# Flashlight Assembly Machine

Manufacturing Systems Project Operations


## Team Members

Jason Osborne

Kirk Betz

Will Griffith

Kevin Nelson


## Prepared for

Edward F. Cross School of Engineering

Walla Walla University

College Place, Washington

## Submitted in Fulfillment of

ENGR 480 Manufacturing Systems

Professor: Ralph Stirling

## Project description

Recently our team was contacted by FlashOfGenius LLC concerning a new single-cell flashlight that the company would like to manufacture. The flash light is an all aluminum body with a magnetic switch. A Cree XR-E light emitting diode, a lens, a rubber washer, and a 3.6v rechargeable LifePO4 battery are sealed inside. FlashOfGenius would like our team to create a custom automated manufacturing system to assemble their new flashlight.

FlashOfGenius sent us the following criteria for the flashlight.

- Components are:
    1. 18650 size battery
    2. Carclo 10199 lens and 10425 holder
    3. Cree XR-E LED mounted to a custom printed circuit board and heat sink.
    4. Magnet to activate Hall switch (4mm x 4mm x 1mm magnet)

- Flash light body consists of three main parts
    1. Nose, with lens, lens holder, and LED module
    2. Tail with battery
    3. Ring with Magnet

- Flashlight assembly description
    1. The lens fits into the nose onto a gasket in the front of the nose and the LED module fits on top of the lens. The magnet ring slides over the nose piece and rotates to activate the Hall switch. The battery fits into the tail piece and the tail piece threads into the nose piece with a gasket seal.

All components need to be fed and automatically assembled to create a working flashlight ready to be packages and shipped.

## Proposed solution

Based on the description from FlashOfGenius, our team proposed an assembly order and method of assembly for the automated system. Our team proposed that we break down the operation into 7 assembly stations and use a turn table to index between the operations.

## Brief Outline of assembly:

1. Nose – Drop nose into some kind of jig to hold it during the rest of the assembly.
2. O-ring – Drop the O-ring into the nose
3. Lens – Pick up the lens from a convertor belt and place into nose
4. LED module / Lens holder – Both would be assembled and then brought in on a convey belt before being picked and placed into the nose.
5. Ring / Magnet – Pick off a conveyor belt and place over the back part of the nose.

6. Battery / Tail piece – A battery would be placed and held in nose piece while the tail piece is lowered and then screwed into the nose piece.

7. Eject Finished Flashlight – Finished flash light would be pulled out of the jig and placed on a conveyor belt leaving the assembly apparatus.

## Apparatus Description

This apparatus has the first three stages of the total flashlight assembly. The three stages include: placement of flashlight head into rotating holding station, O-ring insertion, and lens insertion. This machine once set up and loaded will process through the first three stages of assembly automatically.

## Loading

**Stage 1**

Flashlight Head Placement

Loading- Place flashlight heads into holding tube with head facing down. The holding tube may be loaded with up to 11 heads, see Figure # and #. Note that machine pneumatics must be on before you can load, so that the air cylinder is extended to catch the heads.

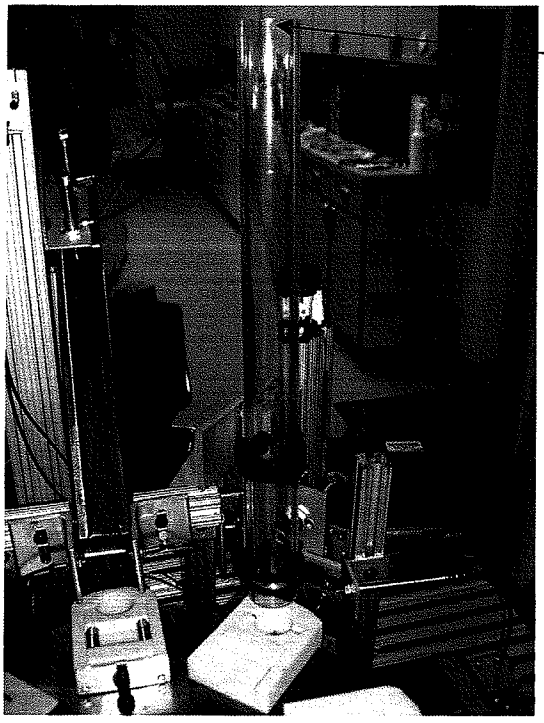



Figure 1: Stage 1

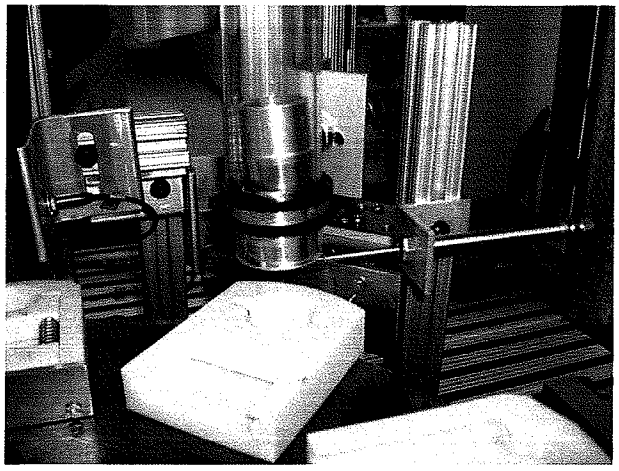


Figure 2: Loaded Flashlight Heads, Stage 1

**Stage 2**

O-Ring Insertion

Loading- O-rings can be placed in single file in the available track space located above the two air cylinders. The o-ring track can hold a max of 5 o-rings.

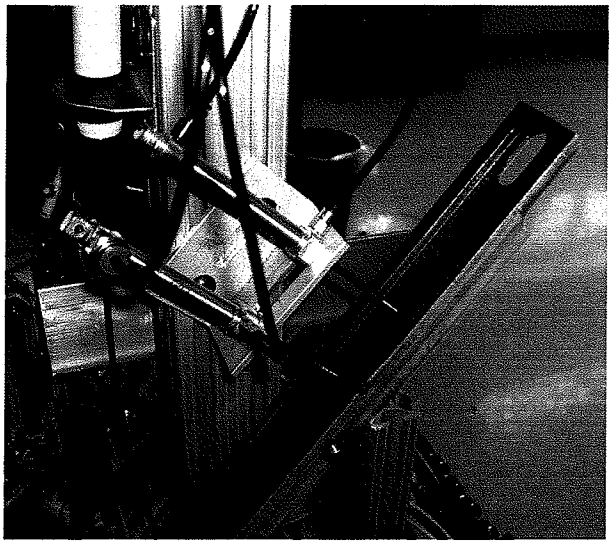


Figure 3: Stage 2

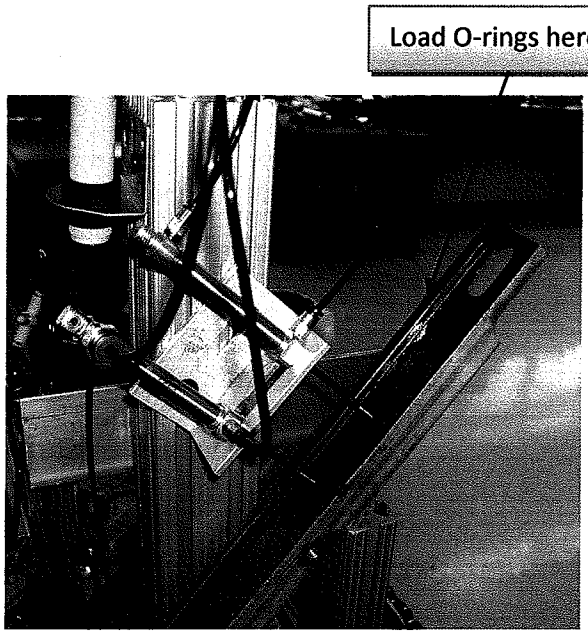



Figure 4: O-rings Loaded, Stage 2

**Stage 3**

Lens Insertion

Loading- Lenses should be placed on the conveyor belt with the flat surface facing down. Position from side to side is not important, lenses will self center.

Figure 5: Stage 3

Figure 6: Lenses Loaded, Stage 3

## Operation

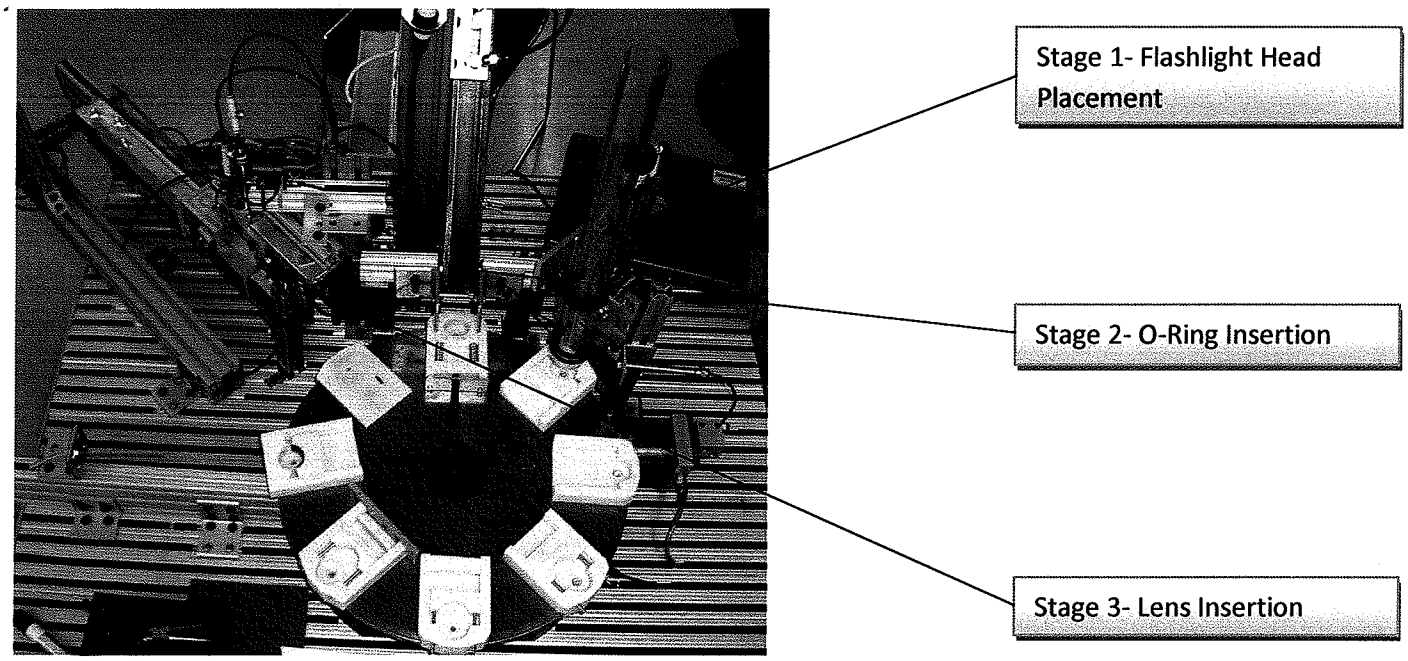



Figure 7: Full Assembly

**Stage 1**

Flashlight Head Placement

Step 1: In this step the round table indexes an empty holder under the holding tube, and the pressing plate pushes against the pins opening up the spring closed holder.

Step 2: With the two air cylinders extended, holding the flashlight heads in place, the lower cylinder retracts allowing the bottom head to drop while the other stay in place.

Step 3: The plate releases the pins allowing the springs to press close the holder onto the head. At the same time, the lower air cylinder extends again.

Step 4: The upper cylinder now retracts allowing the next flashlight head to load into place.

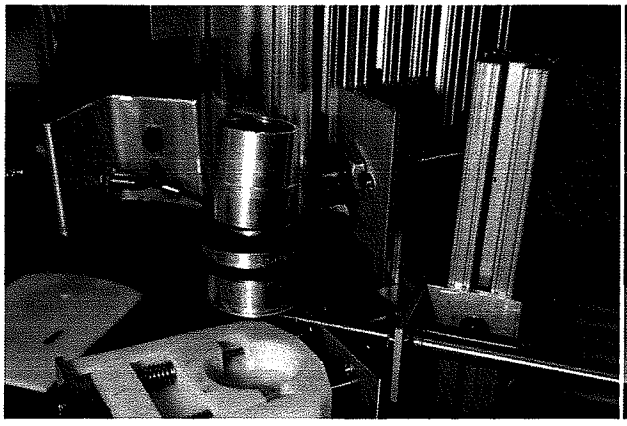


Figure 8: Stage 1-Step 1

Figure 9: Stage 1-Step 2

Figure 10: Stage 1-Step 3

Figure 11: Stage 1-Step 4

**Stage 2**

O-Ring Insertion

Step 1: In this step the o-rings are separated so that only one ring will fall at a time.

