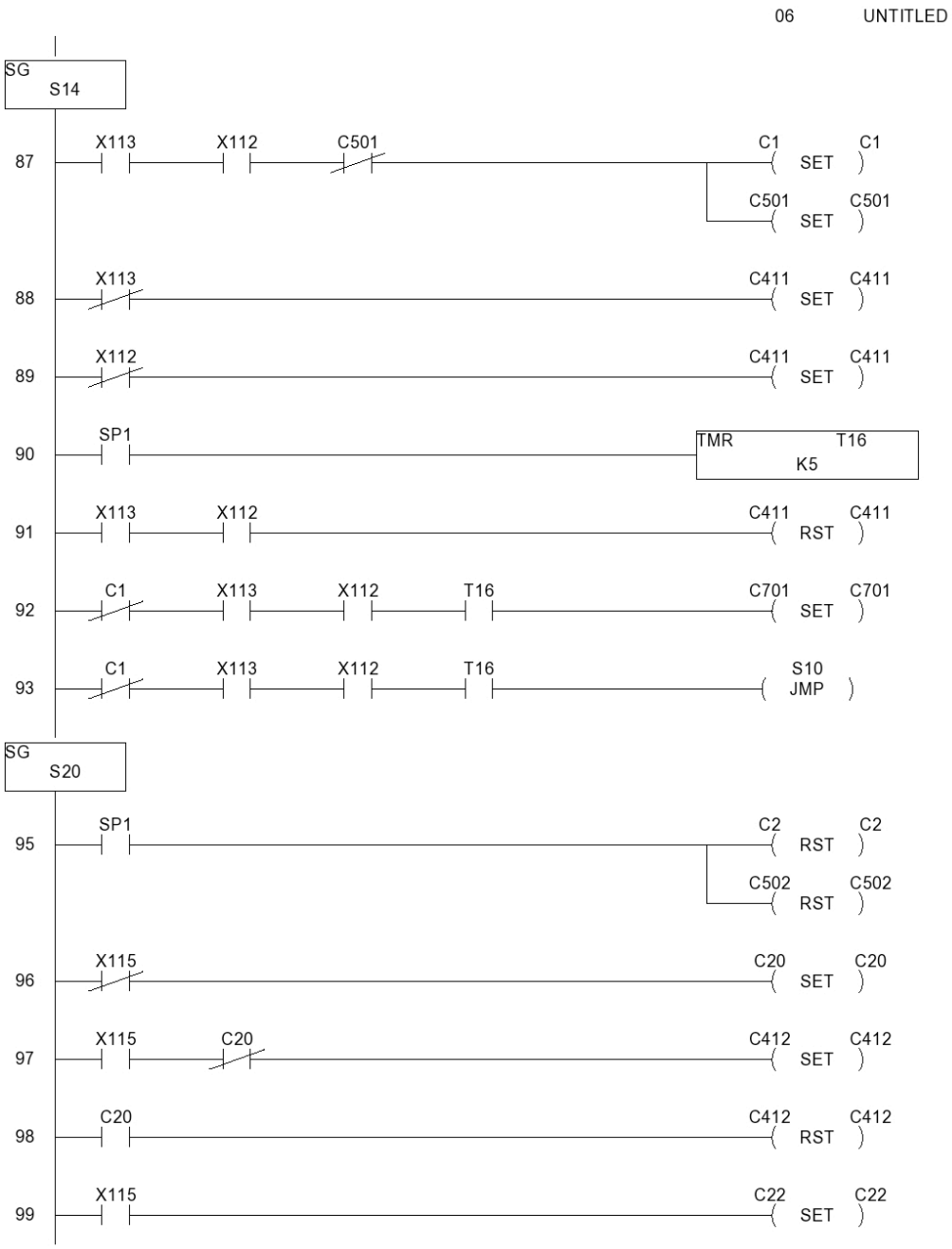

06 UNTITLED
11 C702 C4 SET C7
12 C702 S30 SET S30
S704 JMP
SG S704
14 C703 C5 SET C7
15 C703 S40 SET S40
S705 JMP
SG S705
17 C704 C6 SET C7
18 C704 S50 SET S50
S706 JMP
SG S706
20 C705 C7 SET C7
21 C705 S60 SET S60
S707 JMP
SG S707
23 C706 S70 JMP

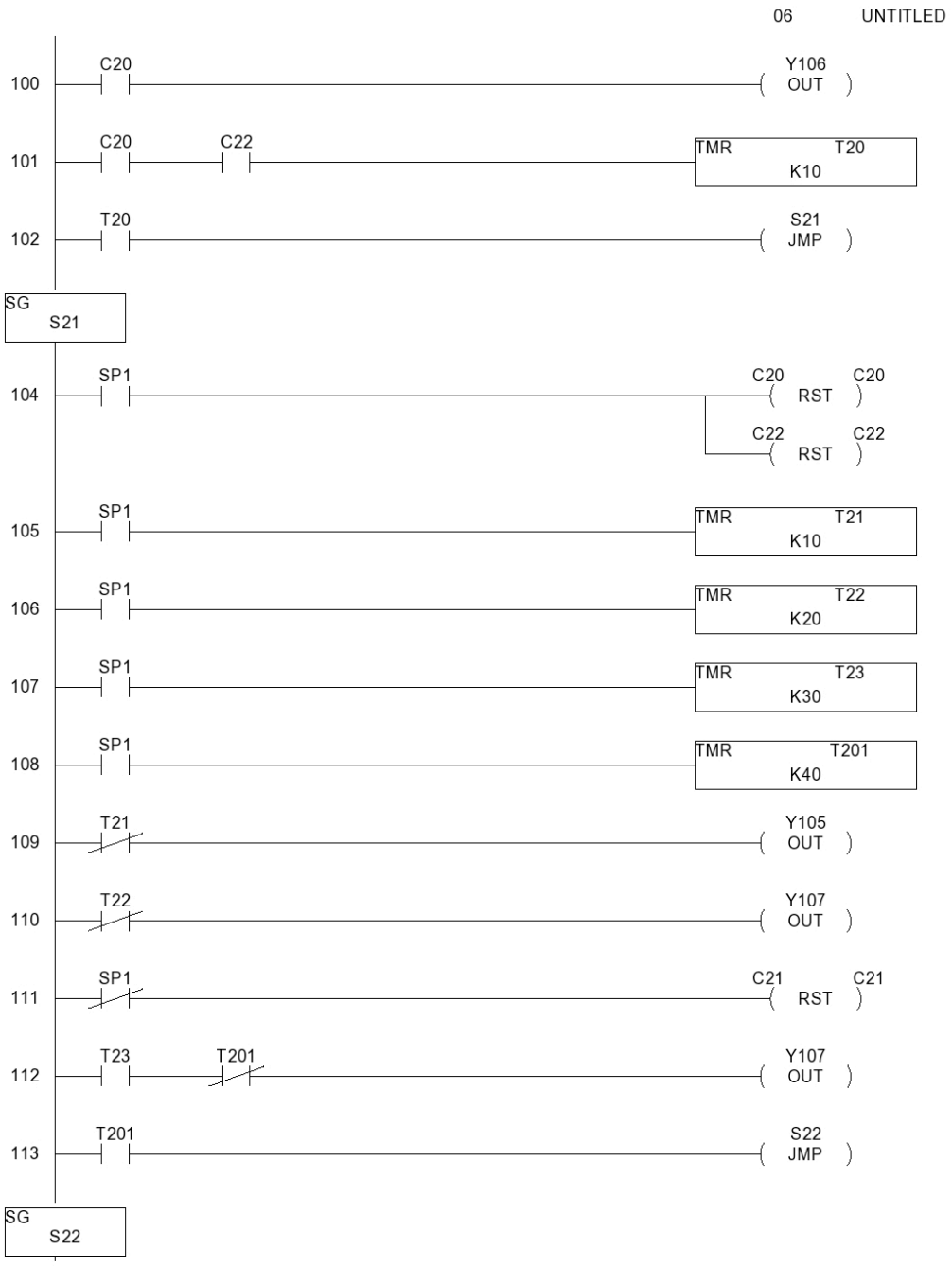

06 UNTITLED
SG
S100
25
SP1
TMR T100
K30
26
C0 C1 C2 C3 C4 C5 C6 A
A
C7 T100 X101
S101
JMP
SG
S101
28
SP1
Y101
OUT
29
C0
S102
JMP
SG
S102
31
C0
TMR T101
K2
32
T101
Y101
OUT
33
C0
TMR T102
K15
34
T102
C1 C7
RST
35
T102
S100
JMP
ISG
S410
37
C410
Y0
OUT
38
C411
Y1
OUT

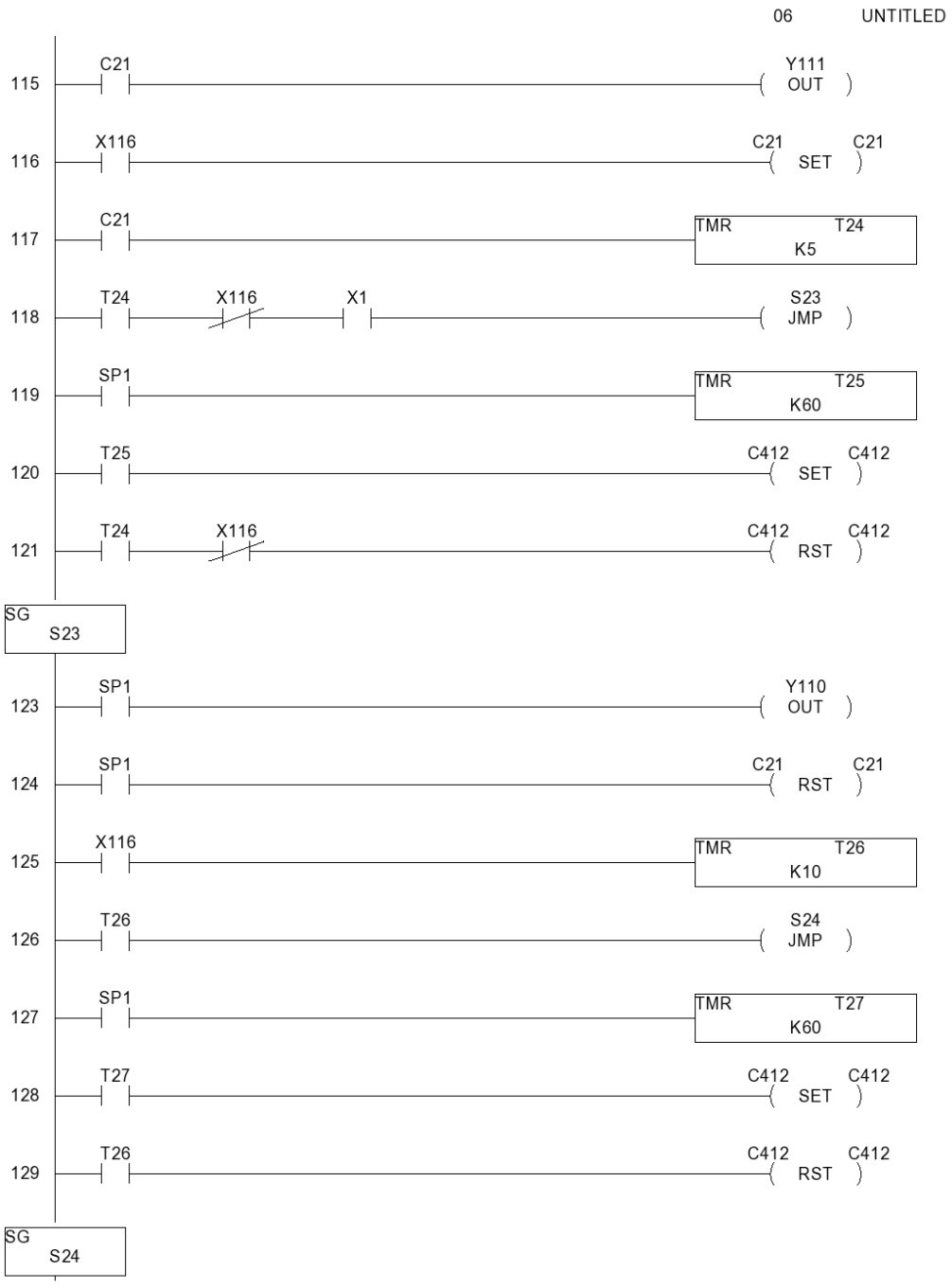

06 UNTITLED
39 C412 Y2 OUT
40 C413 Y3 OUT
41 C414 Y4 OUT
42 C415 Y5 OUT
43 C416 Y6 OUT
44 C417 Y7 OUT
ISG S0
46 X111 C0 SET C0
47 X111 C0 RST C0
48 X110 C410 SET C410
49 X110 C410 RST C410
SG S10
51 SP1 C1 RST C1
C501 RST C501
52 X113 Y102 OUT
53 X113 C411 SET C411

