

Owners Manual

**Burr Puzzle Manufacturing System
Model 2006**

Brought to you by Team Erickson

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Introduction

This is the manual for your new burr puzzle machine. This machine will manufacture burr puzzles consisting of six, 0.75 x 0.75 x 2.25 inch wood blocks. This manual provides an overview and operating instructions for the burr puzzle machine. It is intended that this manual will help ensure the proper and safe operation of the machine. Also included is the machine overview and program documentation.

The 2006 model of the burr puzzle machine continues to build upon previous models. In addition to maintaining a safe and reliable design new features have been added. Among these features are an improved dust collection system and the addition of noise reduction.

This machine was designed, constructed and programmed by Team Erickson.

Specifications

Blocks:

- Hardwood blocks of nominal dimension 0.75 x 0.75 x 2.25 inch, +/- 0.003 (95%). Other woods may also be used but the quality of the finished product may be reduced.

Machine:

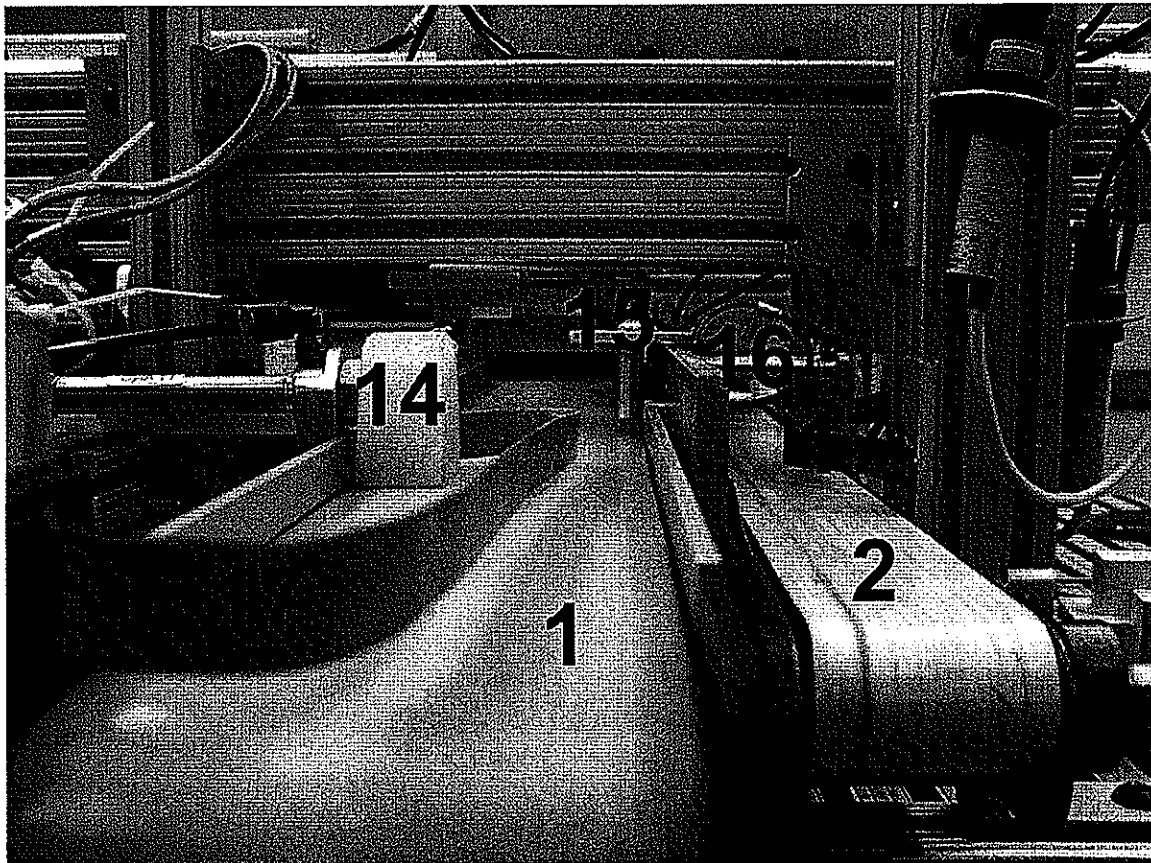
- Blocks enter and exit machine lengthwise via conveyors.
- Capable of 0-4 cuts of 0.375 inch width on any one face of a block.
- Capable of rotating each block to second face for additional cuts.
- Capable of 0-2 cuts of previous dimension on a second face.
- Accepts the 4 inch overhead dust collection system to remove shavings.
- Has a safety kill switch to completely shut down operation.
- Operating noise level of 77.8 dB.
- Operating noise level while cutting of 85.5 dB.

