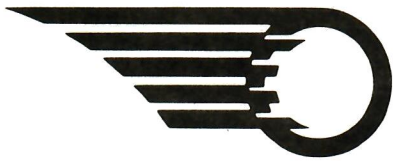
Bally/MIDWAY T.M.



SERVICE BULLETIN BOOK
1988

MIDWAY MANUFACTURING COMPANY
Makers of BALLY MIDWAY
Amusement Games

PRICE: $10.00

BALLY MIDWAY GAMES

SERVICE BULLETIN BOOK
1988

TABLE OF CONTENTS

S E R V I C E B U L L E T I N

November 12,1986

GAME: RAMPAGE UPRIGHT

SUBJECT: CONDOR SWITCHING POWER SUPPLY

Two versions of the Condor Power Supply were used during the Rampage production run. Although either supply will work in your game, the information listed below will help you to understand the difference between them and insure that they are properly connected to your game.

Failure to properly connect your respective power supply can result in game damage.

	Version A	Version B
Bally Midway Part No.	0017-0003-0543	0017-0003-0609
Condor Part No. on PCB	02-30379-0001	02-30485-0001
Connector and No. of Pins	JI,5 J2,20	JI,20
Used with Adapter Cable	No	Yes

NOTE: Games shipped with the version 'B' power supply included an adapter cable. When replacing a version 'B' with a version 'A' power supply, DO NOT use the original adapter cable.

FIELD SERVICE DEPARTMENT

S E R V I C E B U L L E T I N

January 13, 1987

SUBJECT: CONDOR POWER SUPPLY (#SP1016)

We have found that on Bally Midway video games, we are operating the Condor Power Supply at just under the minimum load required for proper operation. Because of this, when turning on a game, the Condor Power Supply may oscillate on and off.

To correct this situation, change resistor R9 to a 750 ohm 1/4 watt. R9 is located under the heatsink for Q2. It is necessary to remove Q2 and the heatsink to change R9.

Also, please note that we have put a ninety (90) day warranty on the Condor Power Supply.

S E R V I C E B U L L E T I N

October 1, 1987

GAME: XENOPHOBE

SUBJECT: Intermittant Reset Lock-Up On The 68000 Video P.C. Boards (A084-91871-E000 and A084-91871-D000)

We have noticed that some XENOPHOBE'S experience an intermittant lock-up problem when the game is turned on. The background appears normal but the characters show up as garbage with a thin line down the right hand side of the screen. This condition usually disappears when the game is turned off and on again.

To eliminate the condition completely, perform the following modification:

1. On the solder side, cut the trace that comes from the left side of the plated through hole between IC10H and IC10J. See Figure 1

2. On the solder side, jumper IC14J pin 13 to IC14J pin 1. See Figure 2.

3. On the solder side, jumper IC14J pin 12, to the plated through hole betweeen IC10H and IC10J. Be sure to scrape the solder mask off the plated through hole before soldering. See Figures 1 and 2. (This is the same plated through hole referenced in instruction 1.)

4. On the solder side, jumper IC14J pin 11 to IC15J pin 9. See Figure 2.

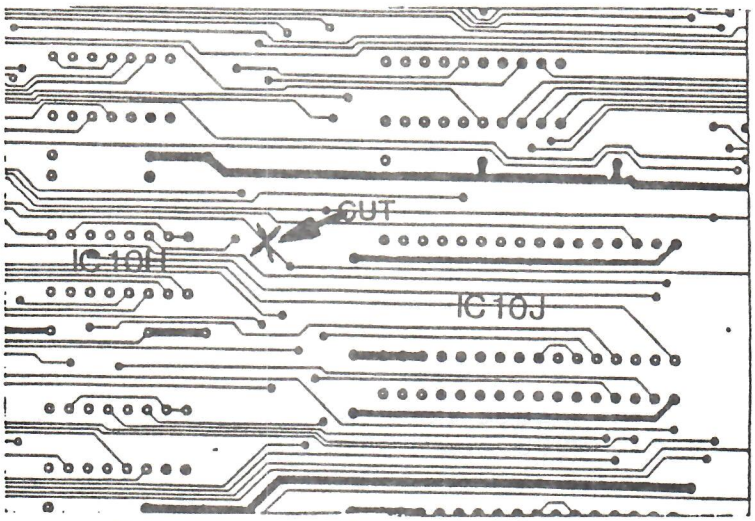
5. On the solder side, jumper IC14J pin 10 to IC14J pin 4. See Figure 2.

6. On the solder side, jumber IC14J pin 9 to the plated through hole between IC12D and IC12E. Be sure to scrape the solder mask off the plated through hole before soldering. See Figure 3.

Please note that all of our production games will have this modification included beginning with game #1410.

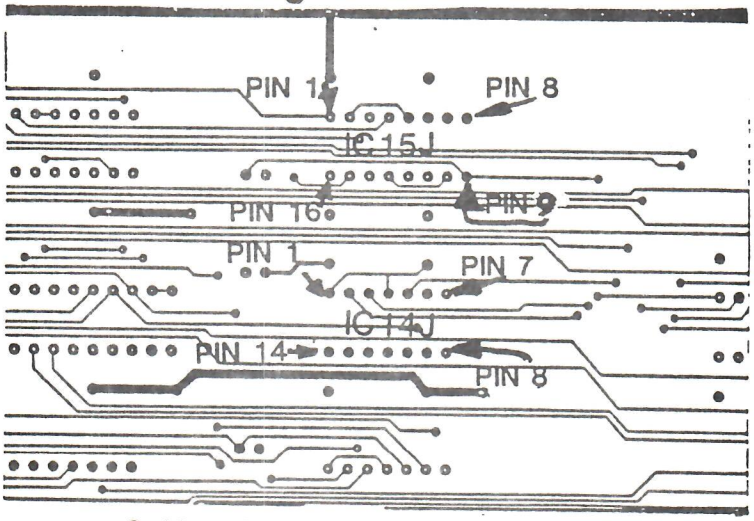
Thank You.

Figure 1



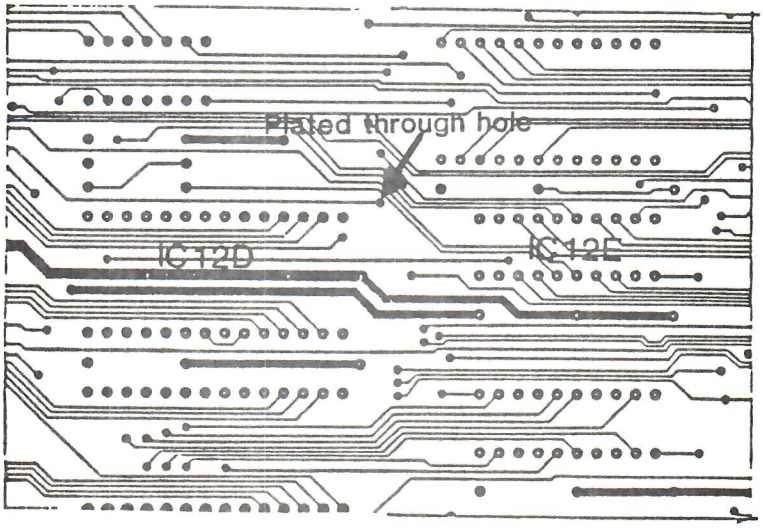
Solder side near ICs 10H & 10J
(To be used in locating cut.)

Figure 2

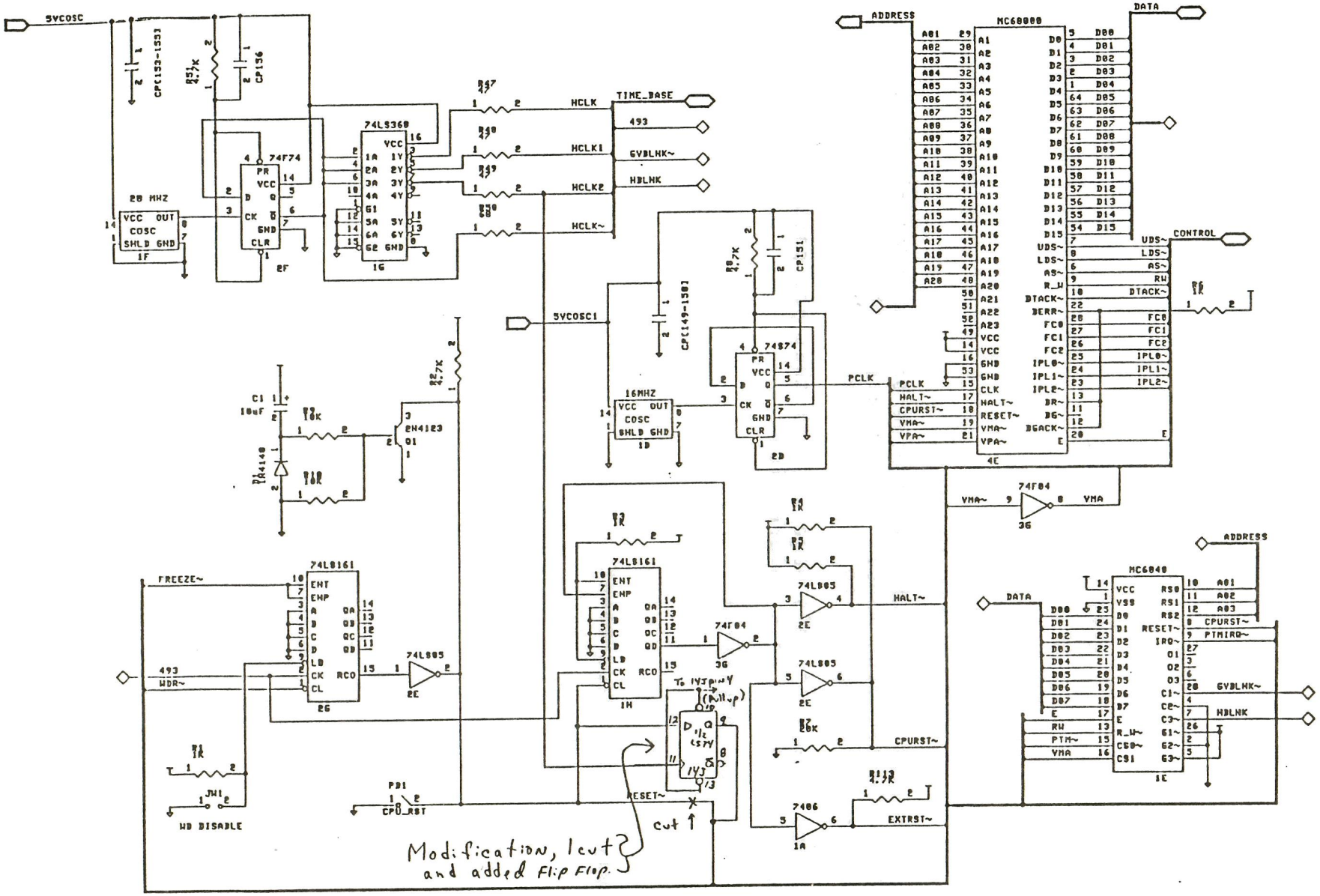


Solder side near ICs 14J & 15J
(To be used in locating pins.)

Figure 3



Solder side near ICs 12D & 12E
(To be used in locating Plated through Hole.)



PROJECT ENG:			USED ON	Bally / MIDWAY MFG. CO. FRANKLIN PK. ILL.
DO NOT SCALE DWG.	HEAT TREAT	SCALE	NO. REQ'D	
DRN.	MAT'L.	MODIFICATION INSTRUCTIONS FOR 68K VIDEO BOARD		PART NO. M057-00E87-A010
CKD. CMM	FINISH	Sheet 5 of 5		
DATE 9/23/87				

March 7, 1988

SERVICE BULLETIN

RE: "RABBIT PUNCH" Wiring Chart

Some of the initial RABBIT PUNCH kits have been shipped missing Page 23 of the Instruction Manual. This page contains all the wiring information necessary to assemble the game.

