

Heathkit of the Month (HotM) #106:
by Bob Eckweiler, AF6C

HEATHKIT

MISCELLANEOUS (LATE for APRIL)

Heathkit GD-1110
BALLY™ by Heathkit
FIREBALL® PINBALL GAME

Introduction:

Every April, in honor of *Fool's Day*, I try to choose one of Heathkit's *recherché* products. Heath sold more than just test equipment, ham gear, TVs, weather and Hi-Fi/stereo kits. Past April articles include a Log Splitter kit (GU-1810), a wooden Candle Sticks kit (F-2587), a \$6,000+ Laptop Computer kit with 3 **megabytes** of RAM (HD-2860-M w/ZA-3034-ME memory extension), a give-away flashlight (GDP-5457), the "Boonie" motor bike kits, (GT-18/GT-101), a Trash Compactor kit (GU-1800) and, for the 100th Heathkit review, the Heath Parasol airplane kit (LNA-40). Once, even a made-up kit was featured (C-7).

Some of the April articles didn't present recondite kits. Before the April 1st idea came to be, the DX-40¹ transmitter was covered (HotM #3), and in 2018 the restoration of the V-6 voltmeter was discussed (HotM #86). There were no April articles in 2010, 2017 or 2019 due to other obligations.

This April the feature kit is the Heathkit GD-1110 *Bally™ Fireball®* Electronic Home Pinball Machine. (See Figure 1). This is not a toy! It is the home version of a full-fledged arcade pinball machine. The very popular commercial version could be found in game arcades throughout the nation at the time. The home version lacks some playfield fea-

¹ Notes are listed at the end of the article. (Page 16)



FIGURE 1: The GD-1110, Heathkit's version of the arcade sized Bally *Fireball™* Pinball Game

tures found in the arcade version. Also the home version has no coin slot and coin box assembly. (That might have made a good accessory, and allow parents to reap back some of their kid's allowance.)

Pinball games have been around for decades. They are very addictive and fun to play in competition with friends; most games can have multiplayer. "The Who" even sang a song about *The Pinball Wizard*².

A Short *Fireball®* Arcade Game History

The *Fireball* was first introduced by Bally to the arcade world in 1972. It is a four player EM (Electro-Mechanical) machine. 3,815 machines were manufactured between 1972 and 2002³. In 1985 Bally introduced the *Fireball Classic®* which is an SS (Solid State) machine initially using a 6800 microprocessor and later a 6802 when the 6800 became obso-

Here is a link to the index of Heathkit of the Month (HotM) articles:

http://www.w6ze.org/Heathkit/Heathkit_Index.html



FIGURE 2: The GD-1110 Bally Fireball® Pinball Game ad from the Christmas 1977 catalog - page 76.

lete. A total of ~2,000 of these machines were manufactured. In 1981 Bally produced a new SS version of the game called *Fireball II™*.

In late 1976 Bally released an SS home version of Fireball. These were sold by Sears, JS&A Group and other outlets. Heathkit sold a kit version of this model. Around 10,000 of the home model were sold. What portion of those sales were by Heathkit is not known.

The 'Bally by Heathkit' Fireball Pinball Game GD-1110

On the front cover of their 1977 Christmas catalog, Heathkit listed five new kits. Each kit was shown as a reflection on a spherical Christmas ornament. The new kits included the ET-3400 Microprocessor Trainer, the AR-1429 AM/FM Stereo Receiver, the GC-1107 Digital Electronic Alarm Clock, the TO-1860 Heath/Thomas Home Electronic Organ and the "New Bally Fireball™ Home Pinball Machine in kit form, see page 77⁴". The actual catalog ad ran on page 76 along with two non-kit items - The GDP-1227 Automatic Telephone Answering System and the New GD-1226 Digital Thermometer. Also sharing the page was the New GD-2225 Klima-Gro® Indoor

Greenhouse. Of the three new items on the page, only the GD-1110 was featured on the

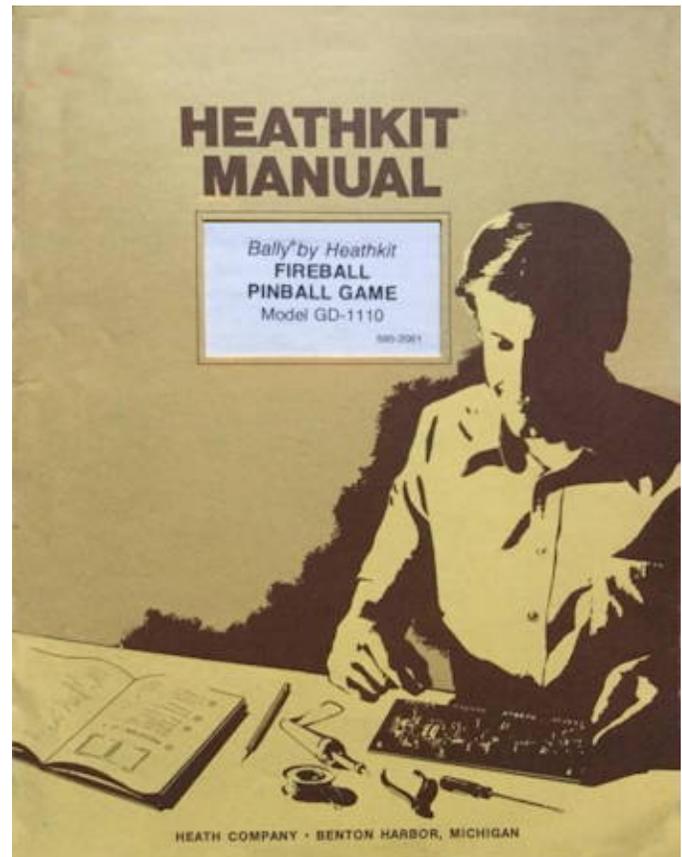


FIGURE 3: The Heathkit Manual that comes with the GD-1110.

front page. **Figure 2** shows the first ad which mentions “Available late November.” The initial mail order price was \$599.95 (\$629.95 at a retail store.) The kit shipping weight was 166 lbs. requiring motor freight. At the time this ran about \$20⁵, but delivery was to a freight terminal near you. The responsibility of getting it from there to the final destination belonged to the purchaser. Home delivery was available at extra cost.