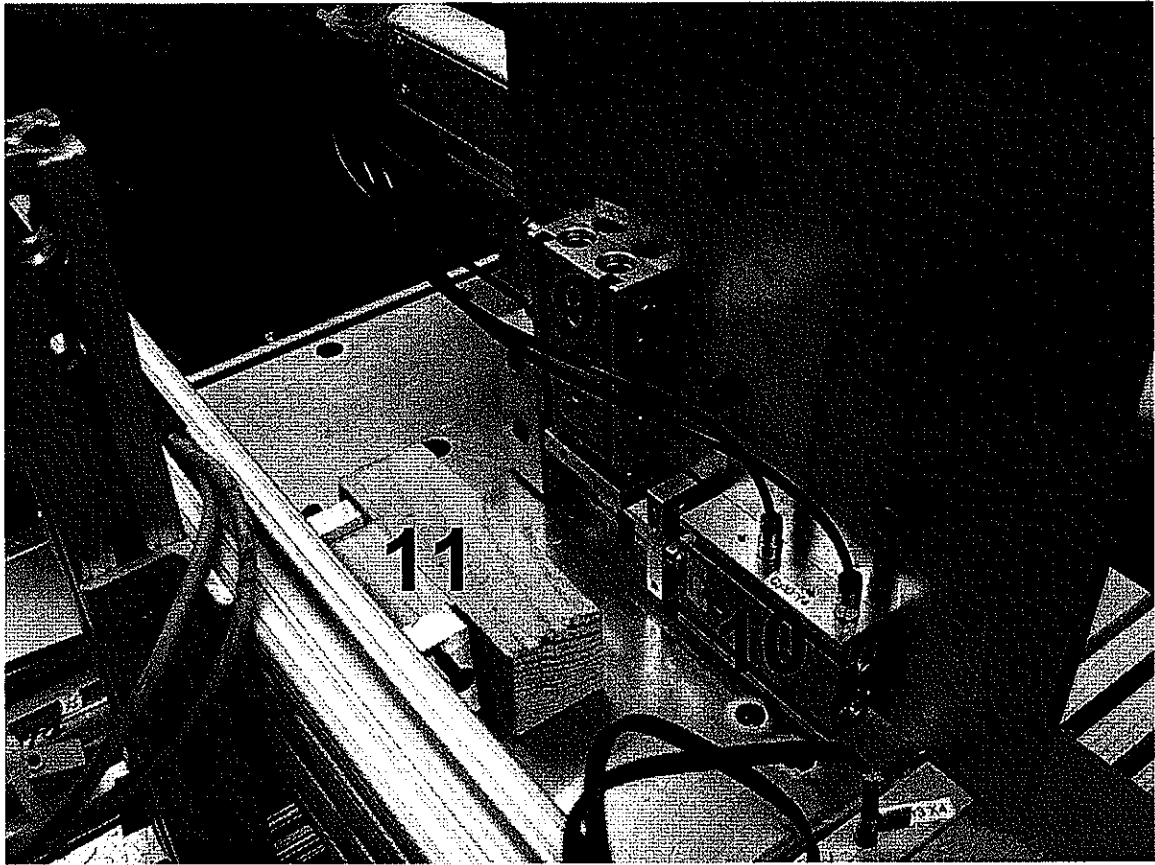
Finished Product:

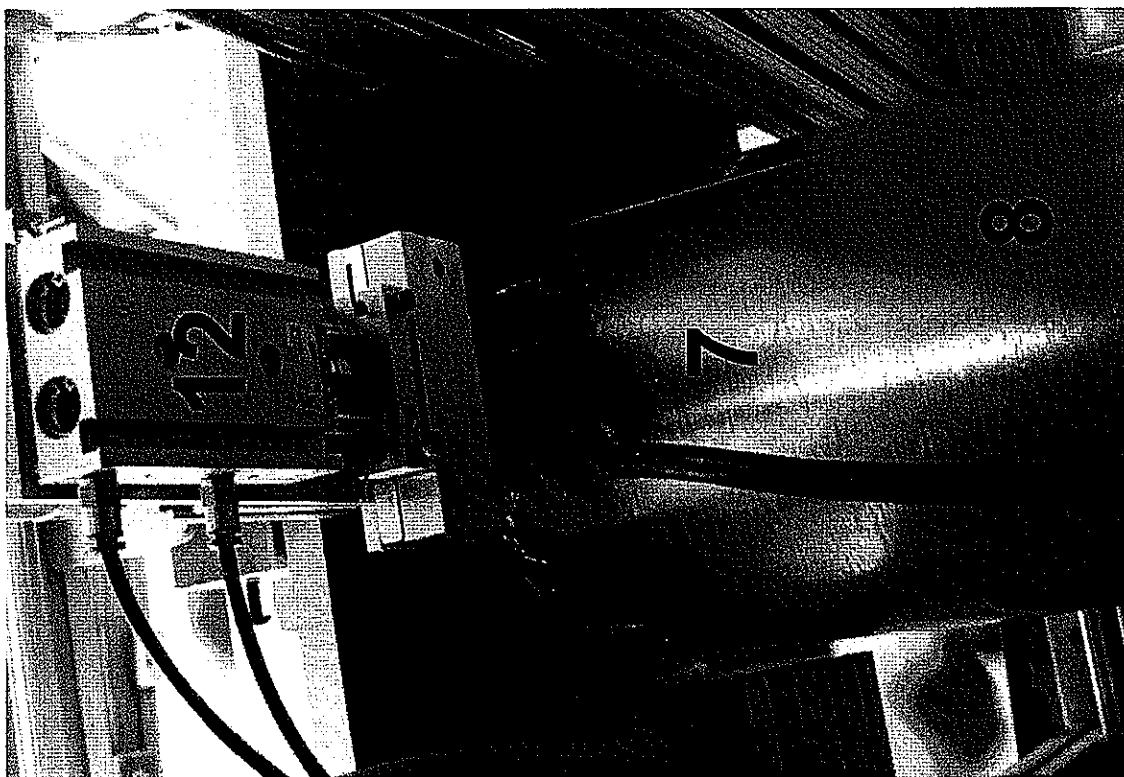
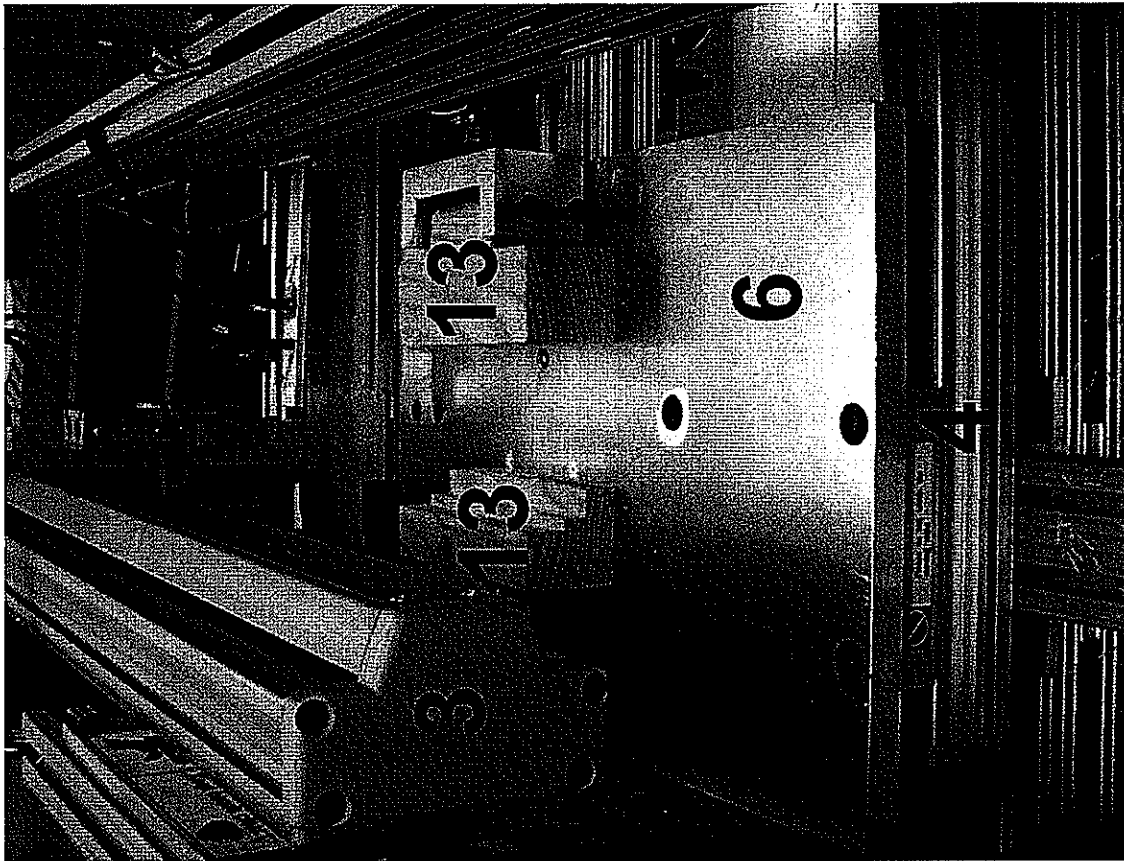
- Cuts should be clean and free of burrs, requiring no additional work.
- A maximum of 2 lbf should be required on any one block during assembly of puzzle (95%).