We've attached a copy of this page and ask that you pass it on to your customer requiring this information.

Thank you for your cooperation.

Bally Midway Service Department

6

WIRING CHART

MASTER CABLE ASSEMBLY 56-PIN CONNECTOR

WIRE COLOR	SOLDER SIDE	PIN	PIN	COMPONENT SIDE	WIRE COLOR
BLACK*	GROUND	A	1	GROUND	BLACK*
		B	2		
RED*	+5VDC	C	3	+5VDC	RED*
RED*	+5VDC	D	4	+5VDC	RED*
		E	5		
		F	6	+12VDC	BROWN@
		H	7		
		J	8		
		K	9		
GRAY	SPEAKER (-)	L	10	SPEAKER (+)	GRAY-BLACK
		M	11		
GREEN~	GREEN VIDEO INPUT	N	12	RED VIDEO INPUT	RED~
VIOLET~	NEGATIVE COMPOSITE SYNC VIDEO INPUT	P	13	BLUE VIDEO INPUT	BLUE~
YELLOW	SERVICE (CREDIT)	R	14	VIDEO INPUT GROUND	BLACK~
		S	15	TEST	WHITE
BLUE-BLACK	COIN 1	T	16	COIN 2	BLUE-WHITE
GREEN-BLACK	2P START	U	17	1P START	GREEN-YELLOW
YELLOW-BLACK	2P UP	V	18	1P UP	YELLOW-WHITE
YELLOW-BROWN	2P DOWN	W	19	1P DOWN	YELLOW-BLUE
RED-BLACK	2P LEFT	X	20	1P LEFT	RED-WHITE
BLUE-YELLOW	2P RIGHT	Y	21	1P RIGHT	BLUE-GREEN
ORANGE-GREEN	2P MISSILE	Z	22	1P MISSILE	ORANGE-RED
WHITE-BLACK	2P FIRE/PUNCH	a	23	1P FIRE/PUNCH	WHITE-BROWN
		b	24		
		c	25		
		d	26		
		e	27		
BLACK*	GROUND	f	28	GROUND	BLACK*

* 18 AWG, 300VDC WIRE
@ DRIVES SOUND SECTION OF LOGIC BOARD ASSEMBLY
~ VIDEO CABLE PORTION OF MASTER CABLE ASSEMBLY

May 6, 1986

S E R V I C E B U L L E T I N

GAMES: "8 BALL CHAMP, BEAT THE CLOCK AND LADY LUCK"

SUBJECT: Manual error. Test point 2 and test point 4 are reversed

ACTION: Please correct respective game manual as follows:

* Test point 2 changed to read test point 4
* Test point 4 changed to read test point 2

OPERATING GAME MANUAL REFERENCE

*	8 Ball Champ;	Page 3-14, Sheet 2 of 7
*	Beat The Clock;	Page 3-14, Sheet 2 of 7
*	Lady Luck;	Page 2-14, Sheet 2 of 7

December 26, 1985

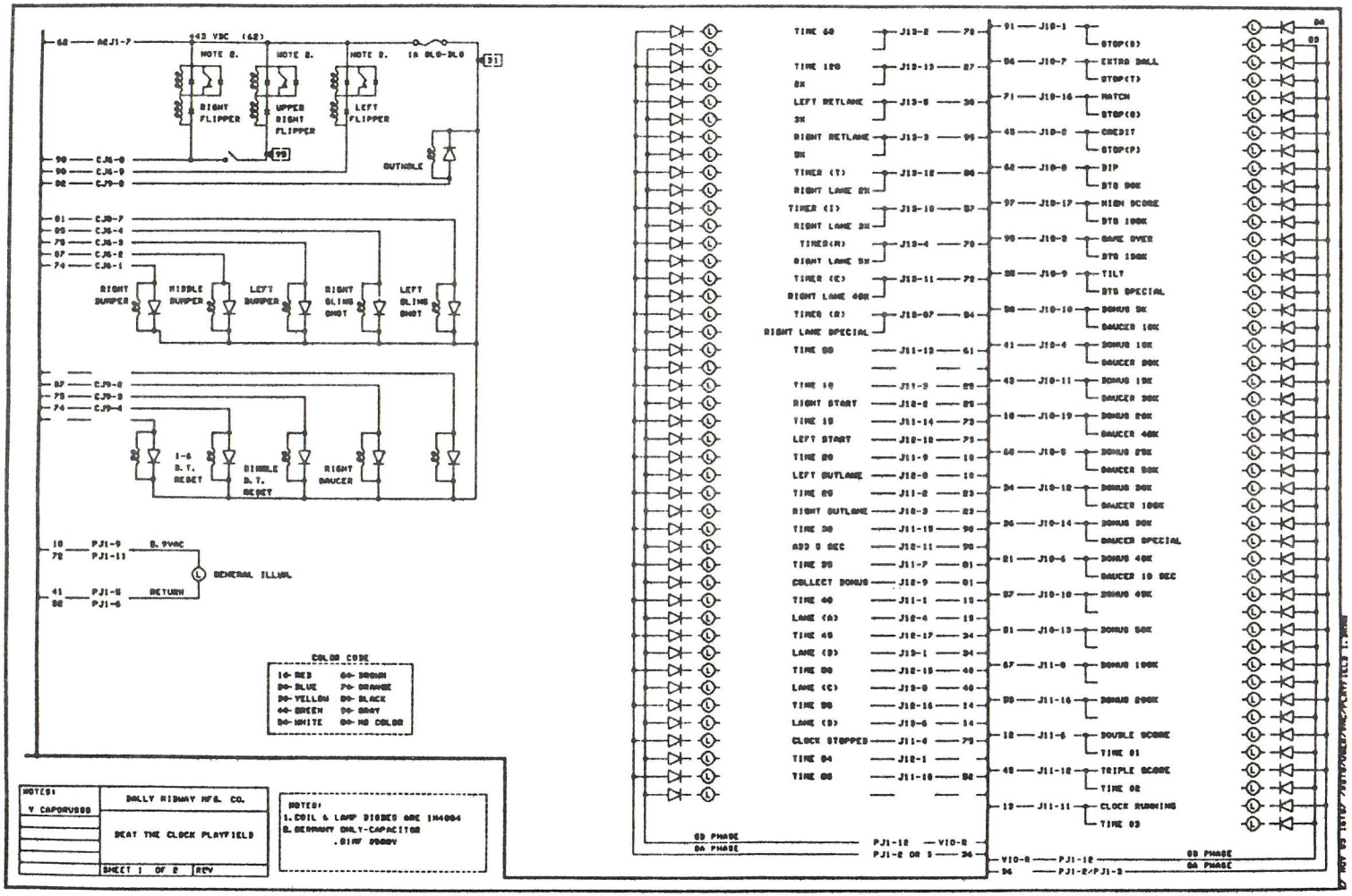
S E R V I C E B U L L E T I N

GAME: "Beat The Clock"

SUBJECT: MANUAL ERROR CORRECTIONS AND ADDITIONS

Please make the following game manual corrections:

PAGE #	READS	CHANGE TO READ
3-16	REF: Sheet 1 of 2 NOTE: coil I.D. incorrect.	Replace with sheet 1 of 2 attached. NOTE: coil I.D. corrected.
3-16	REF: Sheet 2 of 2 Strobe #5 reads: CJ4-2 I4 reads: CJ4-5	Strobe #5 should read: CJ4-1 I4 should read: CJ4-6
3-17	Controller BD-C, J5 Pin 15	Add: SJ1-8


+43 VDC (6Ø)
RIGHT FLIPPER
UPPER RIGHT FLIPPER
LEFT FLIPPER
OUTHOLE
RIGHT BUMPER
MIDDLE BUMPER
LEFT BUMPER
RIGHT SLING SHOT
LEFT SLING SHOT
1-4 B.T. RESET
DIBBLE B.T. RESET
RIGHT SAUCER
8.9VAC
RETURN
GENERAL ILLUM.
COLOR CODE
1- RED
2- BLUE
3- YELLOW
4- GREEN
5- WHITE
6- BROWN
7- ORANGE
8- BLACK
9- GRAY
Ø- NO COLOR
DALLY MIDWAY MFG. CO.
BEAT THE CLOCK PLAYFIELD
SHEET 1 OF 2
REV
NOTES:
1. COIL & LAMP DIODES ARE IN4004
2. GERMANY ONLY-CAPACITOR .01MF 2ØØØV
TIME 60
TIME 120
2X
LEFT RETLANE
3X
RIGHT RETLANE
5X
TIMER (T)
RIGHT LANE 2X
TIMER (I)
RIGHT LANE 3X
TIMER(M)
RIGHT LANE 5X
TIMER (E)
RIGHT LANE 40K
TIMER (R)
RIGHT LANE SPECIAL
TIME 90
TIME 10
RIGHT START
TIME 10
LEFT START
TIME 20
LEFT OUTLANE
TIME 20
RIGHT OUTLANE
TIME 30
ADD 5 SEC
TIME 30
COLLECT BONUS
TIME 40
LANE (A)
TIME 40
LANE (B)
TIME 50
LANE (C)
TIME 50
LANE (D)
CLOCK STOPPED
TIME 04
TIME 00
ØB PHASE
ØA PHASE
PJ1-10 — VIO-R
PJ1-2 OR 3
STOP(S)
EXTRA BALL
STOP(T)
MATCH
STOP(O)
CREDIT
STOP(P)
DIP
STO 90K
HIGH SCORE
STO 100K
GAME OVER
STO 150K
TILT
STO SPECIAL
BONUS 5K
SAUCER 10K
BONUS 10K
SAUCER 20K
BONUS 15K
SAUCER 30K
BONUS 20K
SAUCER 40K
BONUS 25K
SAUCER 50K
BONUS 30K
SAUCER 100K
BONUS 35K
SAUCER SPECIAL
BONUS 40K
SAUCER 10 SEC
BONUS 45K
BONUS 50K
BONUS 100K
BONUS 200K
DOUBLE SCORE
TIME 01
TRIPLE SCORE
TIME 02
CLOCK RUNNING
TIME 03
VIO-R — PJ1-10
PJ1-2/PJ1-3

December 26, 1985

S E R V I C E B U L L E T I N

SUBJECT: Beat the Clock and Future Pinball Games

SYMPTON: The control board L.E.D. flashes 8 times but game fails to power up.

CAUSE: The utility portion of the program contained in U3 has been modified for purposes of internal testing, starting with game #300 of BEAT THE CLOCK.

CURE: A 100K ohm 1/4 watt resister has been connected from the +5 volt buss to pin 12 of U1 (the 6803 CPU).

NOTE: This resistor addition has been made on all control boards containing the updated program and must be made when converting an earlier game (i.e. Eight Ball Champ) to any newer game.

September 15, 1986

S E R V I C E B U L L E T I N

GAME: Beat The Clock

SUBJECT: Parts and Operating Manual Correction

REF: Inside of back cover "CONTROL BOARD" jumper information.

JW8 reads "IN"; Change to read "OUT"
JW9 reads "OUT"; Change to read "IN"

NOTE: JW9 provides an extra switch strobe, ST5 for use in the playfield matrix of BEAT THE CLOCK.

June 26, 1986

SERVICE BULLETIN

SUBJECT: Circlite-Mister 8" 22 Watt
Fluorescent Lamp Assembly

USED ON: Motordome and Future Bally Midway
Pinball Machines

Remove the above circular lamp from inside of back box before transporting game cabinet.

This same information is on a label affixed to the top of the cash box cover.

Please know that this circular lamp is a common part and is available at most electrical outlet stores.