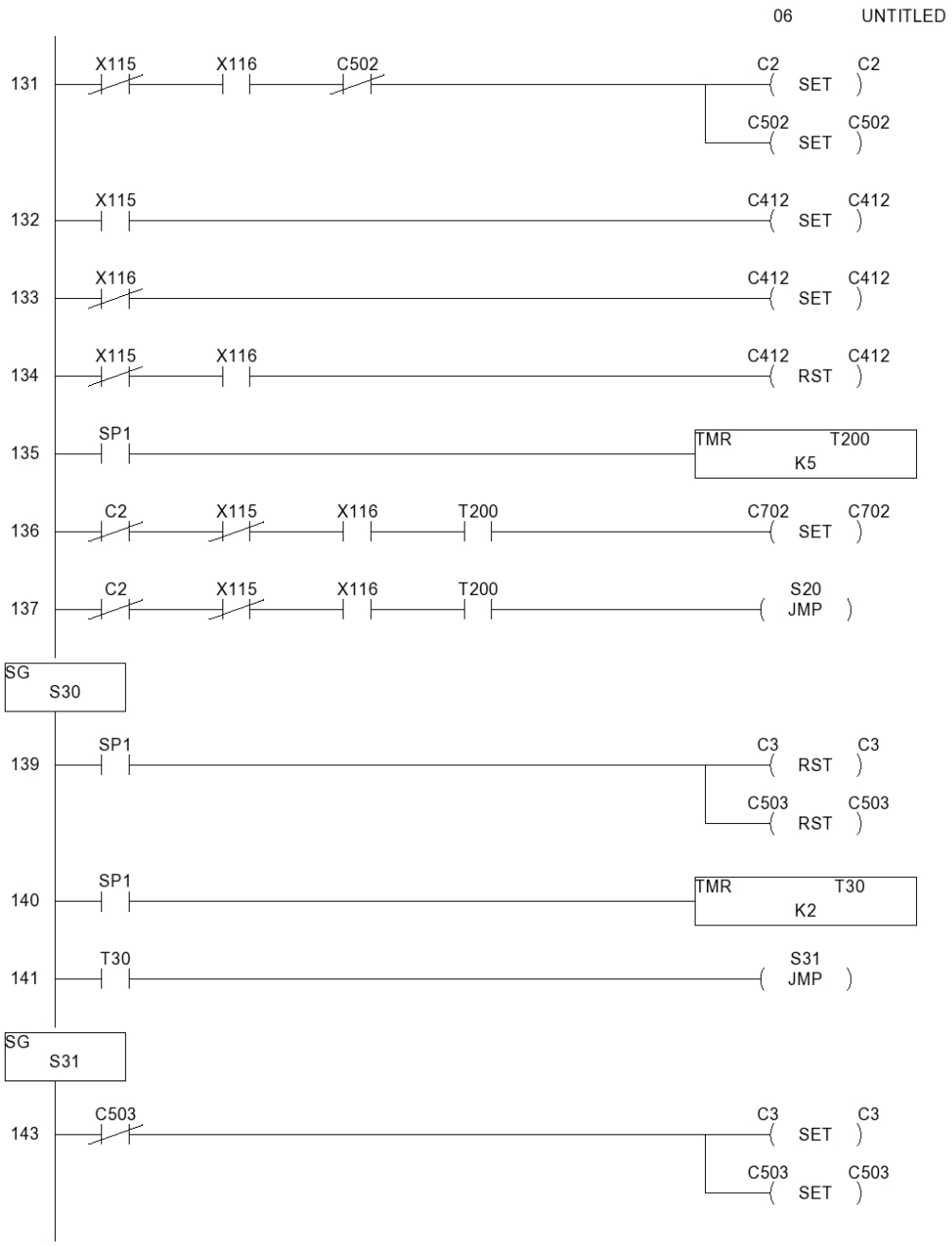

06 UNTITLED
54 X114 X113 S11 JMP
55 X114 X113 C411 RST C411
56 SP1 TMR T10 K60
57 T10 C411 SET C411
SG S11
59 SP1 Y102 OUT
60 SP1 TMR T110 K20
61 SP1 Y104 OUT
62 T110 S15 JMP
SG S15
64 SP1 TMR T117 K10
65 SP1 Y102 OUT
66 T117 S16 JMP
SG S16
68 SP1 Y102 OUT
69 SP1 Y104 OUT

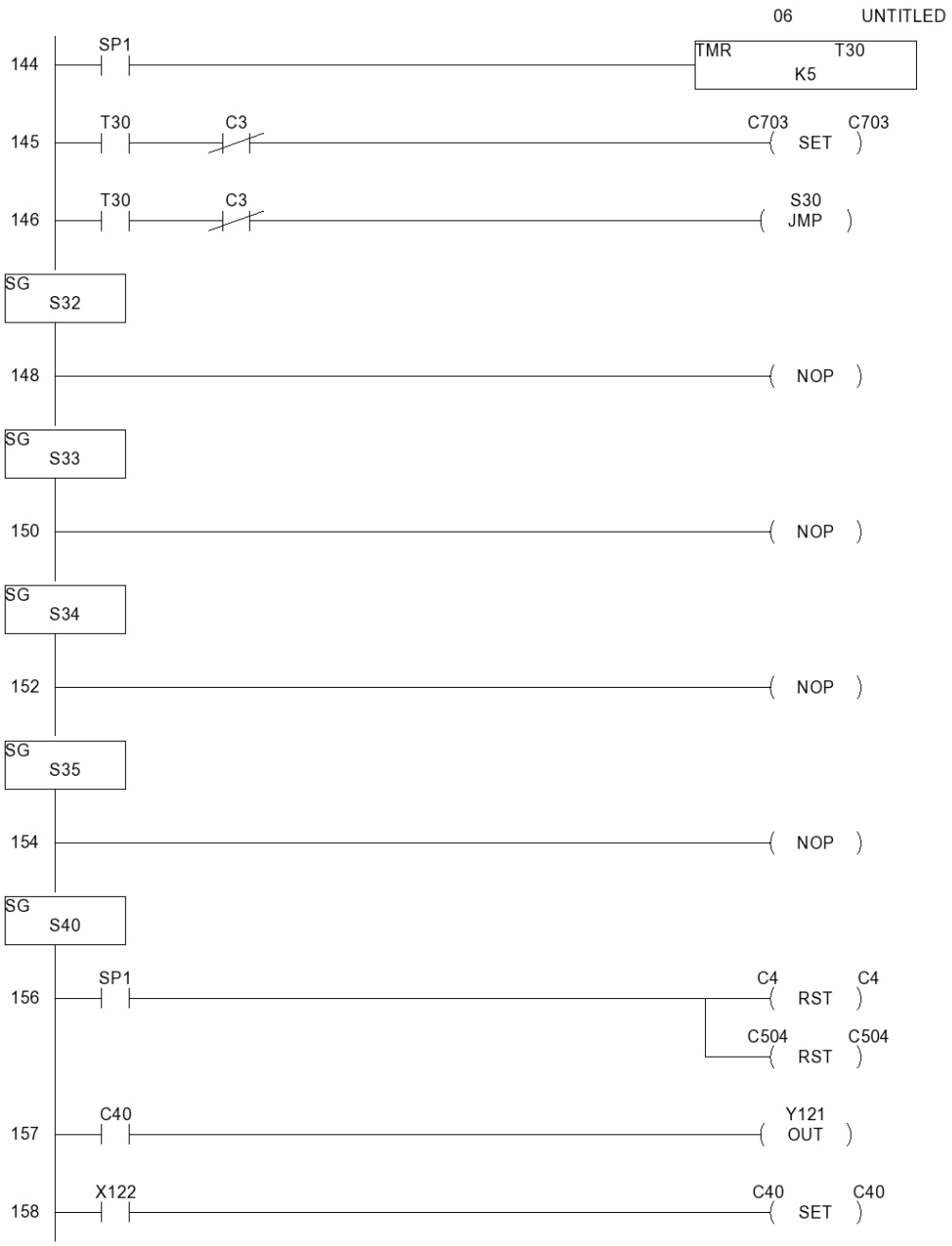

06 UNTITLED
70 SP1 TMR T11 K60
71 T11 C411 SET C411
72 X113 TMR T12 K10
73 T12 C411 RST C411
74 T12 S12 JMP
SG S12
76 SP1 Y102 OUT
77 SP1 TMR T13 K10
78 T13 S13 JMP
SG S13
80 SP1 Y103 OUT
81 X113 TMR T14 K5
82 T14 S14 JMP
83 SP1 TMR T15 K60
84 T15 C411 SET C411
85 T14 C411 RST C411

