Repairing Bally Electronic Pinball Games from 1977 to 1985, Part One.

Scope.
This document is a repair guide for Bally electronic pinball games made from 1977 to 1985. Since **Stern** electronic pinball games use nearly identical electronics, these games are covered too.

Table of Contents

1a. Getting Started: Experience, Schematics,

Manuals.

What Repair Experience Is Expected?
Little experience in fixing pinballs is assumed. Basic electrical knowledge is helpful, but not necessary. I do assume you can solder and use the basic features of a Digital Multi-Meter (DMM) such as measuring voltage and resistance.

Schematics and Manuals.

1b. Getting Started: Necessary Tools

Fixing electronic pinball games will require a few tools. Luckily, most are not that specialized and are easy to get. Please see http://marvin3m.com/begin for details on the basic electronics tools needed.

Non-Specialized Tools Required:

- Work Light: clamp style lamp
- Screwdrivers: small and medium size, phillips and flat head
- Nut Drivers: 1/4", 5/16", and 11/32"
- Wrenches: 3/8", 9/16", 5/8" required, other sizes suggested
- Allen Wrenches: get an assortment of American sizes
- Needle Nose Pliers
- Hemostat. Handy for holding parts and springs. Best to have both the curved and straight versions if possible.
- Right Angled Screwdriver: both phillips and flat head.

Specialized Tools Required:
These specialized electronics tools are needed..

- Alligator clips and wire.
- Soldering Iron.
- Rosin Core 60/40 Solder.
- De-soldering tool.
- Digital Multi-Meter (DMM).
- Logic Probe.

1c. Getting Started: Parts to Have On-Hand

When fixing electronic pinballs, I would highly recommend having some parts on-hand to make things easier and cheaper. All these parts are available from a pinball retailer.

Parts to have:

- #47 light bulbs: Seventyfive is plenty to do most games. Do not use #44 bulbs in these Bally games as they consume more power, and the power supply is already over-stressed.
- Fuses: I would have five of any needed value on hand at all times.
  - 3/4 amp slo-blo (F2, for the display high voltage)
  - 1 amp slo-blo (playfield mounted fuse)
  - 3 amp slo-blo (F6, for the incoming 120 volts AC)
  - 4 amp fast-blo (F3, for the unregulated +5 volts)
  - 5 amp fast-blo (F4, for the solenoids, if game has 2 flippers)
  - 6 amp fast-blo (F4, for the solenoids, if game has 3 flippers)
  - 7 amp fast-blo (F4, for the solenoids, if game has 4 flippers)

    - 10 amp fast-blo (F1, for the CPU controlled lamps)
    - 20 amp fast-blo (F5, for the general illumination)
- Transistors and Silicon Controlled Rectifiers (SCR): keep a few of each of these around:
    - 2N3904 or NTE123AP (used on MPU board)
    - 2N4403 or MPS-3702 or NTE159 (used on MPU board)
    - 2N5060 or NTE5400 (used on Lamp driver board for feature lamps). A silicon controlled rectifier. This is a .8 amp at 30 volt device. Available from Mouser (part# 610-2N5060, $0.39). Also a 2N5062 (.8 amp 100 volt, can work too.
    - MCR106-1 or NTE5411 (used on Lamp driver board for feature lamps). A silicon controlled rectifier. Also known as a T106. This is a 4 amp at 30 volt device. Available from Mouser (part# 519-T106F1, $0.75).
    - 2N5401 or NTE288 (used on Display driver board)
    - MPS-A42 or NTE287 (used on Display driver board)
    - SE9302 or NTE263 or TIP102 (used on Solenoid driver to drive coils). TIP102's are used in so many other pinball games, I would just buy them. They have the same values except the TIP102 is rated at 12 amps, while the SE9302 is rated at 10 amps.
    - CA3081 or NTE916 (used on the Solenoid driver to drive coils). This is the pre-driver transistor array. It looks like a chip, but it's actually several transistors mounted in a chip package.
- Diodes: keep a few 1N4004 and 1N4148 (1N914 or NTE519) diodes around.
- Diode: the diode on the MPU board at VR1 (in the reset section) is a 1N959B (8.2 volts, 1/2 watt). These are no longer available. This diode is used to keep the RESET line low for a short time while the power supply and its associated filter capacitor get wound up to +5 volts. This can be replaced with a 1N4738A diode (8.2 volts, 1 watt). A 1N4739A (9.1 volts) can be used too, as this would hold the RESET line low just a bit longer. Note the 1N959B is mis-labeled in the manual as "1N9598".
- Bridge Rectifiers: keep a few 35 amp, 200 volt (or higher) bridge rectifiers around, with wire leads. The Radio Shack ones that are 25 amp at 50 volts. Just examine them before buying. Often they have much higher ratings. For example, if they say "3502" this means they are 35 amp at 200 volts. But I've also seen "1001" which is 10 amps at 100 volts. Remember, look before buying. I would avoid buying the unlabeled ones. 25 amp bridges work just fine too (but usually there's no cost difference between 25 and 35 amps). The ones being replaced are usually 8 amps!
- MPU U10/U11: 6820 or 6821 PIA chips. Get either and have a few around. Available from Jameco (part# 43596, $2.49).
- MPU U9: 6800 CPU chip. Have at least one good one around. Available from Jameco (part# 43481, $1.95).
- MPU U12: 555 chip. Resides in the "corrosion area". Available from Jameco (part# LM555CN, $0.29) or Radio Shack.
- MPU U19: 4011 chip. Available from Jameco (part# 12634, $0.25) or Radio Shack (part# 276-2411, $0.99).
- MPU U14/U18: 4049B chip. Available from Jameco (part# 13055, $0.25).
- MPU U16: 9602 chip. Available from Jameco (part# 53786, $0.59).
- MPU U8: 5101 RAM chip. This chip frequently goes bad on the MPU board. Have several around. Speed is important on these chip. 100ns to 300ns is required.
- MPU U15: 7437 or 74S37 ttl chip. This is used as a replacement for the discontinued MC3459 chip at U15 on the MPU board (a 74LS37 can be used in a pinch, but is not recommended). Do not use a 7400 or 74LS00 chip (as some people suggest) for a replacement at U15. The 7400 family

of chips can only sink about 4mA, but the U15 chip is required to sink about 30mA. For comparison, the 7437 can sink 48mA, the 74S37 can sink 60mA, and the 74LS37 can sink 24mA (hence the 74LS37 is not recommended, except in a pinch).