Lamp Part Number: "General Electric" FC8T9-WW
(Warm White - Rapid Start)

June 26, 1986

S E R V I C E B U L L E T I N

GAME: "Motordome"

SUBJECT: MANUAL ERROR CORRECTIONS

OPERATING MANUAL GAME #OE14, FM. #OE14-00300-0100

PAGE #	SHEET	DESCRIPTION	CHANGE TO READ
2-18	1 of 1	Motordome Cabinet Diagram	"Not Used (For Future Use)" Is changed to read: "Right Flipper Button" "Right Flipper Button" Is changed to read: "Not Used (For Future Use)"
2-18	1 of 2	Motordome Playfield Diagram	The "1.5A SLO-BLO" fuse Is changed to read: "1A SLO-BLO" The left, middle & right gate coils are drawn common to the 30 (yellow 18 AWG) + 43 V.D.C. buss wire. These coils should be drawn common to the 60 (brown 18 AWG) + 43 V.D.C. buss wire.

PARTS MANUAL GAME #OE14, FM #OE14-00300-0200

PAGE #	ITEM #	READS:
29A	32	"OE14-00101-0000, Right-Platform Support." Change to read: "OE14-00102-0000, Left-Platform Support."

June 26, 1986

S E R V I C E B U L L E T I N

GAME: "Motordome"

SUBJECT: MANUAL ERROR CORRECTIONS

OPERATING MANUAL GAME #OE14, FM. #OE14-00300-0100

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PARTS MANUAL GAME #OE14, FM #OE14-00300-0200

PAGE #	ITEM #	READS:
29A	32	"OE14-00101-0000, Right-Platform Support." Change to read: "OE14-00102-0000, Left-Platform Support."

August 11, 1986

S E R V I C E B U L L E T I N

SUBJECT: Manual Error Correction

RE: 6803 Pinbal Power Module Schematic
Drawing A084-91785-D000

C6 and C7 read .1 UF
Change to read .01 UF

GAME MANUALS INVOLVED:
"8 Ball Champ"
"Beat The Clock"
"Lady Luck"
"Motordome"
"Black Belt"

November 14,1986

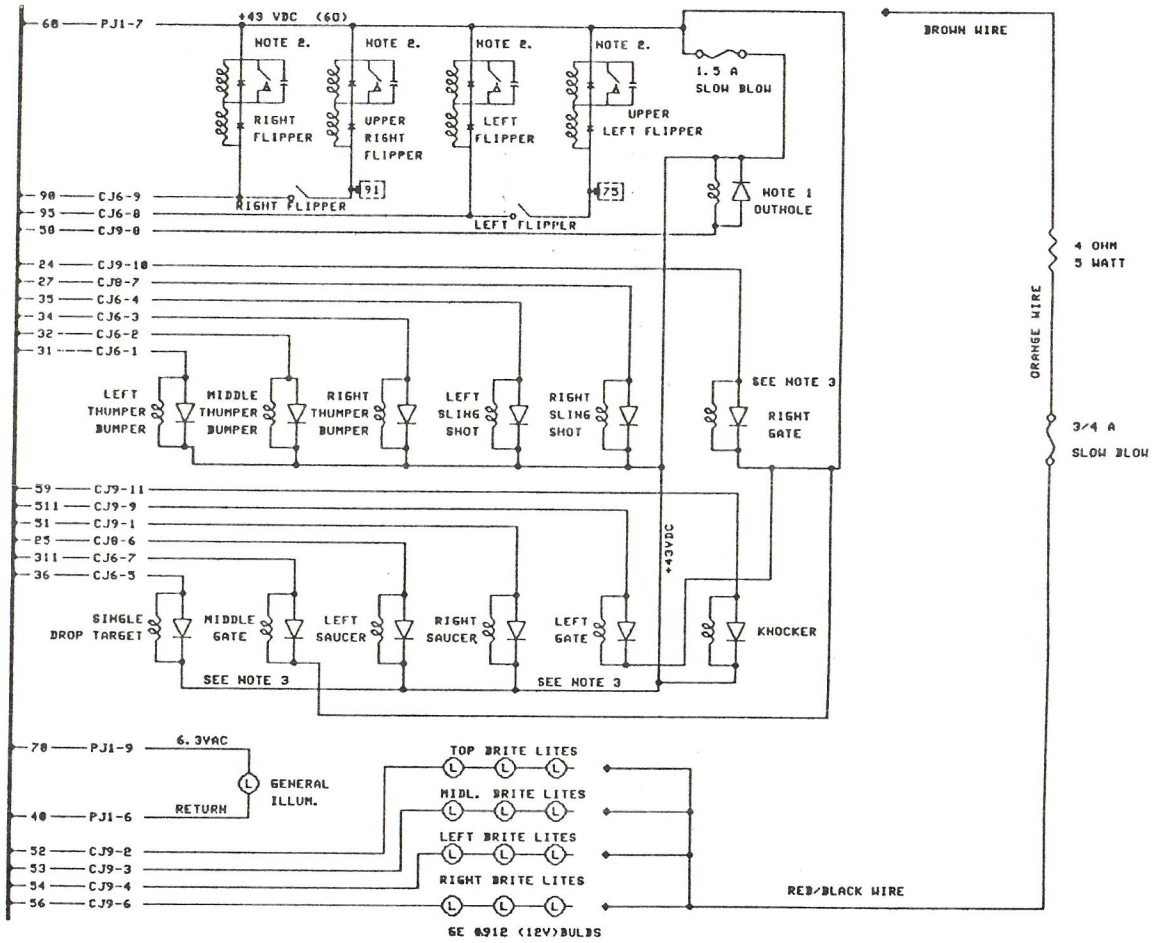
Dear Distributor:

Due to problems that sometimes occur on the Brite-Lite Circuits of Motordome, we are providing a field kit for each of the games you received.

This kit contains a resistor to limit the inrush current when the bulbs are turned on, as well as a lower value fuse to protect the circuit should any irregularities occur.

The kit takes only a few minutes to install and we strongly recommend each of the Motordomes be updated to insure game reliability.

Thank you for your cooperation.



COLOR CODE

1 RED	6 BROWN
2 BLUE	7 ORANGE
3 YELLOW	8 BLACK
4 GREEN	9 GRAY
5 WHITE	0 NO COLOR
	11 VIOLET

NOTES:	BALLY MIDWAY MFG. CO.
D. STERN	MOTORDOME BRIGHT LIGHT MODIFICATION
10/27/86	
	SHEET 1 OF 1 REV

September 15, 1986

S E R V I C E B U L L E T I N

GAME: Black Belt Pinball Machine and Future Games

SUBJECT: Self-Percentaging

Bally Midway is introducing a "Self-Percentaging" feature with BLACK BELT pinball machine.

Please insert the attached "Self-Percentaging" procedure into your BLACK BELT operating manual. Also, add the catagories "Self Percent", "Target Percent" and "Threshold 1 Percent" under "Threshold 1" in the "Percent Options" portion of your operating manual on Page 1-3.

Thank You.

S E L F - P E R C E N T A G I N G

1.) The term Self-Percentaging refers to the game's ability to automatically adjust the score level of Threshold 1 to attain a desired replay percentage, also known as the TARGET PERCENT. (see article #8)

2.) Self-Percentaging also applies to extra balls, when used instead of replays.

3.) Initially, a minimum of 200 games must be played before the Self-Percentaging Process goes into effect. It then monitors the current replay percentage of Threshold 1 ONLY and makes an adjustment, if necessary, every 50 games.

4.) The Self-Percentaging Process will automatically adjust the score level of Threshold 1 ONLY. It makes NO adjustments to OTHER "Award" features in the game.

5.) Located within the "PERCENT OPTIONS" category of your game's test mode are the following registers:

* THRESHOLD 1
* SELF PERCENT
* TARGET PERCENT
* THRESHOLD 1 PERCENT

Each of these registers are explained in detail further in this text.

6.) To set or check the current score level of Threshold 1:
   A.) "Step through" your game's test mode, using the "A" or "B" button on the keypad, until you reach a category titled: "PERCENT OPTIONS".
   B.) Press the "ENTER" button to select this category.
   C.) The first register displayed will be THRESHOLD 1.

THRESHOLD 1 - This register displays the current score level of the 1st Replay Threshold. Enter any value from 0 to 9,999,999 to set the desired score level.

7.) To activate the Self-Percentaging Process:
   A.) "Step through" your game's test mode, using the "A" or "B" button on the keypad, until you reach a category titled "PERCENT OPTIONS".
   B.) Press the "ENTER" button to select this category.
   C.) Again, use the "A" button to "step through" until you reach a register titled: "SELF PERCENT".

SELF PERCENT - This register displays whether the Self-Percentaging Process is OFF or ON. Enter "0" to turn OFF or "1" to turn ON.

8.) To adjust the desired Replay Percentage for Threshold 1:
   A.) "Step through" your game's test mode, using the "A" or "B" button on the keypad, until you reach a category titled "PERCENT OPTIONS".

B.) Press the "ENTER" button to select this category.
C.) Again, use the "A" button to "step through" until you reach a register titled: "TARGET PERCENT".

TARGET PERCENT - This register displays the desired percentage of replays to be awarded for reaching Threshold 1. For example, if you want Threshold 1 to award a replay in 15% of the games played, you would press keys "1", "5" and then "ENTER". This register will then display "15%" as your goal or "TARGET PERCENT".

NOTE: This register automatically defaults to a factory setting of "10%", when the "FACTORY RESET" register is enabled.

9.) The TOTAL Replay Percentage will be 10% or 15% higher with the addition of Match, Special and High Score To Date credits.

10.) To manually check the current replay percentage of Threshold 1 ONLY:
A.) "Step through" your game's test mode, using the "A" or "B" button on the keypad, until you reach a category titled "PERCENT OPTIONS".
B.) Press the "ENTER" button to select this category.
C.) Again, use the "A" button to "step through" until you reach a register titled: "THRESHOLD 1 PERCENT".

THRESHOLD 1 PERCENT - The figure displayed in this register is the actual percentage of replays awarded for reaching Threshold 1. Progress of the Self-Percentaging Process may be monitored by comparing the current value displayed in this register with the "TARGET PERCENT".

11.) The size of adjustment, made by the Self-Percentaging Process to the score level of Threshold 1, is determined by the current difference between the "TARGET PERCENT" (entered by the operator) and the actual percentage of replays awarded for reaching Threshold 1.
* A difference of 10% or more will result in a 10% adjustment.
* A difference equal to or greater than 5%, but less than 10%, will result in a 5% adjustment.
* A difference less than 5% will result in a 1% adjustment.

12.) To check the current score level of Threshold 1, refer to article #6.

13.) When the "CLEAR BOOKKEEPING" register is enabled, the Self-Percentaging Process is reinitiated.

SELF PERCENT	Enter "0" or "1"; "0" disables Self-Percentaging Process, "1" enables Self Percentaging Process.
TARGET PERCENT	Enter desired percentage of replays awarded for reaching Threshold 1.
THRESHOLD 1 PERCENT	Displays actual percentage of replays awarded for reaching Threshold 1.
THRESHOLD 2	Enter 0 through 9,999,999; sets award level and display.
THRESHOLD 3	Enter 0 through 9,999,999; sets award level and display
HIGHEST SCORE	Enter 0 through 9,999,999; sets the High Score replay level and display.

January 29, 1987

Dear Distributor:

Due to problems that sometimes occur on the Brite-Lite Circuits of BLACK BELT, we are providing a field kit for each of the games you received.