The Heathkit \$600 factory kit price didn't save a lot over the factory assembled version offered by other outlets. While JS&A was selling the machine for \$795, their target was for corporate offices, and they offered a money back one month trial. (**Figure 4**) On the other hand Sears, in their Christmas 1977 Wish Book offered the same version fully built⁶ for \$695 (Catalog # 6C 26318N)⁷. However, in the 1978 Sears Catalog the price was reduced to \$645. Just \$15 more than the price

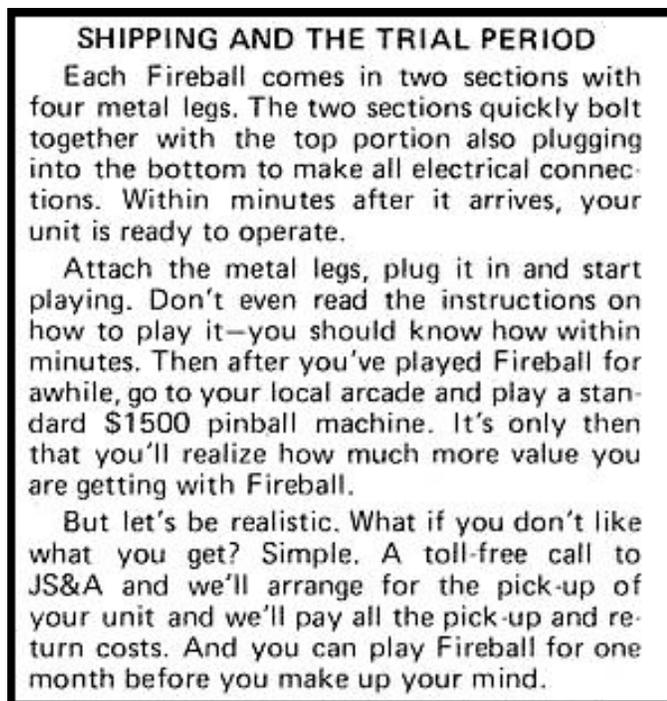


FIGURE 4: In a full-page all text ad focused at businesses JS&A offers a full money back 30 day trial period for buyers. Their price for the Fireball was \$795.

at a retail Heathkit store and \$45 more than from the Heath factory (before motor freight shipping costs).

The GD-1110 sold for about one-and-a-half-years. It last appeared in the Spring 1979 catalog. Why Heath production stopped is unknown. It wasn't because of lack of sales, or else Heathkit wouldn't have offered a new pinball machine in their Christmas 1979 Catalog, where they introduced a kit version of the Brunswick *Aspen* SS pinball game. Perhaps Bally tried to have too much control over the product, and Heathkit decided to look elsewhere? A few items point to this being a possibility; they will be mentioned in passing.

The Commercial v.s. the Home Version:

By no means is the home version an exact copy of the commercial arcade machine. The most notable difference are numerous changes in the playfield. Technically the largest difference is that the original Fireball arcade game is an electromechanical machine using relays, while the home version is a microprocessor based solid-state machine. **Figure 5** is a photo showing the differences in the back box displays between the Commercial EM machine and the home machine. Other than replacing the four mechanical five-digit score counters with a single LED six-digit score display that changes to the current player's score, the back box displays are functionally identical.

While the artwork between the commercial and home games is similar, the playfield of the *Fireball* home game is similar⁸ to three other Bally games sold for home use starting in the late 1976 to 1978 period: *Captain Fantastic & The Brown Dirt Cowboy* (1977), *Evel Knievel* (1978) and *Galaxy Ranger* (1978) *Fireball* was by far the most popular.



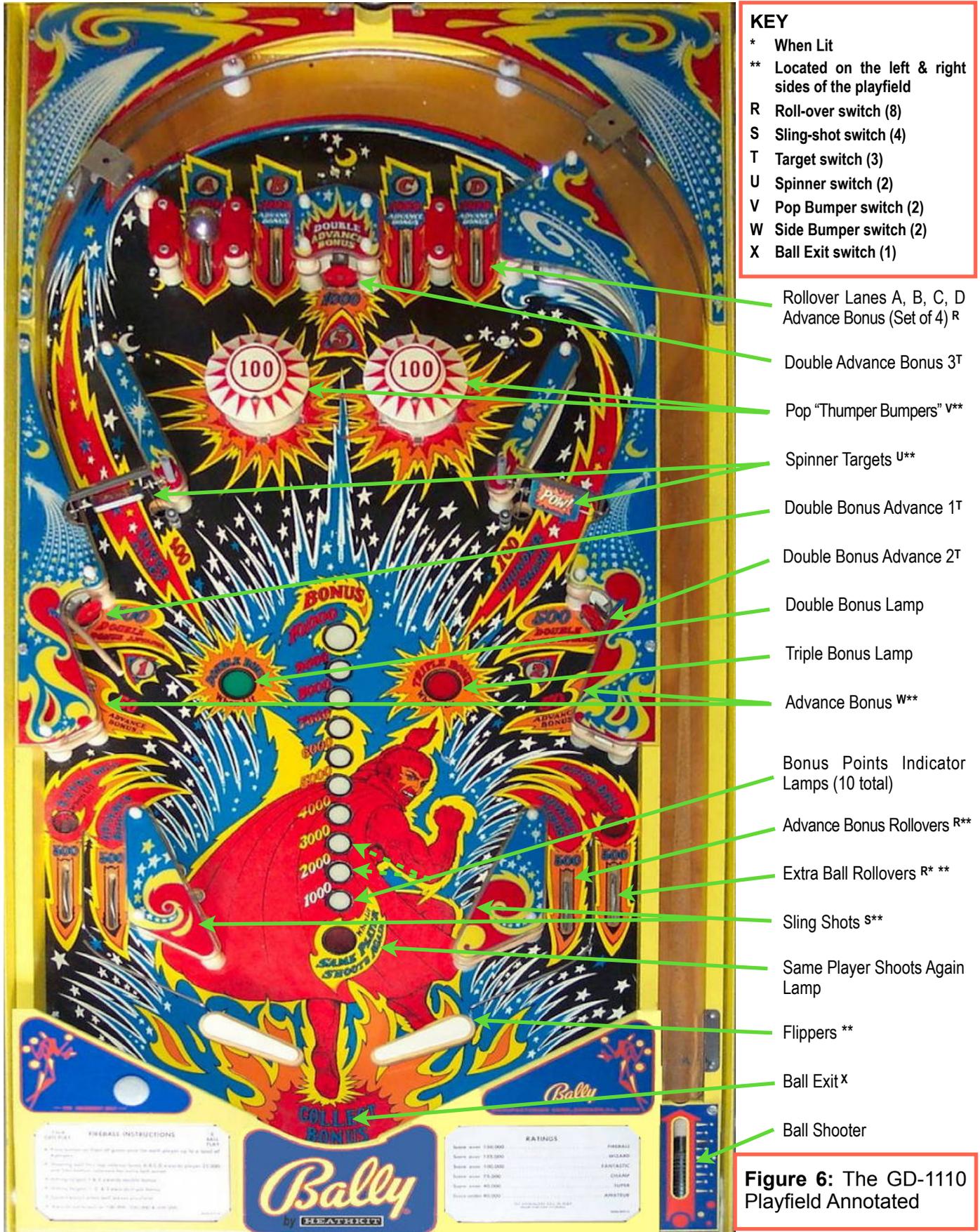
Figure 5: On the left is the commercial EM back box with its four player score displays using mechanical wheels marked 0 to 9. On the right is the home SS back box with a six-digit LED display that shows the score of the current player (digits appear in white box). Both back boxes have four lights to indicate current player, five lights to indicate the ball in play and one light each for **TILT** and **GAME OVER**

Two of the biggest features of the commercial version, missing in the home version, are the “Zipper Flippers” and the Spinning Disc. The “Zipper flippers” normally operate just like regular flippers; one on the left and one on the right near the bottom of the playfield. These are operated by the player by push-button switches on either side of the cabinet. There is a gap between the two flippers wide enough for the ball to pass through and go out of play. The “Zipper flippers”, when actuated by hitting specific target(s) on the field during the play, causes the two flippers to move towards each other, closing the gap so the ball cannot pass between the flippers. The Spinning Disc, located near the center of the playfield is flush with the playfield but has slight ridges. When the ball rolls on to the spinning surface it gets flung off at an arbitrary angle adding difficulty to the play. There are a few additional features on the commercial version that won’t be discussed since they are not part of the home game.