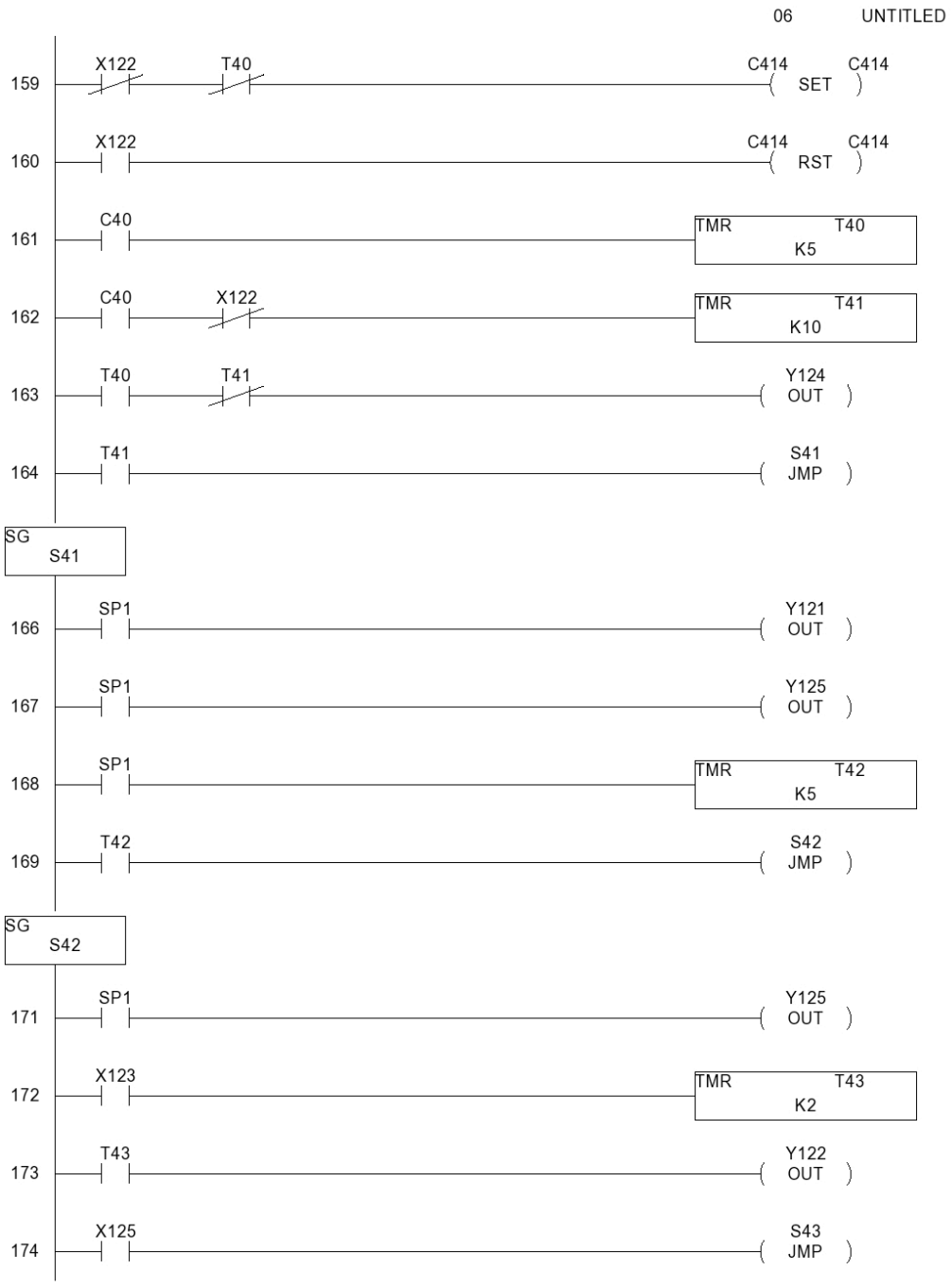

06 UNTITLED
SG
S14
87
X113
X112
C501
C1
SET
C1
C501
SET
C501
88
X113
C411
SET
C411
89
X112
C411
SET
C411
90
SP1
TMR
T16
K5
91
X113
X112
C411
RST
C411
92
C1
X113
X112
T16
C701
SET
C701
93
C1
X113
X112
T16
S10
JMP
SG
S20
95
SP1
C2
RST
C2
C502
RST
C502
96
X115
C20
SET
C20
97
X115
C20
C412
SET
C412
98
C20
C412
RST
C412
99
X115
C22
SET
C22

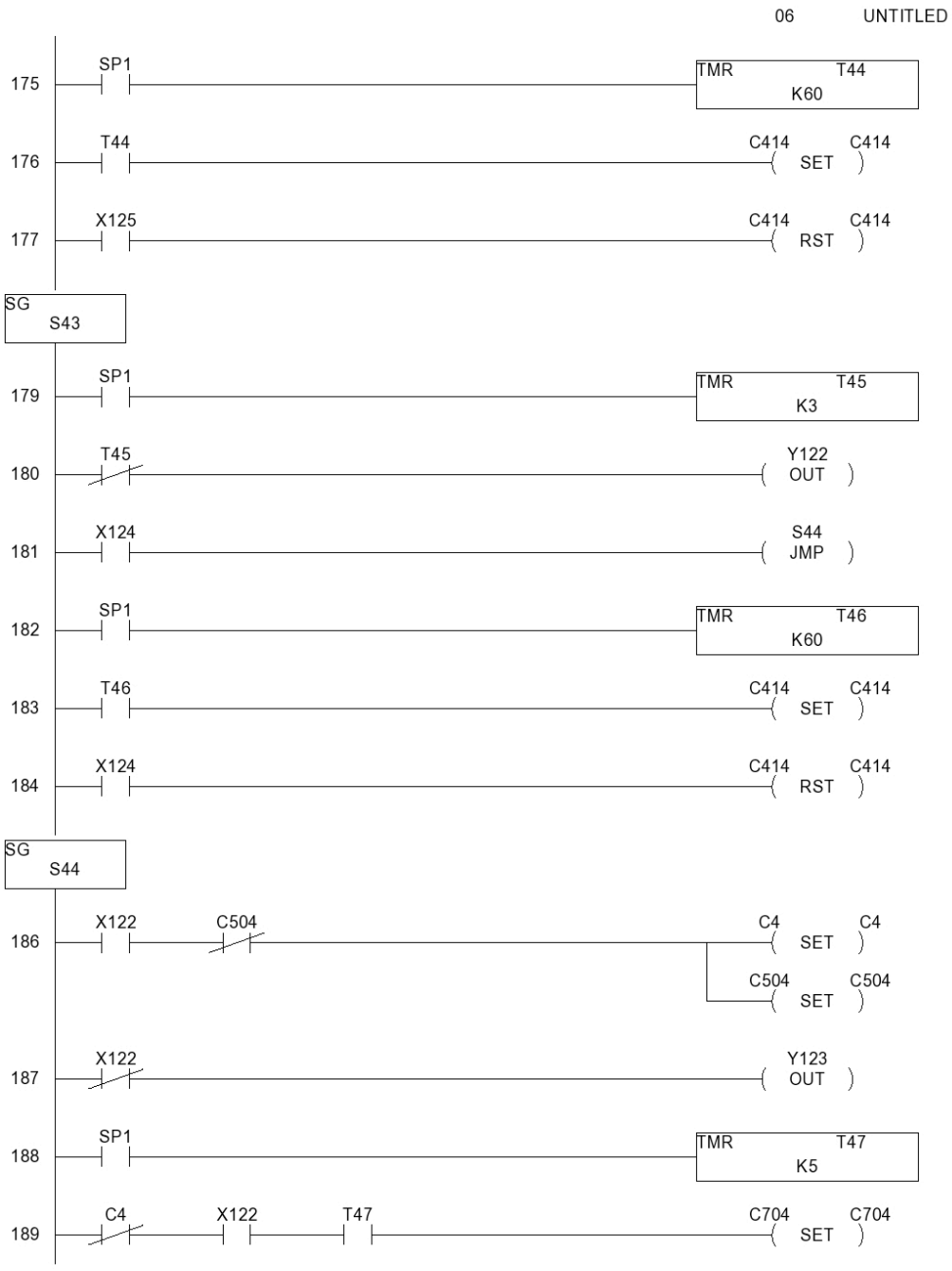

06 UNTITLED
100 C20 Y106 OUT
101 C20 C22 TMR T20 K10
102 T20 S21 JMP
SG S21
104 SP1 C20 C20 RST
C22 C22 RST
105 SP1 TMR T21 K10
106 SP1 TMR T22 K20
107 SP1 TMR T23 K30
108 SP1 TMR T201 K40
109 T21 Y105 OUT
110 T22 Y107 OUT
111 SP1 C21 C21 RST
112 T23 T201 Y107 OUT
113 T201 S22 JMP
SG S22

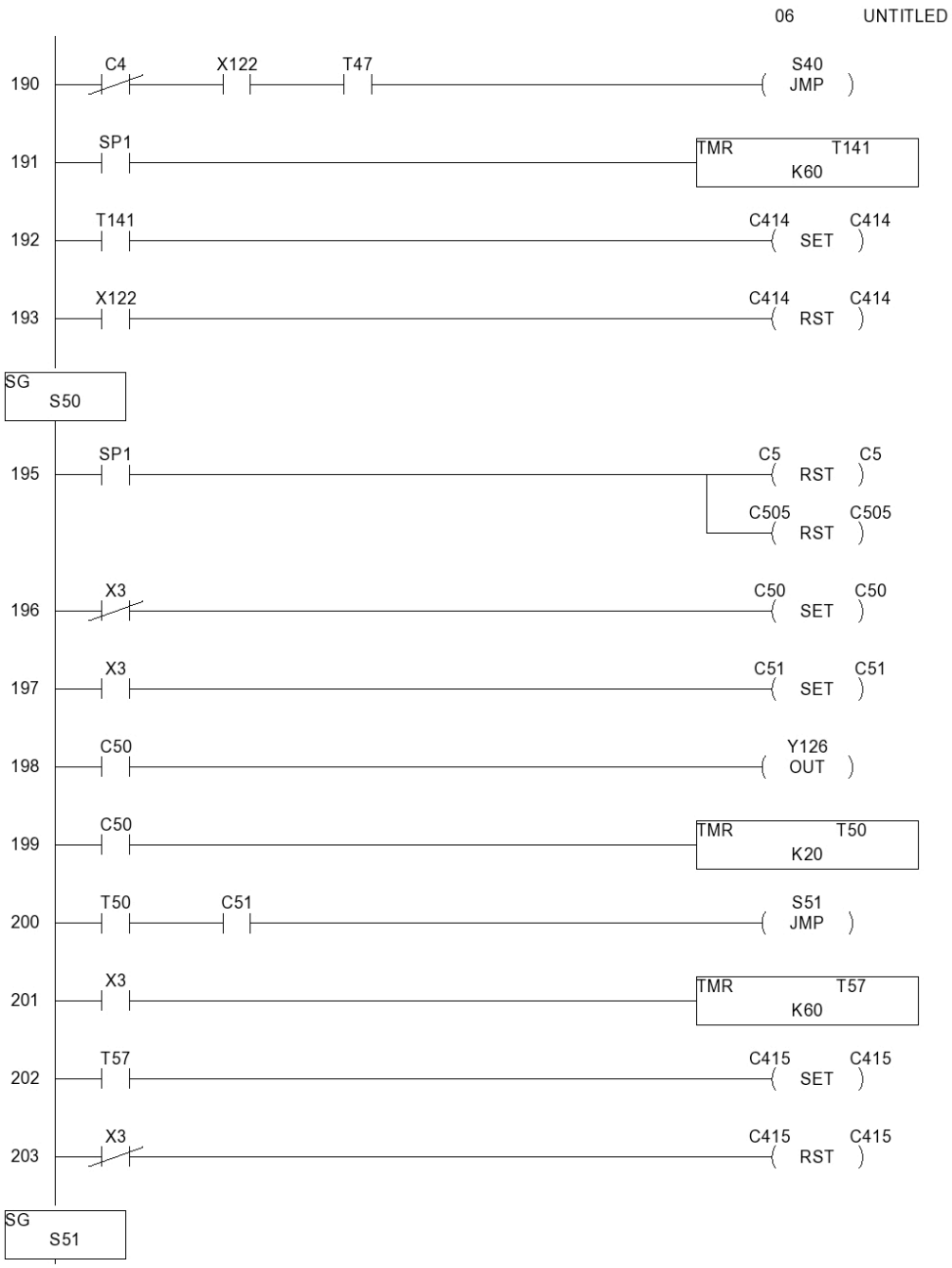

06 UNTITLED
115 C21 Y111 OUT
116 X116 C21 SET C21
117 C21 TMR T24 K5
118 T24 X116 X1 S23 JMP
119 SP1 TMR T25 K60
120 T25 C412 SET C412
121 T24 X116 C412 RST C412
SG S23
123 SP1 Y110 OUT
124 SP1 C21 RST C21
125 X116 TMR T26 K10
126 T26 S24 JMP
127 SP1 TMR T27 K60
128 T27 C412 SET C412
129 T26 C412 RST C412
SG S24