Step 2: The bottom air cylinder retracts allowing the o-ring to fall down the chute where it falls into the flashlight head.

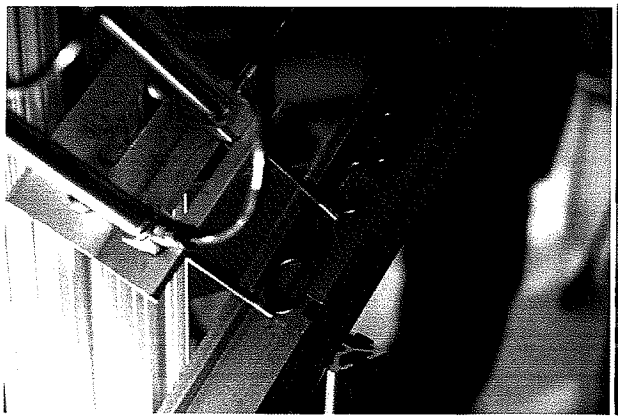


Figure 12: Stage 2-Step 1

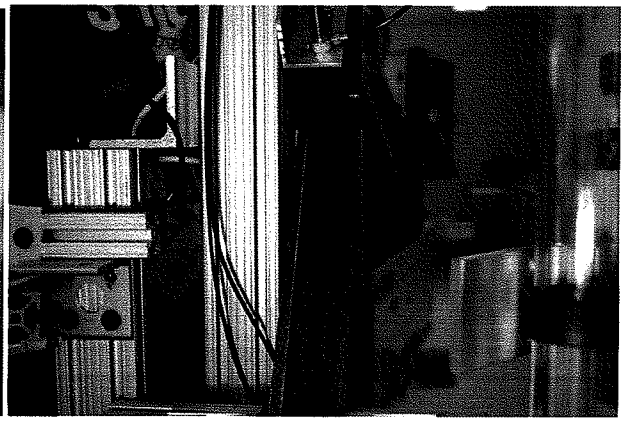


Figure 13: Stage 2-Step 2

**Stage 3**

Lens Insertion

Step 1: The lenses arrange themselves on the center of the conveyer.

Step 2: The cylinder with the vacuum cup drops, attaching to the lens.

Step 3: The air cylinder then retracts picking up the lens, allowing the other lens to move into its space.

Step 4: Here the vacuum tube rotates to be placed over the cylinder.

Step 5: The air cylinder then drops down, lowering the lens into the flashlight head. The vacuum is shut off, dropping the lens.

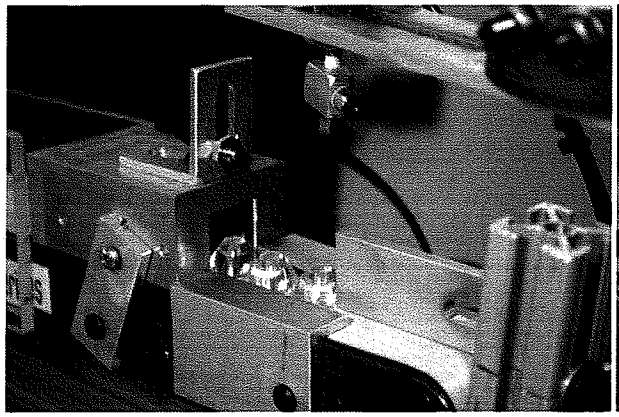


Figure 14: Stage 3-Step 1

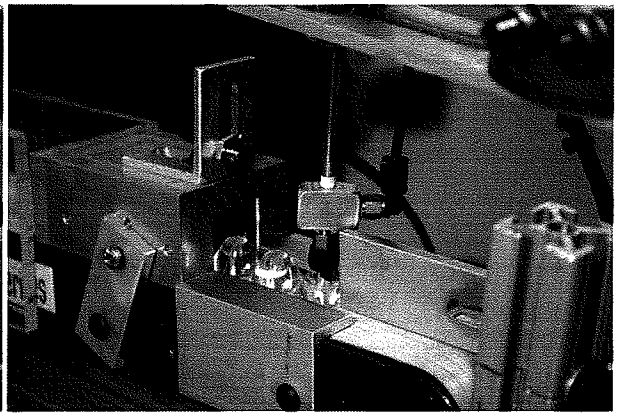


Figure 15: Stage 3-Step 2

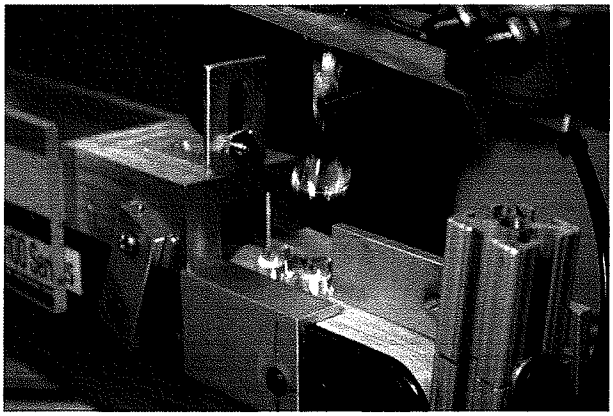


Figure 16: Stage 3-Step 3

Figure 17: Stage 3-Step 4

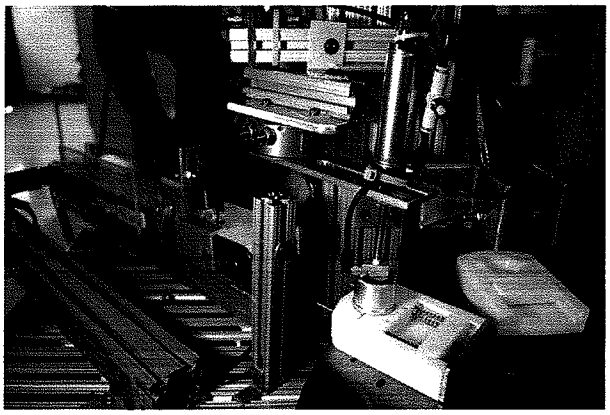


Figure 18: Stage 3-Step 5

**Improvements:**

There are several improvements our team feels could be made to our machine besides building the last 4 stations.

Our o-ring station needs an accurate way to sense that an o-ring has been released and is in the nose.

The 3rd station needs to be built such that the movement of the pneumatics doesn't shake the screws loose and throw off the accuracy of the pick and place apparatus.

**Famous quotes by team members.**

"This computer hates me!" - Will Griffith with the laptops

"oh Will can deal with it" – Rest of the team whenever something wasn't working

"I have defeated you [the machine] you bastard!" – Jason Osborne upon finding an electrical problem

"Here goes nothing... and nothing goes" – Jason Osborne upon the first attempt of running the PLC

"Its Wills Fault! Dang it Will!" – The rest of the team while testing the machine

"Oh yeah, I'll fix that latter" – Will whenever there was a problem

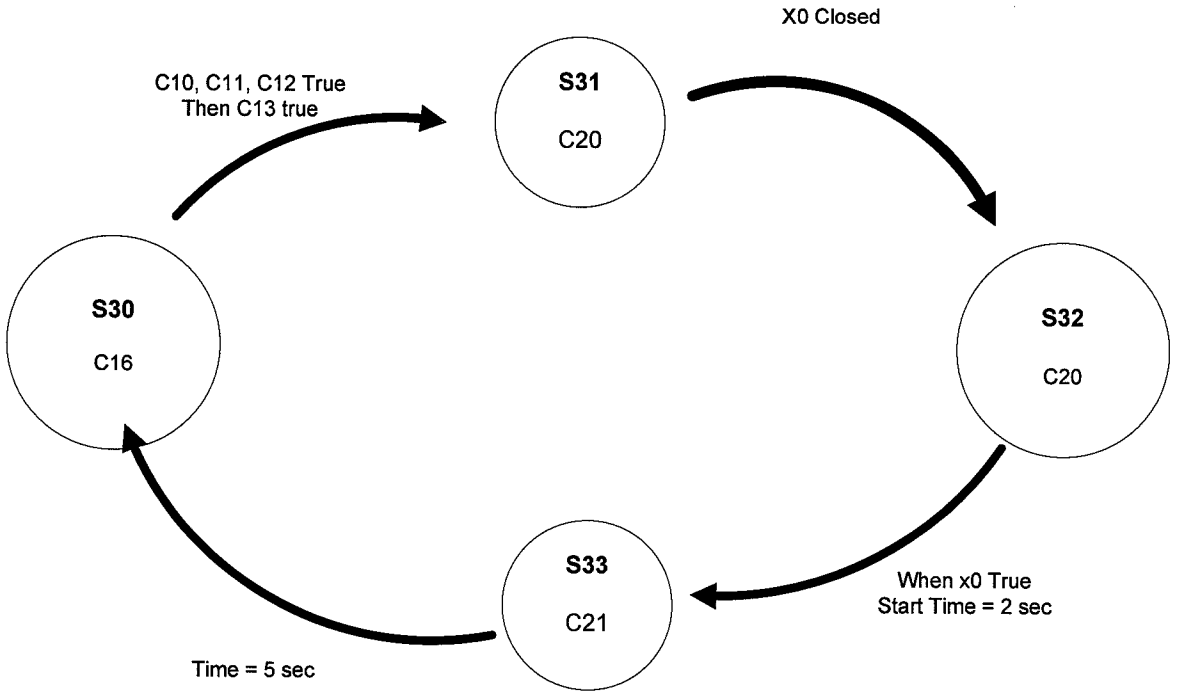
"Okay... in Theory..." Will fixing programming problems

