"World Acclaimed" Wisconsin Bowling Ball Waxer Machine Controller:

**Inputs:**  
- Start.H (S)  
- Gloss.H (G)

**Outputs:**  
- Wax.H (W)  
- SpinBall.H (SB)  
- HEAT.L (H)  
- Buff.L (B)

**Assumptions:**  
- When the person puts in their quarters, start goes true  
- Start stays true for the entire process until the state machine returns to state 000.

**Possible Start Signal**

- SW is normally closed.
- Put in your quarters and SW opens, sets START = H  
- Gloss resets the START signal

**ASM Diagram**
Procedure:

1. Determine ASM flow chart (given in this problem)

2. Count states \( \Rightarrow 5 \)
   
   \( \# \) Compute \# of F/Fs needed \( \Rightarrow 3 \)

3. Label states on ASM flow chart
   
   - try to label such that only one bit will change for each state transition... this will simplify the state variable equations

4. Functional Block Diagram & select F/F Type

5. Next State Table
   
   (See next page)
6) Find State Variable Equations

- since S=T we count
  & when S=F we go to φ & stay
- we can remove S from
  K-Maps and place in
  equations via inspection

i.e. $D_2 = \begin{equation} \text{from K-Map} \end{equation} S$

$D_1 = \begin{equation} \text{from K-Map} \end{equation} S$

$D_0 = \begin{equation} \text{from K-Map} \end{equation} S$

*Also, if our F/Fs
had a clear input signal (low)
we could connect S to this
and remove from the equations,
\[ D_2 = (\overline{GQ}_2 Q_1 Q_0)S \]

\[ D_1 = (Q_2 + Q_1 Q_0 + Q_0 \overline{G} + Q_1 \overline{G})S \]

Check:
- If \( Q_2 = 0 \), go to \( 0 \) \( 0 \) \( 0 \) \( 0 \)\.
- If \( Q_1 = 1 \), else put:
  - if \( Q_0 = 0 \), 110 when \( G = 0 \).
  - if \( Q_0 = 1 \), 110 when \( G = 0 \).

\[ D_0 = (\overline{Q}_1)S \]
Find Equations for Output Variables

- $H$ is only true in state 010 when $G = \text{False}$ (Conditional Output)
  
  By inspection $H = \overline{Q}_2 Q_1 \overline{Q}_0 \overline{G}$

$W, SB, B$ are all unconditional outputs

$W, SB, B$ are all unconditional outputs

and... only dependent on $Q_2, Q_1, Q_0$

\[ W = Q_2 + Q_0 \]

Check in Asm flow chart

\[ SB = Q_2 + Q_0 \]

\[ B = \overline{Q}_2 Q_1 \overline{Q}_0 \]

\[ \text{also you can get this by inspection} \]
Physical Implementation w/Gates

State Eq.: \( D_2 = \overline{Q}_2Q_1Q_0G,\ D_1 = SQ_2 + SQ_1Q_0 + SQ_0G + SQ_1\overline{G} \)
\( D_0 = \overline{Q}_1S \)

These ARE Logic Equations!

Outputs:
\( H = \overline{Q}_2Q_1Q_0\overline{G}, \ W = Q_2 + Q_0, \ SB = Q_2 + Q_0, \ B = \overline{Q}_2Q_1Q_0 \)

Circuitry

State Generator

Output Generation

\( \overline{Q}_2 \quad \overline{Q}_1 \quad \overline{Q}_0 \quad H, L \)

\( Q_2 \quad Q_0 \quad W, H \)

\( \overline{Q}_2 \quad \overline{Q}_1 \quad \overline{Q}_0 \quad B, L \)
8B) Physical Implementation w/ EPROM

Memory Contents

<table>
<thead>
<tr>
<th>Address Value</th>
<th>Hex</th>
<th>Binary</th>
<th>DATA Logic</th>
<th>Actual Voltage to be Programmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>000001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>100000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>100001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>100100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>13</td>
<td>100101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>101000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>101001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>101100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>17</td>
<td>101101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>110000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>19</td>
<td>110001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A</td>
<td>1A</td>
<td>110100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1B</td>
<td>1B</td>
<td>110101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1C</td>
<td>1C</td>
<td>111000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1D</td>
<td>1D</td>
<td>111001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1E</td>
<td>1E</td>
<td>111100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1F</td>
<td>1F</td>
<td>111101</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: X will be programmed "L"

Flip Flops synchronize the events to a clock (they are still needed!)

Next State

Present State

Note: we don't need Q in F/F now

The end!