

Stars 2020

An Update to a
Classic Stern
Pinball Machine

Manufactured in 1978, Stars was one of Sterns first solid state pinball machines. It was the first machine designed by Steve Kirk, and contains a post between the flippers that came to be known as the “Kirk Post.”

The code for Stars was contained in two 2k PROM chips, like many machines of that era. The goals were simple—light the stars and collect the bounty on the right spinner. The drop targets granted the player bonus multipliers, an extra ball, and a special.

The purpose of this project is to update the rules of Stars and re-use as much of the original hardware as possible in the project. A secondary goal is to spend as little money as possible. There’s a third goal of the project that is based in pettiness and revenge, so we won’t talk of it here.

To achieve those goals, this project replaces the M6800 processor in socket U9 with a daughter board connected to J5 on the MPU. That daughter board contains only an Arduino Nano (single board controller), some wires, and connectors. The new code base takes up nearly 30k of space on the Arduino, so it’s nearly seven times as interesting as the old code.

The new features include:

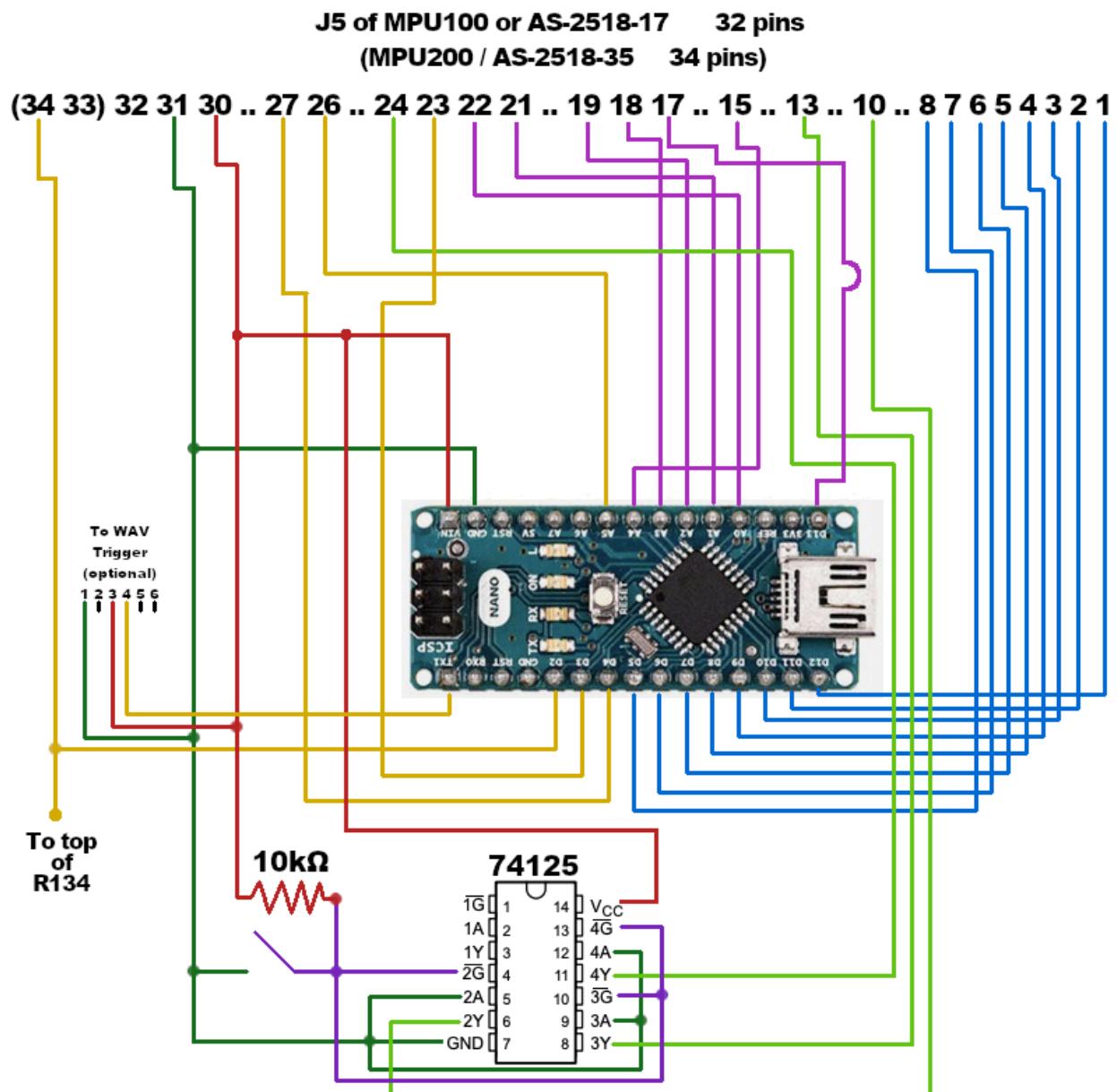
- Multiple brightness levels for the lamps
- Flashing scores when the playfield hasn’t yet been validated
- A skill shot
- Three levels of star collects
- A tally of pop bumper hits that grants rewards at different levels
- A ball save feature
- A “wizard mode” for players who achieve the main goals
- Scoring up to 4 billion

Because this implementation only addresses the PIA chips on the MPU board, it eliminates the need for the PROM, RAM, and cRAM chips at U2, U6, U7, and U8. Because of this, MPU boards with damaged chips or sockets at those locations can still be used. This implementation also uses the EEPROM on the Arduino to store the high score, credits, and audit values, so a battery on the MPU is also not required.

Creating the Arduino Controller Daughter Board

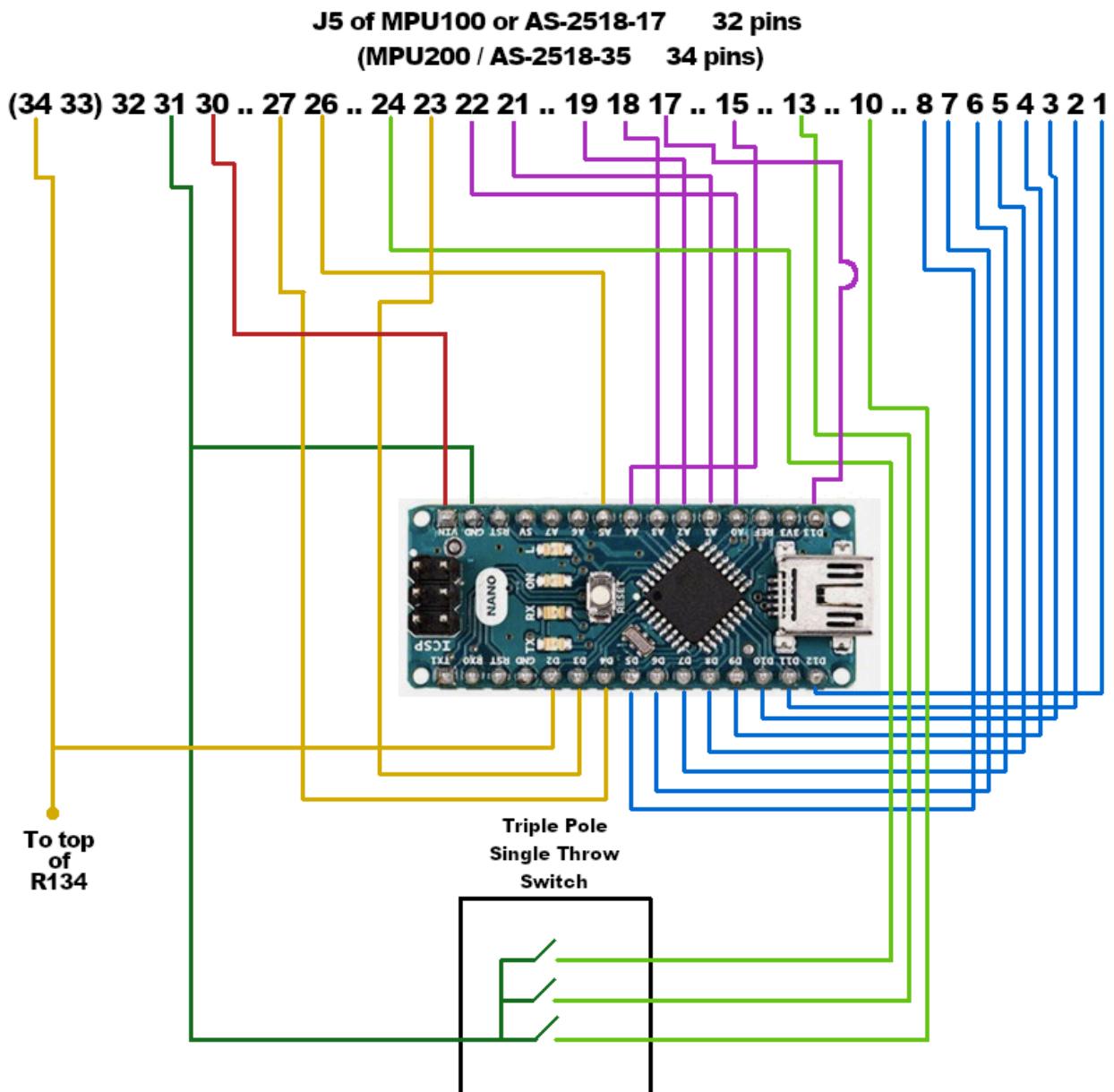
This update to Stars is implemented by wiring an Arduino Nano into J5 on the MPU.