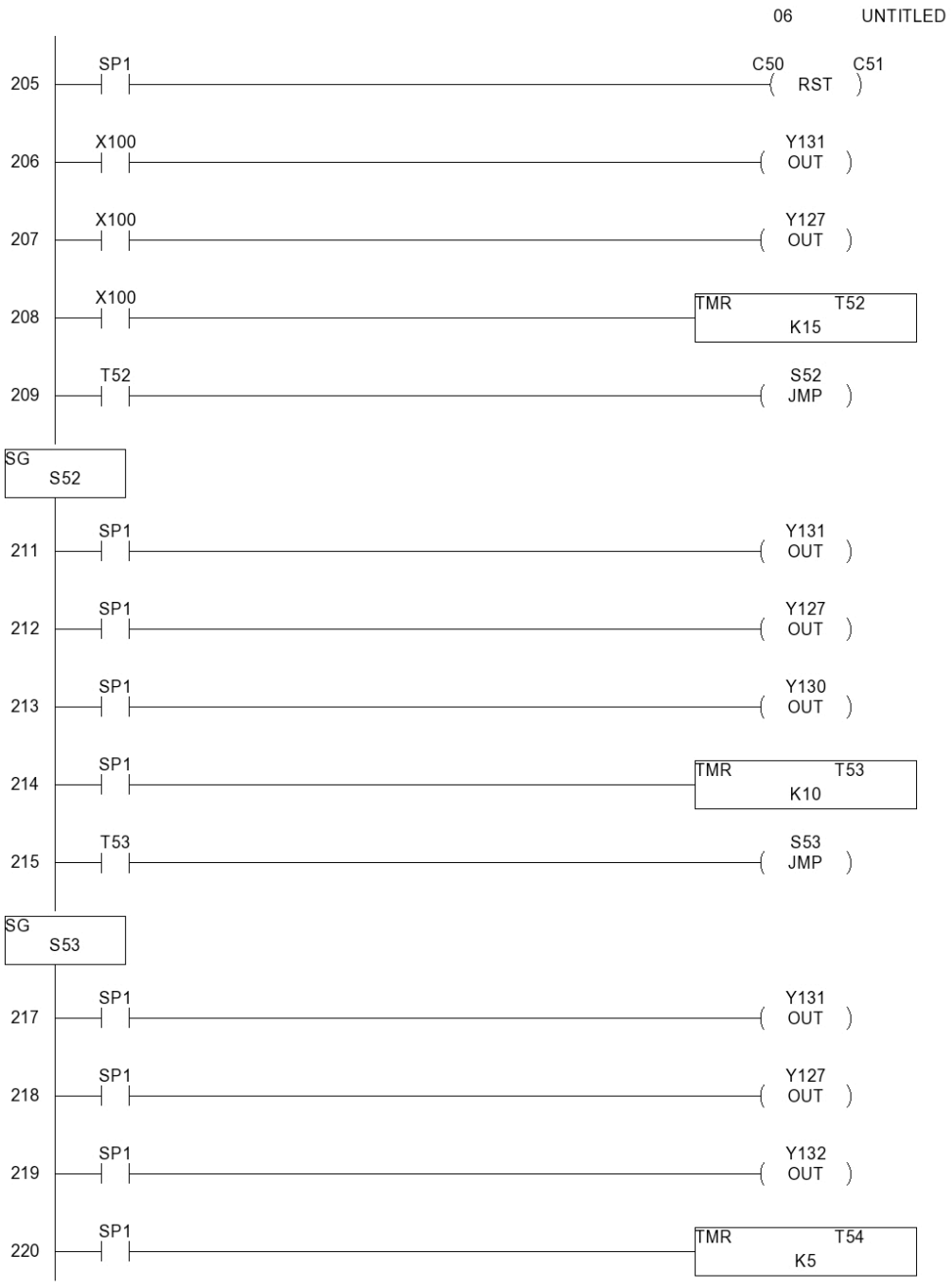

06 UNTITLED
131 X115 X116 C502 C2 SET C2
C502 SET C502
132 X115 C412 SET C412
133 X116 C412 SET C412
134 X115 X116 C412 RST C412
135 SP1 TMR T200 K5
136 C2 X115 X116 T200 C702 SET C702
137 C2 X115 X116 T200 S20 JMP
SG S30
139 SP1 C3 RST C3
C503 RST C503
140 SP1 TMR T30 K2
141 T30 S31 JMP
SG S31
143 C503 C3 SET C3
C503 SET C503

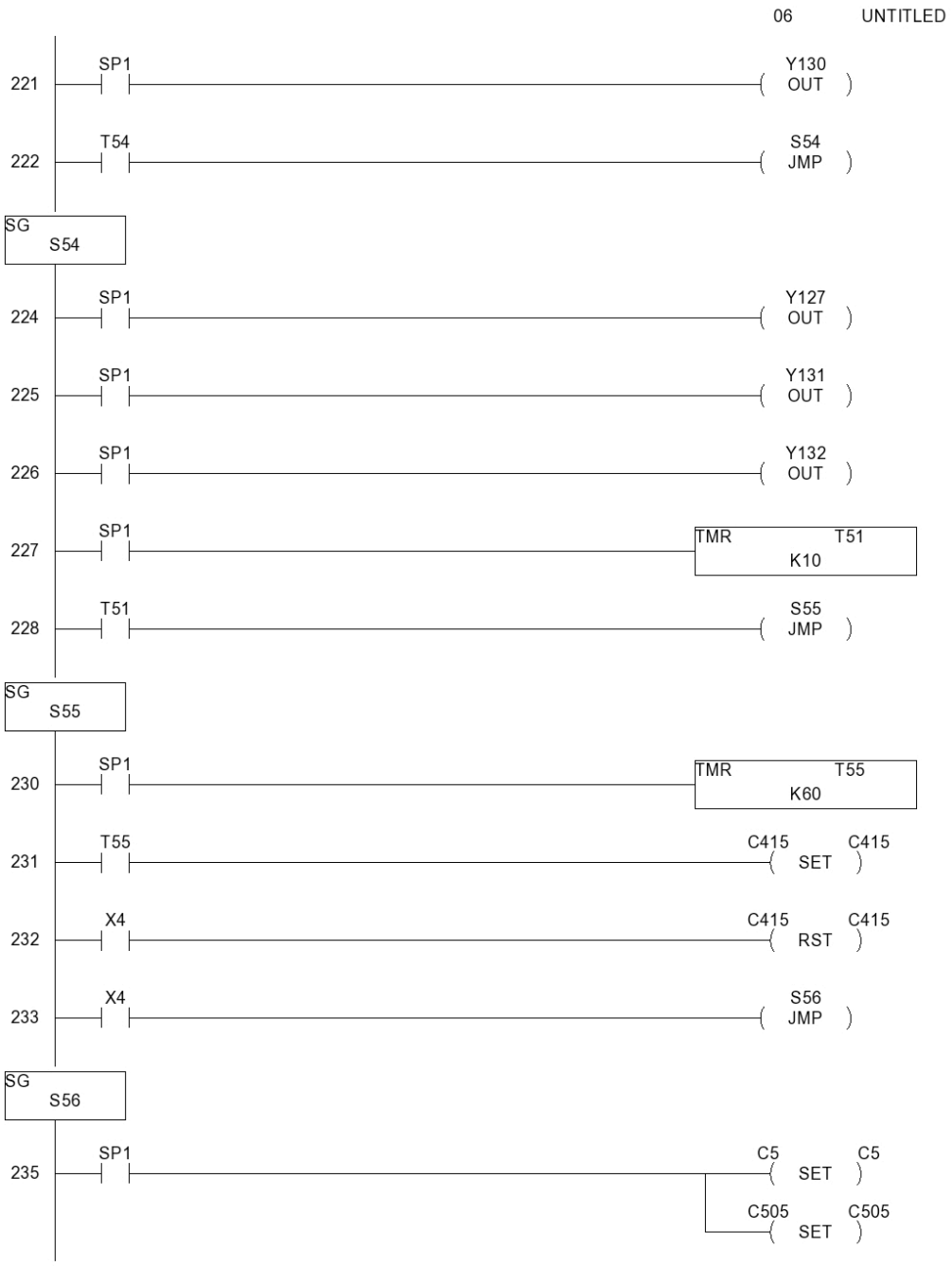

06 UNTITLED
144 SP1
TMR T30
K5
145 T30 C3
C703 C703
SET
146 T30 C3
S30
JMP
SG
S32
148
NOP
SG
S33
150
NOP
SG
S34
152
NOP
SG
S35
154
NOP
SG
S40
156 SP1
C4 C4
RST
C504 C504
RST
157 C40
Y121
OUT
158 X122
C40 C40
SET