Machine Layout

| | | | |
|---|-----------------------------|----|--------------------|
| 1 | Input Conveyor | 10 | Side Clamp |
| 2 | Output Conveyor | 11 | Front Clamp |
| 3 | Linear Actuator 1 | 12 | Flipper Cylinder |
| 4 | Linear Actuator 2 | 13 | Sacrificial Blocks |
| 5 | Block Carriage | 14 | Spacing Cylinder |
| 6 | Router Carriage | 15 | Rotator Pin |
| 7 | Router (inside Vacuum Duct) | 16 | Holding Cylinders |
| 8 | Vacuum Duct | 17 | Guides |
| 9 | Top Clamp | | |







Machine Process

Once the machine has been turned on and everything has been initialized the blocks are placed onto the Feed Conveyor. The first block up the conveyor trips a pass-through sensor which triggers the Spacing Cylinder. This cylinder creates a gap between the blocks. After tripping the sensor the block hits the Rotation Pin. The pin causes the block to rotate perpendicular to the motion of the conveyor. Once the block has cleared the sensor, the next block is allowed through.

When the first block reaches the optical sensors the Holding Cylinders retract allowing it to pass through. In addition to controlling the Holding Cylinders these optical sensors begin a timer. The block reaches the Block Carriage before the timer expires. Upon expiration the Side Clamp secures the block. The whole carriage moves until it is over the Router Carriage.

Upon reaching the location for the first cut both the Top Clamp and Front Clamp are activated, securing the block against both carriages. The Router Carriage moves perpendicular to the block cutting each slot. All of the wood shavings are pulled down past the router by the Vacuum Duct. Upon reaching the end of each cut the Router Carriage returns to its initial position. All of the motions of the carriages are performed by the Linear Actuators. These actuators move between programmed positions by user defined accelerations and velocities. When one actuator reaches a certain position it triggers another activity.

The slots to be cut are defined in memory of the PLC. This data dictates the positioning of the carriages. If a block needs to have slots cut on the second face, it will need to be flipped. To do this both carriages position themselves in a predefined configuration. All three of the clamps release and the Flipper Cylinder is activated. This cylinder extends two cables out of the Router Carriage. These cables lift the back of the block and rotate it forward. The cables then retract and the Front Clamp pushes the block back into position where it is then re-secured by the other two clamps. Any necessary slots are cut in this face in the same manner as before.

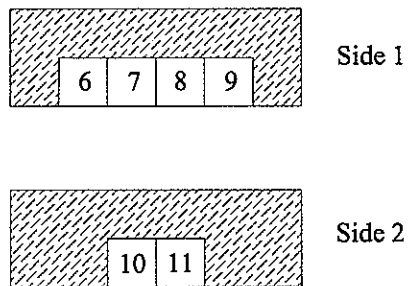
Once all of the slots have been cut the Front and Top Clamps are released. The Block Carriage travels off of the Router carriage, across the Feed Conveyor and over the Output Conveyor. The Side Clamp is released, dropping the block which travels out of the machine.

The Block Carriage returns to its ready position over the Feed Conveyor where it receives the next waiting block. While each block is being cut additional blocks are rotated and lay waiting at the Holding Cylinders. If the machine is continually fed more blocks it will just repeat the process of making sets of six blocks for each puzzle.

Defining & Changing the Puzzle

Changing the puzzle requires the number and locations of slots to be redefined. The following is the procedure to accomplish this task.

1. Connect the PLC to the computer via a data cable.
2. Turn on the PLC and set it to 'TERMINAL MODE'.
3. On the computer, run DirectSOFT32.
4. Open the memory editor: **Tools → Memory Editor → Find → 'v1240'**
5. Memory locations V1240 through V1245 are reserved for the six different blocks. For each binary number a 1 represents a cut and a 0 represents no cut. Desired cuts are held in the 6th-11th bits. The format is '0000011111100000'. This particular sequence would cut four slots in the first side and two in the second.