(This board has been tested on Bally AS-2518-17, Stern MPU100, and Stern MPU200. It should also work on the Bally AS-2518-35 board)



Alternate wiring with 3 pole switch for grounding:

Connection Diagram - J5 to Arduino



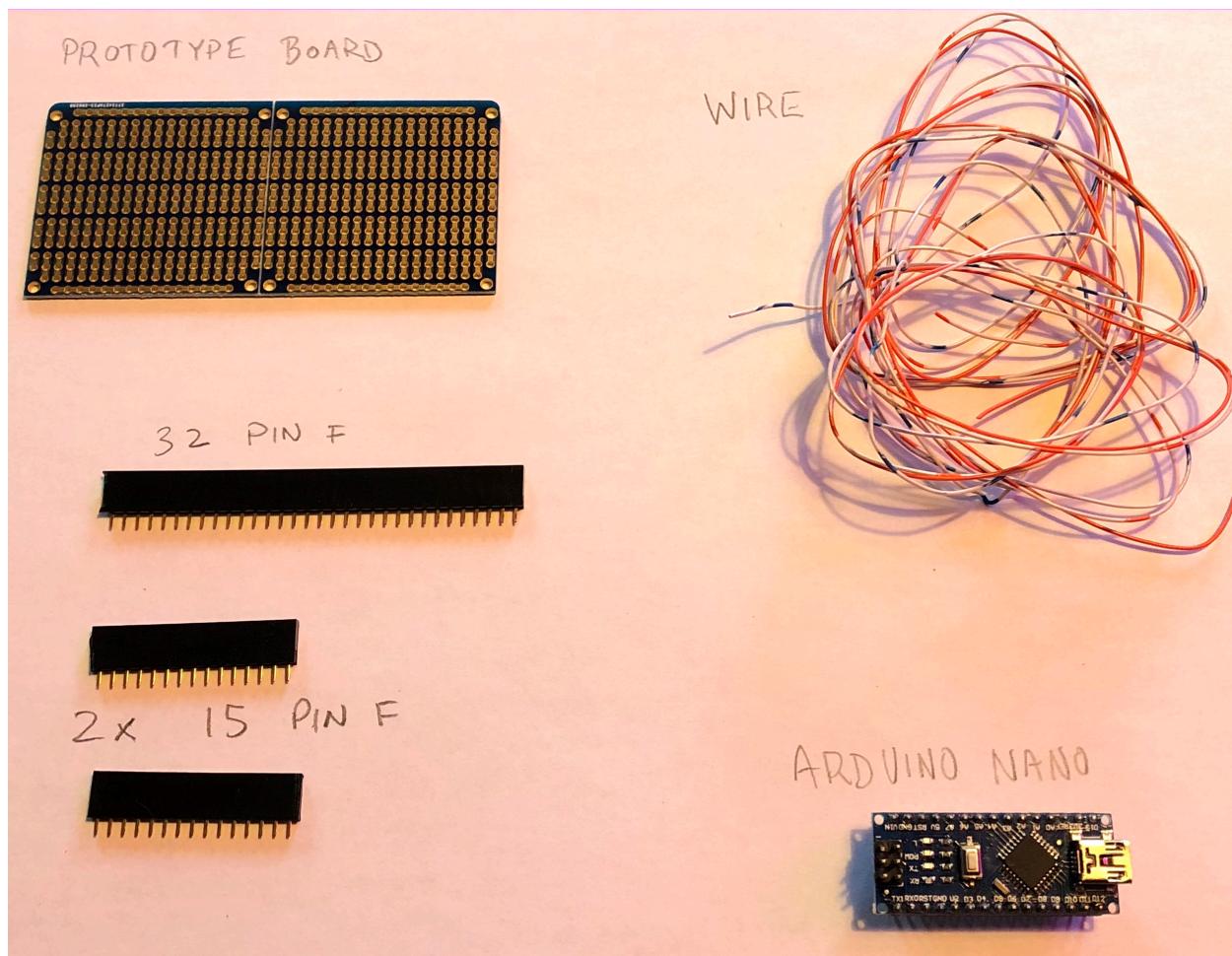
Note: if you go this route, you need to keep the wires short between the switch and the board (less than 50cm). Wires longer than a foot or two will inconsistently ground the address lines on pins 10 & 13. When these lines fail to ground completely the symptoms on the game are extremely odd. Sometimes the flippers will lose power during a game. Other times the displays will show nonsense. Lights may show weird behavior as well. If you want to run a switch behind the coin door, use the other diagram and a tri-state buffer to dual boot.

Connection Chart

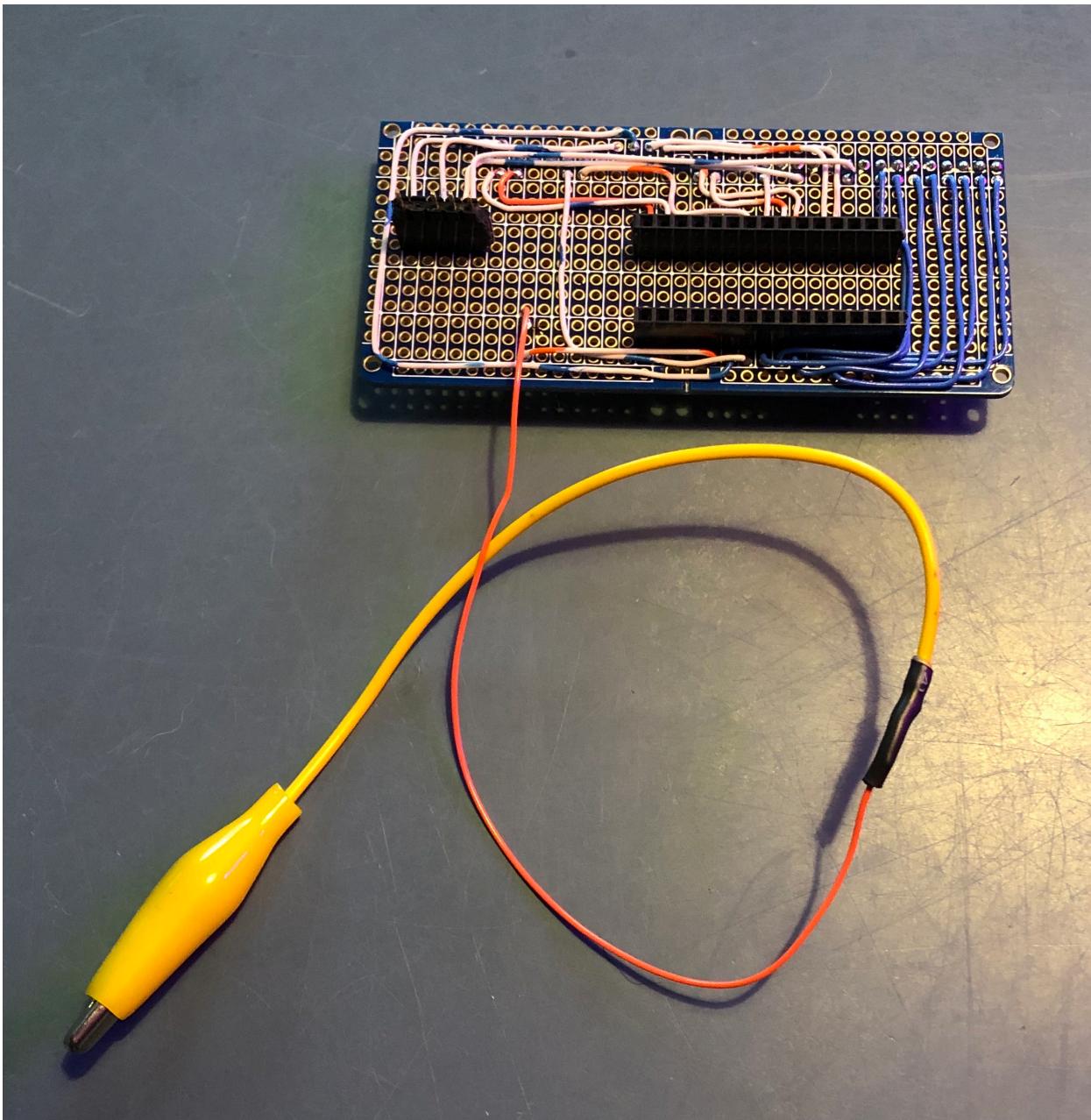
J5 Pin	Nano Pin
31 - Ground	Nano GND
30 - 5V	Nano VIN
27 - Phi 2	D4
26 - VMA	A5
24 - HALT	GND
23 - R/W	D3
22 - Ao	Ao
21 - A1	A1
19 - A3	A2
18 - A4	A3
15 - A7	A4
13 - A9	GND
10 - A12	GND
8 - D0	D5
7 - D1	D6
6 - D2	D7
5 - D3	D8
4 - D4	D9
3 - D5	D10
2 - D6	D11
1 - D7	D12
(U9 pin 4 - IRQ)	D2

NOTE: The grounds for J5:24, 10, and 13 can be achieved through a switch or a line buffer if you want to dual boot the machine. See the above wiring diagrams.