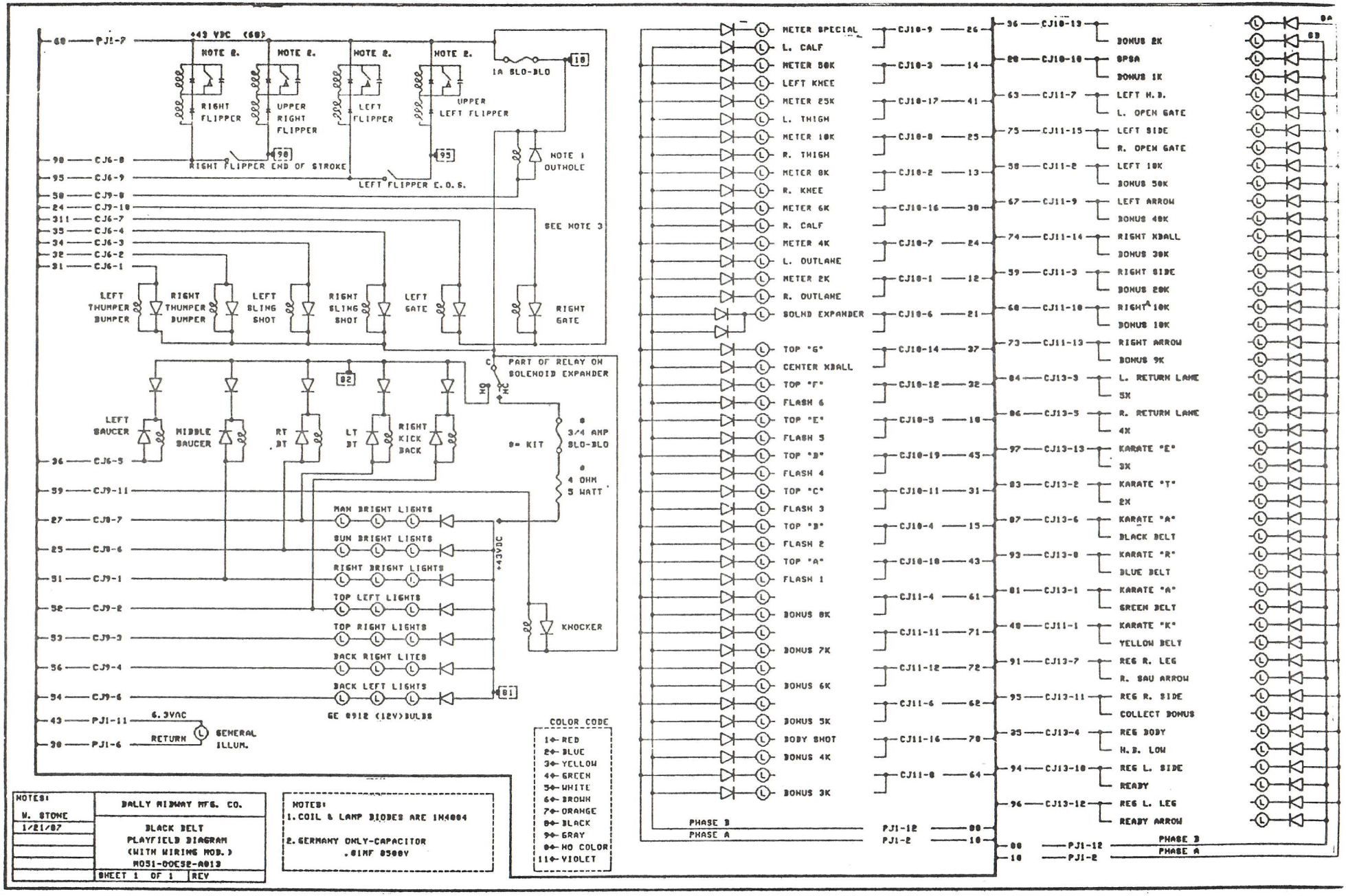
This kit contains a resistor to limit the inrush current when the bulbs are turned on, as well as a lower value fuse to protect the circuit should any irregularities occur.

The kit takes only a few minutes to install and we strongly recommend each of the BLACK BELTS be updated to insure game reliability.

Thank you for your copperation.

Sincerely,

BALLY MIDWAY MFG. CO.


+43 VDC (68)
NOTE 2.
RIGHT FLIPPER
UPPER RIGHT FLIPPER
LEFT FLIPPER
UPPER LEFT FLIPPER
1A SLO-BLO
RIGHT FLIPPER END OF STROKE
LEFT FLIPPER E.O.S.
NOTE 1 OUTHOLE
SEE NOTE 3
LEFT THUMPER BUMPER
RIGHT THUMPER BUMPER
LEFT SLING SHOT
RIGHT SLING SHOT
LEFT GATE
RIGHT GATE
PART OF RELAY ON SOLENOID EXPANDER
LEFT SAUCER
MIDDLE SAUCER
RT JET
LT JET
RIGHT KICK BACK
9= KIT
3/4 AMP SLO-BLO
4 OHM 5 WATT
MAN BRIGHT LIGHTS
SUN BRIGHT LIGHTS
RIGHT BRIGHT LIGHTS
TOP LEFT LIGHTS
TOP RIGHT LIGHTS
BACK RIGHT LITES
BACK LEFT LIGHTS
+43VDC
KNOCKER
GE 8912 (12V) BULBS
6.3VAC RETURN
GENERAL ILLUM.
METER SPECIAL
L. CALF
METER 50K
LEFT KNEE
METER 25K
L. THIGH
METER 10K
R. THIGH
METER 8K
R. KNEE
METER 6K
R. CALF
METER 4K
L. OUTLANE
METER 2K
R. OUTLANE
SOLND EXPANDER
TOP "G"
CENTER XBALL
TOP "F"
FLASH 6
TOP "E"
FLASH 5
TOP "D"
FLASH 4
TOP "C"
FLASH 3
TOP "B"
FLASH 2
TOP "A"
FLASH 1
BONUS 8K
BONUS 7K
BONUS 6K
BONUS 5K
BODY SHOT
BONUS 4K
BONUS 3K
PHASE B
PHASE A
BONUS 2K
SPSA
BONUS 1K
LEFT H.B.
L. OPEN GATE
LEFT SIDE
R. OPEN GATE
LEFT 10K
BONUS 50K
LEFT ARROW
BONUS 40K
RIGHT XBALL
BONUS 30K
RIGHT SIDE
BONUS 20K
RIGHT 10K
BONUS 10K
RIGHT ARROW
BONUS 9K
L. RETURN LANE
5X
R. RETURN LANE
4X
KARATE "E"
3X
KARATE "T"
2X
KARATE "A"
BLACK BELT
KARATE "R"
BLUE BELT
KARATE "A"
GREEN BELT
KARATE "K"
YELLOW BELT
REG R. LEG
R. SAU ARROW
REG R. SIDE
COLLECT BONUS
REG BODY
H.B. LOW
REG L. SIDE
READY
REG L. LEG
READY ARROW
COLOR CODE
1= RED
2= BLUE
3= YELLOW
4= GREEN
5= WHITE
6= BROWN
7= ORANGE
8= BLACK
9= GRAY
0= NO COLOR
11= VIOLET
NOTES:
1. COIL & LAMP DIODES ARE 1N4004
2. GERMANY ONLY-CAPACITOR .01MF 8500V
NOTES:
W. STONE
1/21/87
BALLY MIDWAY MFG. CO.
BLACK BELT
PLAYFIELD DIAGRAM
(WITH WIRING MOD.)
A031-00C52-A013
SHEET 1 OF 1
REV

S E R V I C E B U L L E T I N

January 5, 1987

GAME: Strange Science Pinball Machine

SUBJECT: Feature Operation and Scoring Manual Information

* *

Attached please find the above listed information (pages 1-15 to 1-20), which should be included in your STRANGE SCIENCE Operating Manual, Form No. OE35-00300-0100.

This information was not included in the game manual at the time it was originally released for production.

XIV. STRANGE SCIENCE FEATURE OPERATION AND SCORING

1. BUBBLE BONUS FEATURE

Two Bubble Bonus switches are in this game. One rollover switch is located on the left side of the playfield and the other rollover switch is located in the Shooter Lane on the right side. The Bubble Bonus Value Lights flash sequencially at a constant rate from 5,000 points to 10,000 points to 20,000 points to a maximum of 50,000 points. When the ball makes the rollover switch, the moving value freezes and is awarded. At the start of each ball, a skill shot is scored by trying to make the Shooter Lane's Bubble Bonus switch when its' value is 50,000 points.

2. PARTICLE SEPARATOR & BONUS MULTIPLIER FEATURES

In the Particle Separator tray are three holes which correspond to the letters "L-A-B" (in the back board) and the three lanes below (on the playfield). Each hole has a wire-actuated switch. Each lane has a rollover switch. One of the letters is lit when the ball falls through the hole or rolls through the lane corresponding to that letter. The push button below the right flipper push button on the cabinet allows you to shift lit letter(s) in "L-A-B" to the right. This provides you with Hole Change and Lane Change while attempting to spell "L-A-B" (making any combination of holes and lanes).

At the start of each ball:

1. The Particle Separator flashes two upper Collect Spark Bonus Lights.
2. The Particle Separator is made when the ball closes any of the three hole switches scoring the Collect Spark Bonus (see Spark Bonus Feature). Lighting a letter awards 5,000 points and also 3,000 points are awarded to the Bonus.
3. By initially making the flashing Particle Separator, both the Anti-gravity and it's Collect Spark Bonus Light flash. Completing the flashing Anti-gravity (see Anti-gravity Feature) in turn flashes the Particle Separator again and also flashes the Particle Separator's left Collect Spark Bonus Light.

When it is not flashing, making the Particle Separator awards 10,000 points and adds 3,000 points to the Bonus.

When the ball makes a hole switch or lane switch, "L-A-B" letters score:

1. 5,000 points for lighting the first or second letter in "L-A-B".
2. 1,000 points for a letter already lit.
3. 10,000 points for spelling "L-A-B".

Spelling "L-A-B" also advances the Bonus Multiplier 2X through 6X.

3. ANTI-GRAVITY, EXTRA BALL, & SPECIAL FEATURES

Completing the Anti-gravity shot requires making both the entrance switch and exit switch within three seconds. If flashing, completion of the Anti-gravity awards its flashing Collect Spark Bonus and also adds 5,000 points to the Bonus. If not flashing, completion of the Anti-gravity awards 10,000 points and also adds 1,000 points to the Bonus.

Making the entrance switch alone awards 1,000 points. Making the exit switch alone awards 1,000 points with an additional 1,000 points for each Voltage Level Light lit (see Atomic Generator Feature) and also adds 1,000 points to the Bonus. The exit switch can be made by a direct shot up the center of the game without involving the entrance switch.

The following features are earned by completing the Anti-gravity a certain number of times:

# OF COMPLETIONS REQUIRED	FEATURES EARNED
Every Time	Collect Bonus Light activated
2 Times	Hold Bonus Light activated
3 Times (adjustable)	Extra Ball Light activated
4 Times (adjustable)	Extra Ball awarded
5 Times (adjustable)	Special Light activated

* **REGISTER "Award Count"** controls the number of times on the Anti-gravity (when lit) required to activate the Extra Ball Light, to award the Extra Ball, and to activate the Special Light.

EXTRA BALL LIGHT	EXTRA BALL	SPECIAL LIGHT	ENTER
6 Times	7 Times	8 Times	0
5 Times	6 Times	7 Times	1
4 Times	5 Times	6 Times	2
3 Times	4 Times	5 Times	3

4. ATOM SMASHER, PLAYFIELD VALUE MULTIPLIER, & TIMED EXTRA BALL FEATURES

Up to five balls can be loaded into the Atom Smasher through its rear entrance by using the top Flipper. Every ball loaded collects the upper left Collect Spark Bonus. As the first ball is loaded, a pair of ball stop pins spring up at the Atom Smasher's front entrance to hold the ball on the ramp.