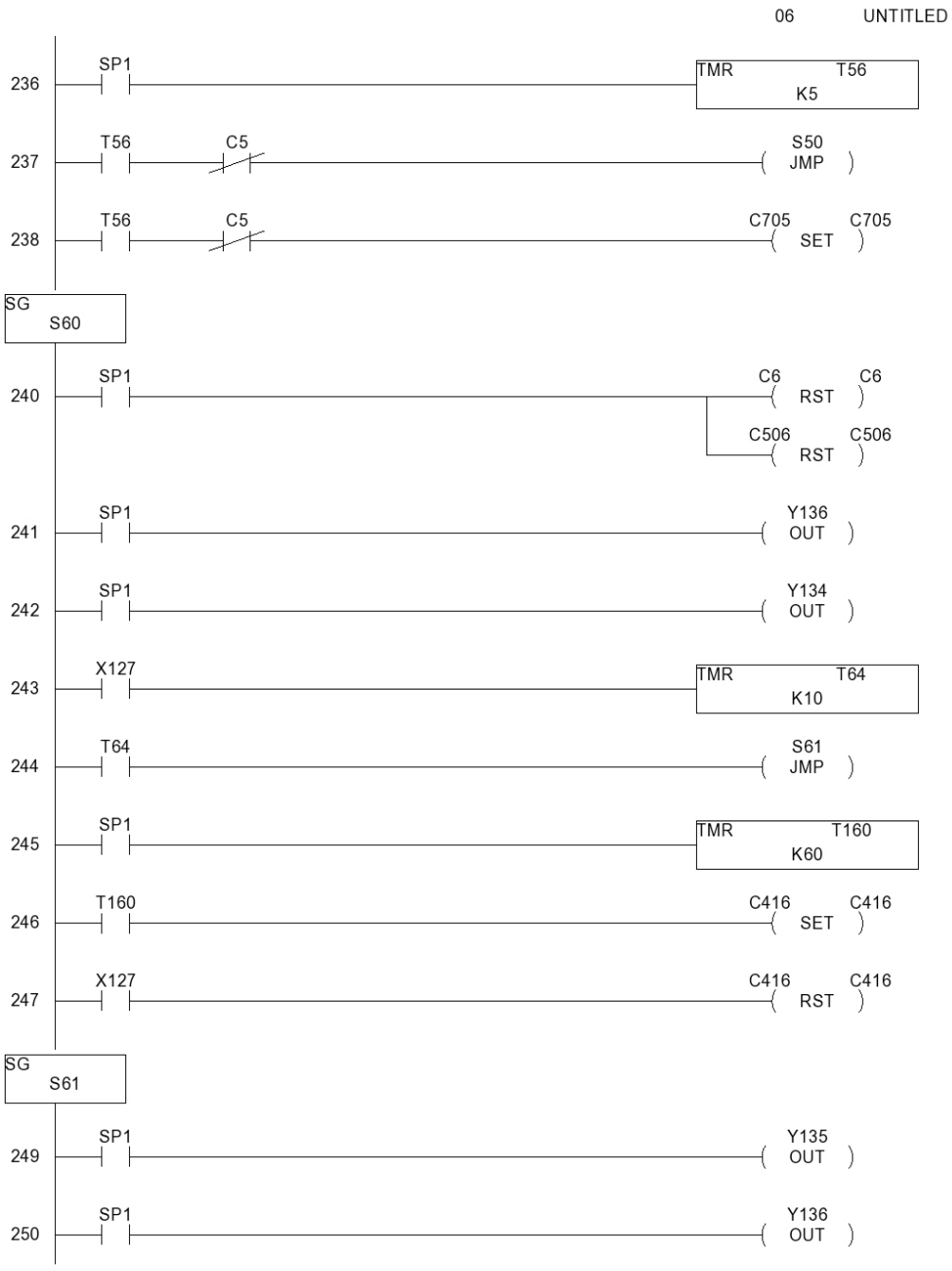

06 UNTITLED
159 X122 T40 C414 SET C414
160 X122 C414 RST C414
161 C40 TMR T40 K5
162 C40 X122 TMR T41 K10
163 T40 T41 Y124 OUT
164 T41 S41 JMP
SG S41
166 SP1 Y121 OUT
167 SP1 Y125 OUT
168 SP1 TMR T42 K5
169 T42 S42 JMP
SG S42
171 SP1 Y125 OUT
172 X123 TMR T43 K2
173 T43 Y122 OUT
174 X125 S43 JMP

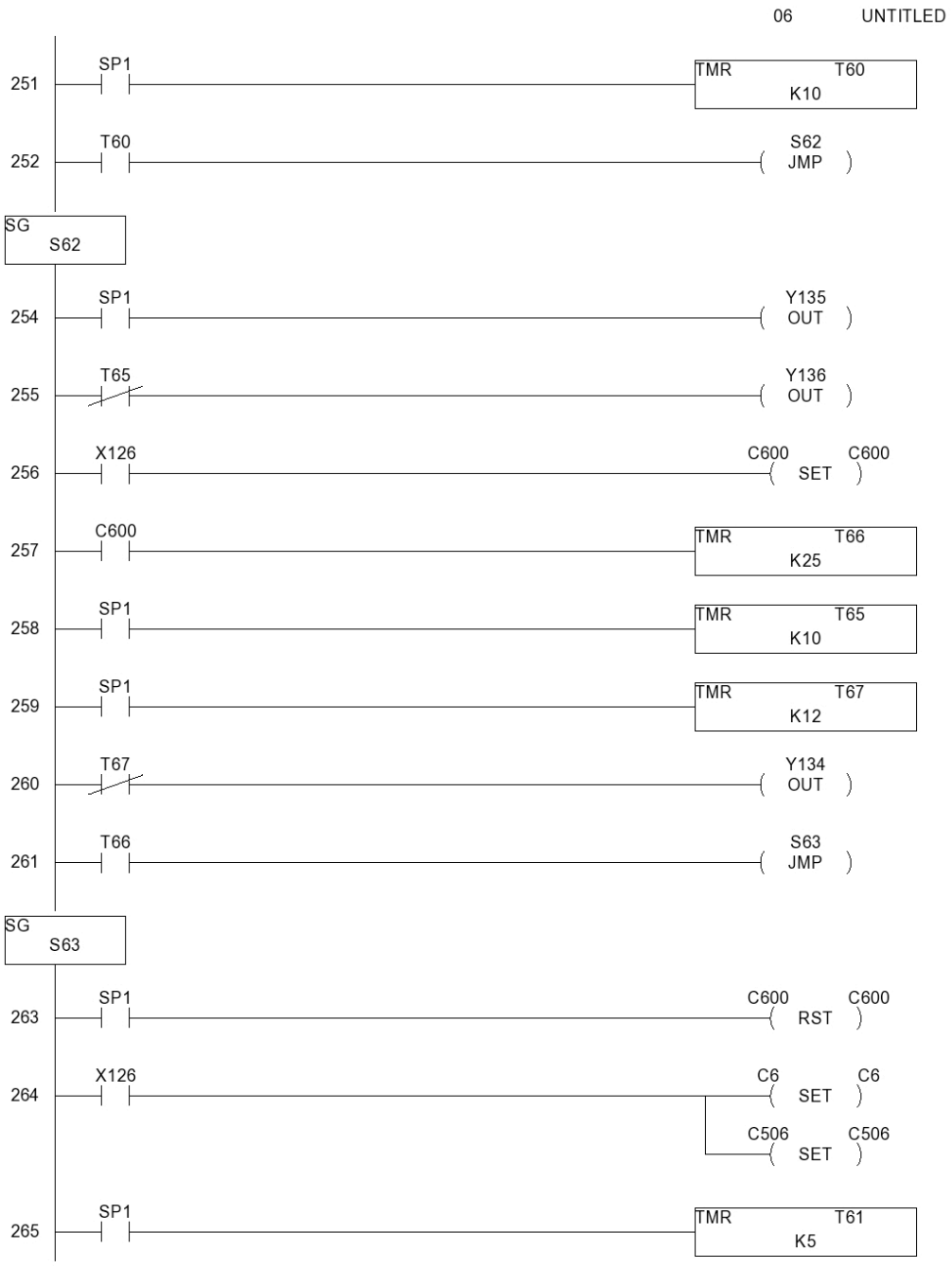

06 UNTITLED
175 SP1 TMR T44 K60
176 T44 C414 SET C414
177 X125 C414 RST C414
SG S43
179 SP1 TMR T45 K3
180 T45 Y122 OUT
181 X124 S44 JMP
182 SP1 TMR T46 K60
183 T46 C414 SET C414
184 X124 C414 RST C414
SG S44
186 X122 C504 C4 SET C4
C504 SET C504
187 X122 Y123 OUT
188 SP1 TMR T47 K5
189 C4 X122 T47 C704 SET C704

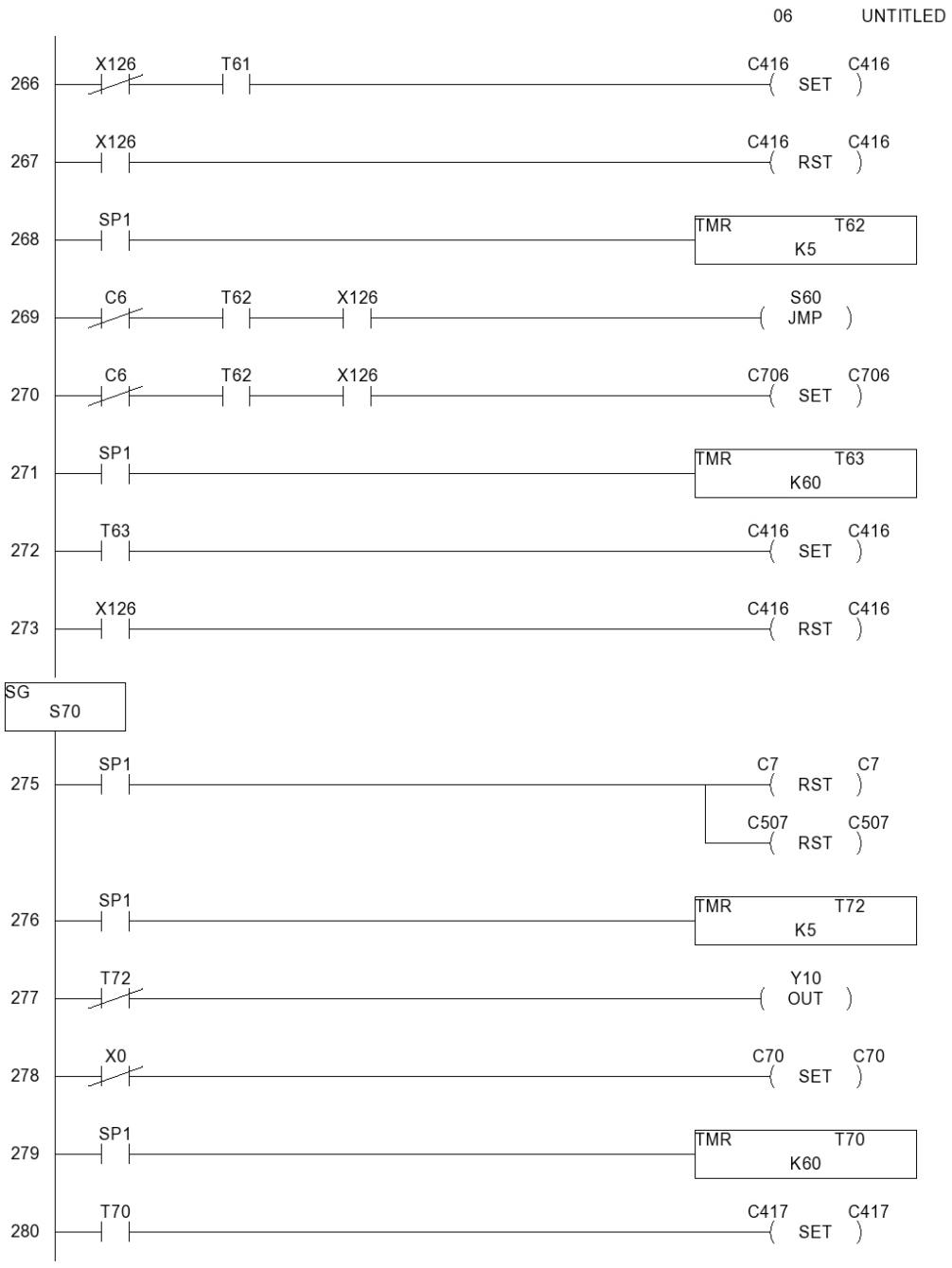

06 UNTITLED
190 C4 X122 T47 S40 JMP
191 SP1 TMR T141 K60
192 T141 C414 SET C414
193 X122 C414 RST C414
SG S50
195 SP1 C5 RST C5
C505 RST C505
196 X3 C50 SET C50
197 X3 C51 SET C51
198 C50 Y126 OUT
199 C50 TMR T50 K20
200 T50 C51 S51 JMP
201 X3 TMR T57 K60
202 T57 C415 SET C415
203 X3 C415 RST C415
SG S51