Parts for custom Arduino interface board



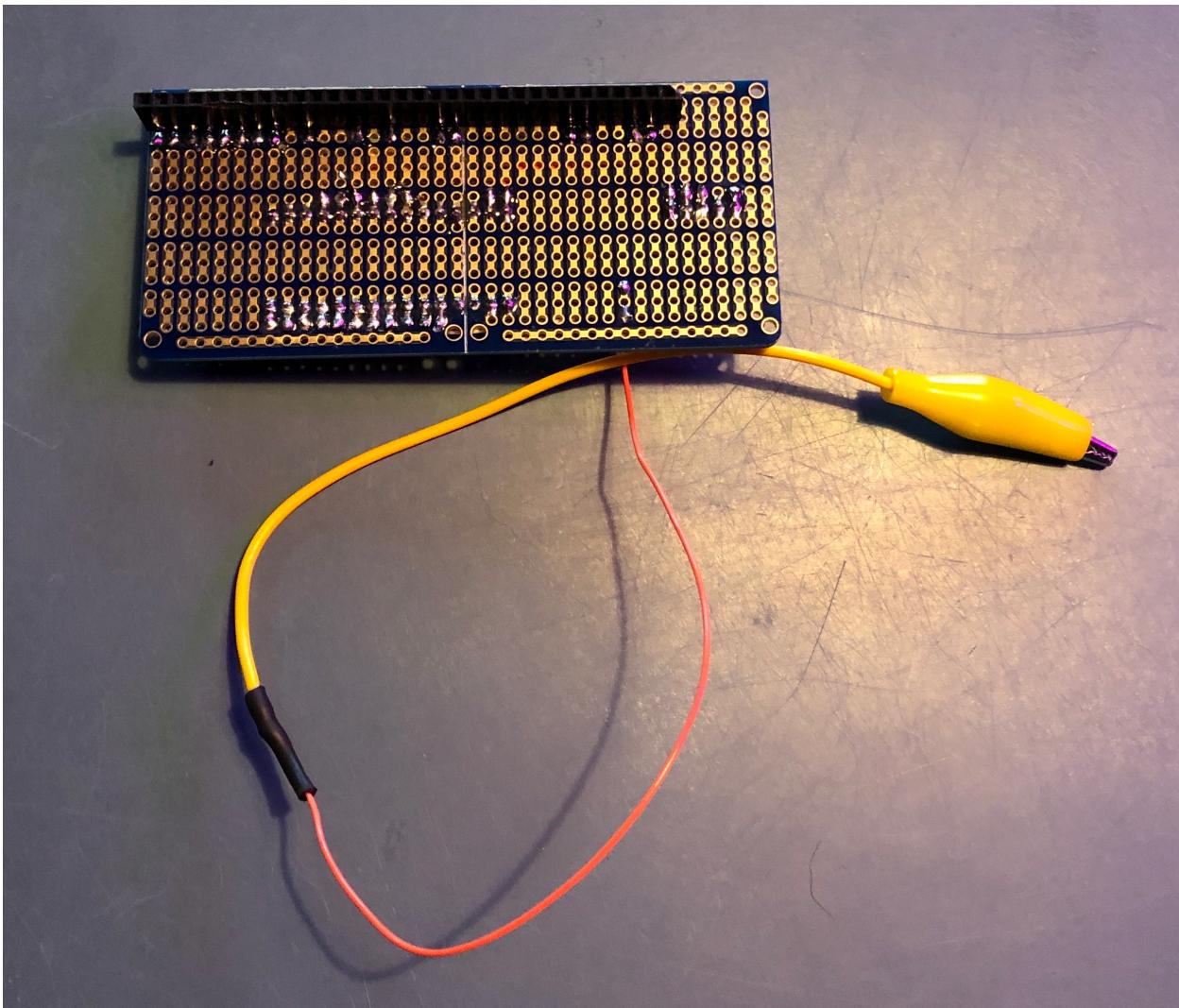
Solder the connectors with wire jumpers as described above



NOTES:

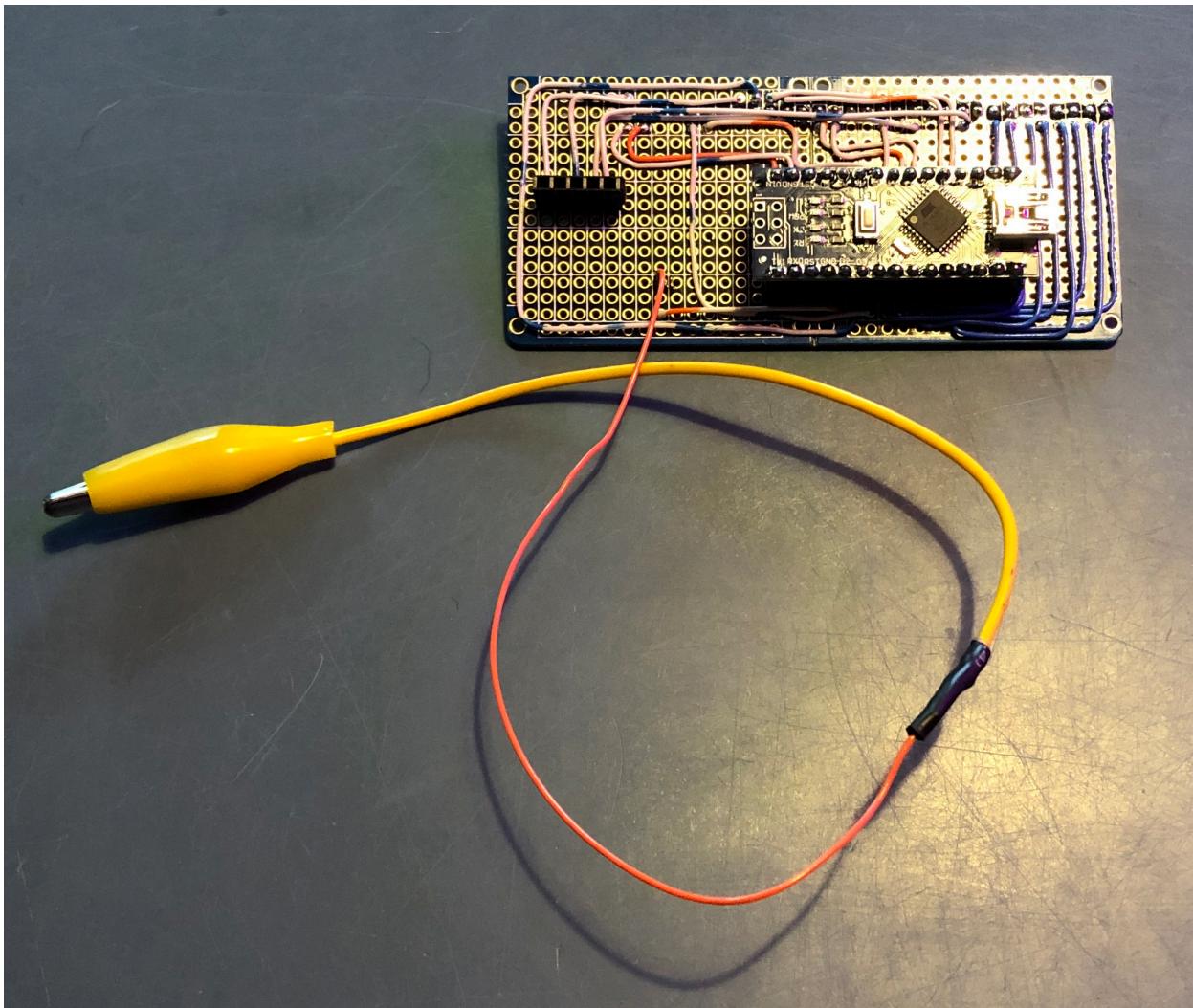
The yellow alligator clip is to be attached to the top leg of R134 so it can sense the IRQ line. On this board, I've wired up a separate header for J5:Pins 24, 10, & 13 so I can ground them through an external switch.

This is what the back of the board looks like (single F connector to plug into J5).



Next, program the Arduino with a computer & the software from <https://github.com/MrEkted/BallySternOS>

Finally, plug in the Arduino



Plug the daughter card into J5. The IRQ line can be connected with an alligator clip to the top leg of R134

Before you turn on your machine for the first time, you should consider testing your implementation with your playfield fuse removed so you don't accidentally cause misfires to your solenoids. Correct output on the displays and lamps will indicate that you've wired everything correctly. Additionally, the project "MachineDiagnostics.ino" is a standalone file that will run the MPU through its paces and report back via the serial port on the Arduino.