One or more balls loaded can be released as follows:

1. Balls stored can be released one at a time by "smashing" the ball in play into the leading held ball at the Atom Smasher's front entrance. This knocks one held ball up the ramp and out across a pair of guide wires from the left side to the right side of the playfield awarding the Collect Spark Bonus and resulting in Multiball play. If, during this type of multiball play, there are remaining stored balls in the Atom Smasher and a ball is loaded through its' rear entrance, the stored balls are released when the ball stop pins are pulled down. When no balls are loaded, a ball can pass through the front entrance and up the ramp. This is the same as "smashing" a ball out and collects the Spark Bonus. "Smashing" a ball out of the Atom Smasher also lights the Extra Ball Light (on a timer which is adjustable) located near the Anti-gravity.

2. When the fifth ball is loaded, the ball stop pins are pulled down and all five balls are released for multiball play awarding 120,000 points. As a result, the ball stop pins will always remain pulled down during this second type of multiball play and every ball loaded will automatically be released.

3. Awards for releasing balls stored in the Atom Smasher are:

# OF BALLS RELEASED	AWARD
2	30,000 points
3	60,000 points
4	90,000 points
5	120,000 points

The Playfield Value Multiplier increases with the number of balls in play at any one time:

# OF BALLS IN PLAY	PLAYFIELD VALUE MULTIPLIER
2	3X
3	6X
4	9X
5	12X

* REGISTER "Extra Ball Timer" controls the length of time the Extra Ball Light flashes after being activated.

LENGTH OF TIME	ENTER
8 seconds	0
16 seconds	1
32 seconds	2

5. "S-T-R-A-N-G-E S-C-I-E-N-C-E", SPARK BONUS, & TIMED SPECIAL FEATURES

Located on either side of the center playfield area are three stand up bullseye targets: left side - "S-T-R-A-N-G-E" lights, right side - "S-C-I-E-N-C-E" lights. When the game begins, one light is on in "S-T-R-A-N-G-E" and one light is on in "S-C-I-E-N-C-E". Each of these lights sweep downwards. The sweep rate is controlled by the "Voltage Level" of the Atomic Generator (see Atomic Generator Feature). The three bullseyes are connected to the center three letters of each word. When a bullseye is hit the corresponding light lights if it was off, and then instantly begins sweeping too. Spelling "S-T-R-A-N-G-E" (or "S-C-I-E-N-C-E") awards 10,000 points. Lighting a letter awards 5,000 points and adds 1,000 points to the Bonus. Hitting a lit letter awards 1,000 points and adds 1,000 points to the Bonus.

Spelling "S-T-R-A-N-G-E S-C-I-E-N-C-E" completely earns the following:

1. The Power Saver is activated (see Power Saver Feature).
2. The Spark Bonus Value is advanced starting from 25,000 points to 50,000 points to a maximum of 75,000 points. This value is reset to 25,000 points for each new ball. The Spark Bonus turns into a moving value during multiball.
3. In the right Outlane a timed Special light is lit (adjustable).

A letter in "S-T-R-A-N-G-E S-C-I-E-N-C-E" is spotted each time.

1. The Anti-gravity is completed by making the entrance switch and exit switch within three seconds.
2. The Particle Separator is made by closing one of its hole switches. Also, one extra letter in "S-T-R-A-N-G-E S-C-I-E-N-C-E" is spotted whenever a letter in "L-A-B" is lit (See Particle Separator Feature).
3. A ball is loaded into the Atom Smasher (see Atom Smasher Feature).

* **REGISTER "Special Timer"** controls the length of time the Special Light flashes after being activated.

LENGTH OF TIME	ENTER
8 seconds	0
16 seconds	1
32 seconds	2
Until end of current ball	3

6. ATOMIC GENERATOR FEATURE

The Atomic Generator area consists of three Thumper Bumpers ("Atomic Generators") and nine Voltage Level Lights ("Volt Meter"). Each time a Thumper Bumper is hit 1,000 points is awarded. Thirteen hits advance the Voltage level to the next light. The Voltage Level Lights range from 100 volts to 900 volts. The Voltage Level is carried over from ball to ball. The Voltage Level Value times ten is awarded each time the Anti-gravity exit switch is made. The Voltage Level controls the sweep rate of the lights on the playfield. The faster the lights sweep, the easier it is to spell "S-T-R-A-N-G-E S-C-I-E-N-C-E". Each Voltage Level has a different background sound.

7. POWER SAVER FEATURE

The Power Saver Feature is initially provided to the first ball (adjustable). When the Power Saver is on, a ball draining through the left Outlane can be saved by pressing the push button below the left Flipper push button on the cabinet. This pulses the Kicker Post at the right moment to knock the ball into the left Flipper Return Lane. After the left Outlane switch is hit, the Power Saver remains on for four seconds.
Spelling "S-T-R-A-N-G-E S-C-I-E-N-C-E" will light the Power Saver if it is off.

* REGISTER "Power Saver" controls the number of new balls to which the Power Saver feature is initially provided.

NEW BALL #	ENTER
None	0
1	1
1 & 2	2
1,2 & 3	3
1 thru 4	4
1 thru 5	5

8. BRAIN TRANSPLANT AND COLLECT BONUS SAUCER FEATURES

The Brain Transplant begins by flashing the left Star Rollover Target when at least 1,000 points of Bonus has been earned (see the Particle Separator feature and the Anti-gravity feature). The left Star Rollover Target scores 130 points when not lit and scores 2,000 points when it's flashing. The Bonus Lights begin to strobe from left to right when the left Star Rollover Target is made. The right Star Rollover Target begins flashing when the Bonus reaches 9,000 points. The right Star Rollover Target scores 130 points when not lit. When it's flashing, making the right Star Rollover Target "completes the Brain Transplant" and collects the Bonus (**not** including the Bonus Multiplier).

The Collect Bonus Saucer awards 5,000 points when not lit. When lit, the Bonus (including the Bonus Multiplier) is awarded.

9. MISCELLANEOUS FEATURES

The left Outlane awards 3,000 points.
The right Outlane awards 20,000 points.
Each Flipper Return Lane awards 5,000 points
Each Sling Shot awards 130 points.
The Rebound awards 230 points.

* REGISTER **"Attract Sound"** enables or disables, when the game is over, the Sound Mode while displaying Hi-score or instructions.

ENABLES SOUND MODE	ENTER
No	0
Yes	1

In Basic Options:

* REGISTER **"Sling Shot"** controls the Sling Shot:

SLING SHOTS: ACTIVE	ENTER
No	0
Yes	1

* REGISTER **"Tilt Warning"** controls the number of Tilt Warnings:

# OF TILT WARNINGS	ENTER
None	0
1	1
2	2
3	3

STRANGE SCIENCE OPERATING MANUAL REVISIONS

On page 1-5, in the "Feature Options" section of "GAME REGISTERS & OPTIONS":

1) The factory setting for the "Power Saver" register is shown as "2". This setting should read as "1".

2) For the "Extra Ball Timer" register, "2=24 sec." should read as "2=32 sec."

3) The factory setting for the "Special Timer" register is shown as "1". This setting should read as "0".

4) For the "Special Timer" register, "2=24 sec." should read as "2=32 sec.".

M051-00E35-A028

S E R V I C E B U L L E T I N

GAME: "STRANGE SCIENCE"

SUBJECT: Multiball Problems

Dear Service Manager:

Maintaining the Bally tradition of the best product support policy in the industry, we are supplying at no charge a STRANGE SCIENCE ball trough kit.

The initial shipments will begin immediately to help resolve multiball problems experienced by some of our customers on STRANGE SCIENCE.

The kit will consist of several new parts producing a reliable assembly, but still requiring some use of the small existing parts on the playfield. Please examine the detailed instructions before discarding parts from the old assembly.

We thank you for your cooperation and apologize for any inconvenience you may have encountered.

SERVICE BULLETIN

May 13, 1987

GAME: "HARDBODY" Pinball

SUBJECT: Ball Escape - Serial Numbers #101 Through #1065

Dear Service Manager:

We have found a ball escape condition on the upper right section of the playfield by the two star roll over buttons.

We will be sending you a "Fix" consisting of: (1) piece of plexiglass, (4) standoffs, (4) screws and instructions. We ask you pass these modifications to all HARDBODY customers on a no charge basis.

Sorry for any inconvience this might have caused you.

Thank you.

Bally Midway Field Service

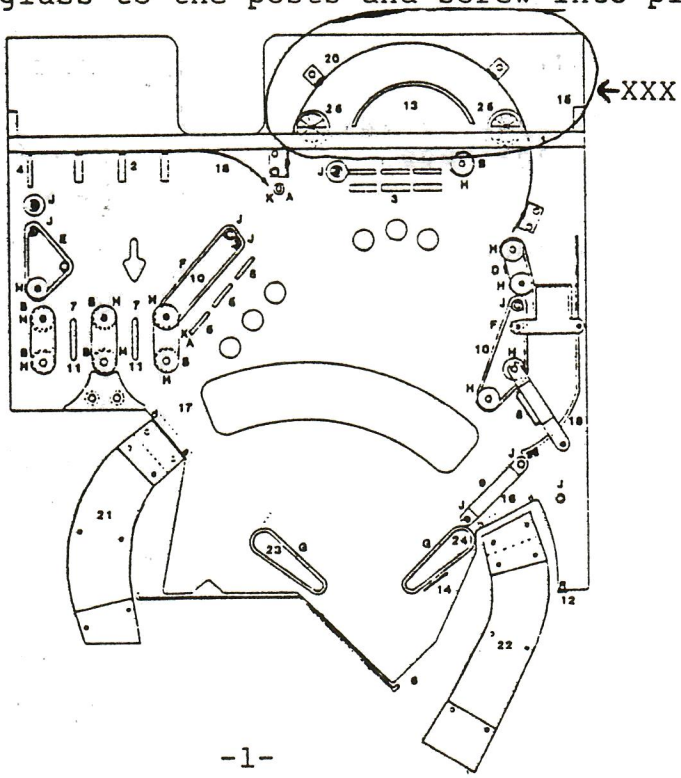
GM/dlm

S E R V I C E B U L L E T I N

GAME: "HARDBODY"

SUBJECT: Ball Escape - Serial Numbers #101 through $1065

1. Refer to Figure 1.
2. Lay plexiglass over position XXX.
3. Put one post at each of the 4 corners using the holes in the plexiglass as guides.
4. Mount plexiglass to the posts and screw into playfield.



Bally Midway Field Service

GM/dlm

March 25, 1987

S E R V I C E B U L L E T I N

GAME: **HARDBODY**

SUBJECT: Changing Shooter Lane Hoop (Chrome Hoops Only)

1. Refer to figure 1.
2. Remove 3 Acorn Nuts holding butyrate at Position A.
3. Lift off butyrate.
4. Remove 2 Philips type screws holding shooter lane hoop (Position B).
5. Replace with new hoop and reassemble.