**Outputs**

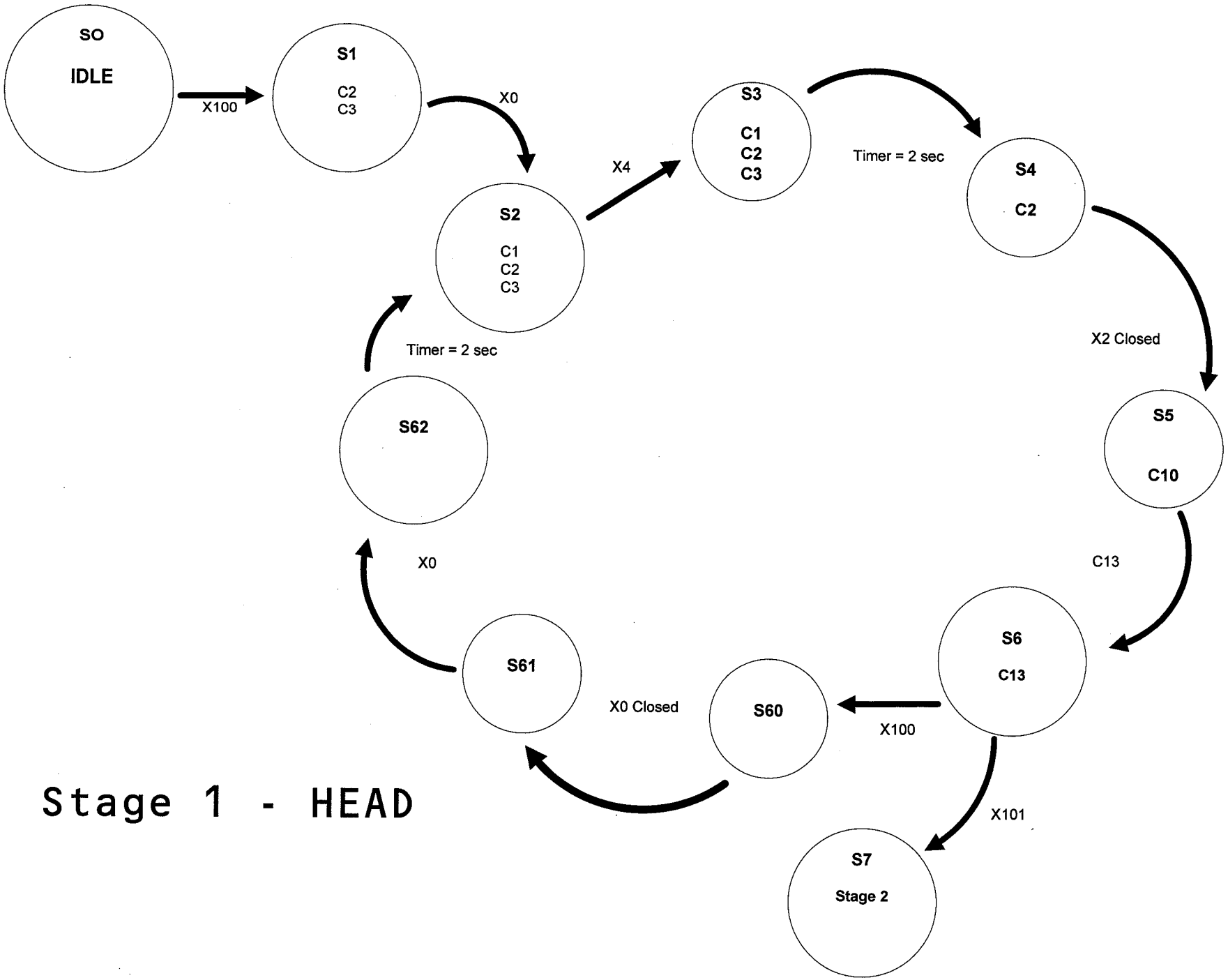
| States | Air # | Transformer # | PLC Outputs # | Description | PLC LINE LABEL | AIR LINE LABEL |
|---|---|---|---|---|---|---|
| Table | 2 | 10 | Y0 | Rotating Table | Y1 Table | Table |
| | 8 | 7 | Y1 | Rotating Table | Y1 Table | Table |
| S1 | 1 | 6 | Y2 | Pin Pushing Piston | Y2 Pin Pusher | S1 Pusher |
| | 6 | 5 | Y3 | Bottom Tube Piston | Y3 S1 Bottom | S1 Bottom |
| | 5 | 4 | Y4 | Top Tube Piston | Y4 S1 Red | S1 Top |
| S2 | L3 | 13 | Y6 | Top Oring Slide | S2 Top O | S2 Top |
| | L4 | 14 | Y7 | Bottom Oring Slide | S2 B | S2 Bottom |
| S3 | L1 | 11 | Y10 | 180 Deg Rotator | S3 180 | S3 Rotator |
| | 10 | 3 | Y5 | Vac | Y5 Vac | S3 Vac |
| | L2 | 12 | Y11 | Piston for Vac | Y11 S3 Piston | S3 Piston |

**Inputs**

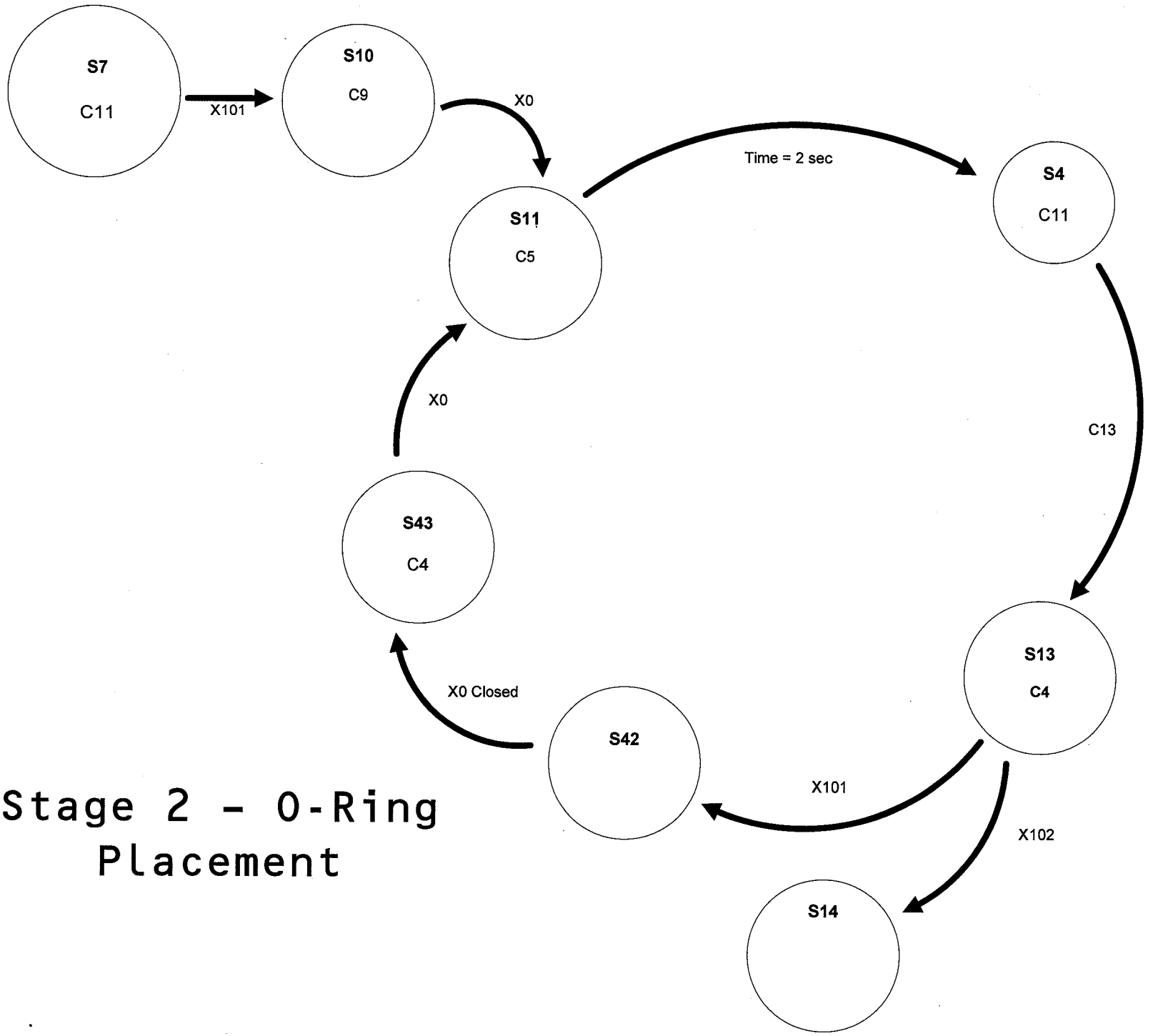
| States | Sensor Location | PLC Input # | Description |
|---|---|---|---|
| Table | Table Sensor | X0 | Senses Table Rotation |
| S1 | Pin Pusher | X2 | Pin Pusher Extended / Open |
| | Pin Pusher | X1 | Pin Pusher Retracted / Closed |
| | Head Drop | X4 | Optical Sensor- Head Release |
| S2 | Oring Sensor | X3 | "Motion Sensor" |
| S3 | Conveyor Piston | X5 | Optical Sensor Piston Extended |



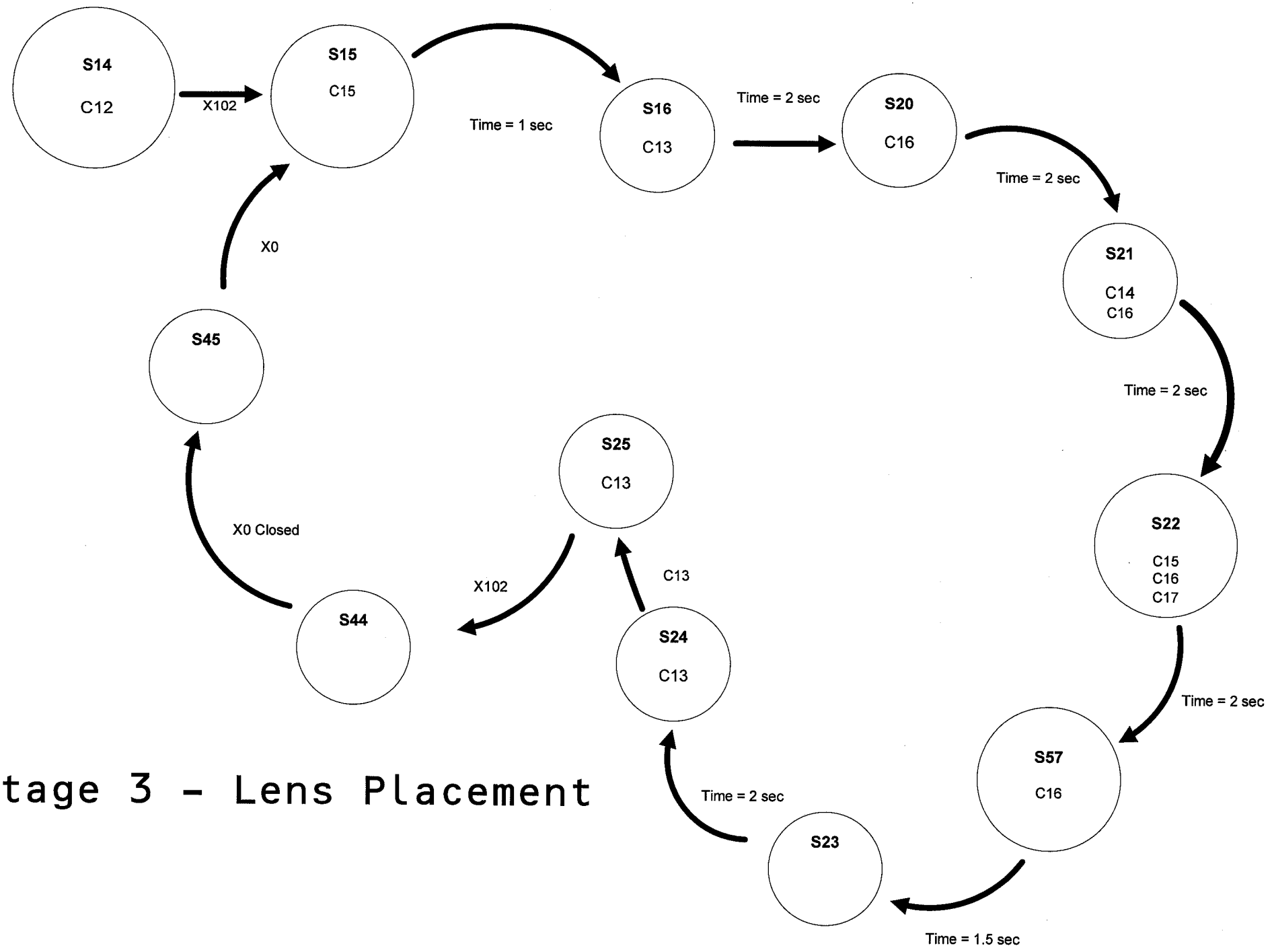

# Stage 0 - Indexing Stage


SO
IDLE
X100
S1
C2
C3
X0
S2
C1
C2
C3
X4
S3
C1
C2
C3
Timer = 2 sec
S4
C2
X2 Closed
S5
C10
C13
S6
C13
X100
S60
X0 Closed
S61
X0
S62
Timer = 2 sec
X101
S7
Stage 2