The GD-1110 Fireball Playfield:

Figure 6 is an annotated view of the playfield. The playfield on the home game has 22 switches activated by the ball hitting, passing over or through a part of the playfield. These are listed in **Table I**. Sixteen of these are passive switches that add to the score or turn on or off conditions of play. Bonus points are accumulated by causing specific switches to be activated, as are double and triple multipliers. When the ball moves out of play these bonuses are added to the score. Six of the switches are active switches. When the ball hits one of them it causes an actuator to kick the ball, influencing its momentum and direction. These electromechanical actuators are part of the slingshot and pop bumper mechanisms. (Bally calls their pop bumpers “**Thumper Bumpers**”). There is also a manual actuator that the player uses to put the ball into play. The actuators are listed in **Table II**.

There are 35 lamps on the playfield. Eleven are for general illumination. Ten, located



along the centerline, indicate the current **BONUS** points. Four lamps indicate the four lanes **A, B, C, D** near the top; when a ball passes through one of the lanes its lamp is extinguished. A lamp is in each of the two pop bumpers; they flash continually. A lamp is associated with each of the three **Bonus Advance** targets; when the target is hit its lamp goes out. The green **Double Bonus When Lit** lamp lights signifying any bonus points will be doubled. The red **Triple Bonus When Lit** lamp lights signifying any bonus points will

be tripled. A lamp is in each of the two **Extra Ball When Lit** alleys (left and right exits), and a lamp is the **When Lit Same Player Shoots Again** indicator along the centerline below the bonus lamps. The lamps are listed in **Table III**.

The playfield also contains a left and right flipper. They are solenoid actuated and each is controlled by a button located on the adjacent side of the cabinet. These, and the Ball Shooter, are the only user controls during play⁹.

The GD-1110 Fireball Back Box:

Figure 5 (right) shows the GD-1110 back box. Behind the GD-1110 glass are 16 lamps and a six-digit LED display. Towards the upper left are four lights behind the numbers 1 thru 4 that indicates the player up. Below that is a white rectangle behind which is the six-digit LED display that displays the current player's score. Each time a player has finished his current ball the display and player lights cycle through each player's current score, stopping with the next player. Below the digital score are five lamps behind five red balls. This indicates the current ball

Playfield Switches		
#	Type	Function / Description / Points
4	Rollover	Lanes A - D (1000 pts.)
2	Rollover	Extra Ball When Lit - Left & Right (500 pts.)
2	Rollover	Advance Bonus (500 pts.)
4	Sling Shot	Left & Right (2 per sling shot)
2	Side Rubber	Advance Bonus (50 pts.)
2	Standup Target	Double Bonus Advance 1 & 2 (500 pts.)
1	Standup Target	Double Bonus Advance 3 (1000 pts.)
2	Pop Bumper	100 points
2	Spinner Target	100 points
1	Ball Return	Ball is out of Playfield. Collect Bonus
22	Total	TABLE I

Playfield Actuators		
#	Type	Function
2	Flippers	Left and Right
2	Pop Bumpers	Left and Right active bumpers
2	Sling Shot	Left and Right
1	Ball Return	Moves ball that exited to Shooter
1	Ball Shooter	Manual - Launches ball into play
8	Total	TABLE II

Playfield Lamps		
#	Bulb	Function / Description / Points
11	#147	Playfield - General Backlighting of the Field
10	#147	Playfield - Bonus Score - 1000 to 10,000 points
4	#147	Playfield - Lanes A - D Active
2	#455	Playfield - Left and Right Pop Bumpers
3	#147	Playfield - Bonus Advance Targets 1, 2 and 3
1	#147	Playfield - Left - Double Bonus When Lit (Green)
1	#147	Playfield - Right - Triple Bonus When Lit (Red)
2	#147	Playfield - Left and Right - Extra Ball When Lit
1	#147	Playfield - Same Player Shoots Again When Lit
35	Total	TABLE III

Back Box Lamps		
#	Type	Function
1	#147	Back Box - TILT Indicator
1	#147	Back Box - GAME OVER Indicator
4	#147	Back Box - PLAYER # 1 thru 4
5	#147	Back Box - BALL IN PLAY # 1 thru 5
5	#147	Back Box - General Backlighting of the Glass.
16	Total	TABLE IV

in play. Each player gets five balls but can win extra balls during play. Extra balls are played in the round in which they are won.

There is a lamp behind each of the two red rectangular boxes below the current ball lights. The one near the left edge lights the word **TILT**, and the one to its right lights the words **GAME OVER**. Five additional lamps provide backlighting for the glass panel.

The GD-1110 Fireball Features:

TILT: A pendulum-type sensor is located inside the cabinet on the left wall. Should a player shake, lift or jar the machine excessively in an attempt to influence the movement of the ball, the sensor will be triggered. The TILT light will illuminate, the flippers, bumpers and sling shots will no longer work, and no more scoring will take place with the ball in play, which will quickly roll out of play. No bonus points will be awarded. If the player has earned a free ball, he will play it now, otherwise play goes to the next player. The TILT sensor's pendulum sensitivity is adjustable internally.

EASY MODE: The Machine may be set to EASY MODE. This changes the amount of points needed to 'win' a free ball. In standard play a ball is awarded at 100,000, 200,000 and 300,000 points. Easy mode cuts this in half to 50,000, 100,000 and 150,000 points.

OPERATION AND SCORE FEATURES

1. Depress start button (located on front of game) once for each player. The number of participating players is indicated by lit areas in the player section of the score glass. (1 2 3 4)
2. After each ball is played the score unit will scan thru each player's score and come to rest on the next player up light in the player section of the score glass.
3. This game is equipped with a memory unit. Each participant plays his own game. That is, any features or partial features scored by a player (top rollovers, targets 1, 2, 3 or extra ball lights) are only his. The partial feature is carried over to the player's next ball and is reset only after the indicated bonus is collected.
4. All target and rollover switches are scored as indicated on the playfield. A ball passing thru a top rollover switch scores 1000 points, turns out its light and advances the bonus score 1000 points. When all top rollover switches are scored a 24,000 point bonus is awarded, the top rollover lights are reset and the lower outside extra ball lights are lit.
5. Hitting targets 1, 2 and 3 (in any order) advances bonus score 2000 points and awards double (1 and 2 made) or triple (1, 2, and 3 made) bonus when ball leaves play area.
6. An extra ball is awarded when the ball played passes over the lower outside rollover switch while the "Extra Ball When Lit" lights are on. (Top rollover switches made). Scores of 50,000 100,000 - 150,000 (extra ball switch in "Easy" position "50k") or 100,000 - 200,000 - 300,000 (extra ball switch in "Hard" position "100k") also awards an extra ball. Extra balls may be accumulated if more than one feature is scored and are indicated by "Same Player Shoots Again" light on lower playfield.