- MPU U20: 14502B chip. Drop the "1" off the beginning of the number to get the generic part number (4502). Available from Mouser (part# 511-4502B, $0.64) and Radio Shack (mail order only, part# RSU-10902245).
- Chip Sockets or Machine Pin Strips: keep 8, 14, 16, 22, 24 and 40 pin sockets around. Get good quality sockets! Note the 22 pin socket may be a bit harder to find, as it's a strange configuration. It's used for the 5101 MPU RAM chip. An even better (but more expensive) alternative is "machine pin strips". These come in a snapable length they can be custom made to any size socket needed. But the really good thing about them is they allow complete access to the socket area. These can be soldered into a board from the top and bottom! They are the highest quality.
- Connector pins and housings: used to repair connectors. Get the .100" crimp-on variety for the MPU and solenoid driver board. Get the .156" crimp-on variety for the rectifier board, display boards, and solenoid driver board. If a crimp-on tool is not available, get one of those too. See the connector section for more details.
- Nylon Coil Sleeves: The 1.75" length is used for most coils in these games.
- Flipper Plunger/Link: used when rebuilding flippers.
- Flipper Coil Stops: used when rebuilding flippers.
- Flipper EOS Switch: used when rebuilding flippers.
- 1 1/16" Pinballs: a new pinball will make the playfield last longer.
- Leg Levelers: replace those old crummy looking leg levelers with brand new ones. 2" are used on these games.
- Rubber Rings: order game-specific ring kits with exactly the rings you need (from Pinball Resource). Don't forget to get flipper rubbers and a shooter tip.

Alle transistoren, ic's en overige componenten zijn leverbaar bij de Flipperwinkel in Arnhem.

1d. Getting Started: Game List

Here are the list of the Bally electronic pinball games from 1977 to 1985 covered in this document. Release date is given, and production numbers are in the parens.

It is very important to know what generation of Power supply, MPU and Sound board the game has.

Bally First Generation with MPU -17 and "chime" sound:
- Power Supply AS2518-18
- MPU AS2517-17

- Freedom, 1/77 (1,500)
- Night Rider, 2/77 (7,000)
- Evil Knievel, 6/77 (14,000)
- Eight Ball, 9/77 (20,230)
- Power Play, 1/78 (13,750)
- Mati Hari, 4/78 (16,260)

STERN First Generation wit 100 MPU and "chime" soun
- Power Supply identical to Bal AS2518-18

- Pinball 7/77 (1,694 SS)
- Stingray 3/77 (3,066)
- Stars 3/78 (5,127)
- Memory Lane 6/78 (2,6

STERN second Generation v

- Strikes and Spares, 6/78 (12,820)
- Black Jack, 6/78 (4,763)

Bally Second Generation with MPU -35 and Electronic Sound module -32:
- Power Supply AS2518-18
- MPU AS2517-35
- Sound Module AS2518-32

- Lost World, 8/78 (10,330)
- Six Million Dollar Man, 10/78 (10,330)
- Playboy, 12/78 (18,250)
- Voltan, 2/79 (365)
- Supersonic, 3/79 (10,340)

Bally Third Generation with Sound module -50:
- Power Supply AS2518-18
- MPU AS2517-35
- Sound Module AS2518-50

- Star Trek, 4/79 (16,842)
- Paragon, 6/79 (9,120)
- Harlem Globetrotters, 9/79 (14,550)
- Dolly Parton, 11/79 (7,350)

Bally Third Generation with Power supply -49 and Sound module -50:
- Power Supply AS2518-49
- MPU AS2517-35
- Sound Module AS2518-50

- Kiss, 6/79 (17,000)
- Future Spa, 12/79 (6,400)
- Space Invaders, 4/80 (11,400) (Sound Module AS2518-51)

Bally Third Generation with Power supply -18 and Sound module -51:
- Power Supply AS2518-18
- MPU AS2517-35
- Sound Module AS2518-51

- Nitro Groundshaker, 1/80 (7,950)
- Silverball Mania, 2/80 (10,350)
- Rolling Stones, 5/80 (5,700)
- Mystic, 6/80 (3,950)
- Hotdoggin', 7/80 (2,050)
- Viking, 7/80 (2,600)
- Skateball, 2/78 (n/a)
- Frontier, 11/80 (1,850)

Bally Fourth Generation with Power Supply -54 and Sound module -61 (Squawk and Talk):
- Power Supply AS2518-54
- MPU AS2517-35

electronic sound:
- Power Supply identical to Bally's AS2518-18
- M-100 MPU
- Sound board SB-100

- Lectronomo 8/78 (2,423)
- Wildfyre 10/78 (2,400)
- Nugent 11/78 (2,671)
- Dracula 1/79 (3,612)
- Trident 3/79 (4,019)
- Hot Hand 6/79 (4,117)
- Magic 8/79 (2,466)
- Cosmic Princess (kit) 8/79 (336)

STERN third Generation with M-200 MPU:
- Power Supply identical to Bally's AS2518-18
- MPU M-200
- Sound board SB-300

- Meteor 9/79 (8,362)
- Galaxy 1/80 (5,150)
- Ali 3/80 (2,971)
- Big Game 3/80 (2,713). First 7 digit score display and first widebody Stern game.
- Seawitch 5/80 (2,503)
- Cheetah 6/80 (1,223)
- Quicksilver 6/80 (1,201)
- Nineball 12/80 (2,279).
- Free Fall 1/81 (1,300)
- Split Second 8/81 (?)
- Catacomb 10/81 (?)
- Iron Maiden 10/81 (?)
- Viper 12/81 (?)
- Dragonfist 1/82 (?)