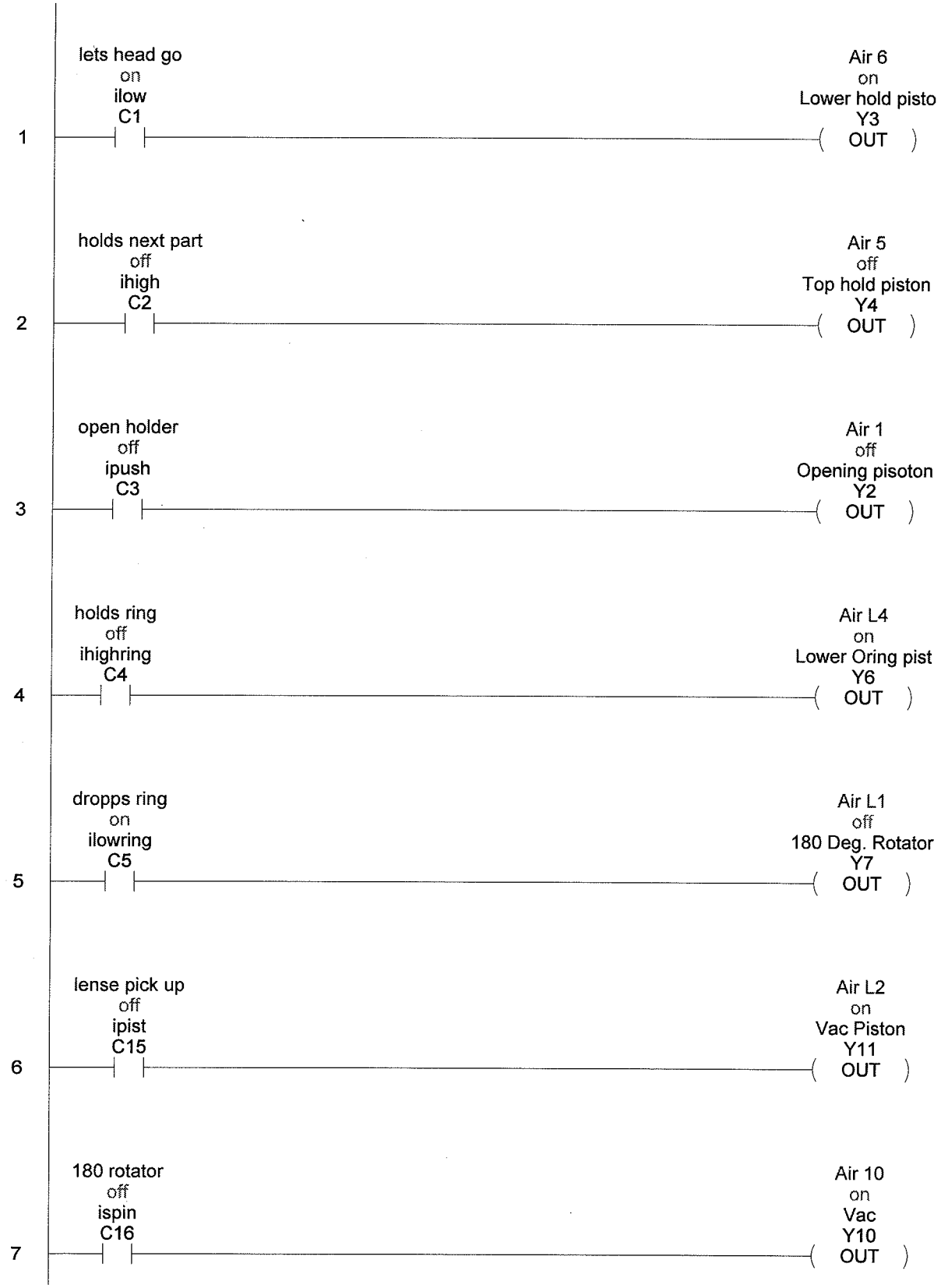
# Stage 1 - HEAD

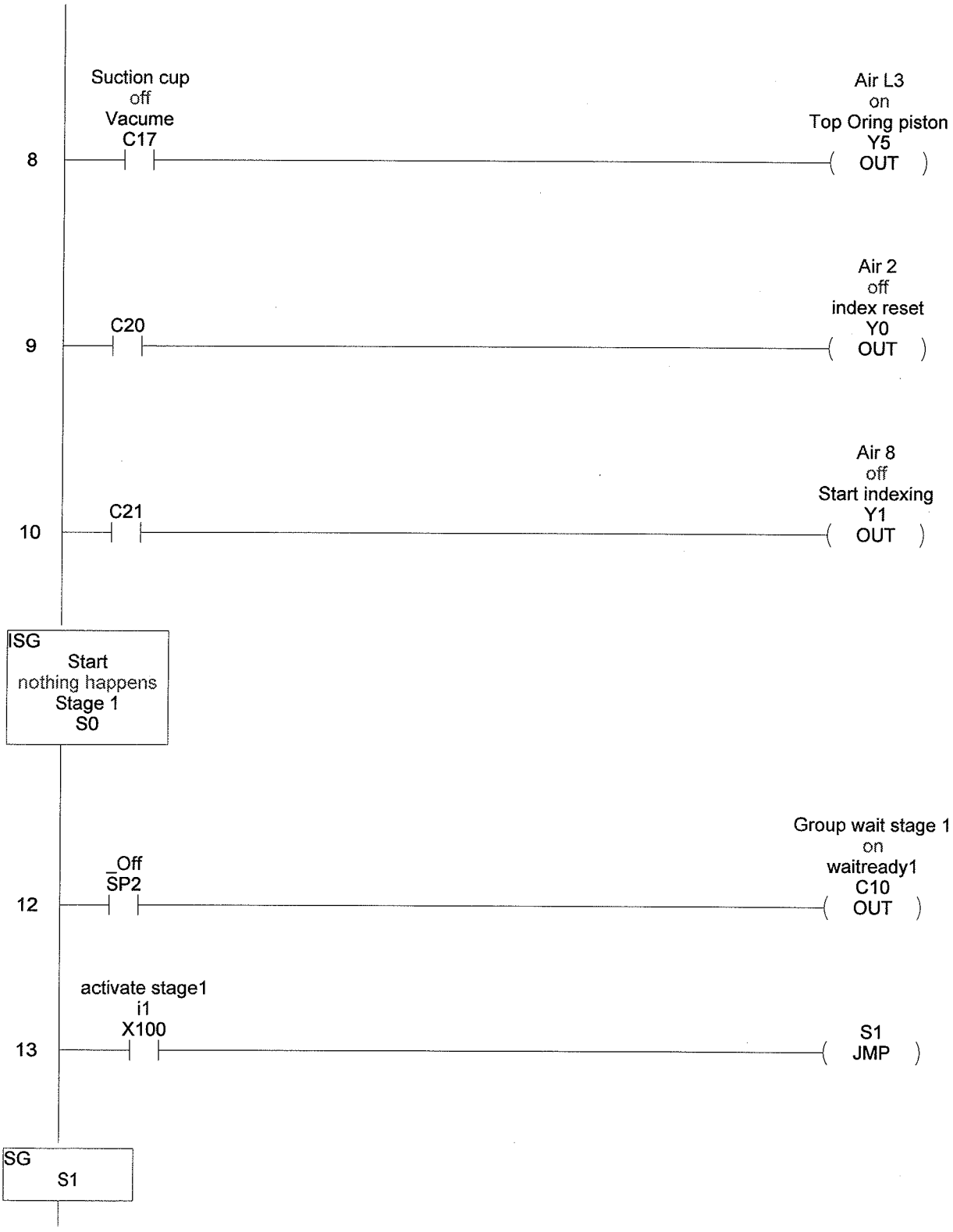


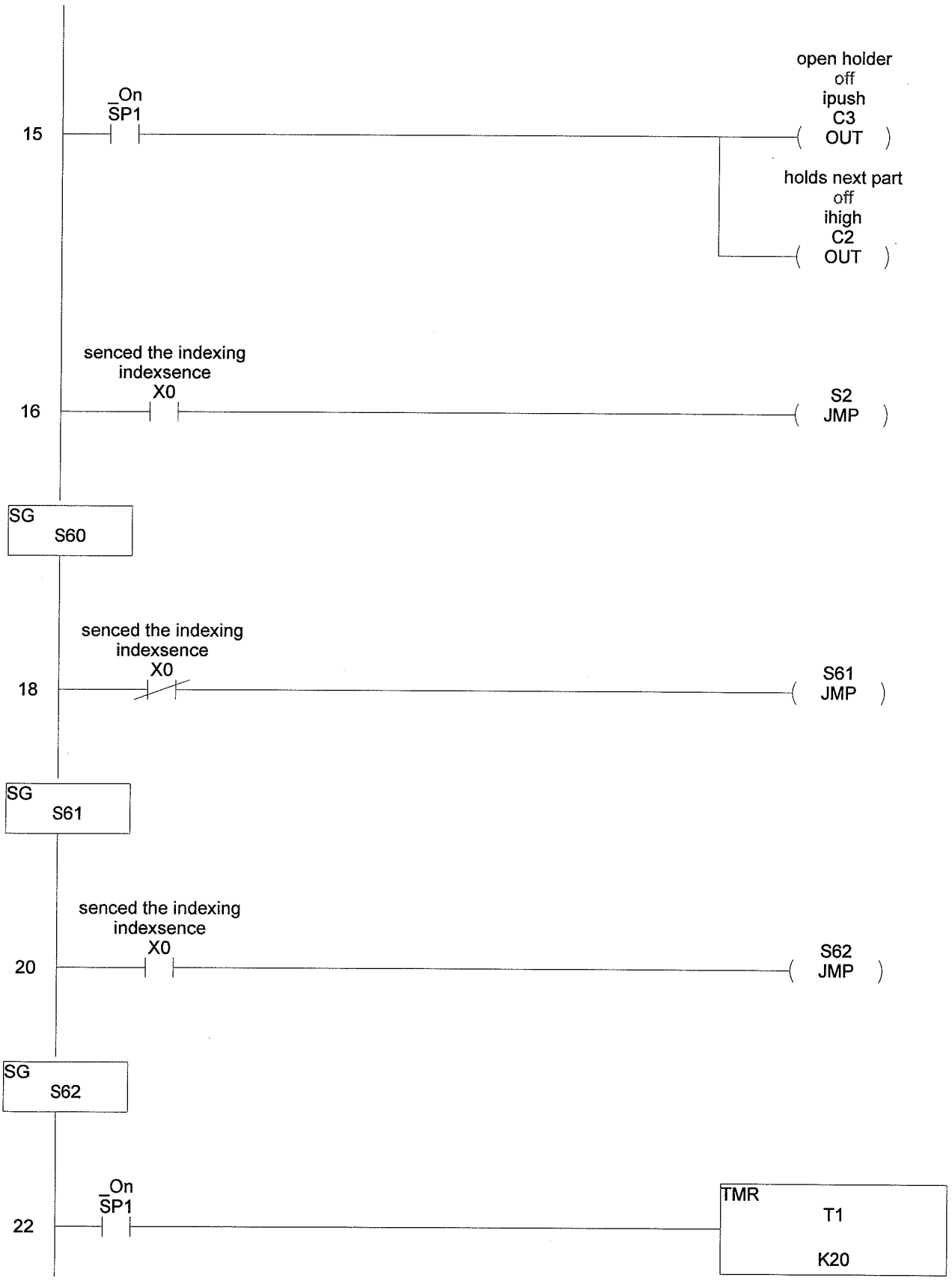

# Stage 2 - O-Ring Placement

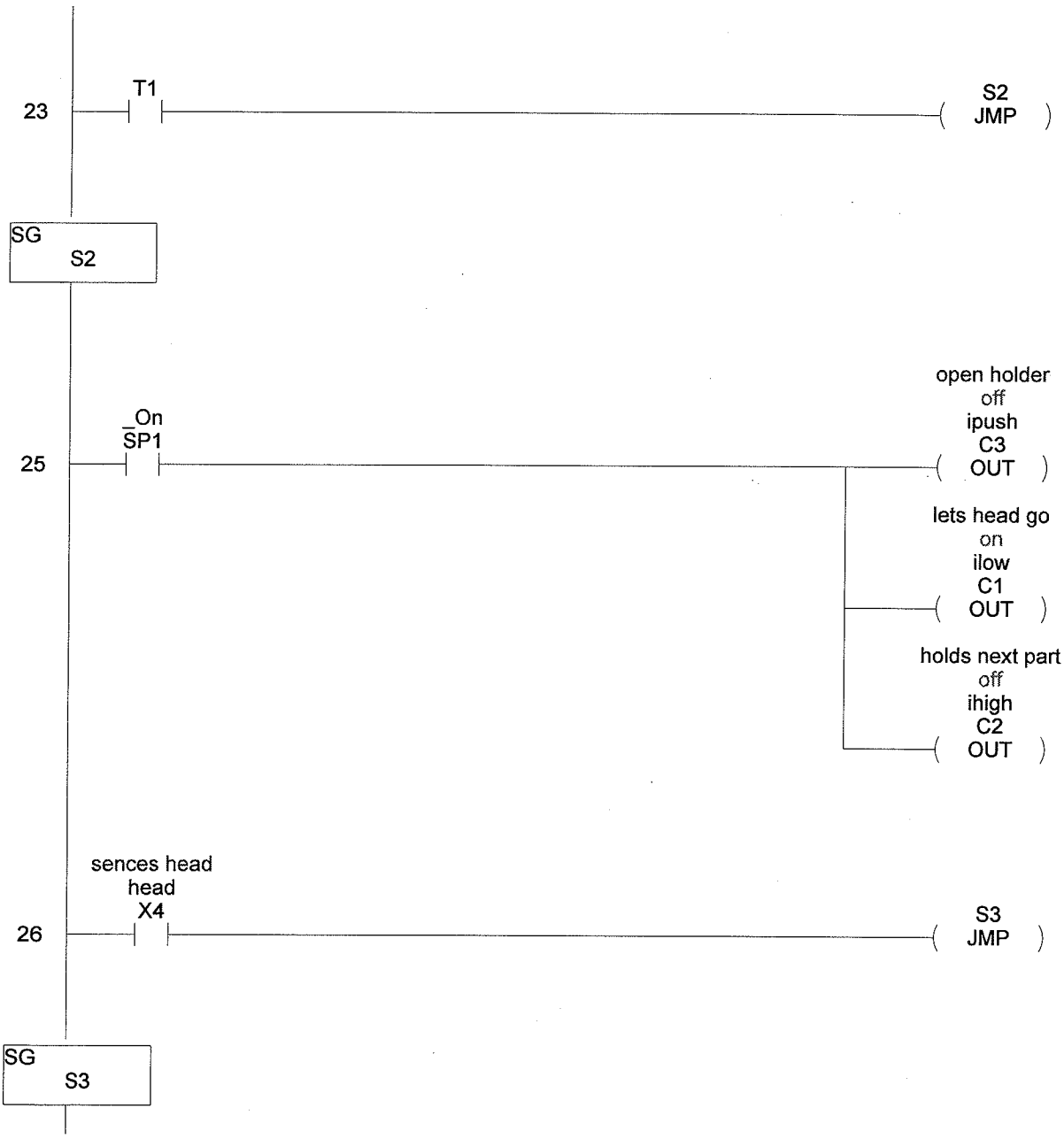


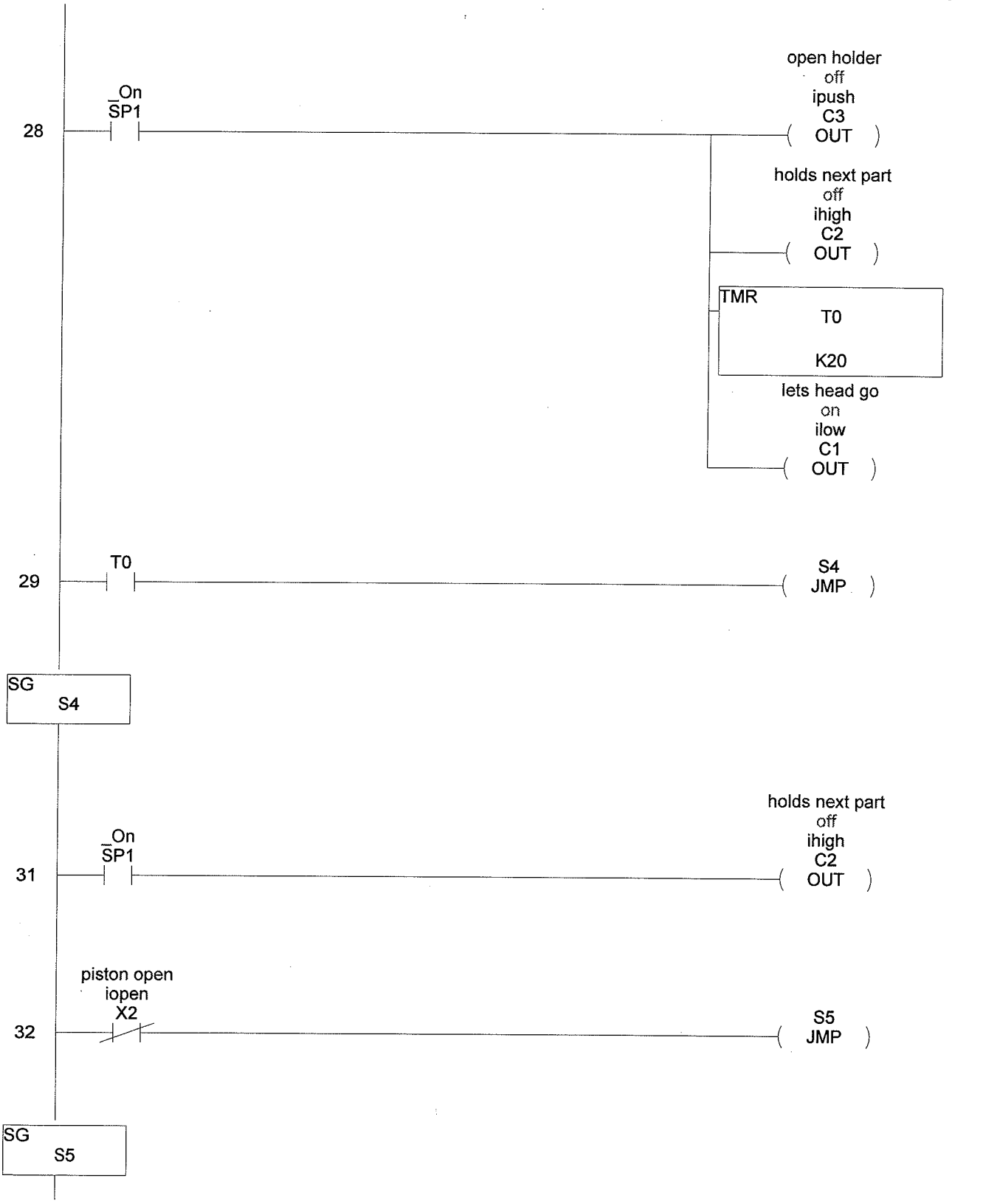

# Stage 3 - Lens Placement

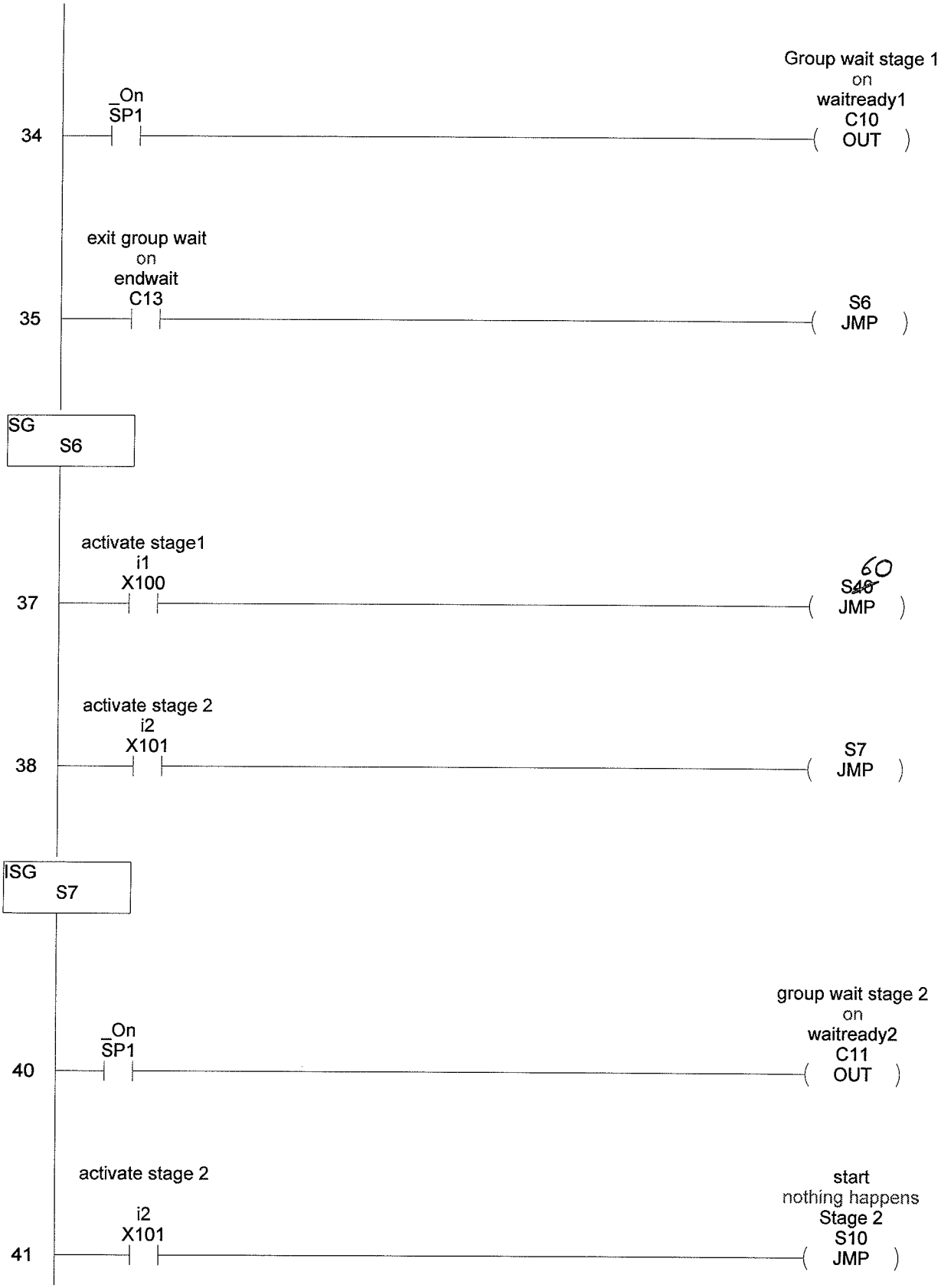

1
lets head go
on
ilow
C1
Air 6
on
Lower hold pisto
Y3
OUT
2
holds next part
off
ihigh
C2
Air 5
off
Top hold piston
Y4
OUT
3
open holder
off
ipush
C3
Air 1
off
Opening pisoton
Y2
OUT
4
holds ring
off
ihighring
C4
Air L4
on
Lower Oring pist
Y6
OUT
5
dropps ring
on
ilowring
C5
Air L1
off
180 Deg. Rotator
Y7
OUT
6
lense pick up
off
ipist
C15
Air L2
on
Vac Piston
Y11
OUT
7
180 rotator
off
ispin
C16
Air 10
on
Vac
Y10
OUT