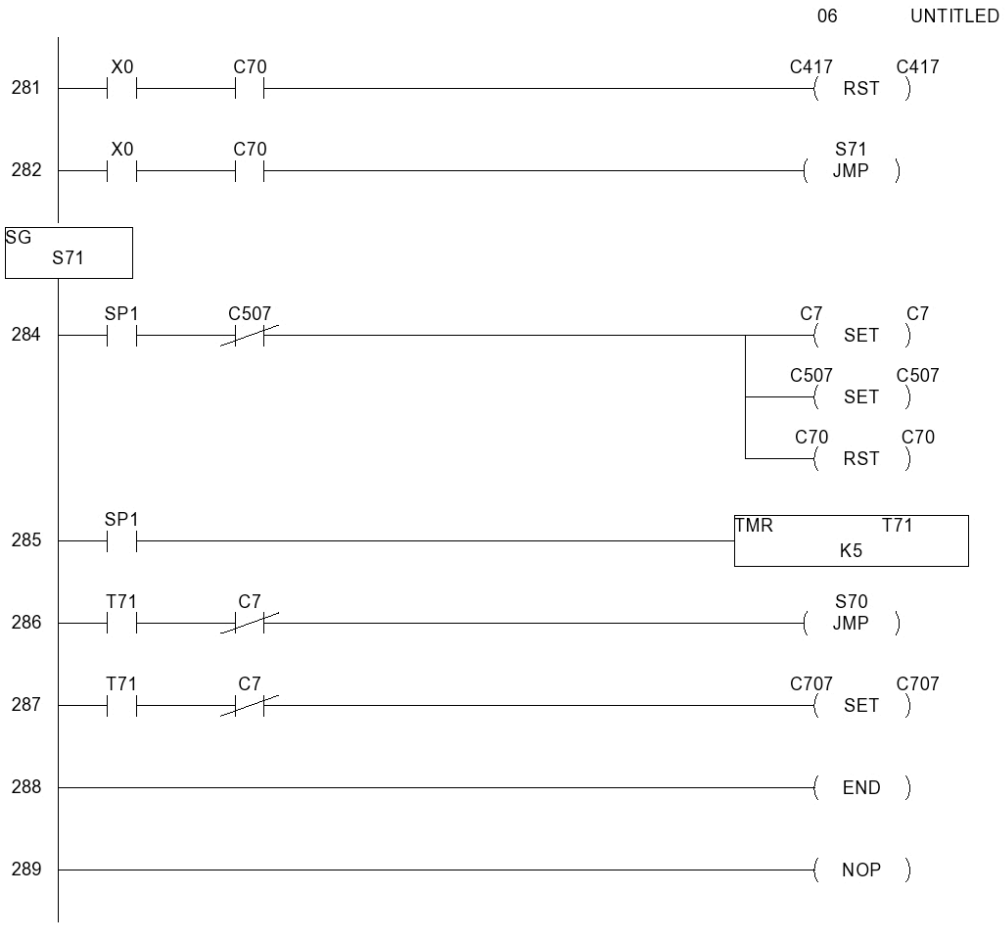

06 UNTITLED
205 SP1 C50 C51 RST
206 X100 Y131 OUT
207 X100 Y127 OUT
208 X100 TMR T52 K15
209 T52 S52 JMP
SG S52
211 SP1 Y131 OUT
212 SP1 Y127 OUT
213 SP1 Y130 OUT
214 SP1 TMR T53 K10
215 T53 S53 JMP
SG S53
217 SP1 Y131 OUT
218 SP1 Y127 OUT
219 SP1 Y132 OUT
220 SP1 TMR T54 K5


06 UNTITLED
221 SP1 Y130 OUT
222 T54 S54 JMP
SG S54
224 SP1 Y127 OUT
225 SP1 Y131 OUT
226 SP1 Y132 OUT
227 SP1 TMR T51 K10
228 T51 S55 JMP
SG S55
230 SP1 TMR T55 K60
231 T55 C415 SET C415
232 X4 C415 RST C415
233 X4 S56 JMP
SG S56
235 SP1 C5 SET C5
C505 SET C505

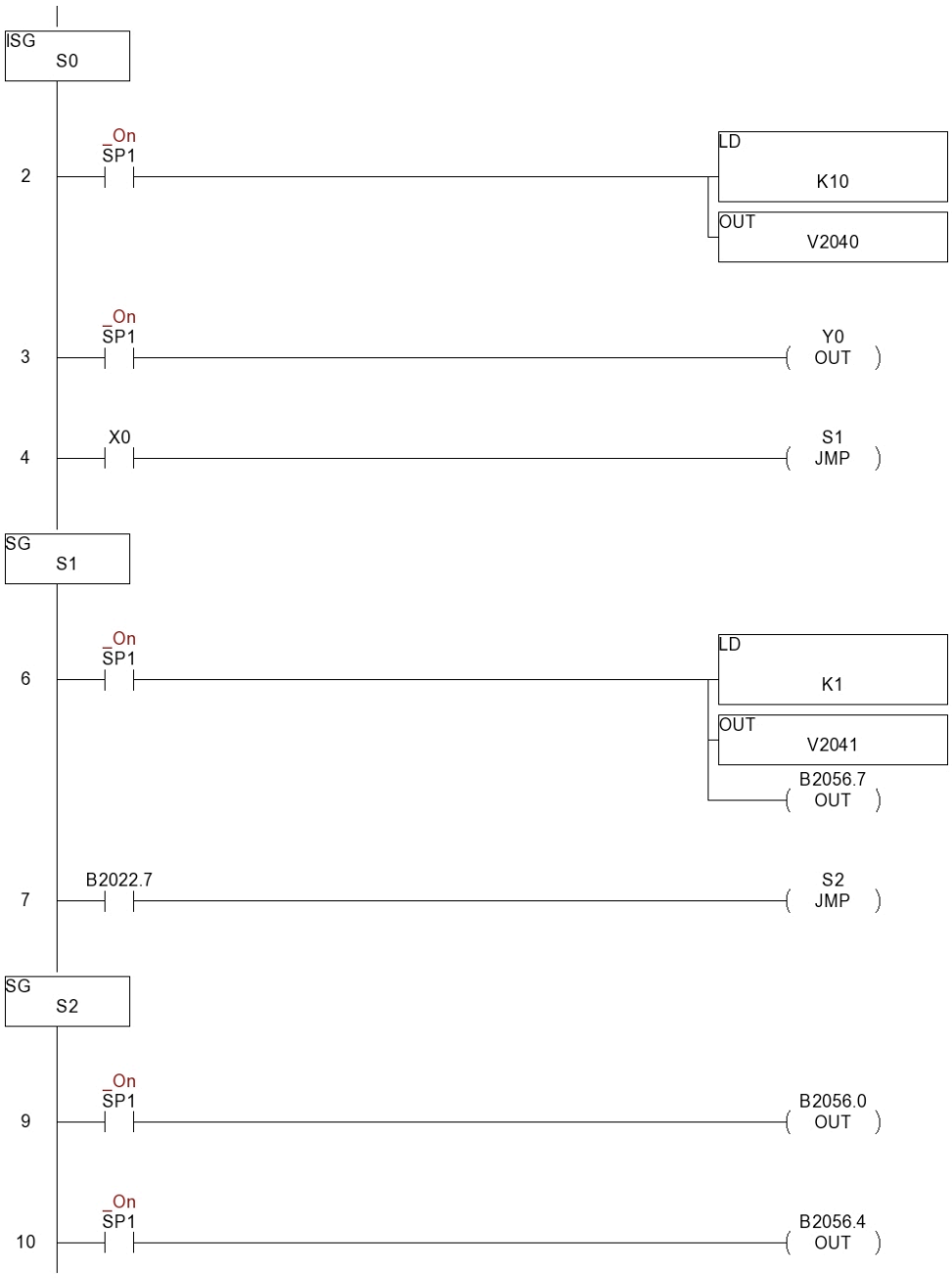

06 UNTITLED
236 SP1 TMR T56 K5
237 T56 C5 S50 JMP
238 T56 C5 C705 SET C705
SG S60
240 SP1 C6 RST C6
C506 RST C506
241 SP1 Y136 OUT
242 SP1 Y134 OUT
243 X127 TMR T64 K10
244 T64 S61 JMP
245 SP1 TMR T160 K60
246 T160 C416 SET C416
247 X127 C416 RST C416
SG S61
249 SP1 Y135 OUT
250 SP1 Y136 OUT

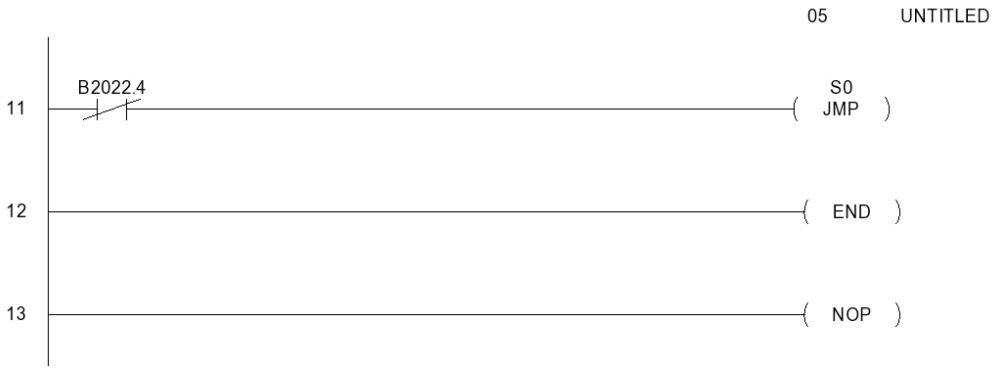

06 UNTITLED
251 SP1 TMR T60 K10
252 T60 S62 JMP
SG S62
254 SP1 Y135 OUT
255 T65 Y136 OUT
256 X126 C600 C600 SET
257 C600 TMR T66 K25
258 SP1 TMR T65 K10
259 SP1 TMR T67 K12
260 T67 Y134 OUT
261 T66 S63 JMP
SG S63
263 SP1 C600 C600 RST
264 X126 C6 C6 SET
C506 C506 SET
265 SP1 TMR T61 K5


06 UNTITLED
266 X126 T61 C416 SET C416
267 X126 C416 RST C416
268 SP1 TMR T62 K5
269 C6 T62 X126 S60 JMP
270 C6 T62 X126 C706 SET C706
271 SP1 TMR T63 K60
272 T63 C416 SET C416
273 X126 C416 RST C416
SG S70
275 SP1 C7 RST C7
C507 RST C507
276 SP1 TMR T72 K5
277 T72 Y10 OUT
278 X0 C70 SET C70
279 SP1 TMR T70 K60
280 T70 C417 SET C417