OPTIONAL - Audio

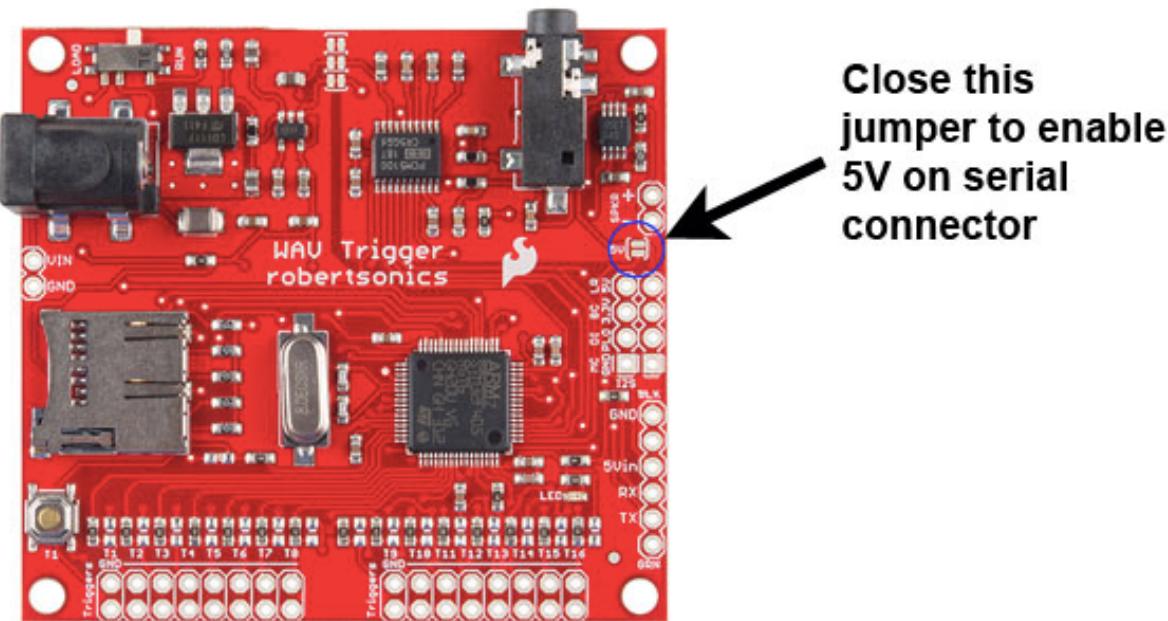
This software also includes support for a WAV Trigger board
<https://robertsonics.com/wav-trigger/>

To connect the Arduino to the WAV Trigger board, you'll need to make the following connections:

J5 Pin 31 (Ground) - WAV Trigger GND
J5 Pin 30 (5V) - WAV Trigger 5Vin
Arduino Pin Do (Tx1) - WAV Trigger Rx

In order to power the WAV Trigger from the serial port header, you'll have to solder a jumper on the solder pads.

<https://robertsonics.com/2015/04/25/arduino-serial-control-tutorial/>



As described on their website, you have to install the library that you download from robertsonics.com. Once you've downloaded the library, you have to install it in the Arduino IDE with: Sketch > Include Library > Zip Library

The wavTrigger.h file needs to be updated in order to use the hardware serial port of the Arduino. Near the top of that file, you'll see a block like this:

```
//  
=====  
=====  
// The following defines are used to control which serial class is  
// used. Uncomment only the one you wish to use. If all of them are  
// commented out, the library will use Hardware Serial  
//#define __WT_USE_ALTSOFTSERIAL__  
//#define __WT_USE_SERIAL1__  
//#define __WT_USE_SERIAL2__  
//#define __WT_USE_SERIAL3__  
//  
=====  
=====
```

Comment out all of those lines (by starting them with “//”) so it knows to use the Hardware Serial port.

Next, you'll put all the sound effects on a MicroSD card and plug it into the slot on the WAV Trigger.

Then, uncomment the following line in Stars2020.ino

Was:

```
//#define USE_WAV_TRIGGER
```

Make it:

```
#define USE_WAV_TRIGGER
```

If you don't ever intend to use the chimes, you can save a bunch of program space by disabling them in the build. To remove chimes from the build, look for a line like this:

```
#define USE_CHIMES
```

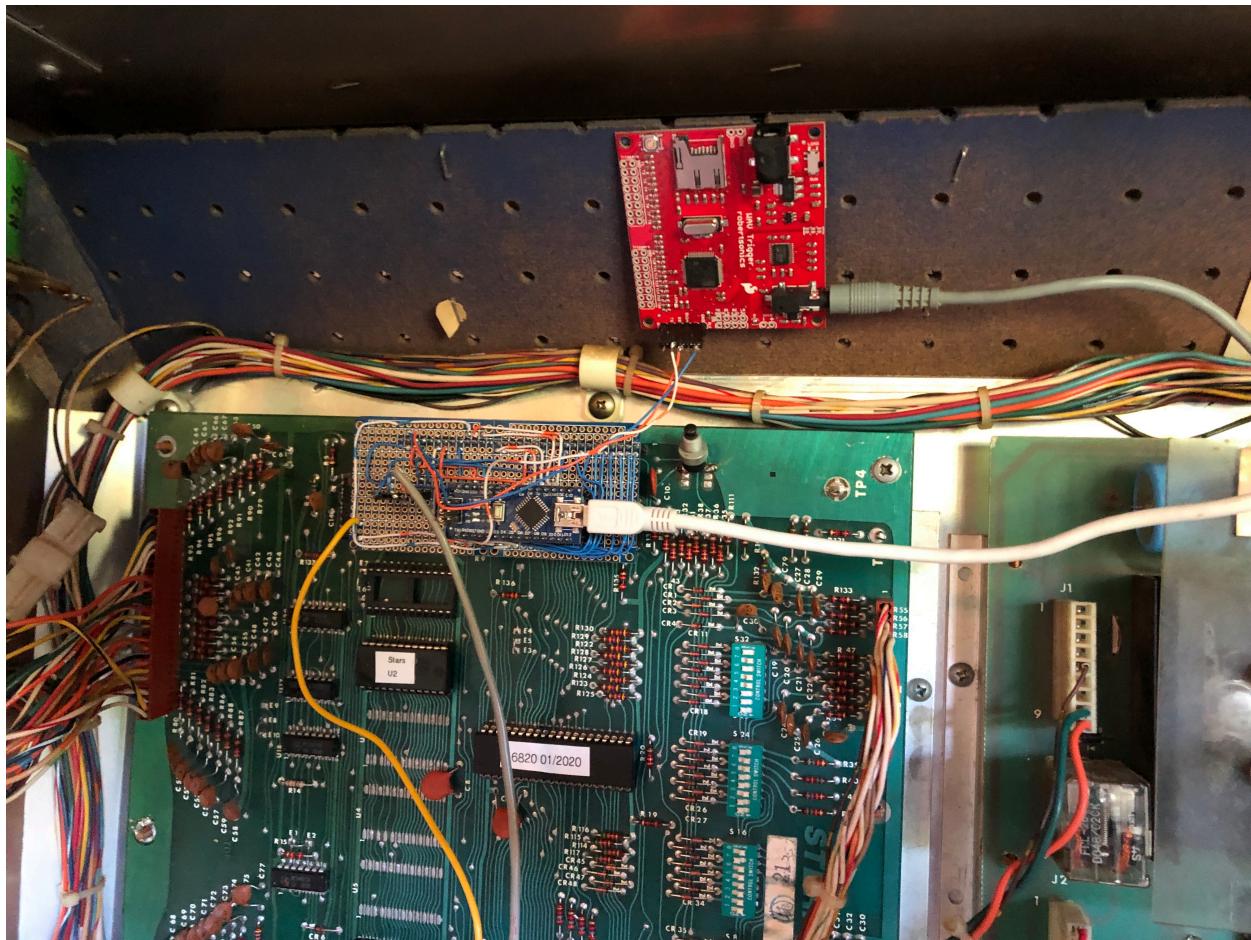
And make it:

```
//#define USE_CHIMES
```

Once the code is built with USE_WAV_TRIGGER, the Music Level will be

adjustable up to level 5. Level 4 just has sound effects. Level 5 adds in the background music.

Finally, plug in some sort of speakers into the 1/8" jack. Here's what my implementation looks like.



If you've built your daughter card

The code repository is located here: <https://github.com/MrEkted/BallySternOS>.

Each machine is represented here with a (name).ino and (name).h that are specific to a machine.

In addition, this repo contains several files that are needed for any machine (support functionality): BallySternOS.cpp - interface to the machine hardware.

BallySternOS.h

SelfTestAndAudit.cpp - base-level self-test modes & audit functions.

SelfTestAndAudit.h.