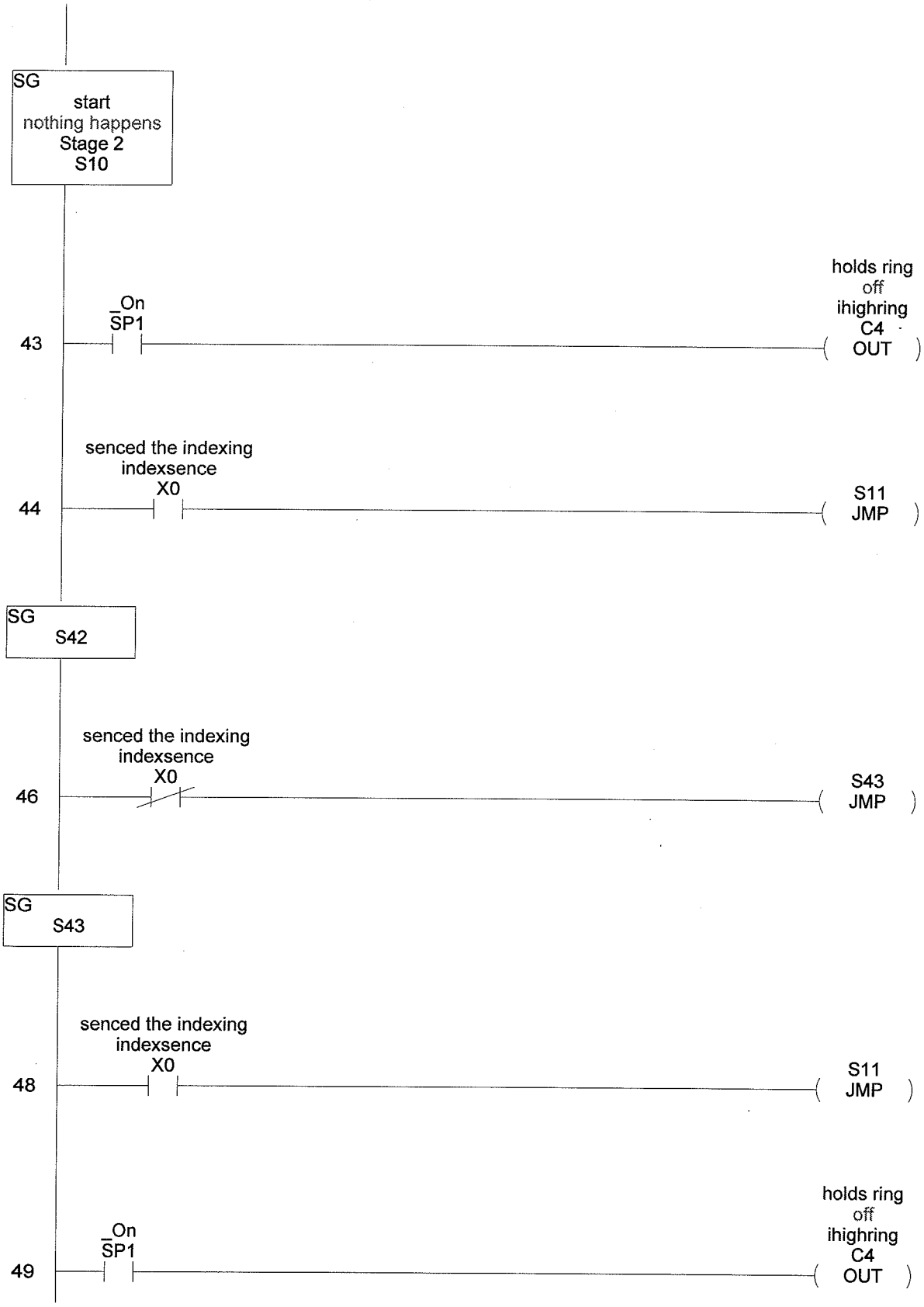

Suction cup
off
Vacume
C17
Air L3
on
Top Oring piston
Y5
OUT
8
C20
Air 2
off
index reset
Y0
OUT
9
C21
Air 8
off
Start indexing
Y1
OUT
10
ISG
Start
nothing happens
Stage 1
S0
_Off
SP2
Group wait stage 1
on
waitready1
C10
OUT
12
activate stage1
i1
X100
S1
JMP
13
SG
S1

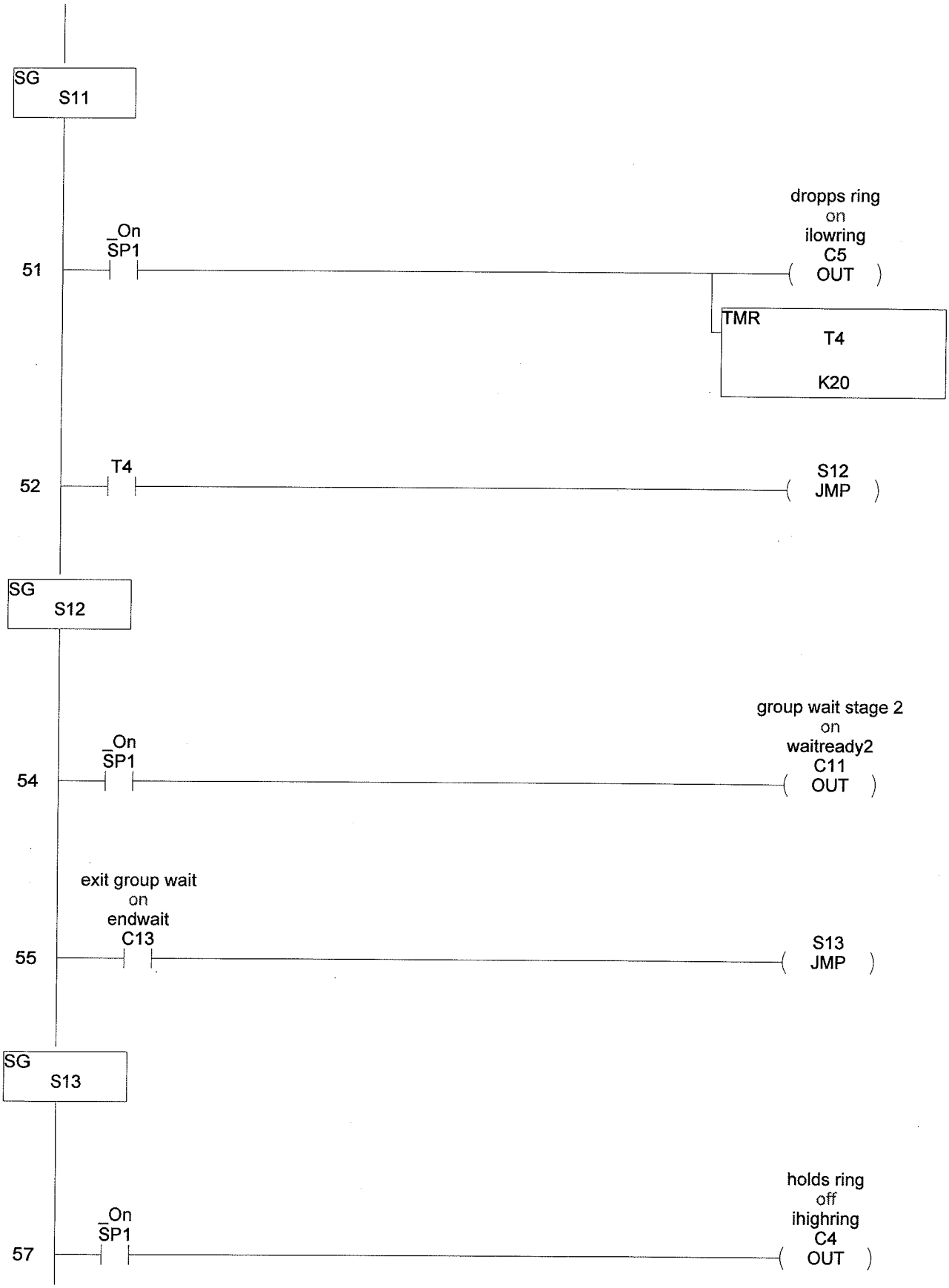

15
_On
SP1
open holder
off
ipush
C3
OUT
holds next part
off
ihigh
C2
OUT
16
senced the indexing
indexsence
X0
S2
JMP
SG
S60
18
senced the indexing
indexsence
X0
S61
JMP
SG
S61
20
senced the indexing
indexsence
X0
S62
JMP
SG
S62
22
_On
SP1
TMR
T1
K20

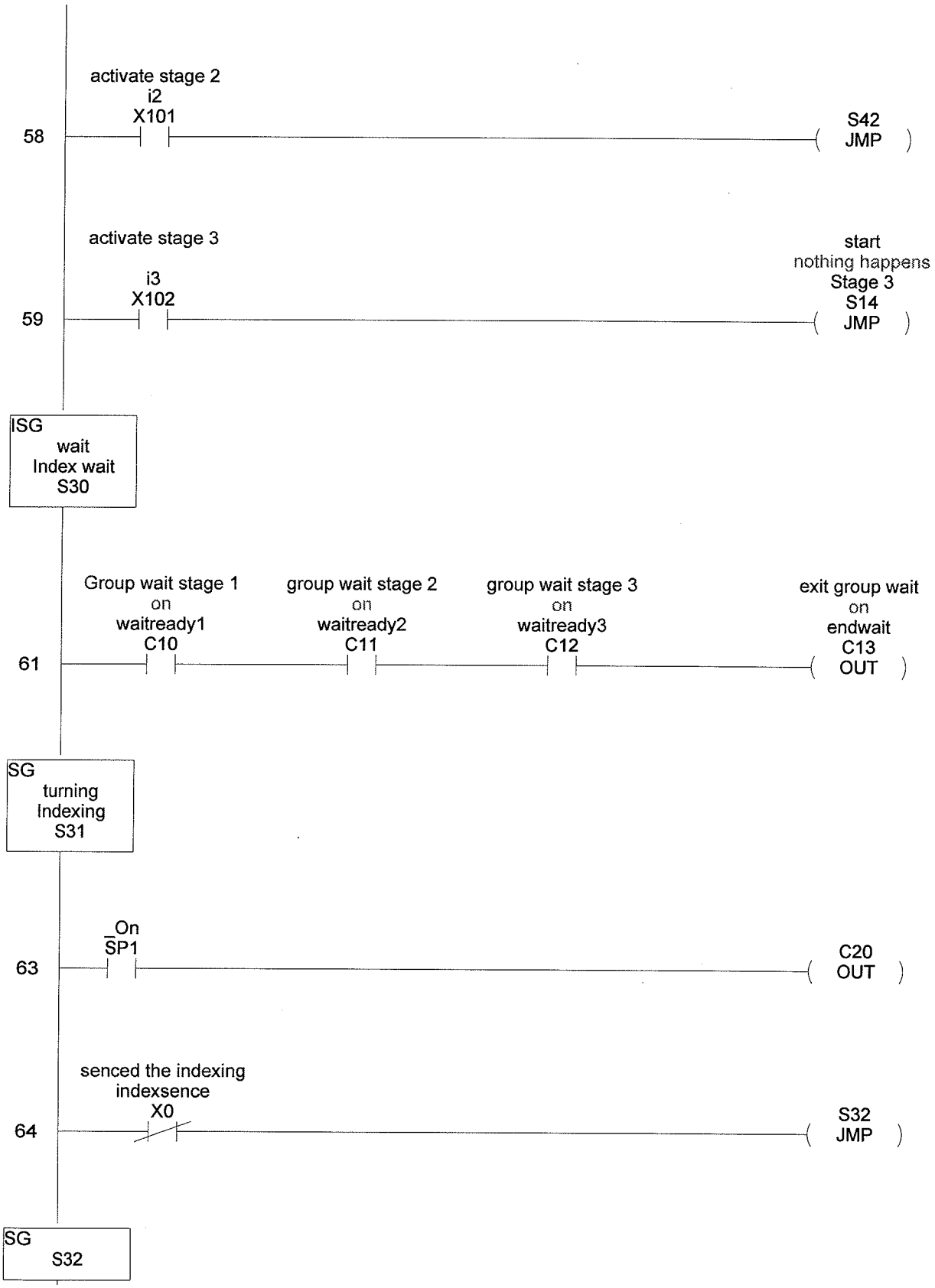

23
T1
S2
JMP
SG
S2
25
_On
SP1
open holder
off
ipush
C3
OUT
lets head go
on
ilow
C1
OUT
holds next part
off
ihigh
C2
OUT
26
sences head
head
X4
S3
JMP
SG
S3