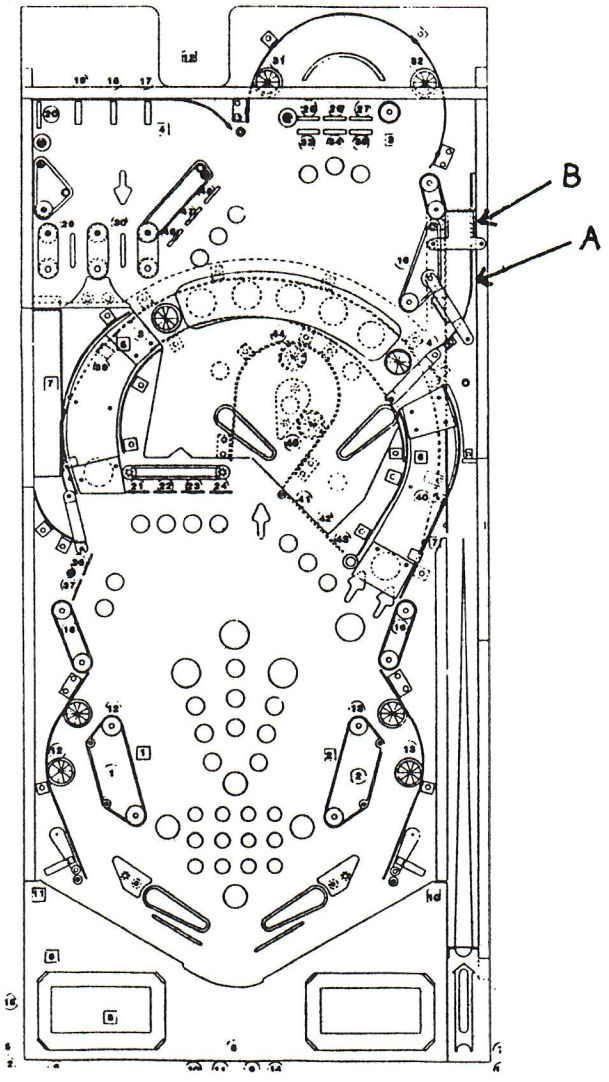


Figure 1

QUALITY ASSURANCE BULLETIN

June 2, 1987

GAME: "PARTY ANIMAL" (Serial #101-200)

SUBJECT: SAUCER UPDATE

Dear Service Manager:

During one of our many Quality Analysis Low Voltage Tests, we have discovered an intermittent weak condition with the 3 saucers (see Figure 1, Item A) on "PARTY ANIMAL". While there isn't any obvious problem, we feel the following modification will enhance the play of the game.

(1) Refer to Figure 2.

(2) Remove Extension Spring (Item 12) and Cotter Pin (Item 8).

(3) Bend Extension Spring Mounting Bracket (Item 15) by hand, so that the Spring Mounting Tab (Item 16) lines up directly behind the plunger (Item 5).

(4) Install the Triangular Clip into each opening of the Roll Pin (Item 7).

(5) Connect the new Spring, making sure one side of the Spring is on the Mounting Tab (Item 16) and the other side is hooked on the Triangular Clip (Item 17).

Service Department

Fig 1

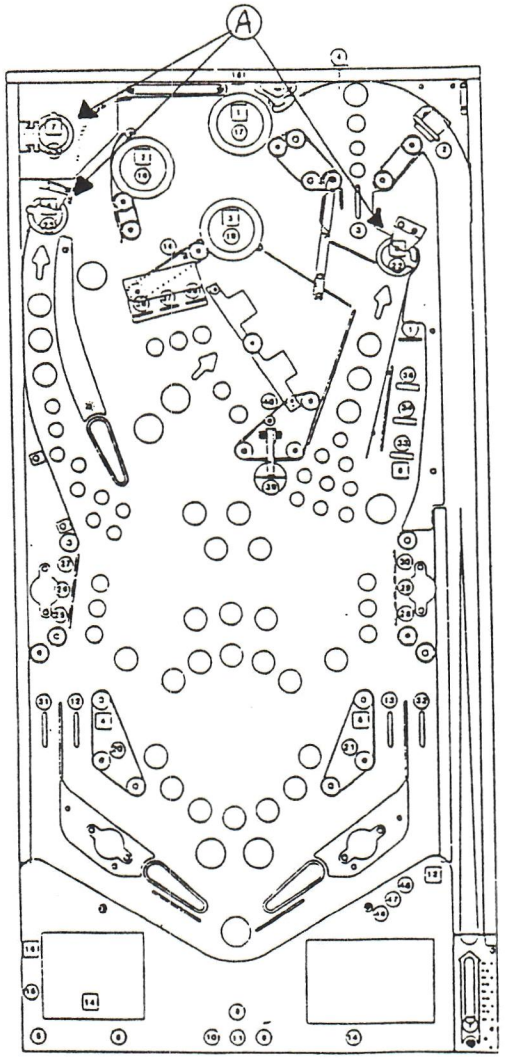
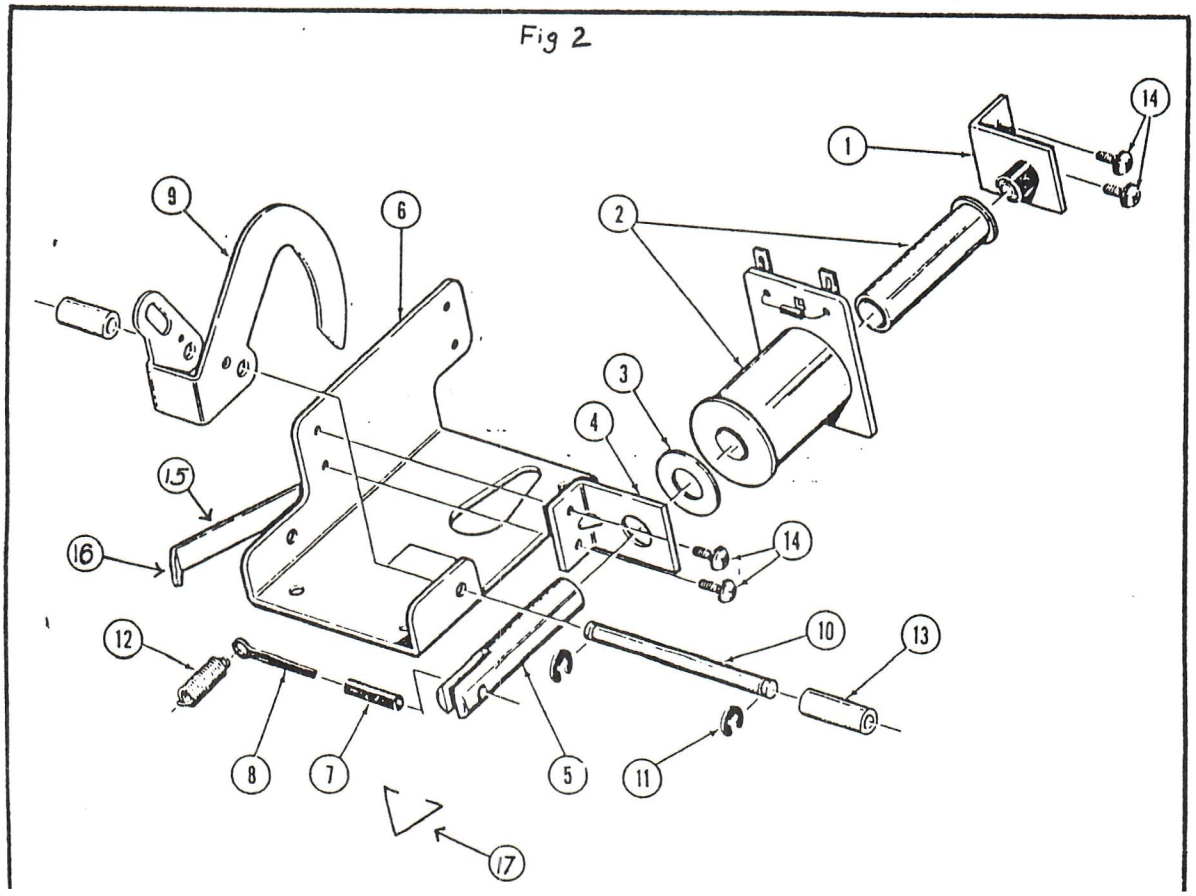


Fig 2



SERVICE BULLETIN

SUBJECT: **HEAVY METAL POWER AMP SHOT**

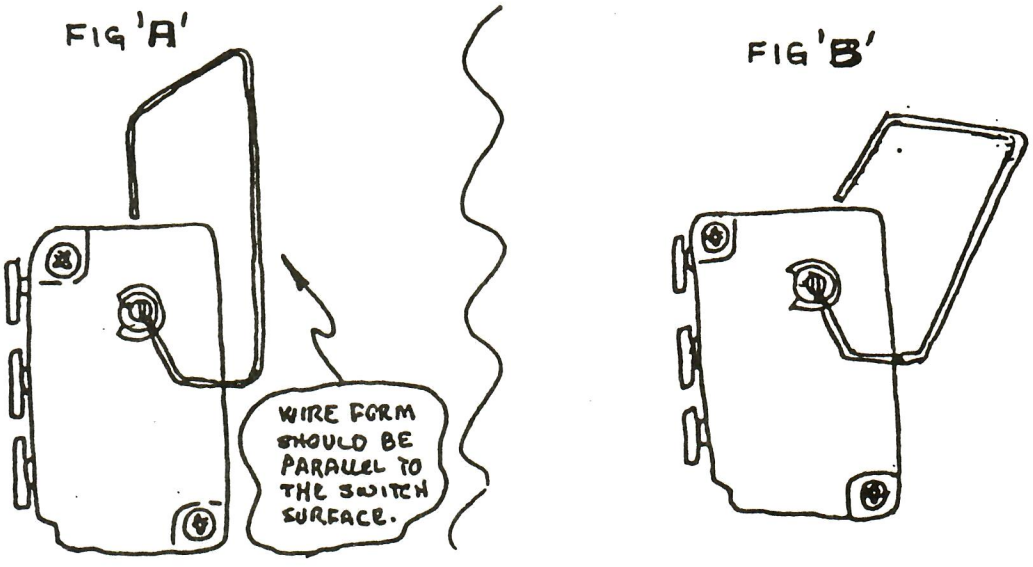
PROBLEM: Game appears to be in the multi-ball state even when there is only one ball on the playfield.

SYMPTOM: When the ball is shot into the Power Amp, it is only held momentarily for a few seconds and then released instead of remaining captive. Additionally, a new ball is not delivered to the shooter lane.

CAUSE: Over a period of time the micro switch wire forms uniformly bend to the right and the vibration of the ball eject kicking the ball into the shooter lane momentarily bounces the one or more of the switch contacts open, thereby confusing the game program as to the number of balls on the playfield.

CURE: Reform the micro switches as indicated in Figure A.

- Figure A illustrates the proper outhole ball trough micro switch wire form adjustment in the relaxed position with no balls in the trough.
- Figure B illustrates an improperly adjusted microswitch wire form.



NOTE: This adjustment should also be performed on PARTY ANIMAL games and STRANGE SCIENCE ball trough kits. Multi ball games beginning with DUNGEONS AND DRAGONS will use an optical sensor board to eliminate any adjustments associated with mechanical switches.

HEAVY METAL EPROM LIST (M051-00H03-A008)
CORRECTION NOTICE

In your HEAVY METAL OPERATING MANUAL, the Eprom List (located on the inside of the back cover) contains two errors.

Jumper "JW8" should be IN ("X" in the "IN" column).

Jumper "JW9" should be OUT ("X" in the "OUT" column).

Disregard the incorrect information for jumpers "JW8" & "JW9" shown in the Eprom List.

M051-00H03-A038

SUBJECT: 6803 CONTROL BOARD POWER UP TEST SEQUENCE

The following is an abbreviated self-test routine for the 6803 Control Board.

1st Flash—(U1) Determine if the internal RAM is good. (6803)

2nd Flash—(U2) Checks to see if the program ROM is good (27128)

3rd Flash—(U3) Checks to see if the program ROM is good (27128)

4th Flash—(U4) Checks to see if the program ROM is good (27128)

5th Flash—(U8) Tests PIAO (6821)

6th Flash—(U7) Tests PIA1 (6821)

7th Flash—(U1) Checks the internal display interrupt generator (6803)

8th Flash—(U12 & U8) Verifies operation of the phase B switched ill. voltage.
NOTE: F5 fuse on the Power Module provides the phase B signal to the Control Board.
(U12, 14584) (U8, 6821)

9th Flash—(U1, U11 & U12) Verifies operation of the Phase A switched ill. voltage.
NOTE: F4 fuse on the Power Module provides the phase A signal to the Control Board.
(U1, 6803) (U11, 4011) (U12, 14584)

The following is an abbreviated self-test routine for the 6809 Sound Board.

1st Flash—(U7) Determine if the external ROM is good.

2nd Flash—(U6) Checks to see if the external RAM is good.