At the moment, code is available for the following machines:

- Stars (Stern, 1978)
- Black Jack (Bally, 1977)
- PinballBaseMachine - basic framework to build a new game from
- MachineDiagnostics.ino - standalone project to test the MPU board

Example instructions to get started with Stars 2020:

- Create a Stars2020 directory (the directory has to be the same name as the project's .ino file for some reason)
- Put these files in the directory (these are all you need for this game):
 - Stars2020.ino
 - BallySternOS.cpp
 - BallySternOS.h
 - SelfTestAndAudit.cpp
 - SelfTestAndAudit.h
 - Stars2020.h
- Open Stars2020.ino in the Arduino IDE (<https://www.arduino.cc/en/Main/Software>)
- You may need a driver for your Nano. If it's a 3rd party Nano (opposed to one from Arduino), then it might use the "Old Bootloader". This is under Tools->Processor. I use a Mac, so I had to install the CH340 driver for my

cheap boards

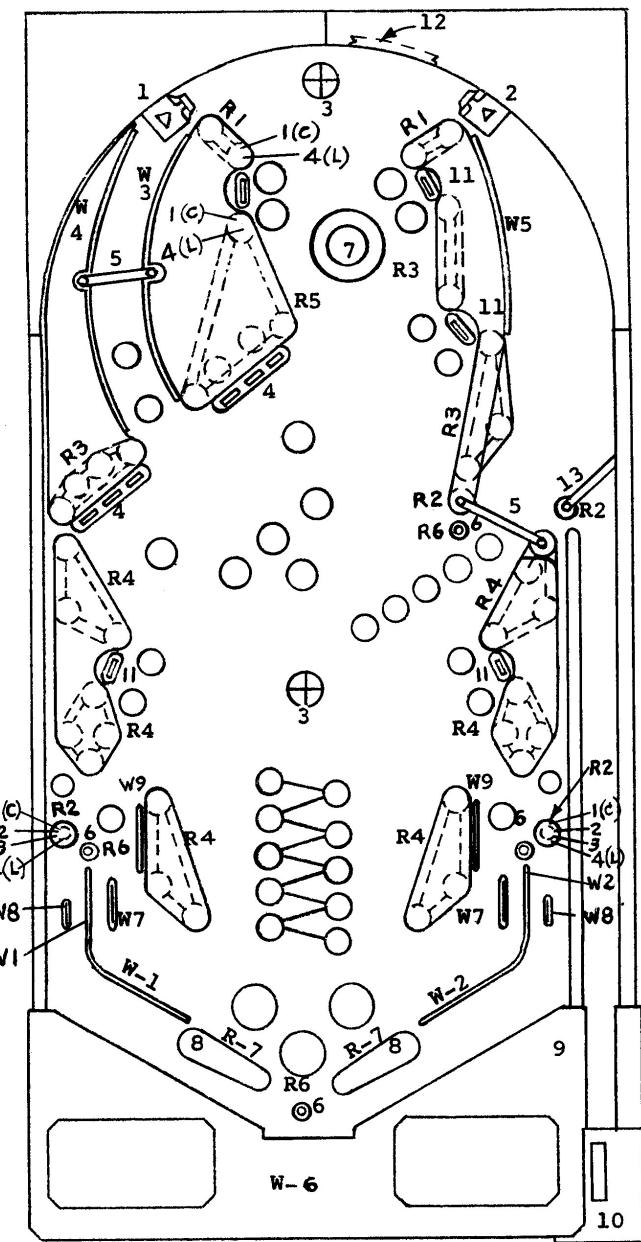
- Compile the project and upload via USB to the board
- Build the hardware

Once the software is downloaded, the timing parameters may need to be tweaked for particular boards. They can be found in BallySternOS.h:

```
// This define needs to be set for the number of loops
// needed to get a delay of 80 us
// So, set it to (0.000080) / (1/Clock Frequency)
// Assuming Frequency = 500kHz, 40 = (0.000080) / (1/500000)
#define BSOS_NUM_SWITCH_LOOPS 70
// 60 us
// So, set this to (0.000060) / (1/Clock Frequency)
#define BSOS_NUM_LAMP_LOOPS 30

// Fast boards might need a slower lamp strobe
#define BSOS_SLOW_DOWN_LAMP_STROBE 0
```

STARS Playfield Chart



RUBBER RINGS

R1	7A-120-100	1" DIA.
R2	7A-120-031	5/16" DIA.
R3	7A-120-150	1-1/2" DIA.
R4	7A-120-200	2" DIA.
R5	7A-120-250	2-1/2" DIA.
R6	7A-125	
R7	7A-121 W	Flipper

GUIDE WIRE & ROLL OVER WIRE

W1	6A-219
W2	6A-220
W3	A-473
W4	A-474
W5	6A-215
W6	A-150
W7	A-149
W8	A-383
W9	6A-101

PLAYFIELD PLASTIC SHIELDS

TOP ARCH SET 13C-102-1L & M
STARS SET 13C-103-1 to 7

MISCELLANEOUS PARTS

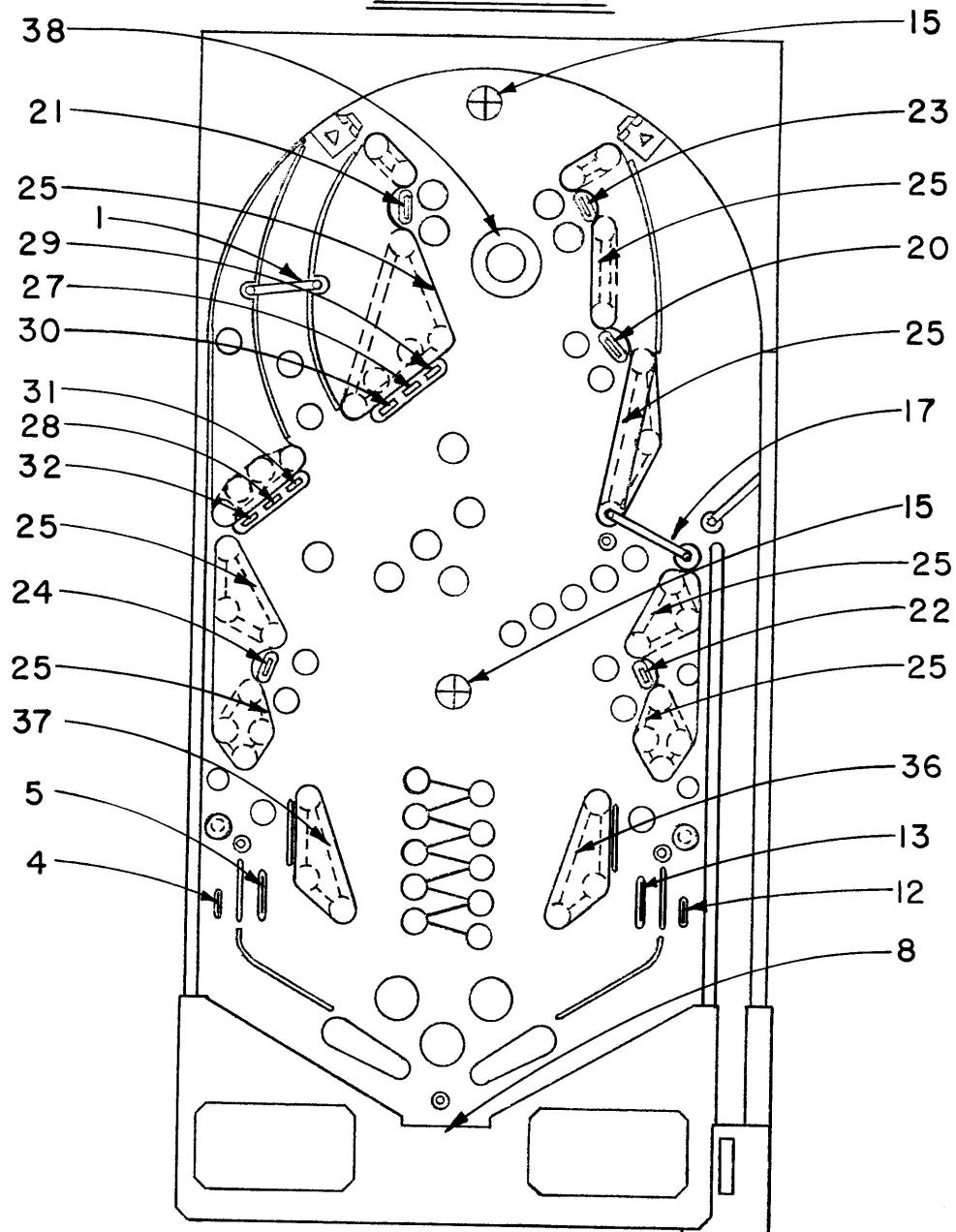
1. BALL GATE, LEFT A-104-L
2. BALL GATE, RIGHT A-104-R
3. ROLL OVER BUTTON ASS'Y A-181
4. BANK TARGET ASS'Y D-393-3
5. SPIN TARGET ASS'Y B-102-2
6. BALL GUIDE POST 2A-200
7. THUMPER CAP 13A-12
8. FLIPPER & SHAFT A-192
- FLIPPER 4B-122-W
9. INSTRUCTION PLATE 14B-1-2
10. SHOOTER GUAGE 14B-2-2
11. TARGET ASS'Y A-461
12. TOP ARCH RAIL 1B-107
13. BALL GATE ASS'Y A-471

1 (C) CONSERVATIVE

4 (L) LIBERAL

I don't have a diagram for the lights.