Operation

Startup

1. Make sure there are no blocks or other foreign objects in the machine.
2. Verify main power and air hose are both connected.
3. Set PLC to 'STOP' setting, this will verify the program has reset.
4. Release kill switch to turn on power.
5. Set PLC to 'RUN' setting.
6. Wait for linear slides to 'home' and return to their starting positions.
7. Turn on vacuum system.
8. Turn on feed conveyor by its driver box.

Feeding & Operating

The operation of the burr puzzle machine is relatively simple. Once it is up and running all that need to be done is feed it blocks on the Feed Conveyor. The machine will continue to machine sets of six blocks as long as it has more blocks waiting.

In case of EMERGENCY hit the big red kill switch. This will kill all power to the system. The Feed Conveyor will continue to run as it is sourced by power that bypasses the kill switch. Make certain the router has time to spin-down before you begin to fix any problems that may have occurred.

Troubleshooting

If the red kill switch is turned on but the router doesn't turn on, check to be sure that the router is plugged in and that the switch on the router is turned on.

When starting up the machine be sure that the PLC has been switched to the 'STOP' position then to the run before starting.

If a puzzle piece does not load in the block carriage properly, immediately hit the kill switch and reset the machine.

If the entries and exits of the router bit are not clean be sure that there are no chips in the way. If the problem persists replace the sacrificial blocks, refer to p. 11 for instructions.

If there are burn marks on the blocks after cutting then it is time for a new router bit, refer to p. 12 for instructions.

Known Issues & Maintenance Checks

Issues

- Hall affect sensors on Front Clamp cylinder can easily be bumped from proper position. If this occurs the cylinder and program may stop functioning.
- When multiple machines are using pressurized air, the Gate Cylinder (Cyl.C) may retract too slowly. This can cause the block to rotate and not seat properly in the Block Carriage.
- If Feed Conveyor is not operating at maximum speed then the blocks may not have time to fully seat against the Block Carriage.
- If PLC is not moved to 'STOP' after kill switch is activated, then it may start back up in the middle of the program. This can result in the machine acting unusual or even jamming.
- On occasion the linear actuator controller experiences an 'Axis Pattern Error' which can cause the machine to freeze.

Maintenance Checks

- Occasionally check fasteners. These will work loose over time due to vibrations.
- Verify guide covering the Holding Cylinder (Cyl.B) rests against the tip of the cylinder shaft.
- Check sacrificial blocks to verify that they remain snug in their holders.

Replacing sacrificial blocks:

There are two sacrificial blocks on this machine, one is stationary and hides the router bit during block translation and the other block is attached to cylinder F which clamps the puzzle piece in place while cutting. The blocks are held in place by six setscrews, the screws can be used to position the block as well as hold it.

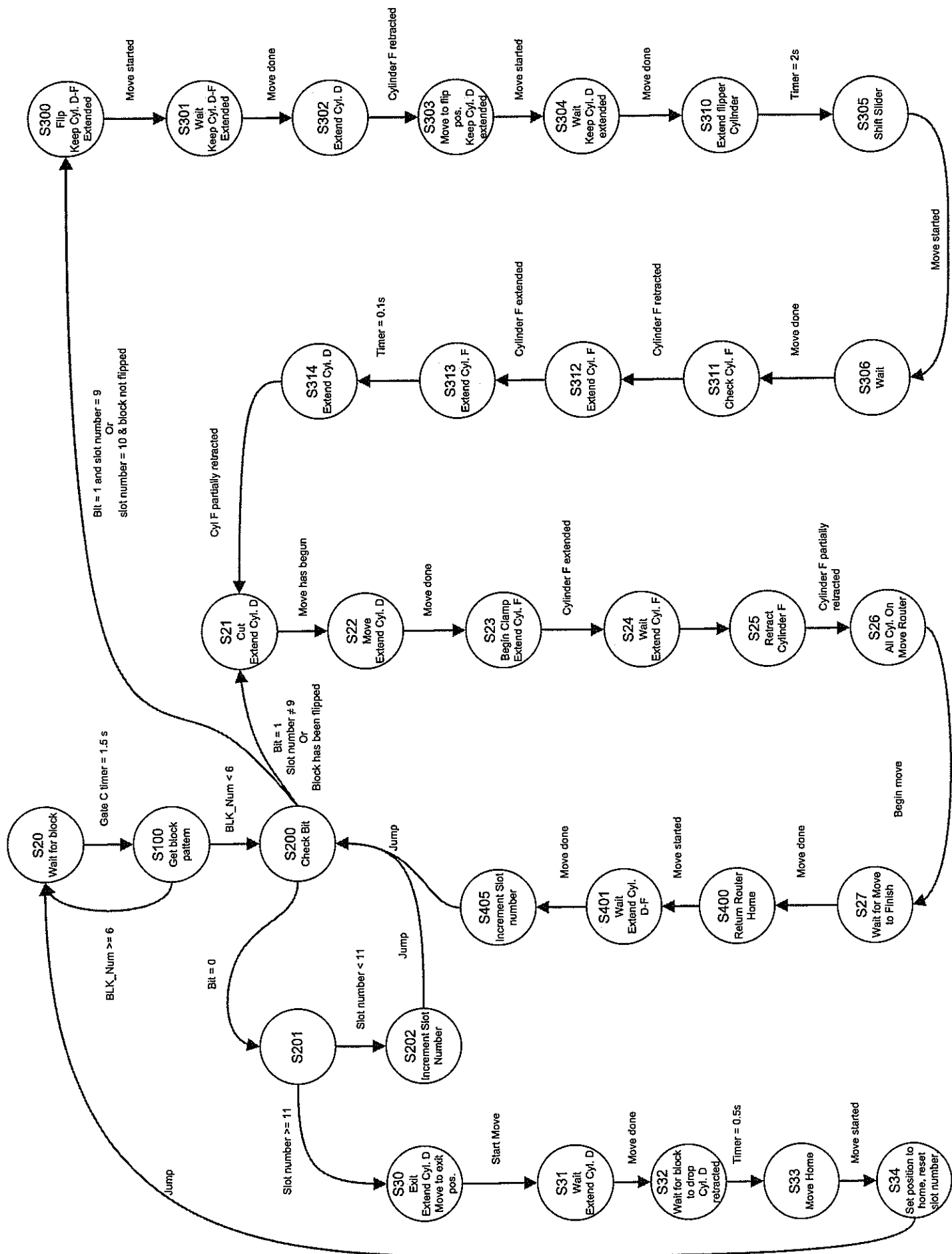
1. Remove the existing blocks and use them as patterns to create new blocks. The optimum block material is a hard wood or Teflon which will not dull the router bit but hold the puzzle piece in place. Take special care in making sure the front face and bottom of the blocks are square with one another. Also be sure that where the stationary block meets the translating back plate is a good fit but does not cause resistance to the motion of the translating back plate.
2. Place the stationary block in its clamp first then slide the translating back plate in front of it. Hold the stationary block against the back of the translating plate and tighten down the screws. Keep in mind that the first time you tighten the setscrews they will imprint the wood making repositioning the block more difficult so take care to position the block right the first time.
3. Turn the machine on and allow the linear slides to home. The router will cut the slot in the stationary block getting the router out of the way for placing the other block.
4. To replace the block on the end of cylinder F, raise the cross bar that holds the cylinder about a 1/8-inch. Place the block in clamp and slide it against the translating back plate with a puzzle piece in place. With the block held tight up to the puzzle piece and the cylinder fully extended, tighten down the setscrews. Now lower the cross bar to ensure that the block cannot rotate on the axis of the cylinder piston.
5. With a puzzle piece in place, fully extend cylinder F. Make sure that sensor X2 is lighting, if not move the sensor until it does. There is a wait state in the program that allows for some forgiveness in the position of the sensor. At this point the machine is ready to cut puzzle pieces. The slot in the second block will be cut with the first puzzle piece.