STERN fourth Generation with voice card:
- Power Supply identical to Bally's AS2518-18
- MPU M-200
- Sound board SB-300
- Voice board VS-100

- Flight 2000 8/80 (6,301)
- Stargazer 8/80 (869)
- Lightning 3/81 (2,350)
- Orbitor One 4/82 (889)
- Cue ??/82 (prototype, never released)
- Lazorlord 10/84 (prototype, never released)

- Sound Module AS2518-61 (Squawk and Talk)

- Xenon, 11/80 (11,000). Uses power supply -54, but not sound module -61. Instead uses sound module -56 with volcalizer module -58. First Bally game with speech.
- Flash Gorden, 2/81 (10,000)
- Eight Ball Deluxe, 4/81 (8250)
- Fireball II, 6/81 (2,300)
- Embryon, 6/81 (2,250)
- Fathom, 8/81 (3,500)
- Medusa, 9/81 (3,250)
- Centaur, 10/81 (3,700). Also has a "Say it Again" -81 reverb card, in addition to the -61 Squawk and Talk module. The reverb card is not required, it just adds reverb to the voices.
- Electra, 12/81 (2,950)
- Vector, 2/82 (3,500)
- Spectrum, 6/82 (994)
- Speakeasy, 8/82 (4,000). AS2518-51 sound board, not Squawk and Talk.
- Rapid Fire, 4/82 (5000)
- Granny and the Gators, 1/82
- Mr & Mrs Pacman, 4/82 (10,600)
- Baby Pacman 4/82, (7,000)
- Eight Ball Deluxe Limited Edition, 10/82 (2,388)
- BMX 1/83 (406). AS2518-51 sound board, not Squak and Talk.
- Centaur II, 5/83 (1,550)
- Goldball, 6/83 (1,750). AS2518-51 sound board, not Squawk and Talk.
- Grand Slam, 8/83 (1,000) (different sound board labeled AS-2888-51)

Bally Fifth Generation with Power Supply -54 and Sound Module B045/B044 (Cheap Squeek):
- Power Supply AS2518-54
- MPU AS2517-35
- Sound Module M-051-00114-B045 (or B044) (Cheap Squeek)

- X's & O's, 2/84 (3,300)
- Kings of Steel, 3/84 (2,900)
- Black Pyramid, 7/84 (2,500)
- Spy Hunter, 10/84 (2,300)
- Eight Ball Deluxe Classic, 11/84 (1,300)
- Fireball Classic, 12/84 (2,000)
- Cybernaut, 5/85 (900)

1e. Getting Started: Lubrication Notes

Pinball machines, for the most part, **do not** require any lubrication. Most parts run "dry". Far more damage can be done to a pinball machine by over-lubricating, than by under-lubricating. As a rule, if in doubt as to lubrication, don't do it! Throw that WD-40 away, it won't be used here.

The only parts that will require any lubrication are metal-to-metal moving parts. There aren't very many in a game. Only ball eject and slingshot hinges. 3-in-1 oil also works on these if needed. But try and keep that lubrication in the tool box and away from the game.

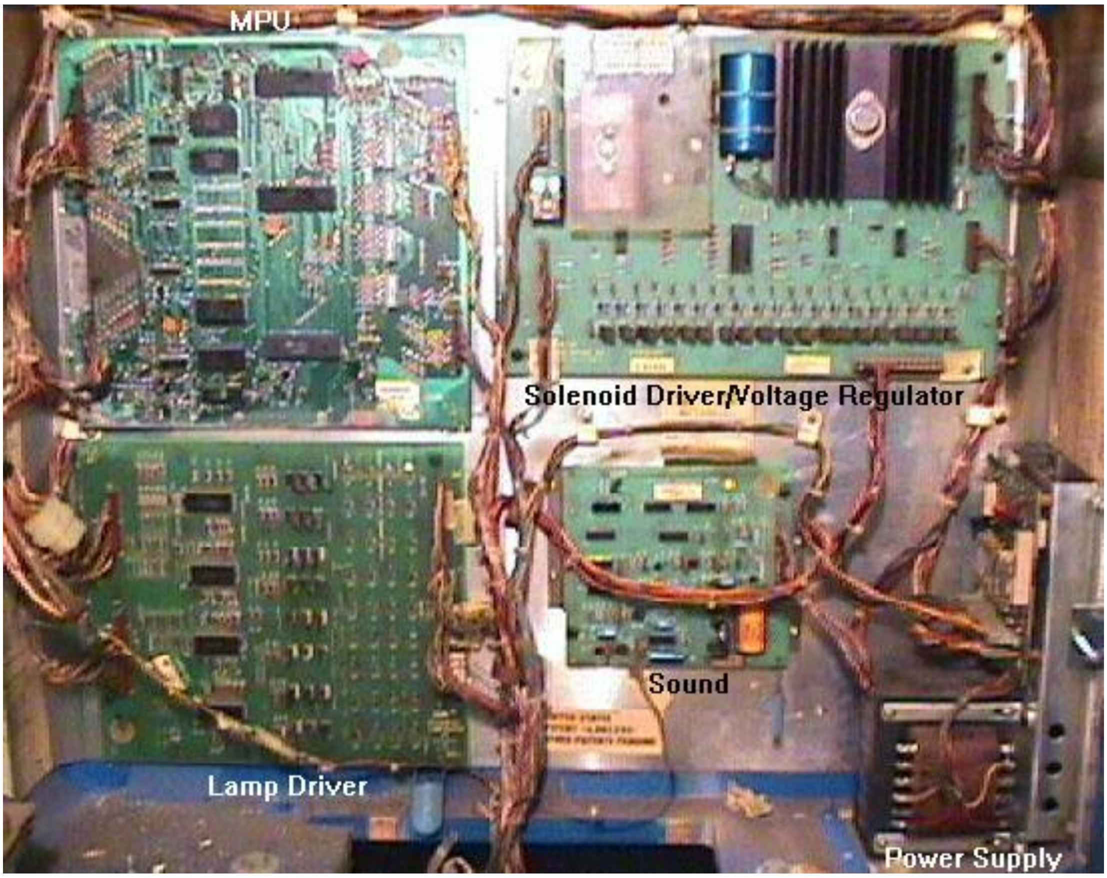
If some prior person did lubricate the game, the lubrication has probably now congealed with the infamous "black pinball dust" to form a thick, black mess. This is unrepairable on coil sleeves, and new parts will need to be installed.

1f. Getting Started: The Circuit Boards

Here are the boards that live in the backbox (head) of the electronic Bally pinball games. This particular game is Bally's 1979 "Star Trek", with a AS2518-18 power supply and a AS2517-35 MPU.