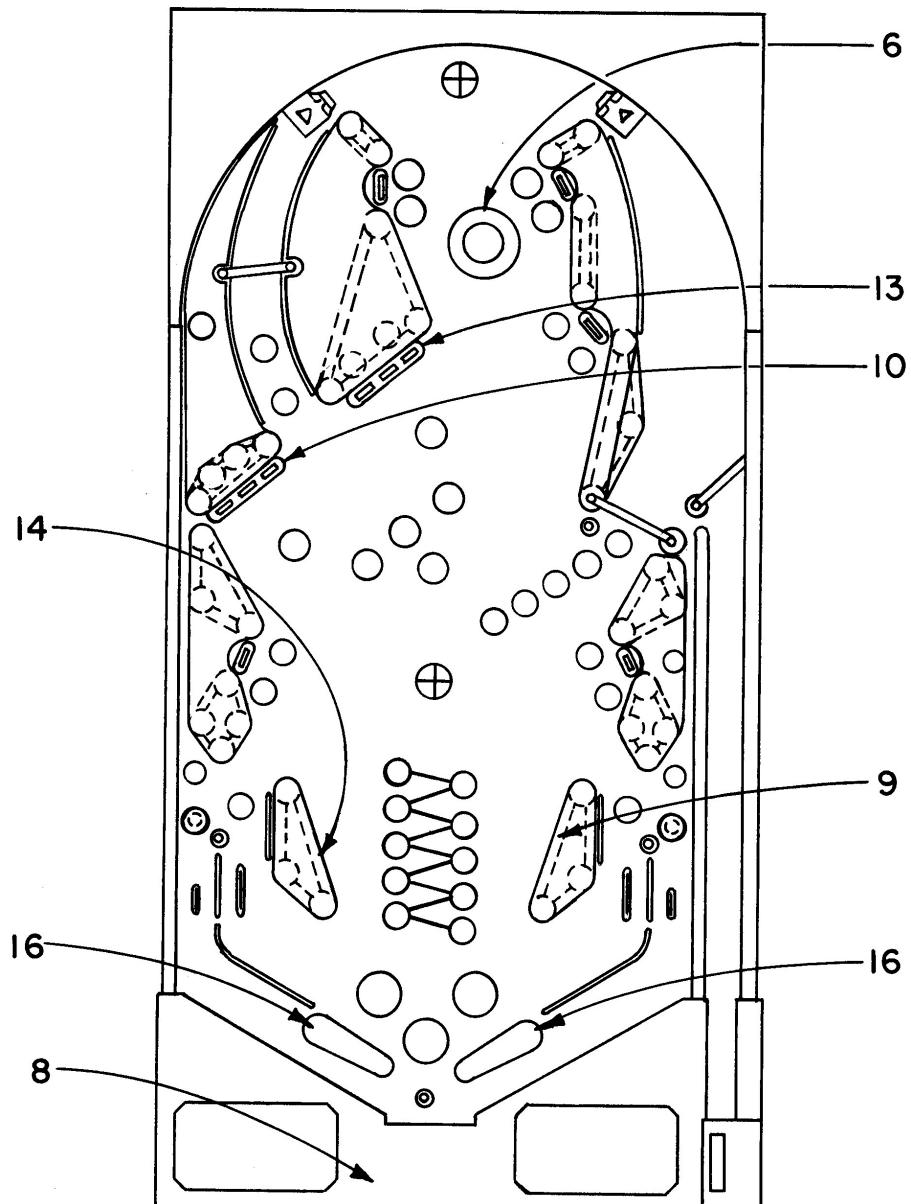
SWITCHES



SWITCHES NOT ON PLAYFIELD:

- | | |
|-----------------|-------------------|
| 6 CREDIT BUTTON | 10 CENTER CHUTE |
| 7 ROLL TILT | 11 LEFT CHUTE |
| 7 PENDULUM | 16 PLAYFIELD VIB. |
| 9 RIGHT CHUTE | 16 DOOR VIB. |
| | 16 TILTBOARD VIB. |

SOLENOIDS



SOLENOIDS NOT ON PLAYFIELD

1 CHIME (10)

7 CHIME (10,000)

3 CHIME (100)

15 KNOCKER

5 CHIME (1000)

17 LOCKOUTS

Sound wiring coming soon.

Stars 2020 Test/Audit/Parameters

00:01 - Lamps
XX:XX - Displays
00:03 - Solenoids
00:04 - Switches
00:05 - Sound
01 - Award Score Level 1
02 - Award Score Level 2
03 - Award Score Level 3
04 - High Score to Date
05 - Current Credits
06 - Total plays (Audit)
07 - Total replays (Audit)
08 - Total times high score beaten (Audit)
09 - Chute #2 coins (Audit)
10 - Chute #1 coins (Audit)
11 - Chute #3 coins (Audit)
12 - Free play off/on (0, 1)
13 - Ball Save Num Seconds (0, 6, 11, 16, 21)
14 - Music Level (0, 1, 2, 3, [4, 5]) [if WAV Trigger is enabled in the build]
15 - Tournament Scoring (0-no, 1-yes)
16 - Reboot
17 - Skill Shot Levels Up Stars (0-no, 1-yes)
18 - Number of Stars to Start With (0-none, 1-one random, 2-three / game, 3-hold over)
19 - Tilt Warning (0, 1, 2)
20 - Award Score Override (0 - 7, 99)
21 - Balls per game Override (3, 5, 99)
22 - Spinner Chime (0-none, 1-half, 2-every, 3-alternating)
23 - Scrolling Scores (0-no, 1-yes)
24 - Extra Ball Award (0 - 100,000) [only used for Tournament Scoring]
25 - Special Award (0 - 100,000) [only used for Tournament Scoring]
26 - Star Level Lock In Award (0=25k times level, or 1,000 - 100,000)
27 - Playfield Validation (0-any switch, 1-allow right spinner)
28 - Wizard Mode Duration Num Seconds (0, 15, 30, 45, 60)
29 - Wizard Switch Reward (0=off, 1,000 - 100,000)
30 - Dim Level (2=50%, 3=33%)
31 - Pop Bumper Goal (30, 45, 60, 90)
32 - Bonus Underlights (0 - off, 1 - dim, 2 - full)
33 - Star Display Mode (0 - dim, 1 - flash, 2 - rapid flash)

**CHECK ALL VALUES YOUR
FIRST RUN -
THERE ARE NO DEFAULTS!**

**Activating the Slam Switch at any
time will reboot into Attract Mode.**

Lamps

Credits Display: **00** / Ball in Play Display: **01**

When first entered, all lamps will flash at 2Hz.

Pressing the Credit/Reset button will change the Player 1 score to 00 and the first lamp will flash. Repeated pressing of Credit/Reset button will cycle through all lamps (00-59) and then loop back around to 99, which will flash all lamps.

Displays

Credits Display: **XX** / Ball in Play Display: **XX**

When this mode is entered, all displays will cycle through the digits (1-9), changing at 4Hz. Pressing the Credit/Reset button will move through the digits one at a time so they can be tested individually.

Solenoids

Credits Display: **00** / Ball in Play Display: **03**

When this mode is entered, the solenoids (0-14) will be energized one at a time and the solenoid number will be displayed in the Player 1 score box. Each solenoid will be energized for 3/120^{ths} of a second.

Pressing the Credit/Reset button will toggle the automatic advance of the solenoid number to energize the same solenoid multiple times in a row.

Switches

Credits Display: **00** / Ball in Play Display: **04**

When this mode is entered, the ID of the first closed switch will be shown in Player 1 score box. Further closed switches will be displayed in Player 2, 3, and 4 boxes. Displays will be blank if there are no closed switches to show.

Sound

FUTURE FEATURE: Credits Display: **00** / Ball in Play Display: **05**

This mode will test the sound features.

Award Score Levels

Credits Display: **00, 01, 02**

The game keeps three Award Score Levels. They are set using the Self Test switch (modes 1, 2, and 3). If an Award Score is set to zero, there is no award given. Otherwise, the award is controlled by the DIP switches (Switch 6) or the Award Score Override (Self Test mode 17). The current Award Score (0, 1, or 2) is shown in the Player 1 score box.

During game play, when an Award Score Level is crossed, the player receives the award (extra ball or credit). For tournament scoring mode (when available), the Award Score Levels will be ignored.

In these three setting modes (1, 2, and 3), the scores are changed with the Credit/Reset button. Pressing the button once increases the score by 1,000 points. Pressing and holding the Credit/Reset button will gradually increase the score. Double-clicking the Credit/Reset button will return the given score to zero.

The Award Score Override (Self Test mode 17) can be set to 0-7, or 99. A value of 0-7 overrides the setting of the DIP switches to award either an extra ball or a credit for the given score. A value of 99 turns off the override so the DIP switch (Switch 6) setting will be used.

High Score to Date

Credits Display: **04**

When a player's score exceeds the High Score to Date, the new High Score is recorded and shown during the Attract Mode. Depending on the DIP switch setting (Switch 15), the game will award 3 Credits when a high score is reached.

In this mode, the score can be changed with the Credit/Reset button. Pressing the button once increases the score by 1,000 points. Pressing and holding the Credit/

Reset button will gradually increase the score. Double-clicking the Credit/Reset button will return the score to zero.

Credits

Credits Display: **05**

This mode allows the operator to see/change the number of credits currently on the machine. The number of credits will appear in the Player 1 score box.