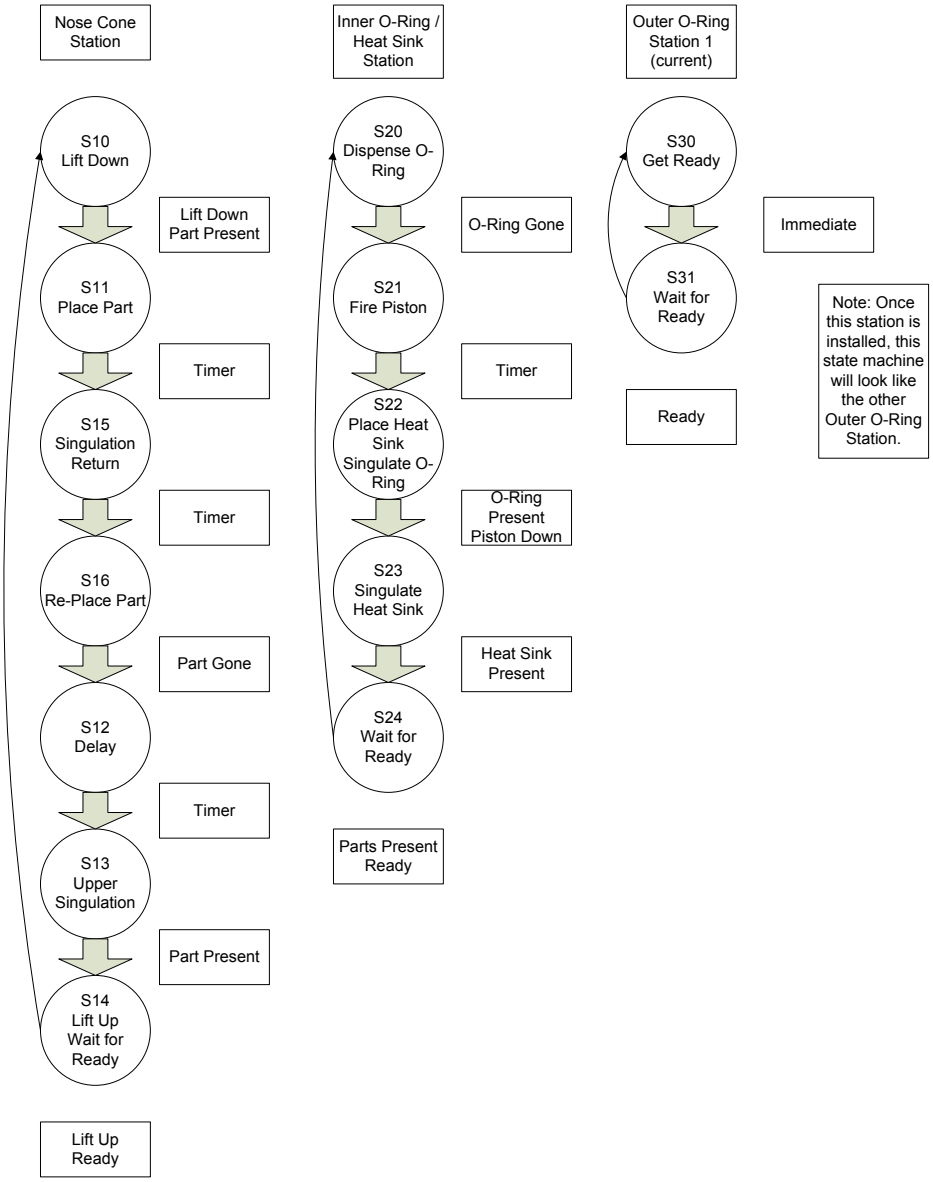

06 UNTITLED
281 X0 C70 C417 C417 RST
282 X0 C70 S71 JMP
SG S71
284 SP1 C507 C7 C7 SET
C507 C507 SET
C70 C70 RST
285 SP1 TMR T71 K5
286 T71 C7 S70 JMP
287 T71 C7 C707 C707 SET
288 END
289 NOP

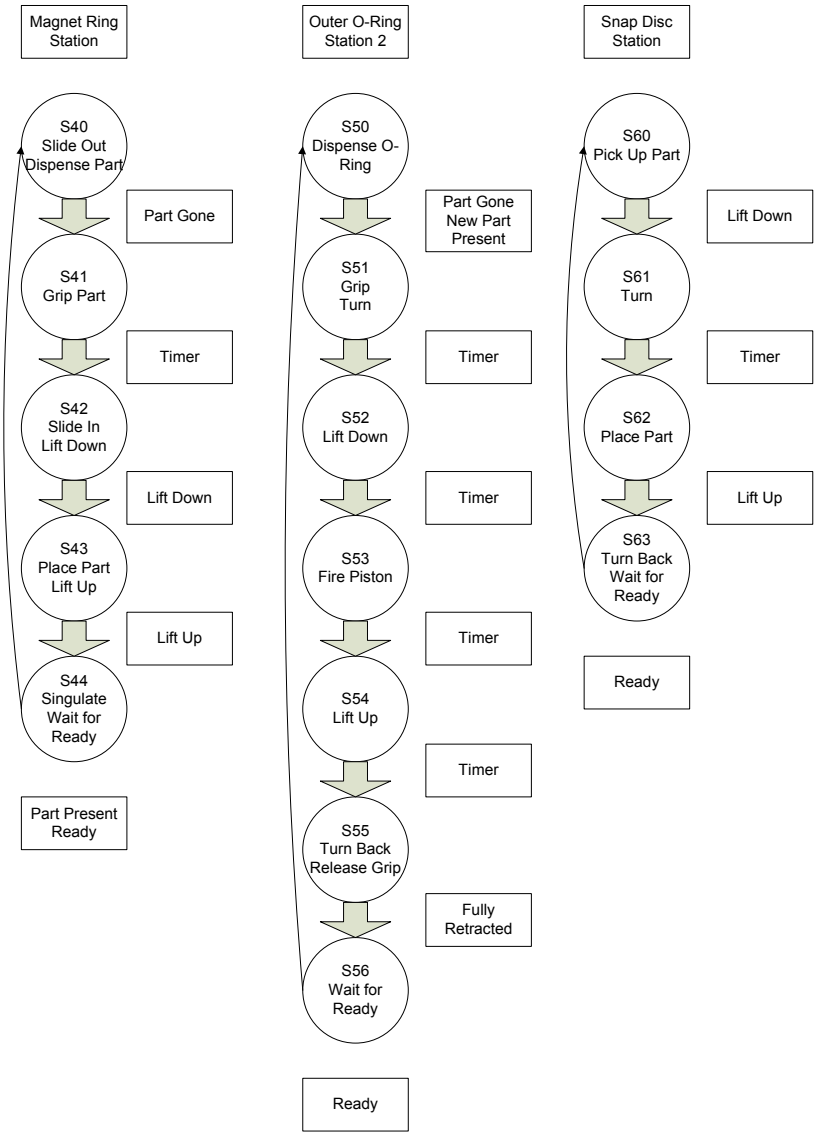
6.1.2 – PLC 2 Logic

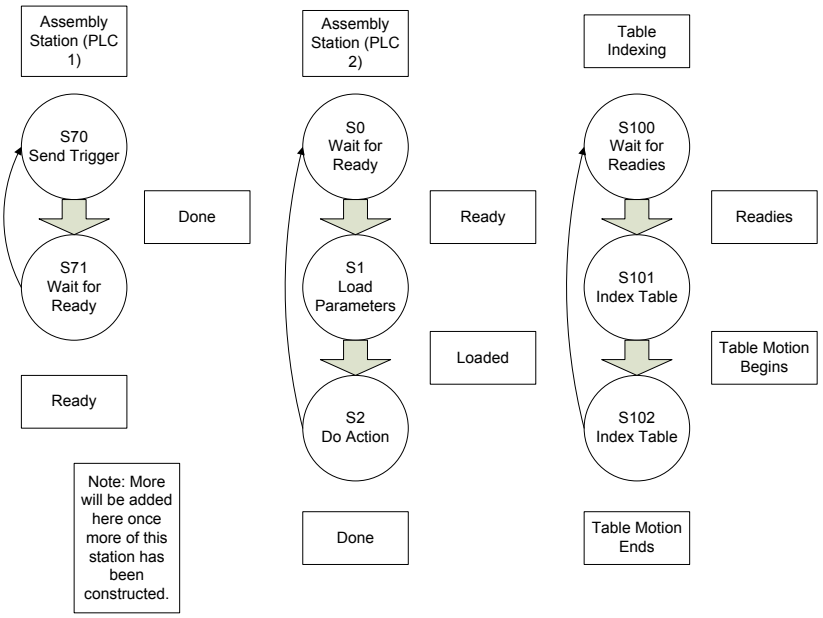

ISG
S0
2
_On
SP1
LD
K10
OUT
V2040
3
_On
SP1
Y0
OUT
4
X0
S1
JMP
SG
S1
6
_On
SP1
LD
K1
OUT
V2041
B2056.7
OUT
7
B2022.7
S2
JMP
SG
S2
9
_On
SP1
B2056.0
OUT
10
_On
SP1
B2056.4
OUT