Figure 7: These are the gaming instructions from a Bally manual; one was included with each Heathkit GD-1110, and this manual is referenced during assembly and test.

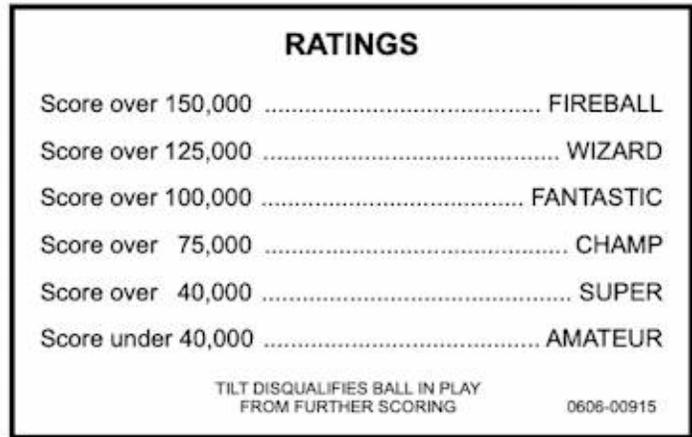
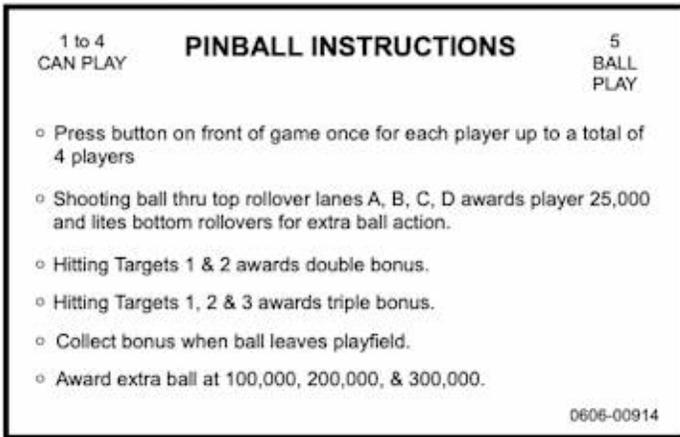


Figure 8: Reproductions of the two information cards located on either side of the *Bally by Heathkit* logo below the playfield. See **Figure 6**. This is the only place the author is aware of (other than the famous Blue-White label) that identifies this as a Heathkit.

The GD-1110 Fireball Game Play:

The instructions for playing an arcade pinball game are sometimes rather scant. Brief instructions describing playing and scoring are often included on cards below the playfield. However, a lot can often be gleaned from the wording on the playfield itself. **Figure 7** is a copy of the instructions that came with the Bally owners manual and **Figure 8** is a copy of the two information cards displayed below the playfield on the Bally (and Heath) home game.

The GD-1110 Fireball Sounds:

To add to the enjoyment of the game, most

pinball machines have sound and music. The GD-1110 is no exception. There are four tones, one each for 50, 100, 500, and 1000 points that sound, when they are awarded; as well as a fifth tone associated with multiple players. There are also seven short song segments that play when specific events are achieved. **Table V** lists them.

The GD-1110 Fireball Controls:

The GD-1110 has controls on the rear of the cabinet as well as controls used when playing the game. On the rear is a push button on-off power switch and a circuit breaker for the AC line; these are part of the power transformer assembly that comes assembled and wired. The assembly also includes a bayonet-type fuse housing and 8-amp fuse for the low voltage field and back box lights. (The fuse is accessed from inside the main cabinet.) There are two slide switches located on a circuit board that are accessible by removing the two screws holding the rear of the back board cover. One switch is a diagnostic switch marked **TEST / PLAY** and the other is the **EASY MODE** switch marked **50K / 100K**. This sets the point level where you will receive another ball. 100K is normal and 50K is “easy mode”.

Fireball Songs	
Song Segment	Plays when...
Beethoven's "Fifth Symphony"	...reset button is pressed.
"Charge"	...top rollovers are made.
"Zip-Pid-De-Do-Da"	...double bonus is made (targets 1 and 2).
Half-time "Fight" Song	...triple bonus is made (targets 1, 2 and 3).
"We're In the Money"	...when extra ball is awarded
"Funeral March"	...game is tilted.
"The Party's Over"	...the game is over.

TABLE V

The player controls are near the bottom of the playfield. On the cabinet front is the **START** button which initiates the game. This button can be pressed repeatedly to increase the number of players up to four. Additional presses just cycle through the four players again. Also on the cabinet front is the ball shooter. This is a spring loaded plunger with a graduated scale that the player uses to start the ball into play. The scale allows the player to gauge how much speed the ball will have leaving the shooter alley. On either side of the cabinet, convenient to the player, are the flipper buttons. They move the two flippers the player uses to keep the ball in play and aim for the various targets to score points and bonus points.

The GD-1110 Fireball Assembly:

It's a Heathkit so assembly is required. The kit comes in two cartons. The first carton contains the cabinet (with the power transformer assembly already installed), the back board and legs, and associated hardware. In Heath's clever manner you use this carton as a temporary table to support the cabinet and install the legs with their levelers. Once the legs are on, the carton can be thrown away. Next, the back board is attached to the cabinet, and the cabinet assembly is put aside.

Most of the circuitry mounts on four circuit boards: The power supply board, the upper playfield board, the lower playfield board and the main logic board.

• Power Supply Circuit Board:

Except for the 18 volt supply, the power supply board uses standard three terminal regulators to supply regulated voltages. The power supply provides: 5.25 volts AC for all the non-switched lamps - five on the backboard, eleven on the playfield plus the two pop bumper, blinking lamps¹⁰; +5 volts regulated

to logic circuits; 5.5 volts (VLED) regulated to score display and speaker driver; +12 volts regulated to logic and tilt circuits; +18 volts regulated by a zener diode and power transistor to the multiplexed lamp drivers; and +22 volts unregulated to the solenoid drivers. The power supply board mounts on the lower rear of the cabinet next to the transformer assembly.

• Upper Playfield Circuit Board:

The upper playfield circuit board holds thirteen diodes, seven switches and five lamps. The diodes isolate the switches and lamps so they can be multiplexed. There are four (A, B, C, D) rollover switches, their associated lights, the upper Double Bonus Advance 3 target with its associated lamp and the two pop bumper switches. The upper playfield circuit board mounts to the underside of the top of the playfield with the lamps and rollover switches extending through openings in the playfield.