3rd Flash—(U8) Checks the PIA. (68B21)

The following is an abbreviated self-test routine for the Sounds Deluxe (68000) Board:

1st Flash—Determines if the ROM (U11) is good.

2nd Flash—Determines if the ROM (U12) is good.

3rd Flash—Determines if the ROM (U13) is good.

4th Flash—Determines if the ROM (U14) is good.

5th Flash—Checks to see if the RAM (U9, U10) is good.

6th Flash—Checks the PIA (6821) (U7).

6803 Control Board Theory of Operation

POWER SUPPLIES

The Control Board requires a regulated +5VDC for its logic circuit operation. In addition, the Power Module provides an unregulated +14 to+18VDC, the phase A and phase B voltages (11VAC),and +43VDC to the Control board.The +14 to+18VDC is used in the Valid power detector circuits; the phase A & B voltages are used for the Zero Crossing detector circuits and the +43VDC is required on the board exclusively for the flipper enable relay. Besides supplying these voltages to the Control Board and other sections of the game, the Power module also provides a regulated +190VDC to the displays and 6.3VAC for general illumination.

RESET CIRCUIT

On power up the µP (microprocessor) requires +5VDC±.25VDC be applied for 100 milliseconds before the RESET line is allowed to swing from 0 to +4.8VDC. The RESET circuit on the Control Board works with the unregulated+14 to+18VDC to prevent the RESET line from going high until the +5VDC supply has had time to stabilize after power on. The zener diode D1 and transistors Q2 and Q3 with R2 through R9 form a Valid power detector circuit that monitors the input voltage to the regulator (coming from the Power Module). This regulator requires a minimum of +7.5VDC input before it provides a +5VDC output. When this condition has been met diode D2 allows C1 to charge through R11.This RC time constant provides the initial 100 millisecond delay to allow the µP oscillator to stabilize. The voltage across C1 is monitored by Q4, Q5, D4, D5 and R12 through R16. When it has reached about +2.5VDC the RESET line snaps high to allow the µP to start program execution. In the event the output of D1 drops below +7.5VDC for an instant, the Valid power detector quickly discharges C1 through R9 and D2 to re-prime the RC time constant and insure a correct RESET cycle when power is re-applied.
The RESET signal is applied to the µP (U1) and the PIAs (U7&U8). Through the switch of Q6 it prevents false data from entering the CMOS RAM (U4) during power-up and utilizing D3, R35, U11 & U12 it sets the mode of operation for the microprocesser. The circuitry forces a 010 code on P20, P21, and P22 of the µP during RESET causing it to come up in an internal RAM external ROM, multiplexed address/data mode.

MICROPROCESSOR,BUS DEMUX,ADDRESS DECODE AND PROGRAM ROM

The Control Module uses a single chip microcomputer the MC6803 as its µP (U1). This µP provides two I/O ports,128 bytes of RAM, a multifunction timer and external ROM capibility. A bus cycle begins on the MC6803 with the Address/Data and R/W lines changing to a known state. Shortly after they are stable the Address strobe clock is output. This is used to latch the low order address lines A0-A7 from the AD0-AD7 bus via U6. After the Address strobe goes low the AD0-AD7 lines become the D0-D7 data bus. One half of a bus cycle later the E (enable) clock output goes high. The addressed device on the bus places data on the AD0-AD7 (R/W high) or takes its data from AD0-AD7 (R/W low) during the E clock . The bus cycle terminates when E goes low . Addresses are decoded by U9 & U10 to determine which external bus device the MC6803 is accessing. The E clock is used to qualify the decoding in timing the data transfer. U5 is an octal bus transceiver which controls the direction of data transmission utilizing the R/W line from the processor chip. The program is provided by U2 & U3 ROMs.These 28 pin sites accept a 128Kbit ROM giving the board a maximum of 32Kbytes of program storage.

1. Control Board Self Test:

The Control Board has as part of its program (U2 &U3) a subroutine designed to check the module each time the power is turned on. No action is required on the operator's part to initiate the test. The program causes the MPU chip to test itself, the program contained in integrated circuits U2 & U3, the MPU's internal scratch pad memory, the CMOS memory (U4), the I/O chips (peripheral interface adadaptors-PIAs) U7 & U8, and the display and zero crossing interupt circuits. If the Control Module finds fault during the course of the self-test, it stops at that point in the test and will not allow game play. It should be noted that the early games using this system did not require U2 for game features and therefore the test for that chip was omitted. These games consisted of Eight Ball Champ ,Beat the Clock and Lady Luck.

A) 1st Flash

After reset the Control Module tests its µP and on chip RAM. It attempts to write -then read back all 256 patterns (0000 0000 to 1111 1111) in each of the 128 on-chip locations. If at any point in this test the µP fails to correctly read back a pattern it has written, it is deemed defective and the µP will not allow the game to come up. If the µP completes the test sucessfully, it flashes the LED and procedes to the next test.

B) 2nd Flash

Next the MPU (U1) attempts to test the ROM U2. It does a vertical checksum of the ROM contents and checks for an all ones result. If the computed checksum is not accurate, the part is deemed defective and the µP will not allow game play. If the checksum is 1111 1111 the µP flashes the LED and procedes to the next test.

C) 3rd Flash

An identical test is now performed on ROM U3. It does a vertical checksum of the ROM contents and checks for an all ones result. If the computed checksum is not accurate, the part is deemed defective and the µP will not allow game play. If the checksum is 1111 1111 the µP flashes the LED and procedes to the next test.

D) 4th Flash

The MPU chip accesses the CMOS RAM U4 (read-write memory). It makes a copy of the contents of the first half of U4. This is necessary because U4 is the battery supplied, non- volitile memory location where the bookkeeping functions and game set-up are stored. It then erases the contents of the first byte of U4 (U4 contains 2Kbytes of "scratch pad" memory). It trys to read back the word 0000 0000. If it can be read back , it adds "1" to the previous word (new word , 0000 0001). It continues to write and read until it reads the word 1111 1111. When this has been done successfully, it repeats the process on the next byte and the following bytes thereafter until it completes the test on byte 1024 . It then restores the memory to the first half of the RAM and saves the contents of the second half. It repeats the process for each of the remaining 1024 bytes one byte at a time and then restores the memory to the second half of RAM. If the MPU, at the end of these tests has read back correctly each of the words it has written, the MPU causes the LED to flash the fourth time.

E) 5th Flash

The µP now tests the PIA U8. It tests each of the two full byte port initialization registers with a 256 pattern test (0000 0000 to 1111 1111). It tests each of the two full byte I/O registers, PA0-PA7 and PB0-PB7 with a 256 pattern test. it then tests the CA2 and CB2 ports. These are initialized as outputs then written into to see if they will store a "1" and a "0". When both these ports are found good, the µP flashes the LED and proceeds to the next test.....

F) 6th Flash

The MPU chips repeats the same procedure it did for the fifth flash except this time it checks PIA U7. If no faults are found it procedes to the next test.

G) 7th Flash

The MPU now monitors its internal "clock". This clock is utilized as a Display Interrupt Generator, creating a pulse once every 1.2 milliseconds. If this interrupt pulse is not detected in U1, the Program will not allow game play until the fault is corrected.

Please note: Jumper JW7, when connected, will disable the Display Interrupt Generator in the MPU chip. This option is provided exclusively for troubleshooting with an oscilloscope.

H) 8th Flash

The MPU chip now monitors PIA port CB1 U8. If transitions from high to low are detected the MPU decides that the Phase B Zero Crossing detector is working. It then causes the LED to flash the 8th time.

If U12,C15,or D9 fails and the CB1 line is stuck high or low the program will not allow game play until the problem is corrected. It is to be noted that this Zero Crossing input is the Phase B switched illumination supply. If the fuse in that line (F5 on the power module) is blown when the power is turned on, the program will not allow game play until the fault on the Phase B line is corrected.

I) 9th Flash

To complete the power up sequence, the MPU now monitors its P20 port U1 pin 8. If transitions from low to high are detected the MPU decides that the Phase A Zero Crossing detector is working. It Then causes the LED to flash the ninth time.

If U11, U12, C16, or D11 fails and the P20 line is stuck high or low the program will not allow game play until the problem is corrected. This particular line is the Phase A switched illumination supply. If the fuse on that line (F4 on the Power Module) is blown when the power is turned on, the program will not allow game play until the fault on the Phase A line is corrected.

J) Game Initialization

The MPU chip, through the program, now initializes the two PIAs, U7 and U8, assigning to each port its role as either an input or output, as required.

It then verifies the integrety of the CMOS RAM U4 information by checking certain bytes to determine if Battery failure has occured or if possibly the +5VDC supply was interupted during a previous write operation to RAM. Should an error be detected the program sets specific registers to factory default conditions.

The game now enters a selective Stuck Switch test to display to the Operator any switches that may effect normal game operation which should be open but are not. It also Resets Drop targets that may be down and kicks out balls remaining in Saucers from the last time the game was played.

The game now enters an attract mode - flashing lights, showing the score thresholds and current credits on the displays, and monitoring the coin and credit switches for closure.

2. Game Play

After completing the self test, or in between games, the MPU spends approximately 40% of its time monitoring the memory record of the momentary switches on the playfield and in the cabinet. The other time is divided between servicing the display update interrupts and the solenoid, lamp momentary switch scanning, and lamp update interrupts.

A)Normal Mode:

The momentary switches are arranged in a "matrix ".The MPU chip, through the program, examines a memory record of the matrix, looking for valid switch closures. If it finds a valid closure, it decodes the address associated with the closure and jumps to the appropiate subroutine.

For example: If the game is in a game over status and the MPU finds that the left coin switch has a valid closure in memory, it jumps to the coin /credit handling routine in the program. This routine reviews the memory record in bookeeping to determine if the maximum credits have been reached. If they have, the coin will not be acknowledged. TheMPU goes back to monitoring the record of switch closures. If the maximum credits have not been reached, the memory record in bookkeeping is reviewed to determine how many credits are to be awarded per coin.These credits are added to the credit register in memory.The record of the number of coins through the left chute are increased by one .

The MPU chip, through the program, now returns to its task of monitoring the memory record of valid switch closures, ready to jump to the appropiate subroutines that deal with the player pressing the credit button, etc.

The memory record of valid switch closures is a qualified memory record.The MPU,as discussed under "Interupts", looks at each switch several times before it makes a decision as to whether or not a closure is valid. This multiple-look is a debounce mechanism that prevents the game points on noise pulses or stuck switches. The debounce criteria is: When the MPU chip reviews the history of a switch to determine if a closure is valid, it must see an "open" in the "oldest " record. There must be a "closed" in an "old" record and a "closed" in the current reading. Only when this criteria is satisfied will it make an entry in the memory record of valid closures that a switch is closed.If it saw a "closed", "closed", "closed", the MPU would assume a stuck switch and do nothing ."Open", "closed", "open"or "closed", "open", "open", are likewise rejected.

The momentry switches in the matrix are the "eyes" and "ears" of the MPU.It is only by means of sensing closures, and reacting to valid closures (during normal operation) that the MPU,through the program, knows what to do next.

B) Interrupts:

An interrupt is a signal to the MPU chip to stop what it is doing and do something else.When the MPU senses an interrupt from the PIA-U8,CA1 or CB1 or from the peripheral port on the µP-U1, P20, it completes the instruction it is working on, and makes a memory record of its contents and its place in the program so that it can get back to what it was doing before it jumps to service the interrupt .When the interrupt is completed, control is relinquished to normal operation. The MPU goes to the memory record of its pre-interrupt contents and methodically refills itself. It then goes about its business as if it had never been interupted.

Interrupts are used for two types of activity in the Bally game. The first is the periodic lamp, solenoid, and momentary switch status update U8, CB1 & U1, P20 and the Display update internal to U1.The second is the signal to go into Self-Diagnostic tests U8, CA1.