Changing router bits:

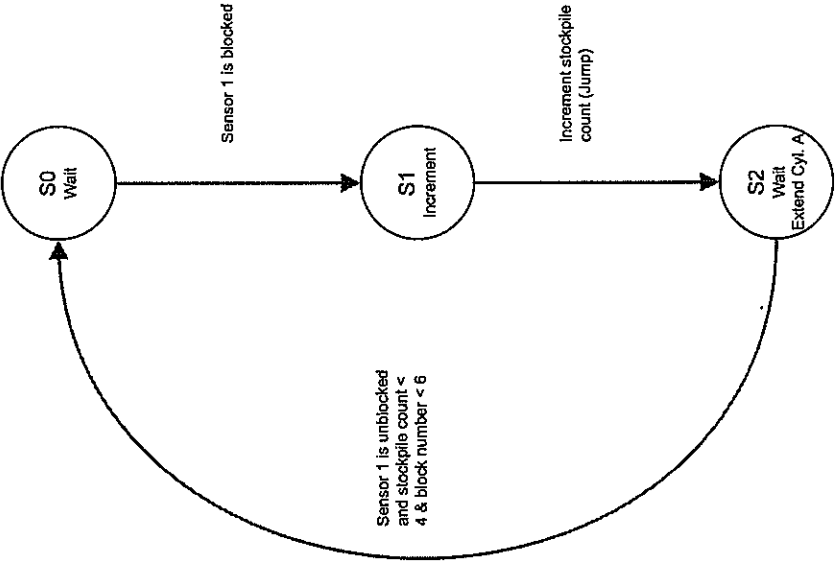
1. Remove the dust cover from around the router by loosening the clamp located directly under the router carriage. Carefully slide the cover down off the router while watching that the flipper lines and power cord slide out of the slots.
2. Open the clamping lever on the router, then press the black release button, which will allow the router to fall out.
3. Using two open-ended 1 1/8 inch wrenches remove the old router bit from router and slide in a new one.
4. Place the router back into its base, which is mounted on the machine, and raise it until the router bit is sticking up 0.37 inches above the router carriage.
5. At this point it is suggested that a puzzle piece be cut to confirm the position of the router.
6. Replace the dust cover over the router being mindful of the power cord and flipper lines.
7. When the dust cover is up tight to the router carriage, tighten down the clamp until dust cover is firm.

Future Improvements

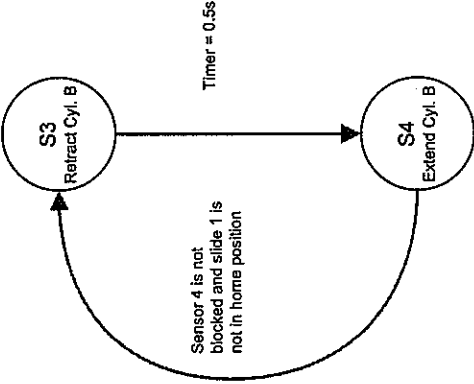
- Implement a simpler setup for the sacrificial blocks: both for their geometry and for the method in which they are installed and held.
- Program the router to make new cuts while moving in both directions instead of just one direction.
- Increase the ease at which the router can be calibrated.
- Further noise reduction.