- In the upper left of the backbox is the MPU board. Particularly noteworth is the lower edge of this board, which is where the battery normally resides (it has been removed in this game).
- Upper right is the Voltage Regulator/Solenoid Driver board.
- Lower left is the Lamp Driver board.
- Lower right is the Sound board.
- Lower right corner is the transformer and power supply board.

A typical Bally backbox showing all the circuit boards.



1g. Getting Started: Voltage Test Points on the Boards.

All the boards in the Bally games have TP "test points". These are points where the voltages can be tested for proper levels. All voltages can be plus or minus 10 percent. Missing voltages can be caused by a blown fuse, a bad header pin, a bad connector, or some other electronic component. Also check the fuses and the connectors first.

Power Transformer Module (Rectifier board):

- TP1 = +5.4 (AS2518-18 version, feature lamps)
- TP1 = +6.5 vdc (AS2518-49 version, feature lamps)
- TP2 = +230 vdc (score displays)
- TP3 = +11.9 vdc (+5 regulated)
- TP4 = 7.3 vac (general illumination)
- TP5 = +43 vdc (solenoid voltage)
- GND = Ground

MPU board:

- TP1 = +5 vdc
- TP2 = +11.9 vdc
- TP3 = +21.5 vdc (comes from +43 vdc solenoid voltage)
- TP4 = Ground
- TP5 = +5 vdc

Solenoid Driver/Voltage Regulator board:

- TP1 = +5 vdc
- TP2 = +190 vdc
- TP3 = +5 vdc
- TP4 = +230 vdc
- TP5 = +11.9 vdc

Lamp Driver board:

- TP1 = +5 vdc
- TP2 = Ground
- TP3 = (only on AS2519-23 version)

Auxiliary Lamp Driver board:

- TP1 = +5 vdc
- TP2 = Ground

Display Driver boards:

- TP1 = +5 vdc
- TP2 = +190 vdc
- TP3 = Ground

Sound module -50:

- TP1 = +5 vdc
- TP2 = Ground
- TP3 = ?
- TP4 = +43 vdc

Sound module -51:

- TP1 = ?
- TP2 = ?
- TP3 = ?
- TP4 = ?

Sound Plus module -56 (Xenon):

- TP1 = +11.9 vdc
- TP2 = +5 vdc
- TP3 = Ground
- TP4 = 0 vdc (without sound), +2.5 vdc (witl sound)
- TP5 = 2.5 vdc

Volcalizer module (used w 56 sound):

- TP1 = Ground
- TP2 = +5 vdc
- TP3 = Analog output
- TP4 = Digital Input
- TP5 = Speech clock

Sound Module -61 module (Squawk & Talk):

- TP1 = Ground
- TP2 = +5 vdc
- TP3 = +11.5 vdc
- TP4 = -5 vdc
- TP5 = Speech volume control voltage
- TP6 = Sound volume c voltage
- TP7 = AY38912 outpu
- TP8 = E
- TP9 = TMS5100 outpu
- TP10 = VMA
- TP11 = TMS5100 clocl
- TP12 = Reset

Sound Module -81 module it again)

- TP1 = Ground
- TP2 =
- TP3 =
- TP4 =
- TP5 =

Sound module -32

- TP1 = +5 vdc
- TP2 = Ground
- TP3 = +11.9 vdc
- TP4 = +43 vdc
- TP5 = +43 vdc (solenoid return)
- TP6 =
- TP7 =
- TP8 =
- TP9 =
- TP10 =
- TP11 = +11.9 vdc
- TP12 = +11.9 vdc
- TP13 = +4 to +8 vdc

1h. Getting Started: Power Supply Power Distribution.

These are the board connectors for the AS2518-18 and AS2518-49 power supply and the circuit board abbrevations. This also covers Stern power supplies (which are identical to Bally's AS2518-18 model).

- A2 P.S. = Power Supply and Regulator board.
- A3 S.D. = Solenoid Driver/Voltage Regulator board.
- A4 MPU = MPU board.
- A5 L.D. = Lamp Driver board.
- A1 Dsp = Display Driver boards connected to the score displays.
- A8 Snd = Sound board.

AS2518-18, -49 Power Supply Power Distribution, by Connector		
A2 P.S. Connector, Pin#	**To Module, Connector, Pin#**	**Function**
J1-1	Playfield	7.3 vac Gen. Illum. return
J1-2	Playfield	7.3 vac Gen. Illum. return
J1-3		Spare, unused
J1-4		Key
J1-5	Playfield	7.3 vac Gen. Illum. Buss
J1-6	Playfield	+43 vdc Solenoid Buss
J1-7	Playfield	+5.4 vdc Switched Illum. Buss
J1-8	Playfield	7.3 vac Gen. Illum. Buss
J1-9 *	Playfield	+5.4 vdc Switched Illum. Buss
J2-1	Cabinet	7.3 vac Gen. Illum. Buss
J2-2	Cabinet	+43 vdc Solenoid Buss
J2-3		Spare (unused)
J2-4		Spare Ground (unused)
J2-5	Cabinet	7.3 vac Gen. Illum. return
J2-6		AC Line, high
J2-7		AC Line, low
J2-8		Key
J2-9	Cabinet	Flipper Solenoid return
J2-10		AC Line, ground
J3-1		7.3 vac Gen. Illum. return
J3-2		7.3 vac Gen. Illum. return
J3-3	A5 L.D. J4-2	+5.4 vdc Switched Illum. return
J3-4	A5 L.D. J4-1	+5.4 vdc Switched Illum. return
J3-5	A3 S.D. J3-6	+230 vdc to voltage regulator (+190)
J3-6		+5.4 vdc Switched Illum. Buss
J3-7		Key

A2 P.S. Connector, Pin#	To Module, Connector, Pin#	Function
J3-8 J3-9 J3-10 J3-11 J3-12 J3-13 J3-14 J3-15 J3-16 J3-17 J3-18 J3-19 J3-20	A3 S.D. J3-12 A3 S.D. J3-5 ** A4 MPU J4-15 A5 L.D. J4-11 A3 S.D. J3-21 A3 S.D. J3-22 A3 S.D. J3-10 A3 S.D. J3-3 A3 S.D. J3-23 A3 S.D. J3-24	+11.9 vdc to voltage regulator (+5) +43 vdc to Flipper Relay A3 S.D. K1 7.3 vac Gen. Illum. Buss 7.3 vac Gen. Illum. Buss +43 vdc Zero Crossing MPU input +43 vdc Solenoid Buss +5.4 vdc Switched Illum. return +11.9 vdc voltage regulator (+5) return (ground) +230 vdc voltage regulator (+190) return (ground) +11.9 vdc voltage regulator (+5) return (ground) +230 vdc voltage regulator (+190) return (ground) +43 vdc solenoid return (ground) +43 vdc solenoid return (ground)

* The J1-9 pin is only on the AS2518-49 rectifier board.
** Lost World and later, via A8 (sound module) J1-9.