Pressing the Credit/Reset button will increase the number of credits up to 20, and then cycle back around to 0.

Audits

Credits Display: **06, 07, 08, 09, 10, 11**

The audit features allow the operator to inspect/reset usage values of the machine.

Double-clicking the Credit/Reset button will reset any of the audit values back to zero.

06 - Total plays - total number of games that have been played since this value was reset.

07 - Total replays - total number of credits awarded since this value was reset.

08 - Total times high score was beaten - total number of times the high score has been beaten since this value was reset.

09 - Chute #2 coins

10 - Chute #1 coins

11 - Chute #3 coins

Free Play

Credits Display: **12**

Player 1 score display will show a “0” meaning Free Play is OFF, or a “1” meaning Free Play is ON. The 0 and 1 are toggled by pressing the Credit/Reset button. As soon as the value is toggled, it is written to memory and the machine can be reset into Free Play mode.

If off, the machine will require a positive credit count in order to start a game. Credits can be added through the coin chutes or through setting mode 5.

If Free Play is on, hitting the Credit/Reset button will start a game (if in Attract mode), add a player (if ball 1 is in play), or restart the game if ball 2 or more is in play.

Ball Save

Credits Display: **13**

The Ball Save timer is controlled through this mode. The Player 1 score display will read 0, 6, 16, or 21. Why those values? I don’t know. Write your own software if you want values that make sense to you. Or, change this software—it’s easy. Seriously, though, those values are because the “21” only shows up for a tenth of a second, and I wanted the display to basically count down from 20, not from 19.

Pressing the Credit/Reset button cycles through the different values. Setting the Ball Save to “0” turns off the Ball Save feature.

Music Level

Credits Display: **14**

This value controls the amount of sound effects played in the game. Setting to “0” makes the sound effects minimal. A “1” gives some sound, and a “2” gives the full

sound. A setting of “3” plays the same level of sounds as “2” but the callouts can be played concurrently. The current level is displayed in the Player 1 score box.

The Credit/Reset button cycles between “0”, “1”, “2”, and “3”.

If the WAV Trigger add-on board is installed and enabled in the build, the values of 4 and 5 will be added as options. Level 4 uses the WAV Trigger for sound effects and Level 5 adds in background music.

Tournament Scoring

Credits Display: **15**

A value of “0” indicates that Tournament Scoring is off. With a value of “1”, Extra Balls and Credits will not be awarded. Instead, the player will get a point bonus (set by parameters 24 & 25). In Tournament Scoring, Award Scores will be deactivated. Pressing the Credit/Reset button toggles between these values.

Reboot

Credits Display: **16**

All displays will show “8007” (meaning BOOT). Pressing the Credit/Reset button will return the machine to Attract Mode.

Skill Shot

Credits Display: **17**

This parameter controls how the skill shot works. If set to “0”, the skill shot only awards points and the star target hit. If set to “1”, the skill shot will light all the stars to the next level and then transition into a roving special light that allows the player to lock in that star level. This is complicated and warrants a detailed

explanation.

During the course of a ball, let's say that the player hits three of the five star targets. Those stars will be lit to the next level. The levels are Dim, Solid, and Flashing. So, the ball starts and the player hits three of the five stars to the Dim level. At the end of the ball, that progress will be lost because that level hasn't been locked. In order to lock the stars, the player needs to light all five levels and then hit the roving star light. After all five stars have been lit to the next level, the red Special lights will cycle around the board and the player has to hit that light in order to lock that level.

The Skill Shot (when this parameter is set to "1") gives the player the opportunity to light the next level all at once and initiate the roving Special light. With this mode on, the player could conceivably lock all the stars to the Flashing level just by completing 3 skill shots and 3 roving star hits.

Pressing the Credit/Reset button cycles this parameter between "0" and "1".

Number of Stars to Start With

Credits Display: **18**

In the original version of Stars, the player began each ball with one random star so the right spinner would have a value. Set to "1", this setting will grant a random starting star to the player at the beginning of each ball, assuming they have no star level locked in. A setting of "2" grants the player at least three stars during the course of their game. During ball 1, they get one star, and then they get two more stars at the beginning of subsequent balls. If they've already earned stars, they don't get additional random ones.

A setting of "3" doesn't grant the player any free stars, but it allows them to hold their stars between balls. If they've collected all the stars for a level when they drain, the skill shot at the beginning of the next ball will also lock in their star level and allow them to progress.

A setting of “0” gives them no stars at the beginning of the ball.

The Credit/Reset button toggles between 0, 1, 2, and 3.

Tilt Warning

Credits Display: **19**

This parameter can be set to 0, 1, or 2, and it represents the number of warnings the player gets before the machine Tilts. At “0”, the machine will tilt at the first hard nudge. A value of “2” will warn the player twice and tilt on the third hit. A tilt warning consists of a sound.

The Credit/Reset button cycles between “0”, “1”, and “2”.

Award Score Override

Credits Display: **20**

Normally, DIP switch 6 controls what the player gets for achieving an Award Score. DIP switch 6 set to “0” awards an extra ball, and “1” awards a credit. This override lets the operator set extra ball or credit for each of the 3 award scores (set in modes 1, 2, and 3) individually.

The Credit/Reset button cycles through the values 0-7 and then jumps to 99. If set to 99, the DIP switch value is used. Otherwise, the award is based on the table below.

Award Score Override	Score 1	Score 2	Score 3
0	Extra ball	Extra ball	Extra ball
1	Credit	Extra ball	Extra ball
2	Extra ball	Credit	Extra ball
3	Credit	Credit	Extra ball

4	Extra ball	Extra ball	Credit
5	Credit	Extra ball	Credit
6	Extra ball	Credit	Credit
7	Credit	Credit	Credit
99	(DIP switch)	(DIP switch)	(DIP switch)

Balls Per Game Override

Credits Display: **21**

Normally, the balls per game (3 or 5) is controlled by DIP switch 7. This setting allows that to be overridden so the operator doesn't have to go inside the head of the machine to change the value.

Pressing the Credit/Reset button cycles through 3, 5, and 99. A setting of 99 means that the balls per game will be set by DIP switch 7. Otherwise, the balls per game comes from this setting.

Spinner Chime

Credits Display: **22**

This parameter allows control of the chimes associated with the spinners. A setting of “0” will play no chimes with the spinners. A setting of “1” will play a chime every other time the spinner switch is activated. Normal behavior is set by “2”, and “3” will alternate between a high and low chime on each spinner switch activation.

Pressing the Credit/Reset button cycles between the four values (0, 1, 2, and 3).

Scrolling Scores

Credits Display: **23**

When the player's score exceeds 999,999, the scores will either wrap around to 0 or they will begin to scroll. A setting of "0" in this parameter will make the scores wrap to 0. A setting of "1" will allow the scores to scroll through the 6-digit displays.

Pressing the Credit/Reset button will toggle this value.

Extra Ball Award

Credits Display: **24**

The Extra Ball Award is only relevant in Tournament Scoring mode. If Tournament Scoring is activated, collecting the Wow! Targets will give this award instead of Shoot Again.

In this mode, the score is changed with the Credit/Reset button. Pressing the button once increases the score by 1,000 points. Pressing and holding the Credit/Reset button will gradually increase the score. Double-clicking the Credit/Reset button will return the given score to zero.

Special Award

Credits Display: **25**

The Special Award is only relevant in Tournament Scoring mode. If Tournament Scoring is activated, collecting the Special Targets will give this award instead of a credit.

In this mode, the score is changed with the Credit/Reset button. Pressing the button once increases the score by 1,000 points. Pressing and holding the Credit/Reset button will gradually increase the score. Double-clicking the Credit/Reset

button will return the given score to zero.

Start Level Lock In Award

Credits Display: **26**

When the player completes a level of stars (by hitting the roving light), they normally receive an award of $25k \times$ the star level. If this value is set to something other than “0”, this score will override that value.

In this mode, the score is changed with the Credit/Reset button. Pressing the button once increases the score by 1,000 points. Pressing and holding the Credit/Reset button will gradually increase the score. Double-clicking the Credit/Reset button will return the given score to zero.

Playfield Validation

Credits Display: **27**

At the beginning of a ball, the Player Up light and score will flash, indicating that the playfield has not been validated. Before the playfield is validated timers (skill shot & ball save) aren’t started and the ball will be returned to the plunger if it lands in the trough.

This setting controls what switches will validate the playfield. A setting of “0” means that any switch validates the playfield. With a setting of “1”, the right spinner is exempted from validating the playfield, unless a star is lit. If a star is lit, then the right spinner scores and the playfield is validated.

Pressing the Credit/Reset button alternates between these values (0 and 1).

Wizard Mode Duration

Credits Display: **28**

This setting controls the duration (in seconds) of the Wizard Mode. The value can be set to (0, 15, 30, 45 or 60) seconds. A setting of “0” disables Wizard Mode.

Pressing the Credit/Reset button will toggle between the values.

Wizard Switch Reward

Credits Display: **29**

During Wizard Mode, each switch hit will grant the reward dictated by this setting. If set to “0”, switches will score no points. The value can be any value between 1,000 and 100,000 points per switch.