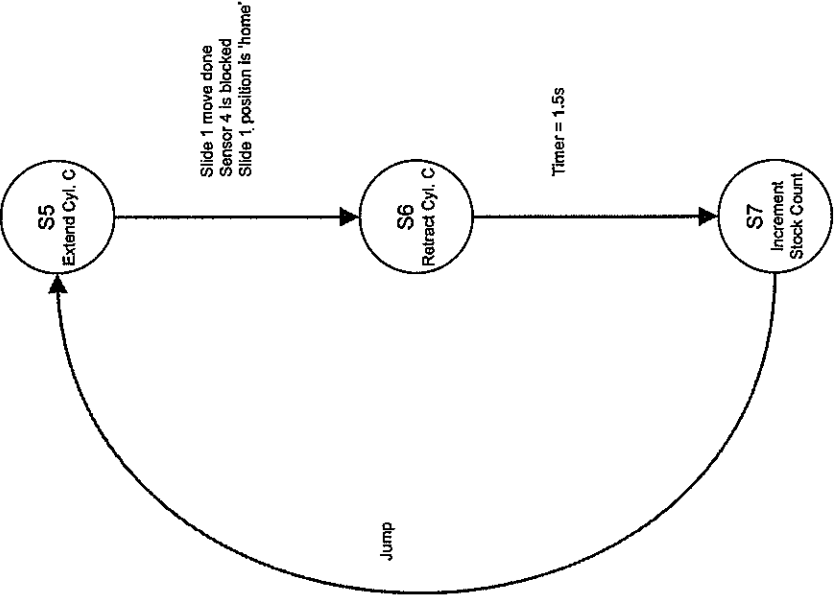
Spacing Cylinder



Holding Cylinder



Gate Cylinder



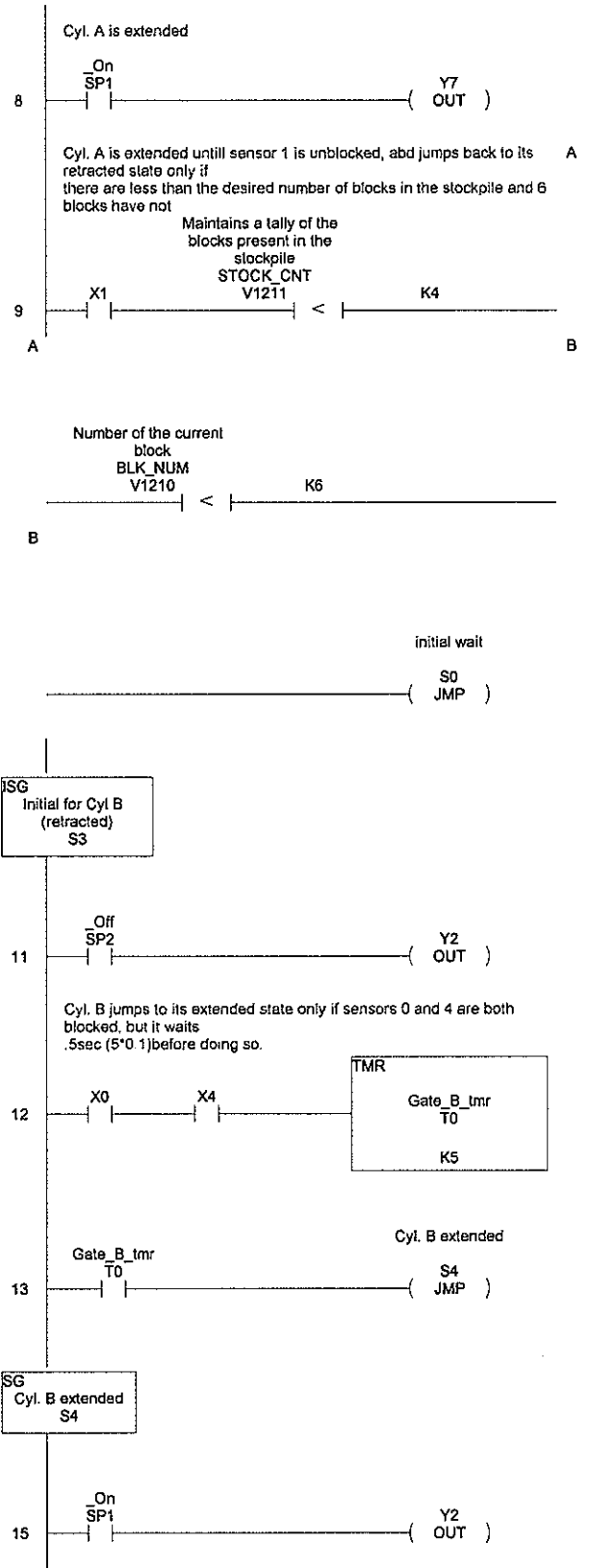
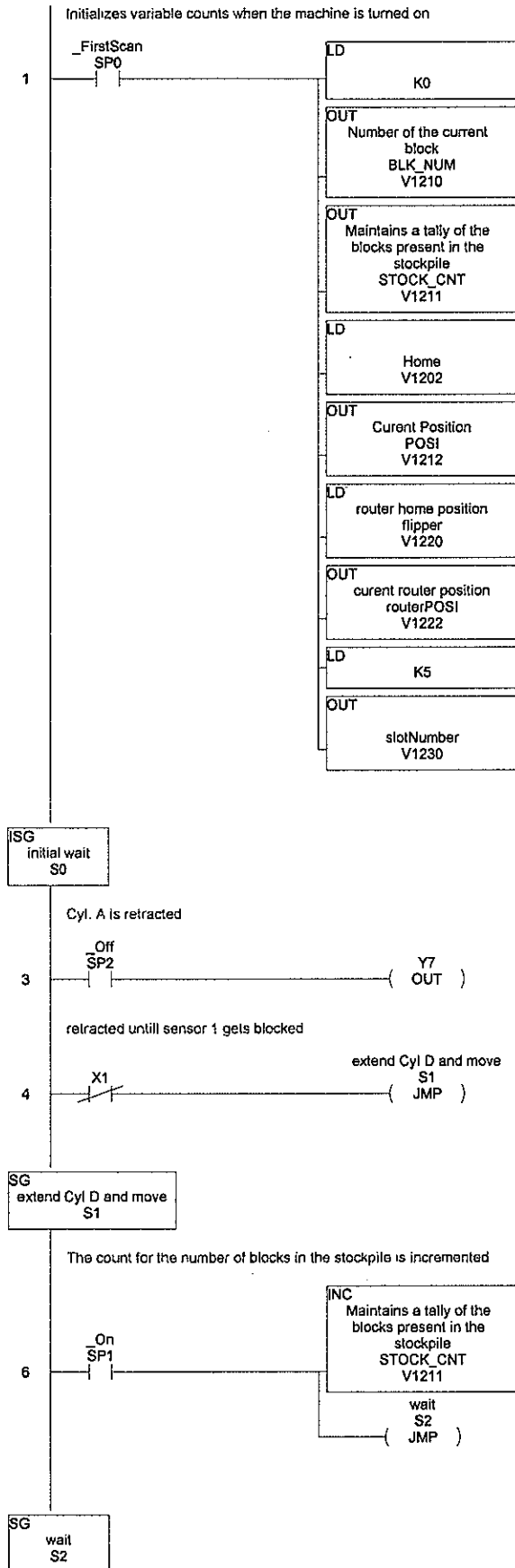
IAI Slide Program & Position Tables