Rectifier Board Fuses.
Here is a list of the rectifier board fuses. This applies to all generations of Bally power supplies from 1977 to 1985.

- F1 = 10 amp fast-blo (CPU controlled feature lamps)
- F2 = 3/4 amp slo-blo (score display high voltage)
- F3 = 4 amp fast-blo (unregulated +5 volts)
- F4 = 5 amp fast-blo (solenoids, if game has 2 flippers)
- F4 = 6 amp fast-blo (solenoids, if game has 3 flippers)
- F4 = 7 amp fast-blo (solenoids, if game has 4 flippers)
- F5 = 20 amp fast-blo (general illumination lights)
- F6 = 3 amp slo-blo (incoming 120 volts AC line power)

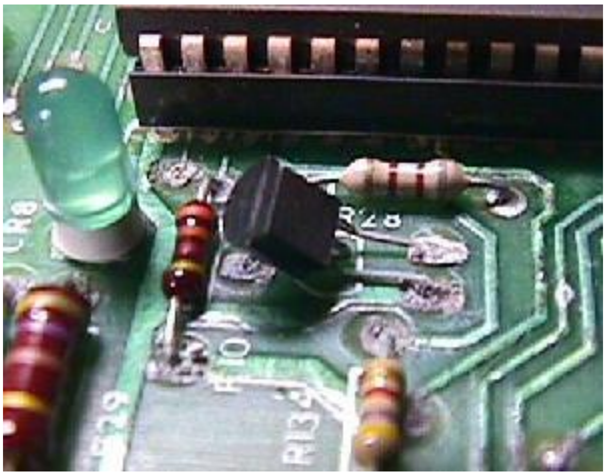
2a. Before Turning the Game On: Removing the MPU Battery and Fixing Corrosion.

A battery was used on all 1977 to 1985 Bally electronic game MPU boards to keep bookkeeping, high scores, and on some games, game options. This battery was a rechargable nicad battery, and was soldered directly to the MPU board. **The original battery MUST be removed (cut off) immediately, and discarded!** The game will function fine without the battery in place (but we'll talk about a replacement too).

The battery section of a Bally MPU board. This battery leaked and corroded the board (see all the green?). None of the components too seriously seriously effected, but there is still a fair amount of work here to fix this board.

The nicad battery used on the MPU board have a nasty habit of leaking corrosive materials on to the MPU board, damaging it. This happens because the battery is over-charged by the MPU board, and due to age. How many 20 year old batteries have been seen that haven't leaked?

Mild corrosion seen here. Although these components haven't been ruined (yet!), this corrosion should at least be neutralized with a vinegar and water wash. Notice the solder pads have turned gray and are no longer smooth. The 40 pin socket for the chip at the top of the picture should also be replaced .



In most cases the corrosion can be repaired. There can be a lot of work involved in doing this repair correctly, if the corrosion affected the electronic components and chip sockets.

Can This Corroded MPU be Fixed?

In my opinion, many Bally MPU boards with battery corrosion can be fixed (I'm taking this approach from a "hobbiest" point of view). Often a MPU board is sent out for repair, and is returned not repaired with a note that says, *"not able to fix, too corroded"*. Perhaps they were right, but from my experience they should have stated, *"not able to fix **economically**, too corroded"*. Remember these repair guys get paid by the hour. With new replacement MPU boards available for $200, and if a repair guy gets paid $50 an hour, and he estimates it will take more than four hours to fix the board, it's just not worth it. But that doesn't stop you or me (the hobbiest) from fixing the board! After all, we work a whole lot cheaper.

The Repair Connection has a very nice web page dedicated to fixing battery corrosion. They explain the pitfalls, and the common mistakes made when attempting this repair. Check it out at http://www.repairconnection.com/acid_damaged_mpu.htm as this is an excellent document.

New Replacement MPU boards.
New replacement MPU boards are now available from:

- www.allteksystems.com, $200.
- www.repairconnection.com, $250.
- www.pbliz.com, $250 to $275.

Personally I like the $200 Alltek board the best of the three, as it is the least expensive, has improved Bally diagnostics, and is DIP switch selectable for any Bally/Stern game. But the other two are also well thought out and seem very good.

Can a Small Amount of Corrosion be Bad?
Yes! Even the smallest particle of corrosion on the MPU board or under a connector's plastic base or under the DIP switches can cause shorts. The size of these shorts is often so small that they cannot be seen even with heavy magnification. The slightest amount of corrosion can short out the switch matrix or the power inputs.

Bead Blasting.
If a bead blaster is available, this is the best way to remove battery corrosion from a board! A bead blaster is mearly a sandblaster, but instead of shooting sand, it shoots small ceramic beads. This is much gentler than sand. To bead blast a board, all the corroded electronic components should first be removed that are in the effected area. Then the board can be bead blasted. Finally, new components are installed to replace the old ones.