The periodic interrupts are generated by the Phase A & Phase B Zero Crossing detectors and the Display interrupt generator on the Control module.The former occurs at a rate of 120 times per second or once each power line zero crossing (60 for Phase A and 60 for Phase B). The second occurs internally in U1 at a rate of approximately 830 times per second.

1)Zero Crossing interrupts:120 times per second, or once each 8.3 milliseconds, the MPU chip senses a zero crossing, time delayed by U12 just enough to allow a voltage to appear at the anodes of the silicon controlled rectifiers that drive the feature lamps before that portion of the interrupt routine begins.

Lamps are updated near the zero crossing to minimize the inrush current associated with a cold filament and hence extend their life.DC powered solenoids, likewise, exhibit a far smaller counter EMF, if turned off near a zero crossing. This helps extend the life of the solenoid driver transistors and other circuit components by keeping large voltage spikes out of the system.
At the start of this routine the MPU looks at the contents of several general purpose timers. If it finds them active, it subtracts "one" from their remaining period. In passing thru, it adds "one" to the random number generator used for the "Match feature" (unless the contents are already equal to nine, in which case, it resets the generator to zero). The random number generator, then, counts from 0 to 9, twelve times a second. This makes it virtually impossible to cheat, and truly random.
The MPU examines the status of the *solinoid period counter.* If it is zero, it turns off all momentary solenoids, and branches to the feature lamp update routine. If it is not zero, it subtracts "one" from the contents of the counter. In general, momentary solenoids(thumper bumpers, slingshots, etc.) are energized for 3 zero crossings (26 milliseconds). Saucer kickers are energized longer to make sure the ball clears the saucer.
The MPU next enters the *feature lamp update* part of the program.Their are 90 single bit entries in U4, the CMOS scratch pad memory. 45 bits corresponding to Phase A and 45 Bits corresponding to Phase B. This is utilized to form a memory "picture" (lamp matrix) of the status (on or off) of each feature lamp in the game.
The MPU will now aquire the first 3 bits from memory, combine it with an appropiate half byte address and send this address and data to the lamp decoders via PIA U8, ports PA0 thru PA7. The low order ports carry the first decode address (0000) generated by the MPU chip thru the program. The high order ports, PA5 thru PA7 contain lamp data from the first 3 bits in memory. The address (0000) goes to each of the three "one of sixteen" decoder chips in the lamp driver section via the lines labeled PA00, PA01, PA02, and PA03 . This is the address of the "0" port (pin 11) of each of these chips. The data is routed to the chips by the foil on the printed circuit board, i.e. PA5 goes to U15, PA6 goes to U16 and PA7 goes to U17.
It is to be noted that pin 11 of chip U15 drives SCR Q23, U16 drives SCR Q70, and U17 drives SCR Q55. Conclusion: the first 3 bits in the lamp matrix in memory chip U4 is a picture of the status of the lamps driven by these three SCRs.
The MPU chip, thru its program, now causes the strobe line (CB2, PIA U8) to go high and low, thereby presenting the first 3 bits of update information to the gates of SCRs Q23, Q70, and Q55. A low (0) at the gate leaves the SCR and it's associated lamp "off ",a high (1) turns it "on". When an SCR is turned on it will stay on for the remainder of the supply line alternation (1/120 second) and turn off at the next zero crossing. It will stay off unless the next update again drives the gate high.
The MPU fetches the second 3 bits from memory, generates an address (0001) and repeats the process. It is now addressing the gates of SCR Q24, SCR Q41, and SCR Q56. It causes the strobe to go high and then low, driving the gates of these SCRs and thereby updating their corresponding lamps.
The MPU fetches the third 3 bits from memory, generates an address (0010) etc. It is now addressing the gates of SCR Q25, SCR Q42, and SCR Q57. It repeats the strobe pulse and the appropriate lamps are updated.
Twelve more quick passes thru the subroutine and each of the 45 SCRs in the lamp section are updated. (Note that <u>not</u> all 45 SCRs are necessarily used in a given game.)The SCRs can be thought of as a type of memory or storage .When the MPU updates the SCR, if it is turned on it will stay on for the rest of the cycle (1/60 of a second).
The next step in the lamp update program is to strobe an address (1111) into the chips U15, U16, and U17. This is a "rest" address and frees the PA0 thru PA7 lines for other purposes. This completes the sequence for updating Phase A lamps and now the whole process is repeated for the Phase B lamps.

The majority of lamps in the game each have one lead commoned to an 11VAC line (Phase A or Phase B). In addition each lamp has a blocking diode tied in series with its phase line to preserve the integrety of that phase.Since the common lines are 90 degrees out of phase, the "B"lamps are all off when the "A" lamps are being updated and conversely the "A" lamps are off when the "B" lamp status is renewed. Since these updates occur so rapidly an observer could believe that both lamps appear to be on at the same time. This procedure allows a single SCR to control the state of two lamp circuits, one for each phase.
In games utilizing the Phase C & D lines the same principles apply with the following rules :
The Phase C line corresponds in timing to the Phase A line.
The Phase D line corresponds in timing to the Phase B line.
Each of these phases supply 24VAC for the bright light circuits.
And only the large SCR drivers (MCR 106-1) may be used in firing these lamps.
The last portion of the zero crossing interrupt routine is to read the *momentary switches* and look for valid closures. PIA U8, ports PB0 thru PB7 are initialized as inputs, PA0 thru PA7 as outputs.The MPU chip, thru the program, sends a pulse down the ST4 strobe line. If a switch is closed the pulse will return the corresponding "I" line. The MPU chip examines the past history (in memory) of the switch and if it finds that the switch was "open","closed" and is now "closed", it makes a memory record of the valid closure. The reaction to this valid closure was discussed previously under Normal Mode of operation.
It is to be noted that stuck switches, a "closed", "closed" and currently "closed" condition is ignored and does not result in a memory record of a valid closure. Thus the game ignores stuck switches. Also,noise conditions such as "open", "closed" and currently "open" do not satisfy the valid closure criteria, and are ignored.
The MPU chip sends a strobe pulse down the ST3 line and monitors the "I" line for returns. It repeats the process of evaluating the previous history of the switches from memory and makes a record of any valid closures. The process is repeated for the ST2, ST1 and ST0 lines. At the end of the time period, the entire switch matrix has been scaned and a memory record of the switches previous and current history is filed together with a record of valid switch closures.
It is to be noted that this multiple reading of a switch takes time, i.e., it must be done over several zero crossings before a valid closure can be verified and recorded. This procedure would spoil the response time to hit a thumper bumper or slingshot or any electromechanical device that must react quickly. To overcome this difficulty, a special, quick reaction subroutine exists in the program dealing with "normal operation". This routine takes place immediately after the memory record of valid closures is reviewed. It consists of a review of the previous and current history of *just* the solenoids that require a quick reaction. If an "open", "closed" record is found, the solenoid is energized. No scoring is involved in this routine. The net result is slingshots and thumper bumpers respond "instantaneously". They are not allowed to score until a valid closure is detected later. Because of this quick reaction subroutine, a noise pulse may cause a solenoid to pull (very-very infrequent). However, no points will be added to the players score. If the pull and scoring ever occur for no apparent reason, it is most probably because of improperly adjusted switch contacts.
The diodes in the switch matrix are steering diodes that prevent sneak paths and subsequent false decodes. On Party Animal, for example, if diodes were not used: when the MPU sends the group strobe pulse down the ST1 line, and a coin is dropped through the right coin chute and both bottom and middle drop targets are down the strobe pulse will be returned down the "I1" line. The game will assume that a coin was dropped in both the left and right hand chutes and award the appropriate credits.
The Zero Crossing Interrupt is now completed. The MPU chip goes into memory and replenishes itself with its place in the program and the data it was processing prior to the interrupt. It then begins and continues in the program as if it had never been interrupted.

2)Display Update Interrupt: 830 times per second the MPU senses an internal display update interrupt. The MPU makes a memory record of its contents and then jumps to service the interrupt.
There is also a memory record for each digit on each of the two displays in the CMOS memory, U4. 14 x 2=28 one byte memory locations are reserved for retaining this data. Each byte is capable of storing 256 states, representing all possible combinations of the segments that may be lit. Because many of these combinations would be unintelligible, we use an abbreviated version of an ASCII lookup table to represent the numbers 0 thru 9 and the letters A thru Z. When we refer to this table we are able to extract exactly what bits should be turned on to illuminate the corresponding segments in a particular digit.
The displays in the Bally Pinball are multiplexed. This means that only one digit per display is on at a given point in time. If a picture of the backbox were taken with a high speed camera, the result might show that at the time the shutter opened, the #6 digit was "on" in both display driver modules.
The multiplex rate is fast enough that humans do not see the flicker. The advantage of multiplexing is that it minimizes the number of leads necessary to control the displays. For example without multiplexing you would need 8 leads for each segment on a digit, times14 digits, times 2 displays equals 224 leads and thats not even including commons or power leads.
The segment data lines (PA10-PA17) for both displays are commoned. The same is true for each of the Binary Digit Select lines (PA04-PA07) and the blanking line. Only a separate display latch strobe line is required for each of the display driver modules. It should also be noted that the comma information is time shared with PA16 & PA17 for Players1and 2 and PA14 &PA15 for Players 3 & 4.
The MPU begins the update by determining which digit was updated last. Assume that this was digit #4. The MPU thru the program, adds one to this number and makes a memory record of this fact for future reference. It causes the blanking line to go high and blank the displays. This keeps each digit clean and crisp looking by preventing flicker during the update.
The MPU chip goes into memory and obtains the segment data for the fifth digit, for the Player 3 & 4 Display. It places this information on the PA10 thru PA17 lines and strobes it into U1 on the display module.
The MPU goes back to memory, obtains the segment data for the fifth digit, for the Player 1 & 2 Display. It places this information on the PA10 thru PA17 lines and strobes it into U1 on the Player 1 & 2 display module at the same time sending the Binary digit select for digit #5 into U2 of both displays.
With this process complete, it removes the blanking pulse thereby enabling digit #5 and returns from the interrupt to whatever it was doing previously.

Assume that the MPU chip is to enable digit #5. The Binary Digit select information 0101 (DCBA) is sent to U2 on both displays. When U2 is strobed, the base of level shifter transistor Q11 is made high. This causes the collector of Q11 to drop from a high, positive voltage (+190 volts DC less the leakage current drop across R31, 100k ohms) to the saturation voltage, approximately .3VDC. The voltage across R31 is now approximately 189VDC (190-.3(VCE SAT, Q11)-.7VDC (VBE, Q23).). The collector of Q23, which was clamped to the +80VDC bus, now rises to approximately 189.7 VDC (190-.3(VCE SAT, Q23). Digit #5 is now enabled.
Assume that the fifth digit of the 1st & 2nd Display module is to display the character "H". The MPU chip looks in the ASCII table and obtains the segment data 0111 0110. It then places this information into chip U1on the display via the PA10 thru PA17 lines. U1, when strobed, latches this input, and as soon as the MPU chip removes the blanking pulse, the bases of transistors Q13, Q2, Q15, Q26 and Q14 are made high by the outputs of U1. The emitter-collector voltage of these transistors, previously at +80VDC due to the blanking pulse, now falls to VCE SAT, approximately +.3VDC. The result is the "b", "c", "e", "f" and "g" segments in the display panel are enabled.

Both of the actions of the previous example result in turning on the character "H" in the 5th digit position on the Player 1 & 2 Display.
It is interesting to note that the 6803 MPU is capable of being interrupted while it is servicing an interrupt. All that is necessary when this happens is for the MPU chip to make a record of where it was in the program and of its contents. It can then jump off and service the interrupt. At the completion of this task, it returns, completes and finally returns to normal operation. An example of this action is a zero crossing interrupt being interrupted by the Display Interrupt Generator.