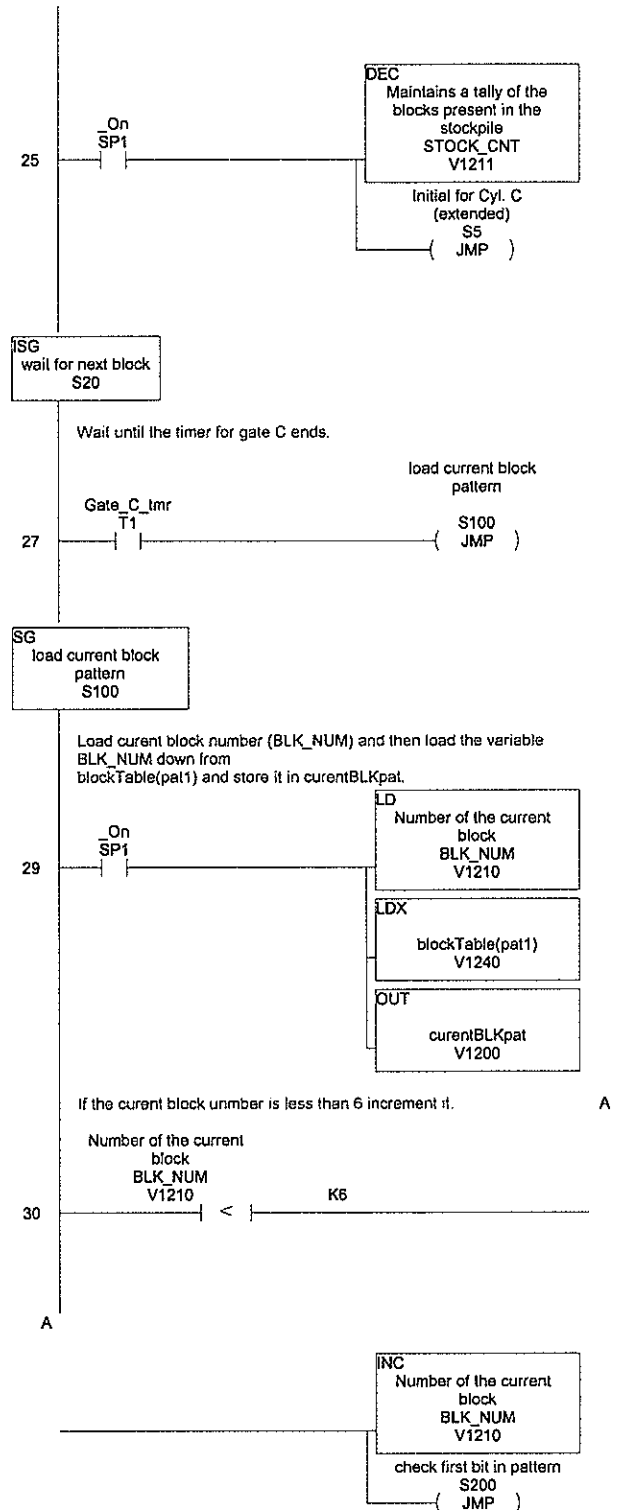
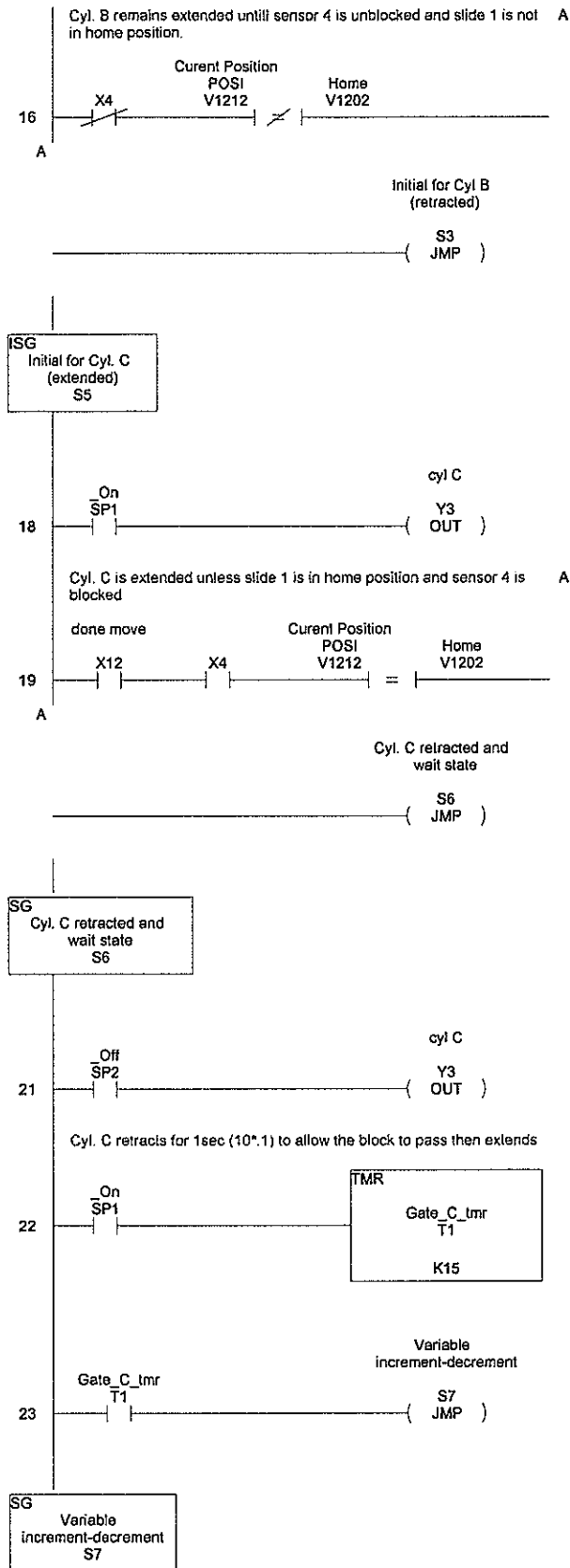
Slide Program