Buy a Bally Reset Section Repair Kit.
Depending on how bad the corrosion is, many parts may need replacement. Instead of ordering all the parts separately, I suggest just buying a "Bally Battery Corrosion Repair Kit" BALLY35-BA-KIT from Ed Krzycki (gpe@cox.net). This kit includes all the resistors, capacitors, diodes, transistors and chips typically ruined by battery corrosion. For a mere $10 (plus $3.50 shipping), this kit is well worth it. See Ed's web page at members.cox.net/gpe/GPE_Kits.html for more information. If for some reason the $10 is too much money, here are the typical parts needed for

- U8 - Static RAM type 5101, 450nS.
- 22 Pin IC socket, machine pin type, for U8 chip replacement.
- C1,C2 - Capacitor, 820pF, Axial Ceramic.
- C5 - Capacitor, 4.7uF, Radial Tantalum.
- C3,C13,C80 - Capacitor, 0.01uF, Axial Ceramic.
- CR5,CR7 - Diode, Switching. 1N4148
- CR8 - Light Emitting Diode, Green.
- CR44 - Diode, Rectifier. 1N4004 (or better)
- R1,R3,R24,R28 - Resistor, 8.2K, 1/4W, 5%
- R2 - Resistor, 120K, 1/4W, 5%
- R11 - Resistor, 82, 2W, 5%
- R12 - Resistor, 270, 1/4W, 5%
- R16 - Resistor, 2K, 1/4W, 5%
- R17 - Resistor, 150K, 1/4W, 5%
- R29 - Resistor, 470, 1/2W, 5%
- R107 - Resistor, 3.3K, 1/4W, 5%
- R112 - Resistor, 1K, 1/4W, 5%
- R134 - Resistor, 4.7K, 1/4W, 5%

- R140 - Resistor, 20K, 1/4W, 5%
- Q1,Q2 - Transistor, 2N3904
- Q5 - Transistor, 2N4403
- VR1 - Diode type 1N4738A, Zener, 8.2V (alternate for 1N9598)

Removing the old battery and fixing corrosion.
If a bead blaster is not available, here's another procedure for removing corrosion.

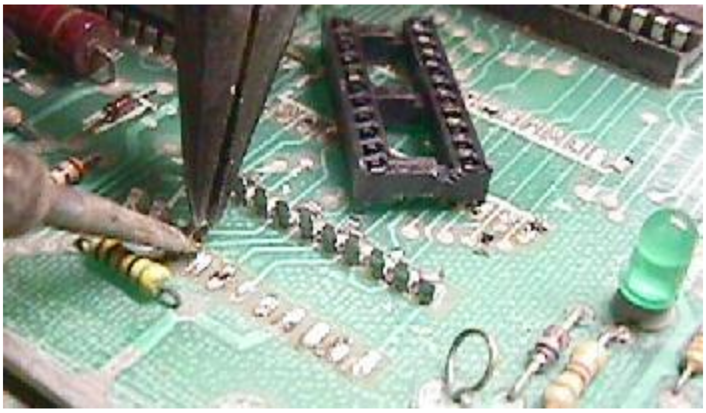
- Remove the MPU board from the head box.
- Cut the old nicad battery off the MPU board and discard.
- If any components are damaged by the battery (look for green and/or gray!), cut them off (leaving as much of the leg in the board as possible), and discard. This includes chip sockets. Chips and transistors are affected more by corrosion than resistors and capacitors. Be more concerned with these. If Ed's reset kit was purchased above (highly recommended), remove ALL the components included in the kit from the MPU board.
- To remove the cut off part's legs from the board, apply some new solder to the leg's solder pad. Then heat the pad and pull the cut off leg out of the board with needle nose pliers.
- Check the connector header pins for corrosion. If they are green or gray, replace the header pins. Remove and discard any header pins that are corroded.
- Desolder all the removed part's holes.
- Desolder all corroded header pins.
- **Tip for desoldering corroded solder:** Often solder becomes so grey/black it can't be heated and desoldered. First try adding some new solder. If that does not work, take a Dremel tool with a tiny wire wheel to the grey/black solder joints.
- Hand sand all green/gray areas with 100 or 150 grit sandpaper. Sand all the grey oxides off the board, so the underlying solder can be melted. Sand until the copper is bright, which will allow solder to stick. If a trace is sanded through, repair it with some wire or copper solder wick (for large traces).
- Wash the pcb with a mixture of vinegar and water (50/50) to neutralize the corrosion. Scrub with a toothbrush.
- Rinse the washed board with clean water.
- Rinse the board with 99% pure alcohol. This will disolve and wash away the water. Repeat this step. The alcohol will evaporate fairly quick.
- Replace any header pins that are corroded with new pins.
- Replace all removed components (except the battery!). Any removed chips should be replaced with good quality sockets or machine pin strips. Any bare copper being soldered may need solder flux to get the solder to stick.
- Check the connectors themselves! If the board had corrosion, the connectors may be corroded! Replace the connector pins if any damage is seen. The connector's plastic base may need to be pried up (on the component side of the board) to see if corrosion is underneath it. Connectors J4 and J1 seem to be most affected by corrosion.
- Check for corrosion around and under the DIP switches. Corrosion here can short the switch matrix lines.

Removing and Replacing Corroded Components.

Step 1: Pry up the old socket base. If a black socket, it will come right off easily, leaving the solder-in socket pins in the board. The brown sockets will not pry up (don't even try!); skip right to step number three. On the black sockets be careful not to damage any traces while prying with the screwdriver tip! Once the socket base is pried up, examine the socket pins for any grey/green corrosion. If the socket pins are clean and undamaged, press the socket base back onto the pins.

Step 2: If the socket pins are grey or green, the entire socket will need to be replaced. With the socket base removed, it is easy to remove the old socket pins. The best way to do this is to heat each individual pin, and pull the pin out of the hole with needle nose pliers. It may be easier to heat the solder joints from the back (non-component) side of the board because the corrosion is usually less there, and the solder will melt better.

After prying up the socket base, heat each pin individually and pull it out with needle nose pliers.

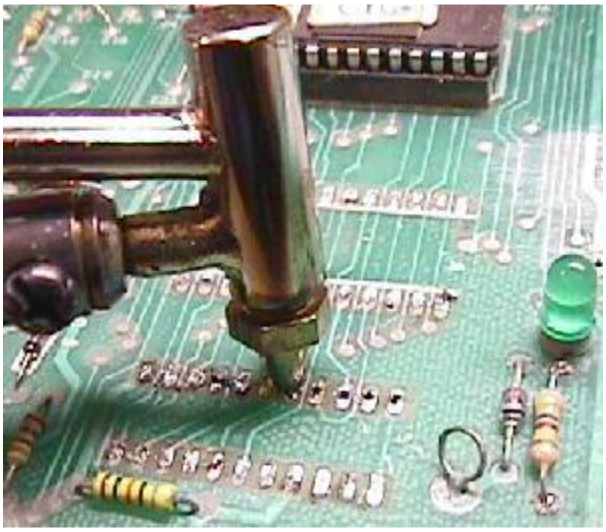


Step 3: Desolder the MPU board chip holes. Using a desoldering iron (Radio Shack $10), desolder the holes. It may be easier to desolder the solder joints from the back (non-component) side of the board because the corrosion is usually less there, and the solder will melt better. Sometimes new solder will need to be added to a solder joint before it can be de-soldered! Sounds silly, but it works.