• Lower Playfield Circuit Board:

The lower playfield circuit board holds twenty-nine diodes, fourteen switches and seventeen lamps. There are two spinner switches - Power Alley on the left and Thunder Smash on the right, two target switches Double Bonus Advance 2 and 3 with their associated lamps, two passive Advance Bonus slingshot switches, four active slingshot switches (each slingshot uses two switches wired in parallel), two Advance Bonus roll-over switches and two Free Ball When Lit roll-over switches with their associated lamps. Also on the lower field are ten Bonus lamps, a Double Bonus When Lit lamp, a Triple Bonus When Lit lamp, and a Player Shoots Again lamp. The lower playfield circuit board mounts to the underside of the bottom of the playfield in a similar manner to the upper circuit board.

• Logic Circuit Board:

Components are installed on the logic circuit board. It contains the microprocessor and its support chips, 27 driver circuits of five different types; four types use transistors and the fifth uses two dual-channel optical couplers. Also on the logic board are the sound circuit, the failsafe circuit, additional power filtering and a Litronix DL6830 6-digit LED display for scoring.

The solid state version of Fireball is based on the Fairchild F8 family of microprocessors, specifically the 40-pin 3850 CPU and two 40-pin 3851 PSUs (Program Storage Unit). The CPU provides 64 bytes of internal RAM and 16 bits of I/O. A 3851 supplies 1K of ROM, interrupts and an additional 16 bits of I/O. Since the program is entered during manufacturing, the part numbers of the two FPU's are proprietary. The CPU on the logic board uses 13 bits of I/O. The first PSU uses 1K of ROM, one interrupt and 9 I/O lines; the second PSU is used only for its additional 1K of program ROM.

• Cabinet Preparation:

After carefully removing the glass top from the cabinet, the power supply board is mounted on the rear cabinet wall next to the power transformer assembly. The speaker, the TILT mechanism, the START and flipper buttons are installed, and the ball shooter is assembled and mounted.

• Playfield Assembly:

The wooden playfield board is laid upside-down in the cabinet and the eleven static lamp sockets are mounted and wired. Brackets, static bumpers, posts, guides, rails, a ball gate, spinner gates, the two pop bumper bodies, and the ball shooter guide are assembled and mounted. The ball return ramp and 'ball kicker' are assembled, aligned and mounted to the base of the ramp. The "ball

kicker" sends the ball up the ramp to the shooting alley in front of the ball shooter.

• Left & Right Flipper Assemblies:

Two flipper solenoid assemblies are constructed next. They are mirror images of each other. Each consists of 32 parts. They are mounted to the under side of the playfield.

The solenoid coil on each flipper has two windings connected in series, a high current winding and a low current winding. A leaf switch shorts out the low current winding when the flipper is in its inactive state. When the button is pressed current is applied to the high current winding directly and the solenoid moves with high force. Since the player controls the button, and may want to hold the flipper for more than just a moment, the leaf switch opens at the end of the flipper movement, connecting the low current coil in series with the high current coil, significantly reducing the current draw to prevent overheating the coil. The other solenoids are microprocessor controlled and have a single coil and a low duty cycle.

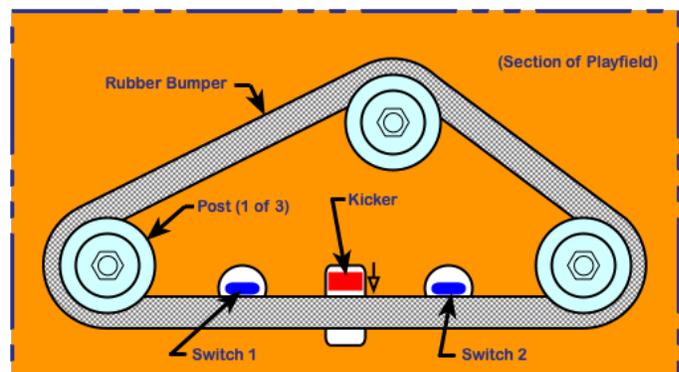


Figure 9: Each GD-1110 slingshot has three posts holding a rubber bumper (O-ring). Only the longest side is active. Should the ball hit that side with enough energy to close one of the two switches a pulse is sent to the kicker solenoid which hits the bumper adding momentum to the ball. The two switches and kicker mechanism are below the playfield and protrude through holes.

• Left & Right Slingshot Kicker:

Two identical slingshot kickers are assembled. Each consists of two assemblies, the kicker assembly that mounts with the kicker arm extending through the playfield, and the solenoid assembly that mounts to the bottom of the playfield. **Figure 9** describes the slingshot operation.

• Pop Bumper Solenoids:

Before the solenoids for the pop bumpers are assembled, the pop bumper light sockets are soldered to the static AC lamp lines installed earlier. The assembled solenoids are then mounted to the underside of the playfield. **Figure 10** shows the pop bumper operation.

• Harness Installation and More:

Two prefabricated wiring harnesses are supplied with the kit. They are installed using cable clamps on the underside of the playing field. The harness comes with connectors installed that mate with the connectors on the four printed circuit boards. The harnesses are plugged into the two playfield boards in the main cabinet and wired to the components not on a circuit board. The AC power cord and the unconnected ends of the harness are routed through a slot into the back box.

• Back Box Assembly:

Static lamps that illuminate the back box artwork are wired, the logic circuit board is mounted into the back box, and the harnesses are connected.