05
UNTITLED
11
B2022.4
S0
JMP
12
END
13
NOP

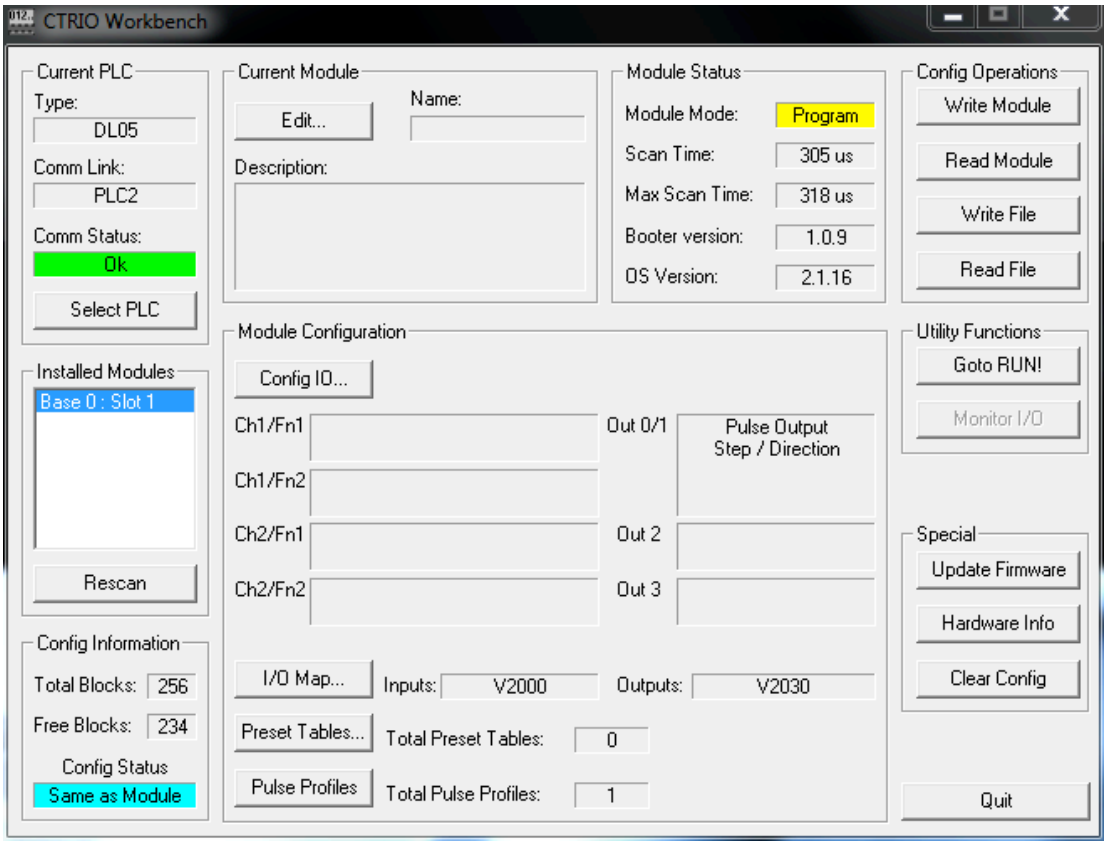
6.2 – State Diagrams

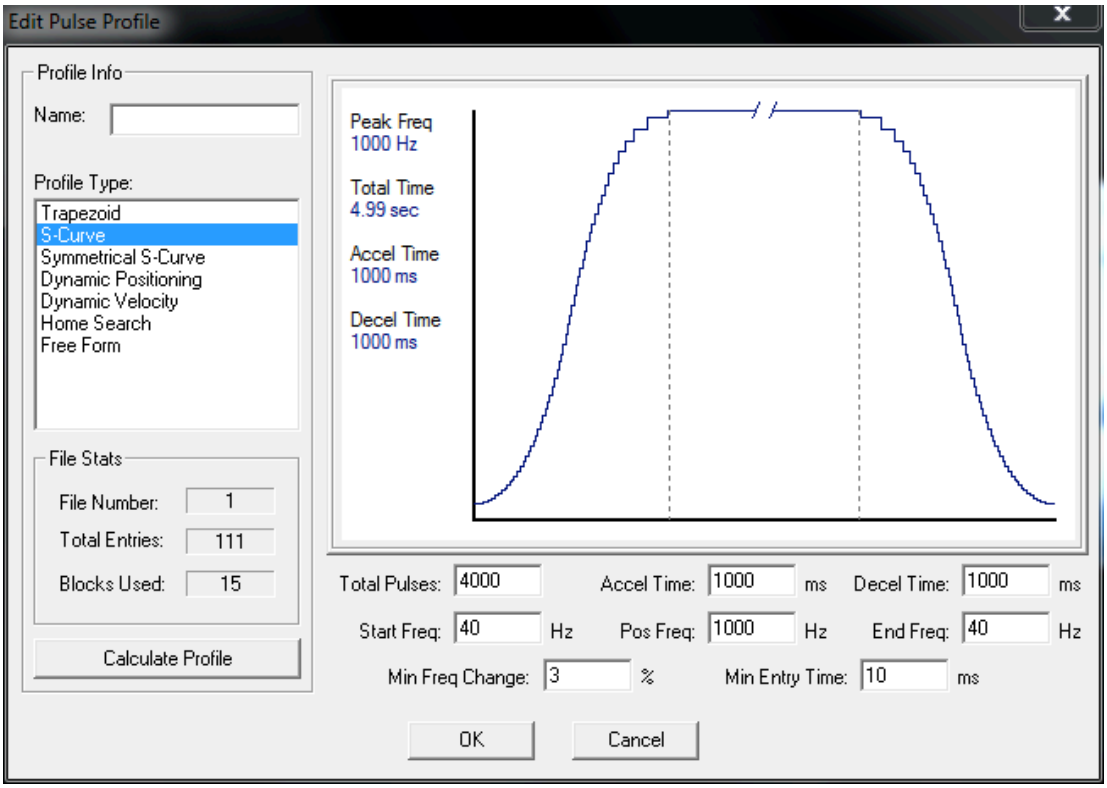



Magnet Ring Station
S40 Slide Out Dispense Part
Part Gone
S41 Grip Part
Timer
S42 Slide In Lift Down
Lift Down
S43 Place Part Lift Up
Lift Up
S44 Singulate Wait for Ready
Part Present Ready
Outer O-Ring Station 2
S50 Dispense O-Ring
Part Gone New Part Present
S51 Grip Turn
Timer
S52 Lift Down
Timer
S53 Fire Piston
Timer
S54 Lift Up
Timer
S55 Turn Back Release Grip
Fully Retracted
S56 Wait for Ready
Ready
Snap Disc Station
S60 Pick Up Part
Lift Down
S61 Turn
Timer
S62 Place Part
Lift Up
S63 Turn Back Wait for Ready
Ready


Assembly Station (PLC 1)
S70 Send Trigger
S71 Wait for Ready
Ready
Done
Note: More will be added here once more of this station has been constructed.
Assembly Station (PLC 2)
S0 Wait for Ready
S1 Load Parameters
S2 Do Action
Done
Ready
Loaded
Table Indexing
S100 Wait for Readies
S101 Index Table
S102 Index Table
Table Motion Ends
Readies
Table Motion Begins

6.3 – Stepper Motor Program





6.4 – Wiring Table

Input/Output Number	Location	Description
X0	Wiring	Link to 2nd PLC
X1	1st O-Ring Station	Piston Down
X2	Wiring	Start Button
X3	3rd O-Ring Station	Part Not Present
X4	3rd O-Ring Station	Lift Up
X100	PLC	Switch 0
X101	PLC	Switch 1
X102	PLC	Switch 2
X103	PLC	Switch 3
X104	PLC	Switch 4
X105	PLC	Switch 5
X106	PLC	Switch 6
X107	PLC	Switch 7
X110	Index Station	Cup Present
X111	Index Station	Part Present
X112	Nose Cone Station	Lift Up
X113	Nose Cone Station	Part Present
X114	Nose Cone Station	Lift Down
X115	1st O-Ring Station	Part Not Present
X116	Heat Sink Station	Part Present
X117	2nd O-Ring Station	Part Not Present
X120	2nd O-Ring Station	Lift Up
X121	Not Used	
X122	Magnet Ring Station	Part Present
X123	Magnet Ring Station	Slide In
X124	Magnet Ring Station	Lift Up
X125	Magnet Ring Station	Lift Down
X126	Snap Disk Station	Lift Up
X127	Snap Disk Station	Lift Down
PLC2 – X0	Wiring	Link to 1st PLC
Y0	Indicator Lights	Light 0
Y1	Indicator Lights	Light 1
Y2	Indicator Lights	Light 2
Y3	Indicator Lights	Light 3
Y4	Indicator Lights	Light 4
Y5	Indicator Lights	Light 5
Y6	Indicator Lights	Light 6
Y7	Indicator Lights	Light 7
Y10	Wiring	Link to 2nd PLC
Y101	Table	Index

Y102	Nose Cone Station	Lift
Y103	Nose Cone Station	Upper Singulation
Y104	Nose Cone Station	Lower Singulation
Y105	1st O-Ring Station	Upper Singulation
Y106	1st O-Ring Station	Lower Singulation
Y107	1st O-Ring Station	Piston
Y110	Heat Sink Station	Upper Singulation
Y111	Heat Sink Station	Lower Singulation
Y112	2nd O-Ring Station	Singulation
Y113	2nd O-Ring Station	Turn
Y114	2nd O-Ring Station	Lift
Y115	2nd O-Ring Station	Grip
Y116	2nd O-Ring Station	Piston
Y117	Not Used	
Y121	Magnet Ring Station	Slide
Y122	Magnet Ring Station	Lift
Y123	Magnet Ring Station	Upper Singulation
Y124	Magnet Ring Station	Lower Singulation
Y125	Magnet Ring Station	Grip
Y126	3rd O-Ring Station	Singulation
Y127	3rd O-Ring Station	Turn
Y130	3rd O-Ring Station	Lift
Y131	3rd O-Ring Station	Grip
Y132	3rd O-Ring Station	Piston
Y133	Not Used	
Y134	Snap Disk Station	Lift
Y135	Snap Disk Station	Turn
Y136	Snap Disk Station	Vacuum
PLC2 – Y0	Wiring	Link to 1st PLC
PLC2 – Module	Assembly Station	Link to Stepper Motor
C0	Ready	Index Station
C1	Ready	Nose Cone Station
C2	Ready	1st O-Ring / Heat Sink Station
C3	Ready	2nd O-Ring Station
C4	Ready	Magnet Ring Station
C5	Ready	3rd O-Ring Station
C6	Ready	Snap Disk Station
C7	Ready	Assembly Station
C20		1st O-Ring Station Part Ready
C21		Heat Sink Station Part Ready
C22		1st O-Ring Station Part Gone
C40		Magnet Ring Station Part Ready
C50		3rd O-Ring Station Part Ready
C51		3rd O-Ring Station Part Gone
C70		Assembly Station Motor Started

C410	Error	Index Station
C411	Error	Nose Cone Station
C412	Error	1st O-Ring / Heat Sink Station
C413	Error	2nd O-Ring Station
C414	Error	Magnet Ring Station
C415	Error	3rd O-Ring Station
C416	Error	Snap Disk Station
C417	Error	Assembly Station
C501	Logic	Nose Cone Station
C502	Logic	1st O-Ring / Heat Sink Station
C503	Logic	2nd O-Ring Station
C504	Logic	Magnet Ring Station
C505	Logic	3rd O-Ring Station
C506	Logic	Snap Disk Station
C507	Logic	Assembly Station
C600		Snap Disk Station Lift Up
C701	Startup Cycle	Nose Cone Station
C702	Startup Cycle	1st O-Ring / Heat Sink Station
C703	Startup Cycle	2nd O-Ring Station
C704	Startup Cycle	Magnet Ring Station
C705	Startup Cycle	3rd O-Ring Station
C706	Startup Cycle	Snap Disk Station
C707	Startup Cycle	Assembly Station
S0	Index Station	State 1
S10	Nose Cone Station	State 1
S11	Nose Cone Station	State 2
S12	Nose Cone Station	State 5
S13	Nose Cone Station	State 6
S14	Nose Cone Station	State 7
S15	Nose Cone Station	State 3
S16	Nose Cone Station	State 4
S20	1st O-Ring / Heat Sink Station	State 1
S21	1st O-Ring / Heat Sink Station	State 2
S22	1st O-Ring / Heat Sink Station	State 3
S23	1st O-Ring / Heat Sink Station	State 4
S24	1st O-Ring / Heat Sink Station	State 5
S30	2nd O-Ring Station	State 1
S31	2nd O-Ring Station	State 2
S32	2nd O-Ring Station	State 3
S33	2nd O-Ring Station	State 4
S34	2nd O-Ring Station	State 5
S35	2nd O-Ring Station	State 6
S40	Magnet Ring Station	State 1
S41	Magnet Ring Station	State 2
S42	Magnet Ring Station	State 3

S43	Magnet Ring Station	State 4
S44	Magnet Ring Station	State 5
S50	3rd O-Ring Station	State 1
S51	3rd O-Ring Station	State 2
S52	3rd O-Ring Station	State 3
S53	3rd O-Ring Station	State 4
S54	3rd O-Ring Station	State 5
S55	3rd O-Ring Station	State 6
S56	3rd O-Ring Station	State 7
S60	Snap Disk Station	State 1
S61	Snap Disk Station	State 2
S62	Snap Disk Station	State 3
S63	Snap Disk Station	State 4
S70	Assembly Station	State 1
S71	Assembly Station	State 2
S100	Table Index	State 1
S101	Table Index	State 2
S102	Table Index	State 3
S410	Error System	
S600	Startup	
S702	Startup Cycle	1
S703	Startup Cycle	2
S704	Startup Cycle	3
S705	Startup Cycle	4
S706	Startup Cycle	5
S707	Startup Cycle	6
T10	S10	Timeout
T11	S11	Timeout
T12	S11	Delay
T13	S12	Delay
T14	S13	Delay
T15	S13	Timeout
T16	S14	Delay
T20	S20	Delay
T21	S21	Delay
T22	S22	Delay
T23	S21	Delay
T24	S22	Delay
T25	S22	Timeout
T26	S23	Delay
T27	S23	Timeout
T30	S30	Delay
T40	S40	Delay
T41	S40	Delay
T42	S41	Delay

T43	S42	Delay
T44	S42	Timeout
T45	S43	Delay
T46	S43	Timeout
T47	S44	Delay
T50	S50	Delay
T51	S54	Delay
T52	S52	Delay
T53	S52	Delay
T54	S53	Delay
T55	S55	Timeout
T56	S56	Delay
T57	S50	Timeout
T60	S61	Delay
T61	S63	Delay
T62	S63	Delay
T63	S63	Timeout
T64	S60	Delay
T65	S62	Delay
T66	S62	Delay
T67	S62	Delay
T70	S70	Delay
T71	S71	Delay
T72	S70	Delay
T100	S100	Delay
T101	S102	Delay
T102	S102	Delay
T110	S11	Delay
T117	S15	Delay
T141	S44	Delay
T160	S60	Delay
T200	S24	Delay
T201	S21	Delay