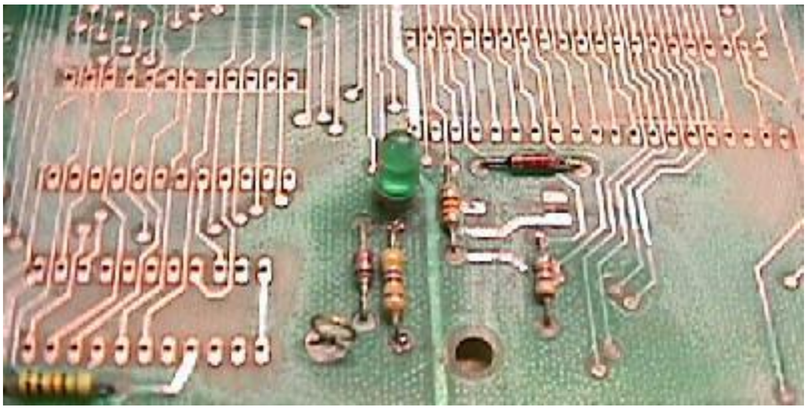
Step 4: Examine the connector header pins for corrosion. Pry up the header pin's plastic base on the component side of the board to see underneath it, and around the pins. If any corrosion is found, remove the header pins so the corrosion can be removed. Especially important is the J4 (power!) connector. But any corrosion on the MPU board connectors can cause adjacent connector pins to short together.

Step 5: Examine the DIP switches for corrosion. Any corrosion around the DIP switches can cause these switches to short together, giving all kinds of strange switch matrix problems.

Desoldering the holes.



Step 6: Sand the area with 100 or 150 grit sandpaper to remove any corrosion.
After the holes have been desoldered, the area is sanded clean.



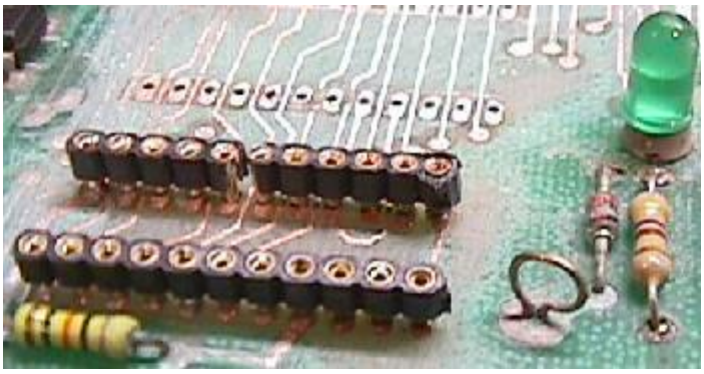
Step 7: Wash the board in a 50/50 solution of white vinegar and water (as descibed above).

Step 8: After the board is dry, sand the corroded area again with 150 grit sandpaper.

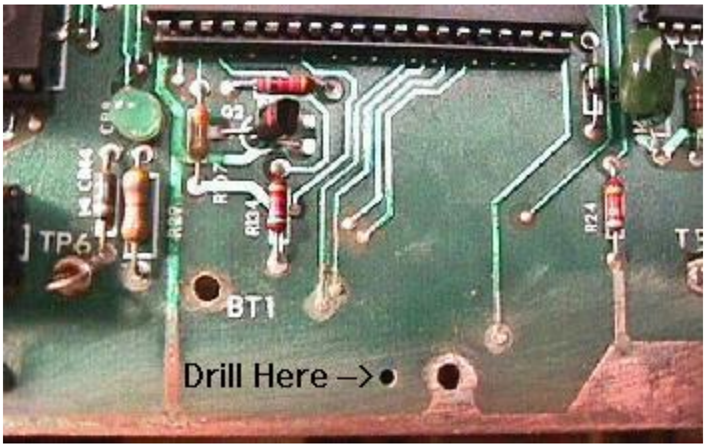
Step 9: Replace any damaged traces on the board. For large (thick) traces (like the ground rail surrounding the outside of the board), use desoldering braid. For small traces, use wire wrap wire. For medium traces, use stranded 24 guage wire. Use rosin soldering flux (Radio Shack) to help solder stick to copper.

Step 10: Install machine pin strip sockets, or some other high quality socket with an OPEN base (so the traces can be seen under the socket!). Strip sockets are the best because they allow complete access to the traces around the socket. **HIGHLY SUGGESTED:** solder the machine pin sockets from the top of the board too (cheap sockets will not allow this). Often the plated through circuit board holes are damaged, and the only connection between the traces on the top and bottom of the board is the socket's pins. Use rosin solder flux (Radio Shack) on bare copper to get the solder to stick better.

Machine pin strip sockets. This is the best replacement socket as it allows access to the component side traces which would normally be covered by a conventional socket. Note they come in strips, breakable to the number of pins needed. Use solder flux on those bare copper traces to get solder to stick better. Also it's a good idea to solder the *machine pin strip sockets on BOTH sides of the board.*



Mounting the battery back-up capacitor.
A hole is drilled right next to the negative battery mounting hole for the memory back-up capacitor. This is done because the capacitor is much shorter than a battery.



Easier Soldering Tricks.
Often damaged copper traces are difficult to solder. Even after sanding the traces to a bright copper color, sometimes solder will not stick easily to the traces. To help with soldering, here are few tips:

- The longer one waits to solder after sanding the traces shiney, the harder the soldering. Untreated copper will start to oxidize quickly in the air, from humidity.
- Use rosin flux paste for easier soldering. This is available in small tubes from Radio Shack. Just apply the paste to the copper traces, and solder normally. The flux will allow new solder to stick much easier to copper board traces.