In this mode, the score is changed with the Credit/Reset button. Pressing the button once increases the score by 1,000 points. Pressing and holding the Credit/Reset button will gradually increase the score. Double-clicking the Credit/Reset button will return the given score to zero.

Dim Level

Credits Display: **30**

The Dim Level adjustment allows the operator to choose the duty cycle of “dim” lights. At a level of 2, a dim bulb will be lit 50% of the time. At a level of 3, a dim bulb will be lit 33% of the time. With some bulbs, a noticeable flash will be present at a duty cycle of 33%. With other bulbs, a 50% duty cycle will appear nearly the same as a fully-lit lamp. This adjustment should be re-checked on new machines or if the bulbs are changed.

When in this mode, the bonus lamps will toggle between the dim value and the full-lit value (every second). This allows the operator to see the contrast between the two.

Pressing the Credit/Reset button will toggle the dim level between 2 & 3.

Pop Bumper Goal

Credits Display: **31**

This parameter adjusts how many pop bumper hits are required to achieve the pop bumper goal. When one third of the goal is reached, the rollovers will be lit for 1k bonus. At two-thirds, the in/out lanes will be lit for 3k bonus. When the pop bumper goal is reached, the pop bumper score rises to 1k per hit, and the in/out lanes will flash (for 6k bonus).

Pressing the Credit/Reset button will cycle through the values 30, 45, 60, and 90 hits.

Bonus Underlights

Credits Display: **32**

This parameter adjusts the brightness of the lights below the current bonus indicator. For example, if the bonus is currently 5k, the 5k light will be lit and the lights under that will either be off, dim (default), or full brightness. Use caution with the full brightness setting. Too many concurrent lights can pull too much current from the power supply.

Pressing the Credit/Reset button will cycle through the values 0, 1, and 2.

Star Display Mode

Credits Display: **33**

This parameter adjusts how the different star levels are displayed.

A value of “0” will show level one stars as dim, level two stars as solid, and level three stars as flashing.

A value of “1” will show level one stars as flashing slowly, level two stars flashing

faster, and level three stars as solid.

A value of “2” works the same as “1” except the flashing is more rapid.

Pressing the Credit/Reset button will cycle through the values 0, 1, and 2.

DIP Switches

DIP Switches

1 - Credits/Coin (BORING & UNIMPLEMENTED)

2 - Credits/Coin (BORING & UNIMPLEMENTED)

3 - Credits/Coin (BORING & UNIMPLEMENTED)

4 - Credits/Coin (BORING & UNIMPLEMENTED)

5 - Credits/Coin (BORING & UNIMPLEMENTED)

6 - High Score = (Extra Ball, OFF), (Replay, ON)

7 - Balls per Game = (3, OFF), (5, ON)

8 - Melody = (Simple, OFF), (Full, ON)

9 - Credits/Coin (BORING & UNIMPLEMENTED)

10 - Credits/Coin (BORING & UNIMPLEMENTED)

11 - Credits/Coin (BORING & UNIMPLEMENTED)

12 - Credits/Coin (BORING & UNIMPLEMENTED)

13 - Credits/Coin (BORING & UNIMPLEMENTED)

14 - Not Used

15 - High Score to Date = (Free Games, ON), (Nothing, OFF)

16 - Not Used

17 - Max Credits = (5, OFF-OFF-OFF) to (40, ON-ON-ON)

18 - Max Credits second digit

19 - Max Credits third digit

20 - Credit Display = (No, OFF), (Yes, ON)

21 - Match Feature = (None, OFF), (Yes, ON)

22 - Bonus Countdown on/off - I'm not opposed to this, and it would be simple, but not done yet

23 - Not Used

24 - Targets Down for 3X - (only 1 set needed, OFF), (both sets needed, ON)

25 - Max Number of Players = (2, OFF), (4, ON)

26 - WOW! = (Nothing, OFF), (Extra Ball, ON)

27 - Not Used

28 - Not Used

29 - Not Used

30 - Star Special - not implemented

31 - Special Award - not implemented in this way

32 - Special Award - not implemented in this way

Coin Chutes

Right now, any of the coin chute switches will add 1 credit. A sound is played when a credit is added (controlled by Music Level).

This ignores the Credits/Coin DIP switches entirely.

Coin Lockout

If the number of credits is at the maximum value (set by DIP switches 17, 18, and 19), then the coin lockout will be energized. Otherwise, it's not.

Credit Reset

Pressing the Credit/Reset button in Attract Mode will start a 1-player game if the machine is in Free Play or there is at least 1 credit. (Pressing the button again during ball 1 will add a player.)

Skill Shot

At the start of the ball, the red lights associated with each star will flash in sequence. This is referred to as a “Roving Skill Shot.” Hitting the Roving Skill Shot will award a bonus score (25,000), play a sound, and award the star associated with the standup target that was hit.

If the Skill Shot setting (parameter 15) is set to 1, hitting the Roving Skill Shot will also light all the stars to the next level and initiate the “Lock In Shot.” The Lock In Shot looks exactly like the Roving Skill Shot, but it locks in the stars at the given level so they will still be lit on subsequent balls.

Ball Save

If enabled (parameter 13), the Ball Save will cause the “Same Player Shoots Again” light to flash at the beginning of the ball for a number of seconds. The Ball Save can be set to 0, 6, 11, 16, or 21 seconds. If the ball drains during the Ball Save time, the ball will be kicked back out to the plunger and the ball save will be over.

During Ball Save time, the amount of time left for ball save will be shown on the credits display.

At the beginning of each ball, the player’s score flashes until the first switch is hit. The timer doesn’t start until the first switch hit. The right spinner doesn’t count to start the timer.

Stars Goal

There are 5 star standup targets on the board and a light next to them to show when they have been hit (White, Green, Yellow, Purple, and Amber). The star lights have four states: off, dim, solid, and flashing. The stars also have a red special light associated with each standup.

When the game starts, the player has no stars. The player’s goal is to light all the stars to the next level and then “lock” that level by hitting a Lock In Shot. After all

the stars are lit, a roving red light will move from star to star every second. Hitting the standup next to the roving light locks in that level.

Once the player has advanced all the stars to flashing, and locked in that level, the red lights will all flash randomly (and the stars will continue to flash) to indicate that the stars goal has been completed. That goal will remain completed for the remainder of the game or until Wizard Mode has been achieved and finished.

The right spinner is worth the (Number of Stars Lit) x 200 points. Each level of each star is worth 200, so the maximum value for each spin is (5 stars) x (3 levels) x 200 points, or 3,000 points per spin.

The skill shot at the beginning of the ball can also light all the stars to the next level if parameter 15 is set to allow it.

Bumper Goal

Hitting the bumper at the top of the board awards 100 points and advances the player towards the next Bumper Goal. The number of bumper hits remaining is displayed (momentarily) in the credits box.

At 20 hits (40 remaining) the two rollovers on the board are lit.

At 40 hits (20 remaining) the in-lanes/out-lanes are lit (they toggle based on switches).

At 60 hits (0 remaining) the in-lanes flash.

Drop Targets Goal

When the drop target banks are completed, they award the following goals:

- 2x Bonus Multiplier
- 3x Bonus Multiplier

- WOW! Award (extra ball or nothing, depending on DIP switch 26)
- Special (based on something—I don't remember)
- Special (again? Sure.)
- Hurry-up on left spinner

Collecting the 2x Multiplier either requires one bank or both banks, based on the setting of DIP switch 24.

If the drop targets are completed six times, the left spinner lights flash for 30 seconds, or until the left spinner is hit. If it's hit in that 30 seconds, the drop target special light will flash for the remainder of the ball, indicating that the drop target goal has been completed.

Scoring notes:

- Targets score 500
- Hitting the outer targets before the center will light either center target for 7,000.
- Dropping either center target will add 400 points to the left spinner (both for +800 points). The left spinner is worth 200 by itself, so both center targets down will make it worth 1,000.

Awards

Points & bonus awards are noted on the playfield, but here's a rundown.

- Drop Targets - 500, unless lit for 7,000
- Pop Bumper - 100
- Left Spinner - 200 + center targets x 400
- Right Spinner - 200 x Num of Stars
- 10-pt Switches - 10 points
- Slingshots - 10 points
- Stars - 500, 600, 700 for different levels or 25,000 for skill shot (and +1 Bonus)
- In-lanes - 500, or 3,000 + 3 Bonus when lit
- Rollover - 500 and +1 Bonus when lit

Wizard Mode

Once the stars goal, pop bumper goal, and drop targets goal have been achieved, the player enters the Wizard Mode. The completion of the goals is noted with flashing lights. Stars completion is marked by all the stars & star special lights flashing. The pop bumper goal will flash the insane lights, and completion of the drop targets goal will flash the drop targets special light.

In Wizard Mode, the player's score box continues to show their score. The other score boxes will show a countdown timer. Wizard Mode lasts 30 seconds by default, so the score boxes will countdown from 30.

During Wizard Mode, all switches will score 25,000 points by default. At the end of the mode, the stars are reset, and the pop bumper counter is reset. The player retains the drop targets completion for the rest of their ball.