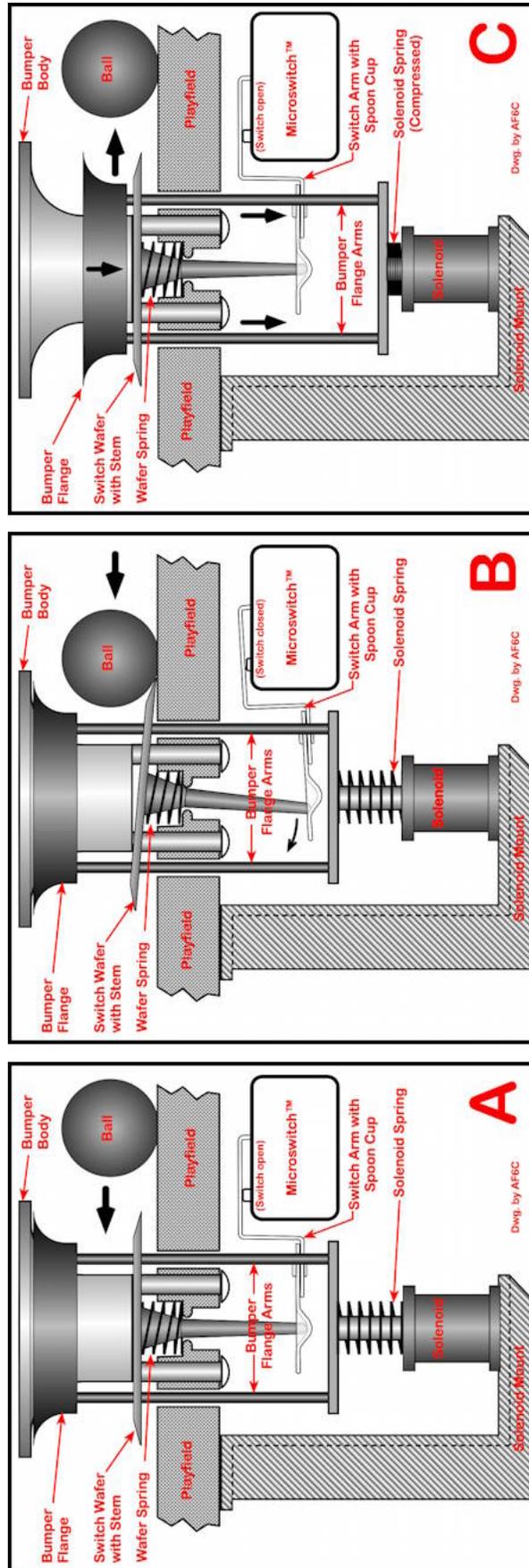


Figure 10: - The ABCs of the 'Thumper Bumper' - 'A' shows the pop bumper in its normal state with a ball approaching. The switch wafer is free to move; it has clearance holes for the bumper flange arms and mounting posts for the bumper body. The end of the wafer stem sits in the dish of the wafer. This forces the wafer to tilt and activate the switch independent of what direction the ball approaches. The closed switch sends a signal to the microprocessor.
 - **'B'** shows the ball rolling onto the wafer. This forces the wafer to tilt and activate the switch independent of what direction the ball approaches. The closed switch sends a signal to the microprocessor.
 - **'C'** Shows the solenoid actuating upon command from the processor, strongly pulling the flange arms and flange down. The flange strikes the ball and pushes it with a strong force away from the pop bumper.

• Test Circuit:

A simple test circuit is assembled on a five-lug terminal strip. This strip mounts under an existing screw holding the power transformer shield. The simple 3 resistor and LED circuit is shown in **Figures 11 & 12**. Its operation is discussed in the next section.

At this point the assembly is complete except for some finishing touches after the pinball is working properly. The wiring harness has yet to be connected to the power supply board.

Adjustments and Tests:

Before power is applied each of the numerous switches are adjusted to operate at the correct position. This is done by gently bending the switch arms on the microswitches or adjusting the contact gap on the leaf switches. The guide rails are then adjusted so a ball rolling down them hits the correct spot on the playfield. Finally the ball shooter is aligned and lubricated.

Initial power supply testing uses the test circuit to check that the numerous voltages are within range. The test circuit common lead is connected to a convenient ground point on the power supply circuit board. With the red lead pushed onto the #1 lug, only voltages above about 9.5 volts will cause the LED to light. This is used to check for the presence of voltage on the 12V, 18V and 22V outputs (The LED should light). And the absence of excessive voltage on the 5V and VLED outputs (The LED should NOT light). The red lead is then moved from lug 1 to lug 2 of the terminal strip. Here the LED will light above about 3.5 volts. This is used to confirm the voltage is present on the 5V and VLED (~5.5V) outputs. If the voltages all appear correct then the harness connector is plugged into the power supply circuit board.

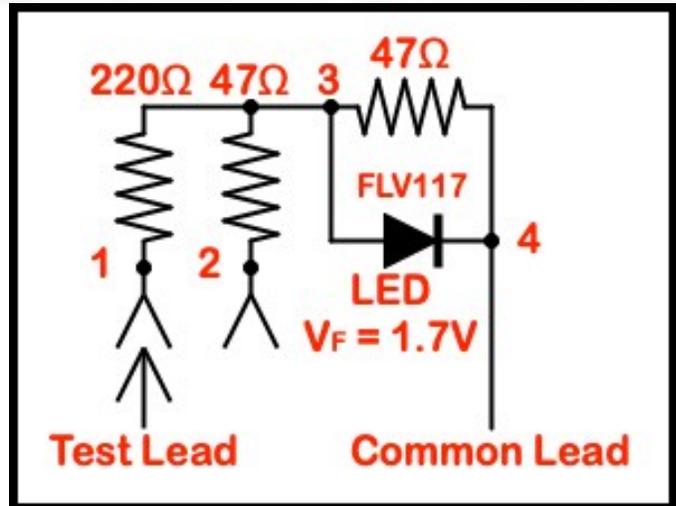


Figure 11: This simple test circuit used to check power supply voltages.

Diagnostic Tests:

The game has a diagnostic mode built into the microprocessor program which is run. After cycling through the tests the display should indicate all zeros. If not, the display will indicate a code indicating a stuck or misaligned switch. The codes are given in the Bally manual that comes with the kit.

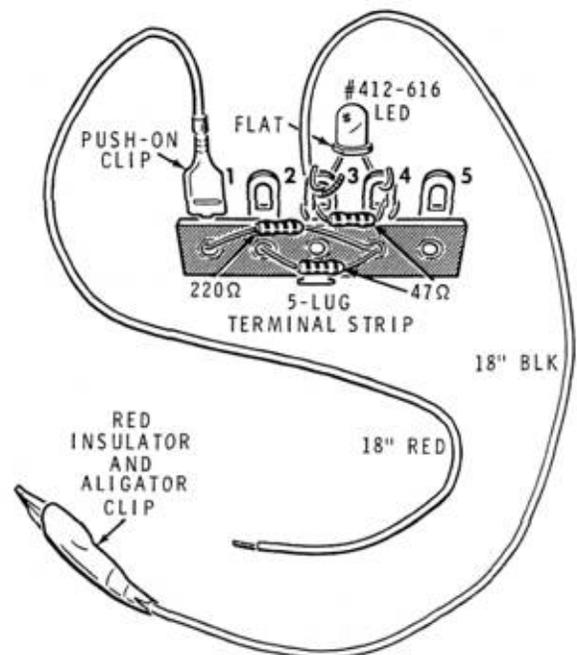


Figure 12: A sketch from the manual showing the test circuit assembly.

Assuming all checks out well, the Playfield Tests are conducted. A 25-step procedure is run by manually actuating switches. After each step the score and lamp status should agree with the results listed. Also during various steps the sounds that should be heard are given. The 24th and 25th steps involve TILting the machine to check that it functions properly.