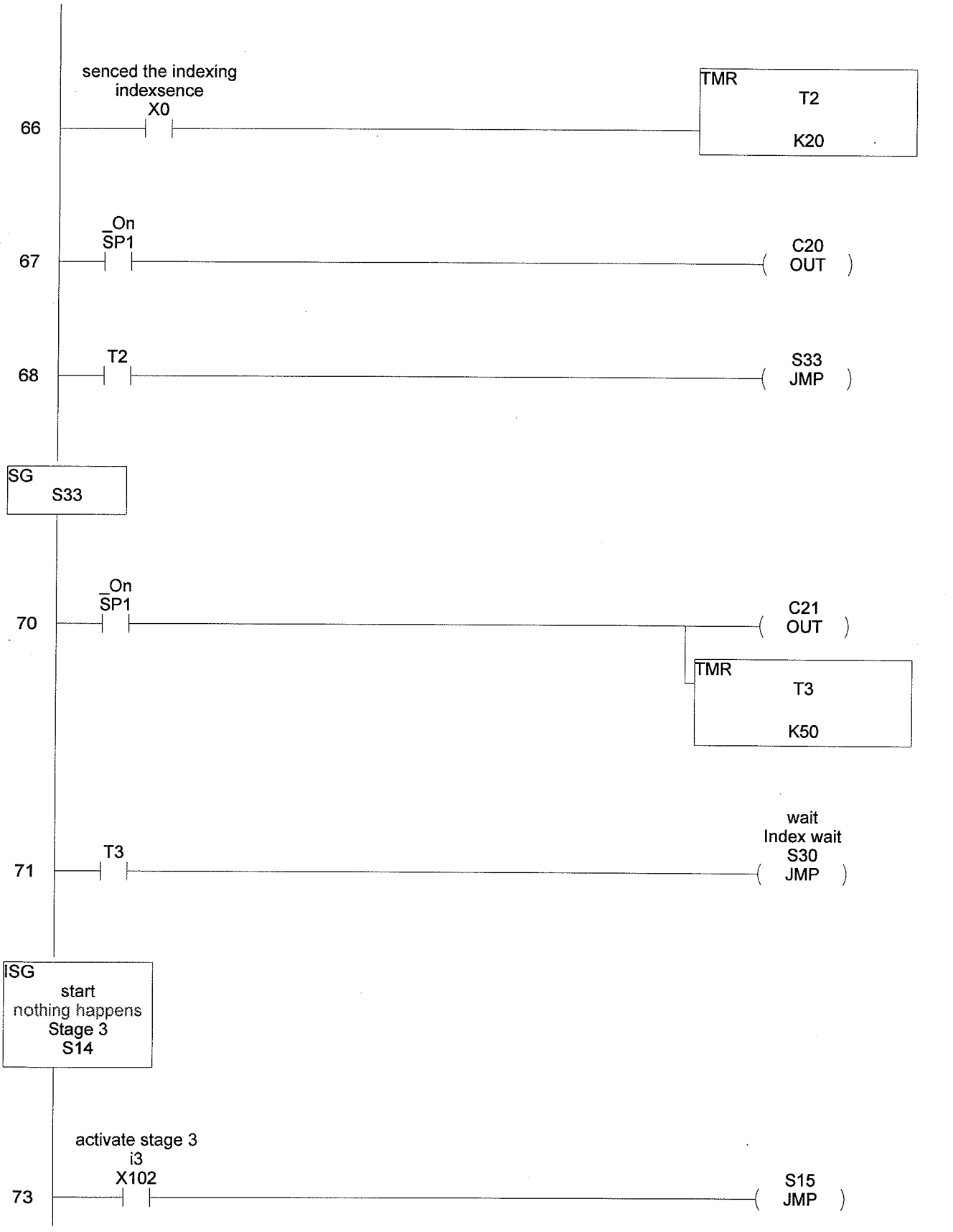

28
_On
SP1
open holder
off
ipush
C3
OUT
holds next part
off
ihigh
C2
OUT
TMR
T0
K20
lets head go
on
ilow
C1
OUT
29
T0
S4
JMP
SG
S4
31
_On
SP1
holds next part
off
ihigh
C2
OUT
32
piston open
iopen
X2
S5
JMP
SG
S5

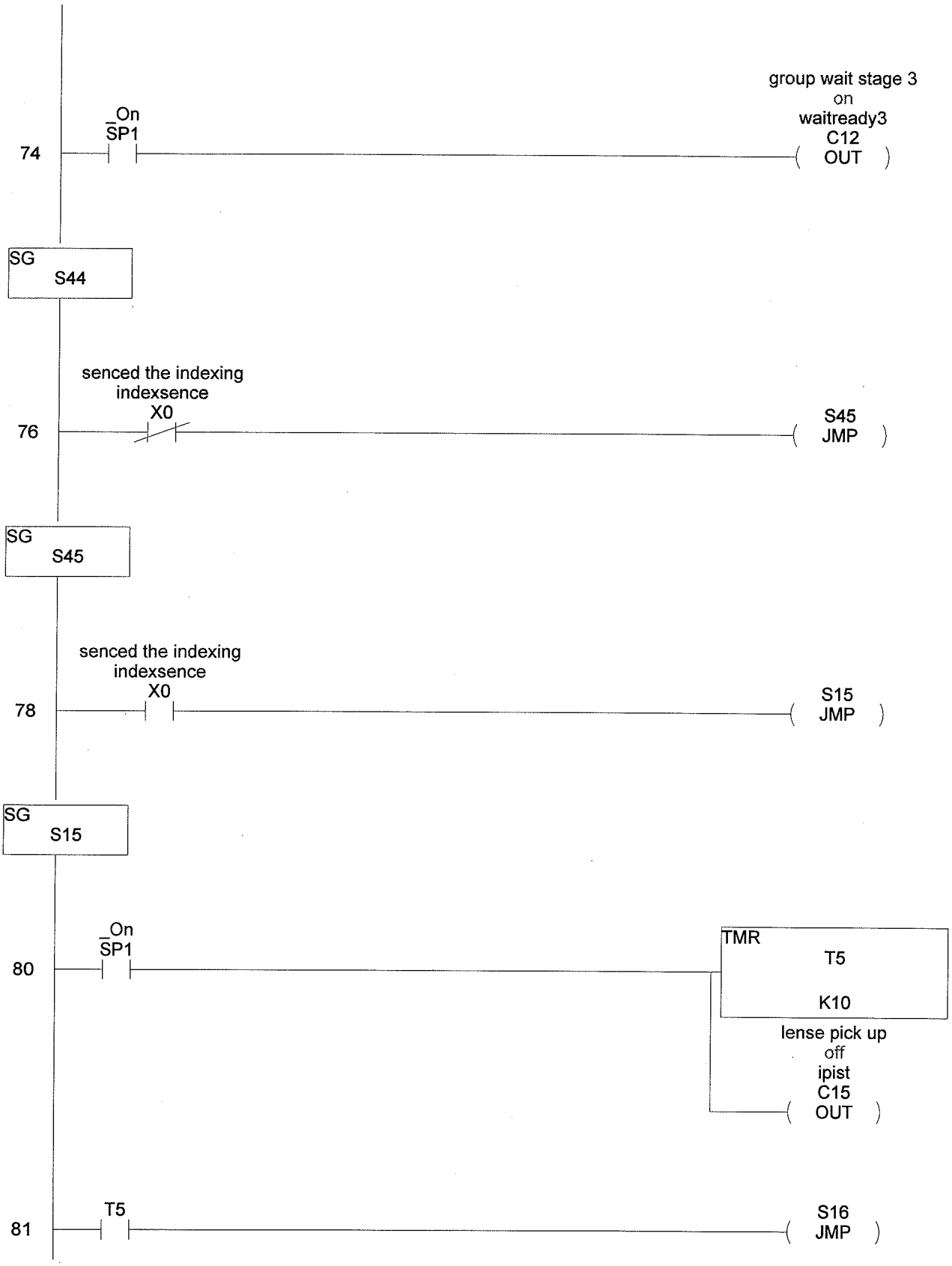

Group wait stage 1
on
waitready1
C10
OUT
_On
SP1
34
exit group wait
on
endwait
C13
35
S6
JMP
SG
S6
activate stage1
i1
X100
37
60
S40
JMP
activate stage 2
i2
X101
38
S7
JMP
ISG
S7
group wait stage 2
on
waitready2
C11
OUT
_On
SP1
40
activate stage 2
i2
X101
41
start
nothing happens
Stage 2
S10
JMP

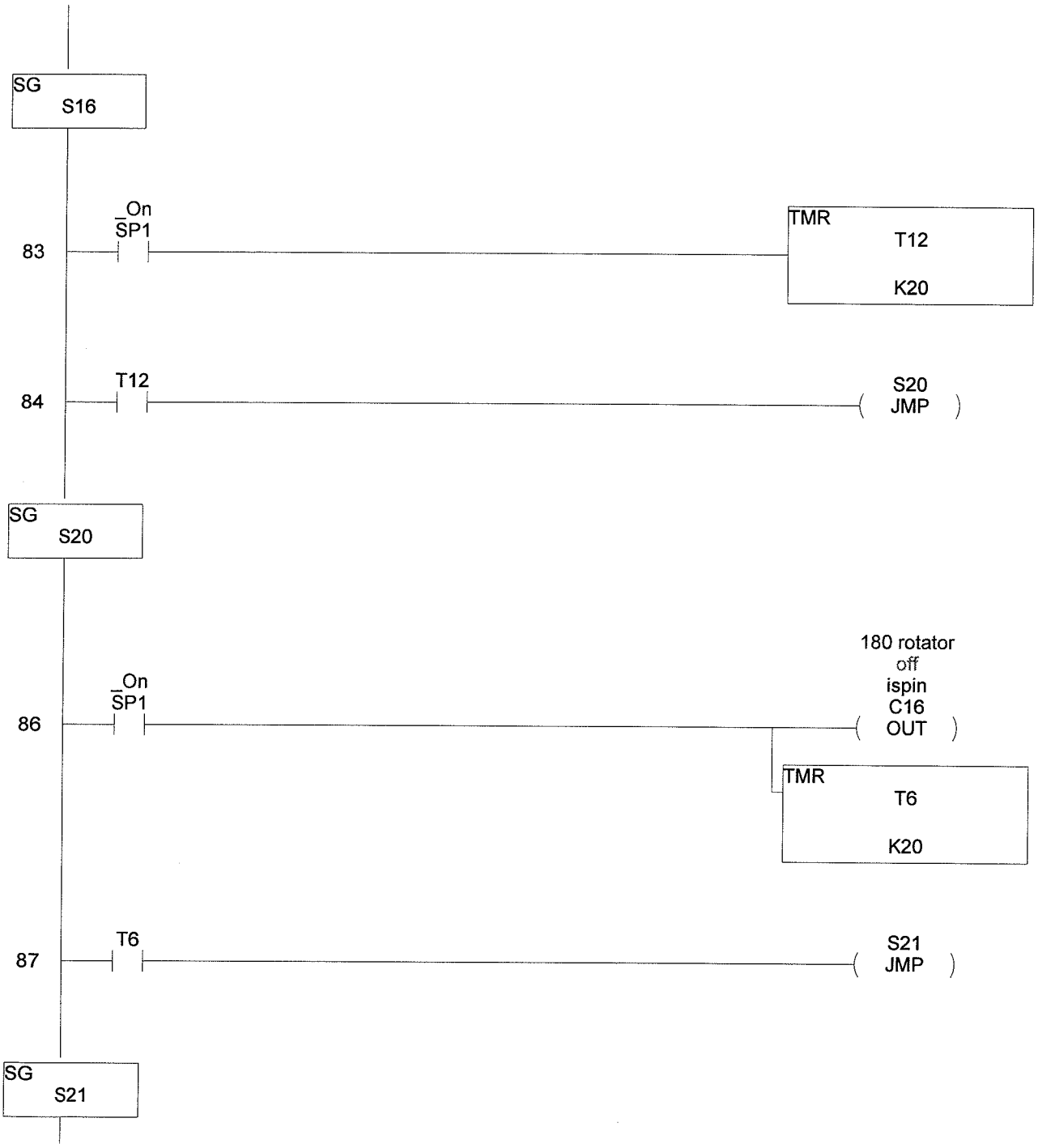

SG
start
nothing happens
Stage 2
S10
43
_On
SP1
holds ring
off
ihighring
C4
OUT
44
senced the indexing
indexsence
X0
S11
JMP
SG
S42
46
senced the indexing
indexsence
X0
S43
JMP
SG
S43
48
senced the indexing
indexsence
X0
S11
JMP
49
_On
SP1
holds ring
off
ihighring
C4
OUT