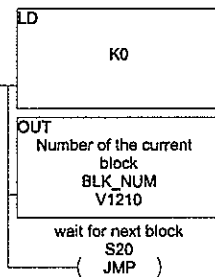
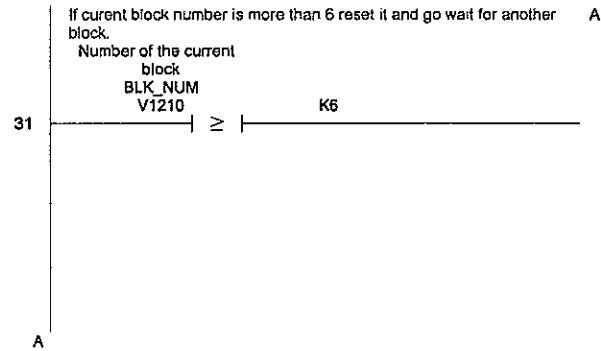
| Step | E N Cnd | Cmnd | Operand1 | Operand2 | Pst | Comment |
|------|---------|------|----------|----------|-----|-------------------|
| 1 | | SVON | 11 | | | SERVOS ON BOTH AX |
| 2 | | HOME | 11 | | | HOME AXIS 1&2 |
| 3 | | ACC | 0.9 | | | SET ACCEL |
| 4 | | VEL | 50 | | | SET VELOCITY |
| 5 | | MOVP | 6 | | | PICK UP POS. |
| 6 | | BTON | 302 | | | |
| 7 | | TAG | 1 | | | |
| 8 | | WTON | 15 | | | Wait for START |
| 9 | | BTOF | 302 | | | Reset Move Done |
| 10 | | IN | 16 | 19 | | Load pos to 99 |
| 11 | | ADD | 99 | 2 | | 0 input -> Pos 2 |
| 12 | | MOVP | *99 | | | Move to pos # |
| 13 | | WTOF | 15 | | | Wait for /START |
| 14 | | BTON | 302 | | | Move Done |
| 15 | | GOTO | 1 | | | |
| 16 | | | | | | |

Slide Points

| Point No. | Acc. | Vel. | Axis 1 (mm) | Axis 2 (mm) |
|-----------|------|------|-------------|-------------|
| 1 | - | - | - | - |
| 2 | - | - | - | - |
| 3 | 0.3 | 200 | 0.000 | - |
| 4 | 0.3 | 100 | 263.450 | - |
| 5 | 0.3 | 200 | 259.120 | - |
| 6 | 0.3 | 100 | 93.195 | 0.000 |
| 7 | 0.3 | 200 | 245.740 | - |
| 8 | 0.3 | 200 | 254.693 | - |
| 9 | 0.3 | 200 | 263.767 | - |
| 10 | 0.3 | 200 | 273.350 | - |
| 11 | 0.3 | 200 | 254.693 | - |
| 12 | 0.3 | 200 | 263.767 | - |
| 13 | 0.3 | 50 | - | 0.000 |
| 14 | 0.3 | 3 | - | 32.000 |
| 15 | 0.3 | 100 | - | 0.000 |
| 16 | - | - | - | - |

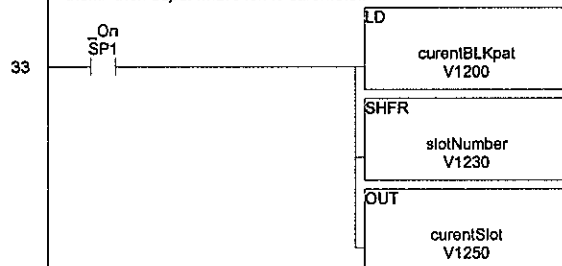






SG check first bit in pattern
S200

Load the previously stored 16bit pattern and shift to the left slotNumber bits and discard them. then output what's left to currentSlot.

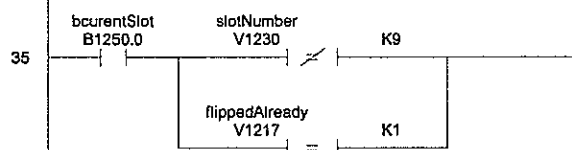


Now look at the first bit of what's left.

If it's zero, go increment slotNumber.



If the bit is a one and it's not the slot to flip, or the block has already been flipped, go cut. A

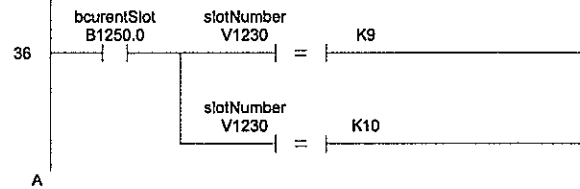


A

move to cut position

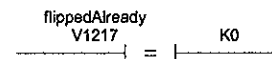
S21
JMP

If the bit is a one and it is the slot to flip, or it is the last slot but the block has not yet been flipped, then go flip the block. A



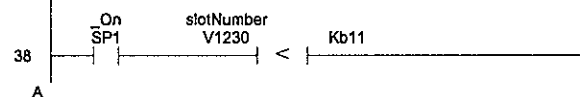
Flip

S300
JMP



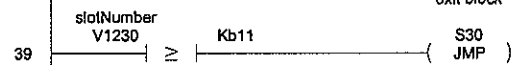
SG S201

Dump the block only of the six slots (slot numbers 5 - 10) have been dell with meaning current slot number is now 11 A



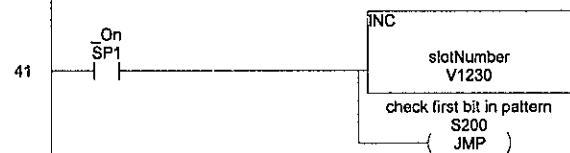
S202
JMP

exit block



SG S202

Increment the slot number and go back to check it.



SG move to cut position
S21

turn on Cyl D