Final Assembly:

Final assembly involves installing decals on the spinner gates, sling-shot covers and sides of the playfield. The lower play field cover is then installed and with it the Heathkit blue and white label with the S/N and model information. The back box cover is installed on the back of the back box. The ball is placed on the play field and the glass cover is cleaned and installed. The front trim molding is then installed to hold the glass in place. *“This completes the assembly of your Pin Ball Game.”*

Multiplexing Operation:

In play, the microprocessor continuously scans all the switches to detect their position. At the same time it scans the lamps, lighting them in response to the action of the ball in the playfield. This scanning is done in a matrix as shown in **Figure 13**. The switch contacts S1 ... S22, TILT, START, EASY and TEST look like capacitor symbols. Each switch is isolated by a diode. The driver for each horizontal wire (MX0 to MX7) raises the wire's voltage to 18 VDC under processor control one at a time, and then the voltage is read on the SW0 - SW3 vertical lines; 18 V indicates a closed switch. The lamps operate differently. LT0 through LT3 are connected to drivers that are also controlled by the processor. When activated, these drivers provide a low impedance to power common. While one of the horizontal lines is being driven (18 VDC) the

processor activates the drivers to the vertical lines B1 - B4 for the lamps to be lit. Though the lamps are on only 1/8 of the time, the 7 volt lamps, being driven by 18 V, remain bright.

Table VI identifies the switches and lamps.

Bally and Heathkit:

In looking over the manual some things stand out. First there are no schematics in the Heathkit manual. I was able to find schematics online¹¹ but it seems Bally had some strict rules as to what Heath could and couldn't do. The most obvious indication of Bally's control is the part numbers. Almost all the part numbers start with 218. Even simple parts like resistors, and capacitors, diodes, transistors and ICs that are in Heath's parts inventory have a 218 part number. The only parts that don't start with 218 are Heath supplied tools (nut drivers, Allen wrenches, etc), IC sockets (Boards made by Bally evidently have their ICs soldered in place), the blue and white Heath label, the Heathkit assembly manual and some small lengths of wire. The test circuit, an innovation of Heathkit, uses standard Heathkit part numbers. Simply put, if the part is in the Bally manufactured game it has the 218 part number.

Throughout the manual Heath warns to be sure to use the part numbers given in the manual if you have to order parts. My guess is that Bally was, in fairness, getting a cut of the sale of spare parts. Though that must have been a nightmare for Heath's bookkeeping department. It will be interesting to see if Heath's later pinball machine, licensed from Brunswick, also had separate part numbers.

One thing can be said is the mechanical parts Bally supplied are top notch and can be expected to last a long time. The switches on the play field are real Microswitch products

and the solenoids are heavy duty, both the same as used in their commercial machines.

In doing research for this article, one common failure mode cropped up numerous times, failure of the 18V regulator circuit on the power supply board. There is an 18V zener diode in series with 33Ω resistor across about 23 volts. The diode, a 1N5355B is rated for 5 watts and the resistor is rated at 2-watts (or on some units 5 watts). These components tend to fail and scorch the circuit board. A high line voltage may be partially to blame. Perhaps the resistor and diode should be mounted a quarter inch above the circuit board and 1 square inch piece of copper sheet soldered to each diode lead as a heatsink to help dissipate the heat.

Solid-State vs. Electro-Mechanical:

There is no question that the GD-1110 kit would never have existed if it weren't for microprocessors and solid-state electronics. To get an idea of the complexity and labor intensiveness of an EM machine look at **Figure 14** and **15**. They show the very complex insides of the commercial EM Fireball machine ¹².

Ramblings:

I now know a lot more about how a pinball game works than I did before. I had planned to write short bits on Heath's version of the Brunswick Aspen game, but this article went longer than planned.

The DX-40 will probably be my next restoration? It is sitting in the garage reasonably cleaned up and I'm slowly collecting parts.

I'm also searching for single RCA phono jacks (434-42). I have an SB-300 that must have sat in water front panel up. All eleven jacks are badly corroded as well as the AC line cord socket (432-4). Amazingly, the alu-

Matrix Switch & Light Identification			
SW. #	Switch Function	Lamp #	Lamp Function
S1	A Roll over	L1	A Roll over active
S2	B Roll over	L2	B Roll over active
S3	C Roll over	L3	C Roll over active
S4	D Roll over	L4	D Roll over active
S5	Dbl. Bonus Adv. #3	L5	Dbl. Bonus Adv. #3 active
S6	Dbl. Bon1us Adv. #1	L6	Dbl. Bonus Adv. #1 active
S7	L. Bumper	L7	Double bonus light
S8	R. Bumper	L8	Triple bonus light
S9	Dbl. Bonus Adv. #2	L9	Dbl. Bonus Adv. #2 active
S10	Power Alley Spinner	L10	Bonus 10,000
S11	Thunder Smash. Spinner	L11	Bonus 9,000
S12	L. Adv. Bonus Sw.	L12	Bonus 8,000
S13	R. Adv. Bonus Sw.	L13	Bonus 7,000
S14	L. Sling Shot	L14	Bonus 6,000
S15	L. Sling Shot	L15	Bonus 5,000
S16	R. Sling Shot	L16	Bonus 4,000
S17	R. Sling Shot	L17	Bonus 3,000
S18	L. Adv. Bonus Roll over	L18	Bonus 2,000
S19	R. Adv. Bonus Roll over	L19	Bonus 1,000
S20	Ball eject SW.	L20	Shoot Again
S21	L. Extra ball Roll over	L21	L. Extra ball light
S22	R. Extra ball Roll over	L22	R. Extra ball light
TILT	TILT switch	TILT	TILT light
START	Start SW.	OVER	GAME OVER light
EASY	50K / 100 K SW.	P1 - P4	Players #1- #4 lights
TEST	Test mode SW.	B1 - B5	Balls #1 - #5 lights