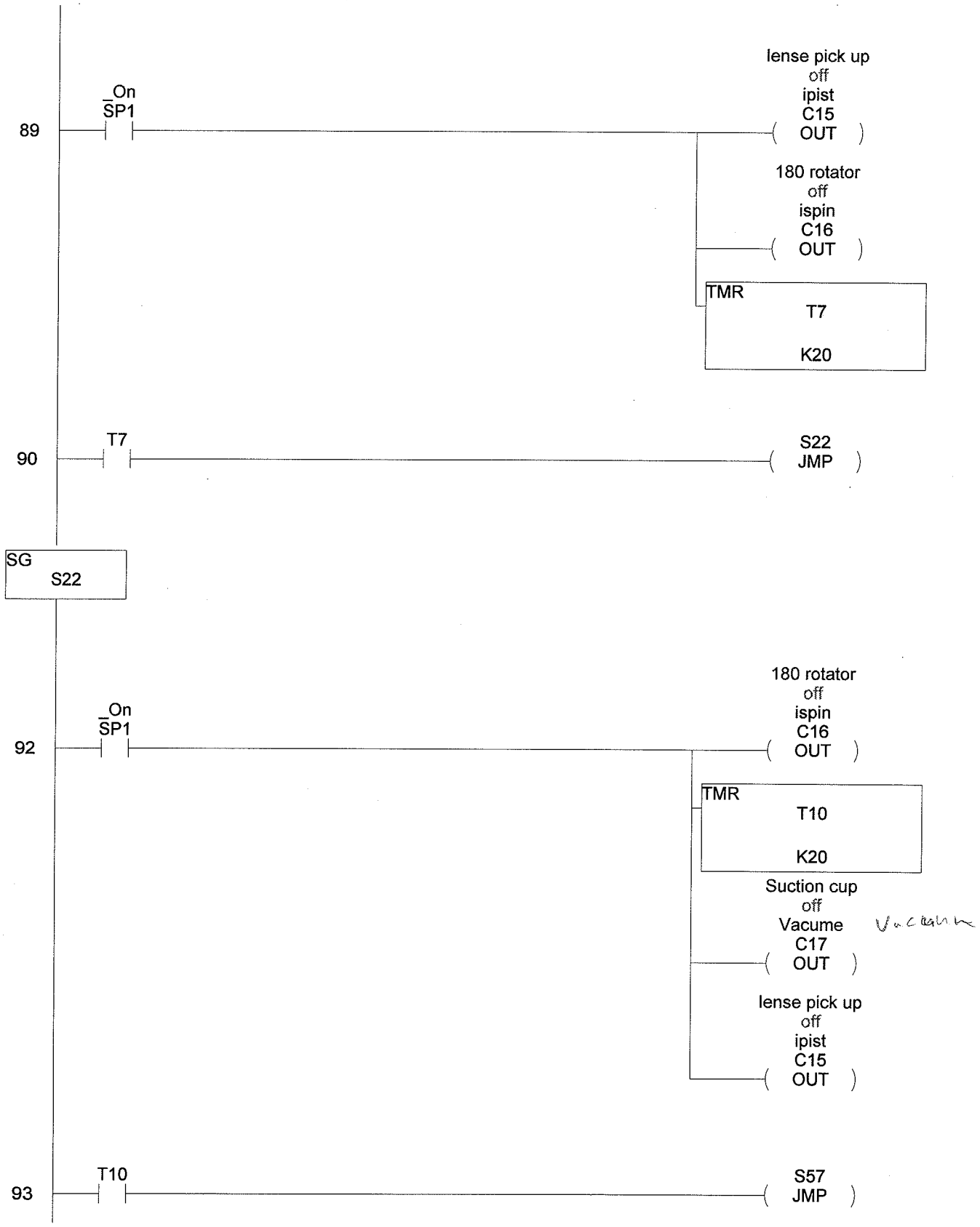

SG
S11
dropps ring
on
ilowring
C5
OUT
_On
SP1
51
TMR
T4
K20
T4
52
S12
JMP
SG
S12
group wait stage 2
on
waitready2
C11
OUT
_On
SP1
54
exit group wait
on
endwait
C13
55
S13
JMP
SG
S13
holds ring
off
ihighring
C4
OUT
_On
SP1
57

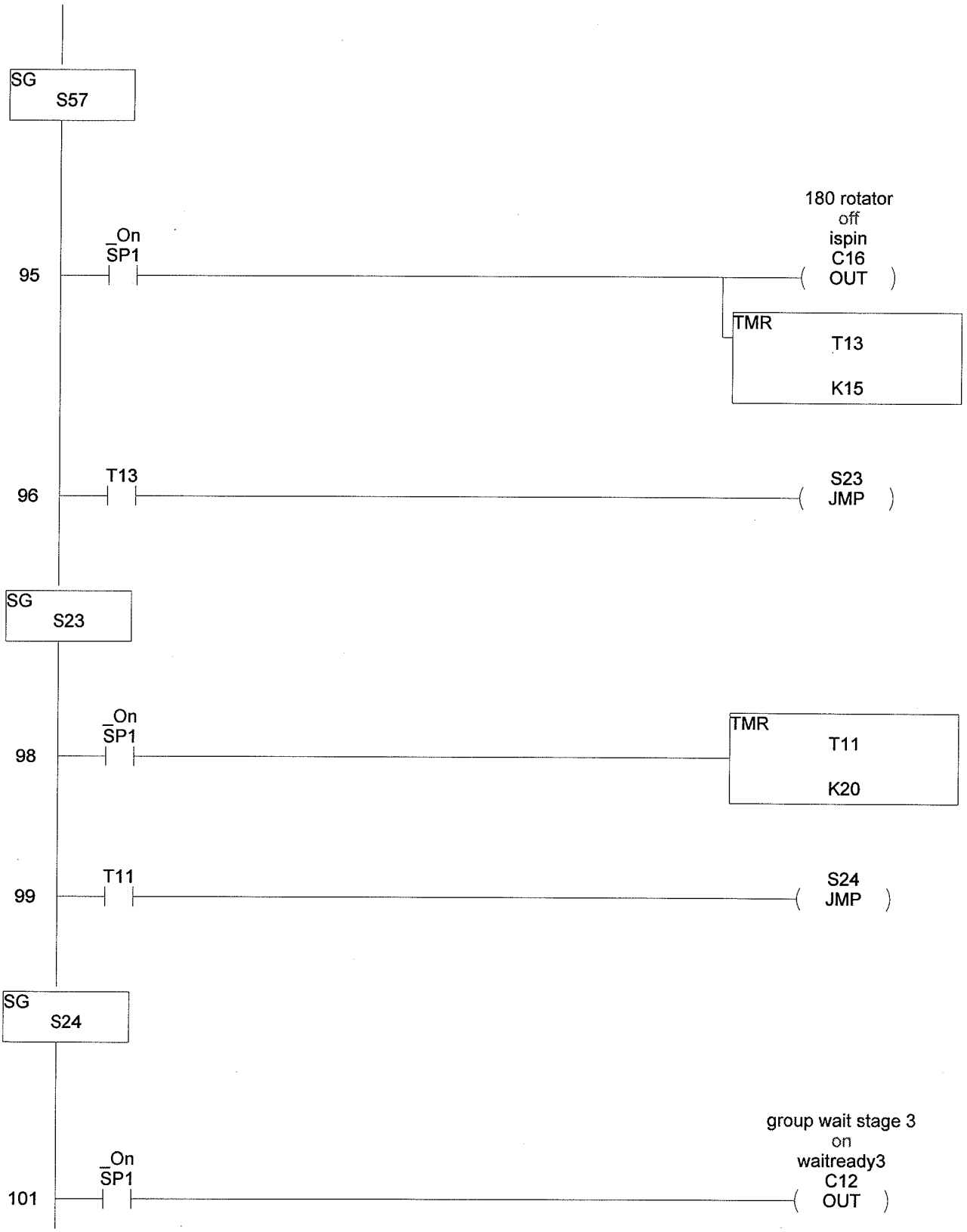

activate stage 2
i2
X101
58
S42
JMP
activate stage 3
start
nothing happens
Stage 3
S14
JMP
i3
X102
59
ISG
wait
Index wait
S30
Group wait stage 1
on
waitready1
C10
group wait stage 2
on
waitready2
C11
group wait stage 3
on
waitready3
C12
exit group wait
on
endwait
C13
OUT
61
SG
turning
Indexing
S31
_On
SP1
63
C20
OUT
senced the indexing
indexsence
X0
64
S32
JMP
SG
S32

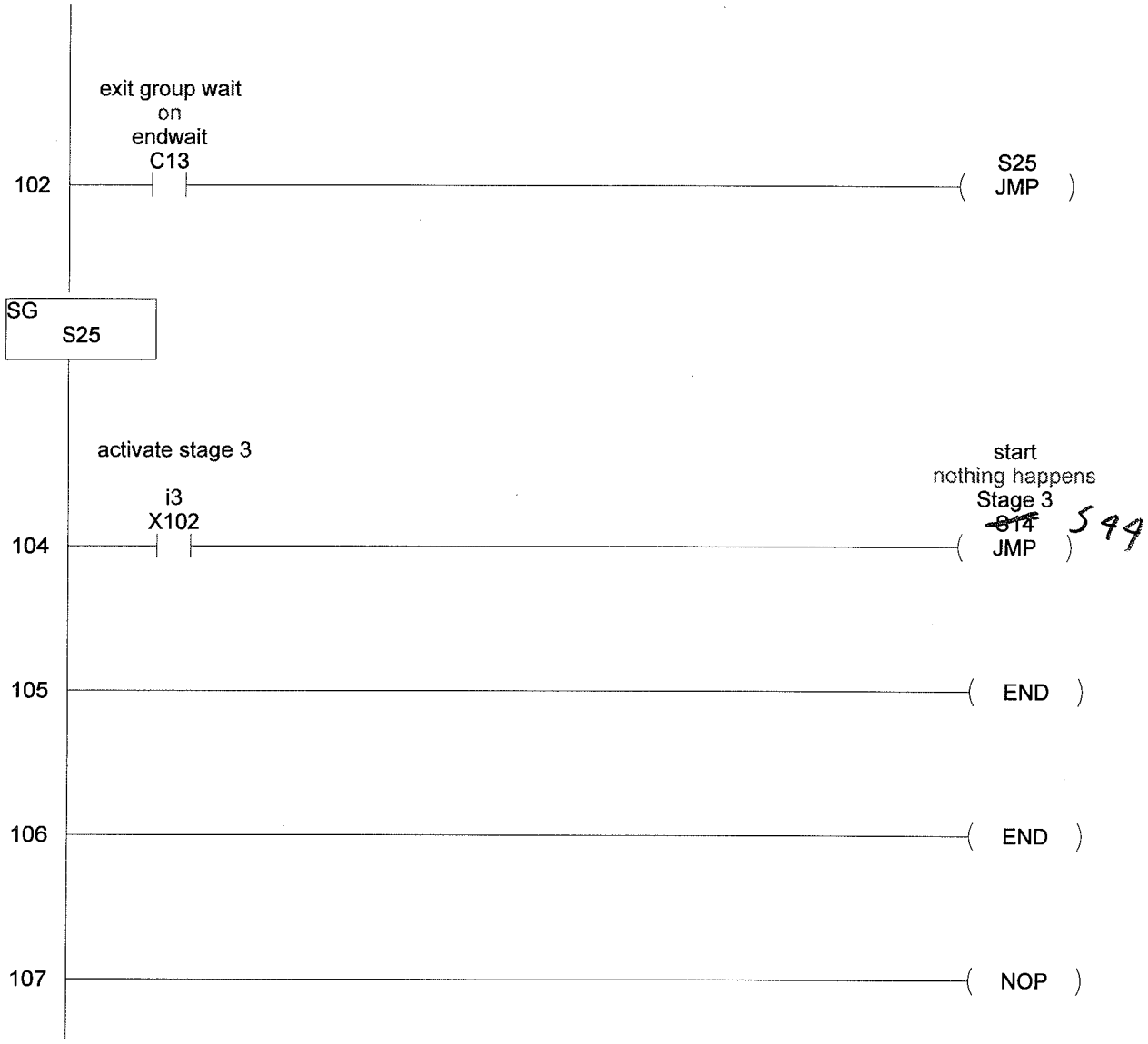

senced the indexing
indexsence
X0
66
TMR
T2
K20
_On
SP1
67
C20
OUT
T2
68
S33
JMP
SG
S33
_On
SP1
70
C21
OUT
TMR
T3
K50
wait
Index wait
S30
T3
71
JMP
ISG
start
nothing happens
Stage 3
S14
activate stage 3
i3
X102
73
S15
JMP


group wait stage 3
on
waitready3
C12
OUT
_On
SP1
74
SG
S44
senced the indexing
indexsence
X0
76
S45
JMP
SG
S45
senced the indexing
indexsence
X0
78
S15
JMP
SG
S15
_On
SP1
80
TMR
T5
K10
lense pick up
off
ipist
C15
OUT
T5
81
S16
JMP


SG
S16
83
_On
SP1
TMR
T12
K20
84
T12
S20
JMP
SG
S20
86
_On
SP1
180 rotator
off
ispin
C16
OUT
TMR
T6
K20
87
T6
S21
JMP
SG
S21


89
_On
SP1
lense pick up
off
ipist
C15
OUT
180 rotator
off
ispin
C16
OUT
TMR
T7
K20
90
T7
S22
JMP
SG
S22
92
_On
SP1
180 rotator
off
ispin
C16
OUT
TMR
T10
K20
Suction cup
off
Vacume
C17
OUT
lense pick up
off
ipist
C15
OUT
93
T10
S57
JMP


SG
S57
180 rotator
off
ispin
C16
OUT
_On
SP1
95
TMR
T13
K15
T13
96
S23
JMP
SG
S23
_On
SP1
98
TMR
T11
K20
T11
99
S24
JMP
SG
S24
group wait stage 3
on
waitready3
C12
OUT
_On
SP1
101


exit group wait
on
endwait
C13
102
S25
JMP
SG
S25
activate stage 3
i3
X102
104
start
nothing happens
Stage 3
~~S14~~
JMP
549
105
END
106
END
107
NOP