TABLE VI

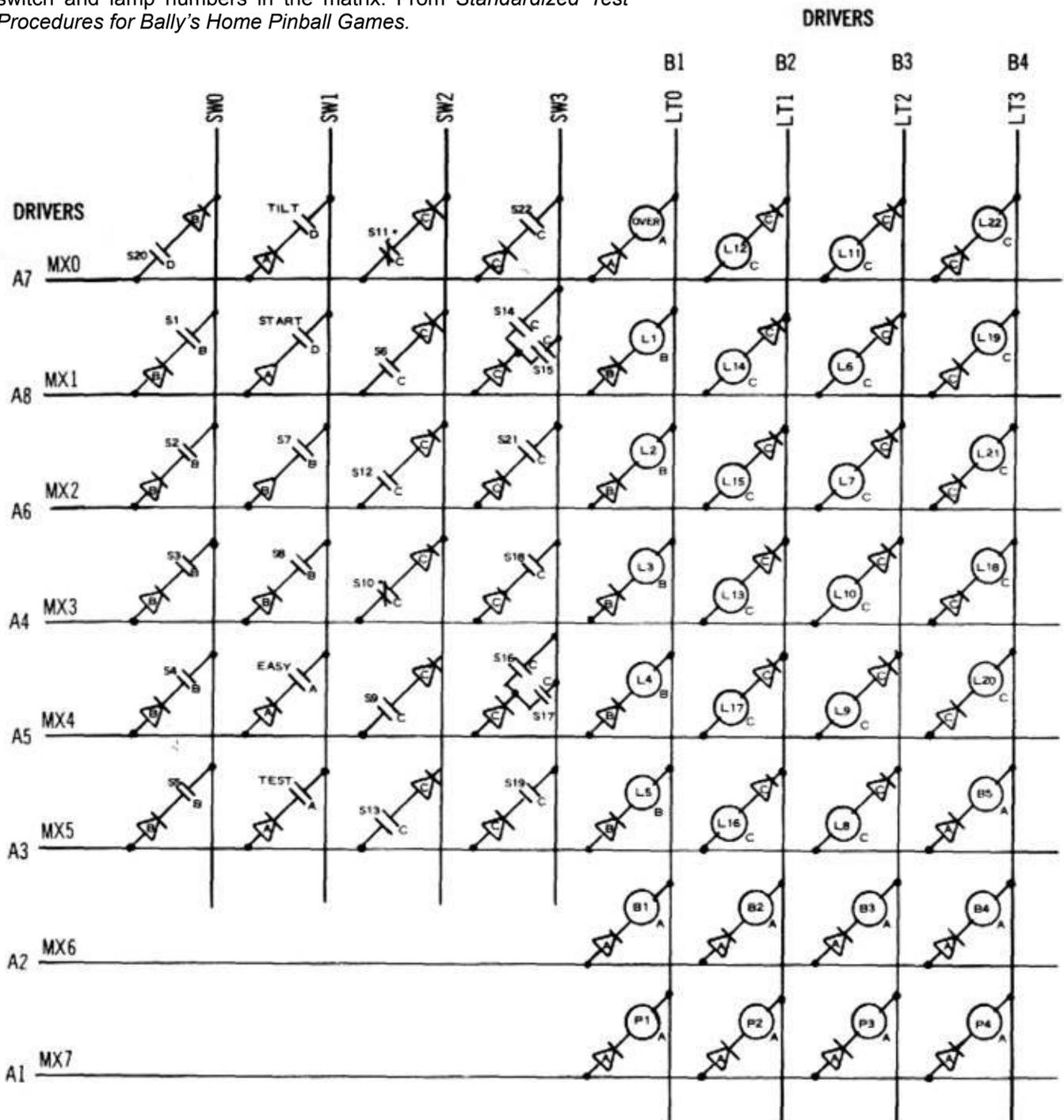
minum chassis wasn't damaged, though the cabinet paint is compromised.

What's on the horizon? I'm not sure what the next kit will be, I'm aiming for a ham radio related Heathkit.

73, from AF6C



Figure 13: The Microprocessor Matrix that scans the switches and operates the playfield and back box lamps. **Table VI** correlates the switch and lamp numbers in the matrix. From *Standardized Test Procedures for Bally's Home Pinball Games*.



NOTE: S-10 and S-11 are mechanically held activated; a ball will deactivate them.

- A = Located on Logic PCB
- B = Located on Upper Playfield PCB
- C = Located on Lower Playfield PCB
- D = Located in Playfield Cabinet

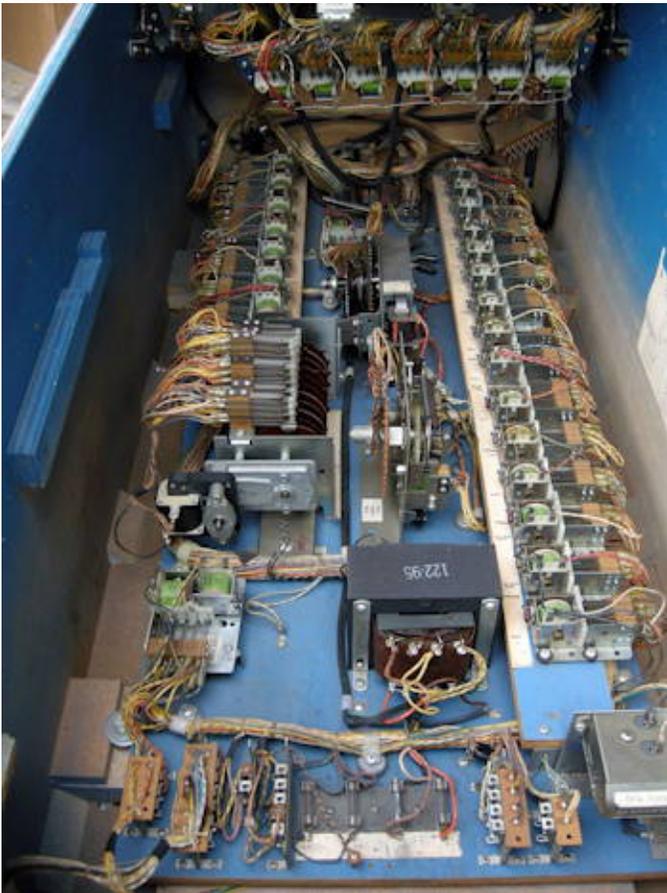


Figure 14 ¹¹: This is the inside of the commercial EM *Fireball* game main cabinet. A lot of relays and stepping relays are needed because the microprocessor was still on the drawing board. Wiring this as a kit would take a lot of evenings. Not shown are the solenoids and switches on the playfield. I wonder if Bally hired engineers from the telephone company? They were the relay logic pros.



Figure 15 ¹¹ (Left): This is the inside of the commercial EM *Fireball* game Back Box. Note the large mechanical rotary displays for scorekeeping and the thick wiring harness. The microprocessor and multiplexing LED display simplified the back box to to one easily assembled circuit board, a few lights and hardware to mount the board.

Notes:

1. Look for a future article covering the DX-40. There were some circuit changes during production that were not covered in the initial article.
2. <https://www.youtube.com/watch?v=hHc7bR6y06M>, The Who: **Pinball Wizard**.
3. Statistics from: <https://www.ipdb.org>
4. This is a quote from the Christmas 1977 catalog.
5. In the same catalog Heath mentions a Motor Freight price of \$20 to ship the 153 lbs. GD-2225 and optional GDA-2225-1 Indoor Klima Grow Greenhouse & Stand to a freight terminal near you.
6. The factory assembled model requires some additional assembly. The legs must be attached and leveled and the back box bolted on to the main cabinet and the two plugged together.
7. The catalog is available at: <https://atariage.com/forums/applications/core/interface/file/attachment.php?id=814708>
8. Excluding artwork, Captain Fantastic...’s playfield is identical to Fireball. *Evel Knievel* and *Galaxy Ranger* have a third flipper that replaces the left sling shot; otherwise they were identical.
9. Other than applying English to the cabinet. Too much and the machine TILT sensor will actuate.
10. Two types of lamps are used on Fireball; The two Pop Bumpers each use a #455 bayonet blinking bulb and the rest of the game uses a #147 wedge bulb.
11. A rough schematic is available at: <http://www.w6ze.org/Heathkit/sch/GD1110.gif>
12. Photos and statistics are from the Internet Pinball Database <https://www.ipdb.org> Photo credit goes to Larry Wolfe.

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Remember, if you are getting rid of any old Heathkit Manuals or Catalogs, please pass them along to me for my research.

Thanks - AF6C