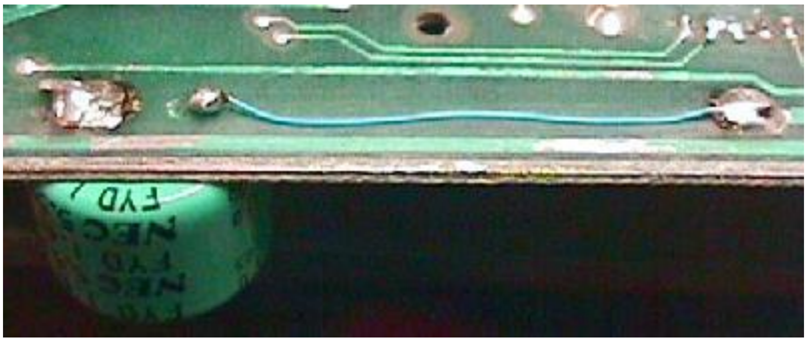
New Battery
To replace the original battery, add a remote three "AA" battery pack and a 1N4001 diode (banded diode end first connected to the pcb "+" pin, and the non-banded end connected to the positive lead of the battery pack). The diode is used so the recharging circuit doesn't try to charge the AA batteries. The game can also work with **no battery**. Not having a battery means that your high scores and operating audits won't be saved. Personally, I find this acceptable. But some Bally games also save game options (like sound styles), so you may need a battery in these games, or the sound options will always go back to the default setting.

Memory Back-Up Capacitors.
If one insists on having a battery (can't live without those high scores!), I would

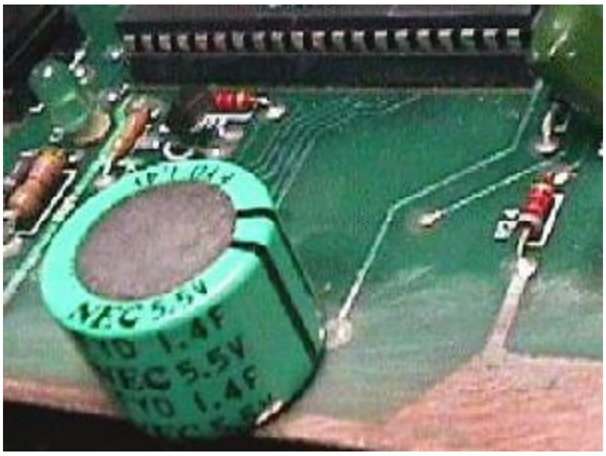
recommend installing a memory back-up capacitor instead. These capacitors will charge when the game is on, and slowly discharge to keep the memory alive when the game is off. The advantage to these capacitors is they never wear out, and they won't leak corrosive materials. The best of all worlds in my opinion. Their down side is the game must be on for about one hour every month to maintain their charge (though I have heard them keeping a charge up to six months). Also, the game must be on for about several hours continuously to initially charge the capacitor. These capacitors are about the size of half a single AA battery. Jameco (800-831-4242) sells 1 Farad memory caps, part# 142957, $3.95 each, $3.49 for ten or more.

Installing the Memory Back-Up Capacitor.
After removing the battery and addressing any board corrosion, install the memory back-up capacitor. Drill a hole for the second lead of the back-up cap, just to the side of the negative battery lead (see picture above). Then mount the cap in the board, and bend the leads to hold it in place. Solder the cap in place. On the second lead which goes throught the hole drilled, solder a two inch wire. Extend the wire to the other battery terminial hole on the MPU board. Note the minus and positive leads were not labeled on the cap I installed. There was only a black line on the cap to designate the negative lead.

The underside of the MPU board with the memory back-up cap installed. Note the positive cap lead that goes through the newly drilled hole must be jumped back to battery board solder position.



The memory back-up capacitor, installed in the MPU board. Note the cap lead with the black lines going to it is the negative lead.



2b. Before Turning the Game On: Rebuilding the Power Supply

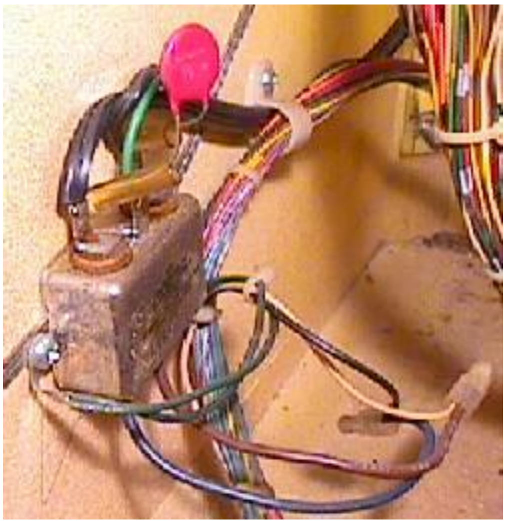
The Stern and pre-1981 (before Xenon) Bally power supply's rectifier board on Bally electronic games is notorious for being under-powered and troublesome. I suggest doing these power supply modifications before even turning the game on. Chances are there is a rectifier board problem anyway!

There are three different version of the Bally electronic rectifier board. The most common is AS2518-18 (which is identical to the rectifier board used in Stern games too). This is the most troublesome design, and will require some upgrades. The least common is AS2518-49, and was only used on Kiss, Future Spa, and Space Invaders. This rectifier board also will need some upgrades. The AS2518-54 rectifier board as used in Xenon (10/80) and later is quite good, and requires no upgrades (other than possibly replacing header pins, if tarnished).

The Power Cord.
Make sure it's a three prong cord. If someone cut off the third prong, replace the cord and/or the plug. The third GREEN wire goes to the line interface filter. That's the small silver box in the bottom of the cabinet (see below).

The Varistor.
Known as VR1, the varistor's job is to aborb large voltage spikes. The first thing the power cord attaches to is the varistor. If the power line gets struck by lightning, the voltage spike coming down the power line can toast anything in its path. The varistor will absorb this spike and short itself, preventing damage to the game (electricity will take the shortest path of least resistance). A blown varistor is usually obvious; it will no longer look like a red disc capacitor, but will be a molten mess with two wires attached to it.

The red varistor and the line filter, as found in the cabinet of a Bally game.

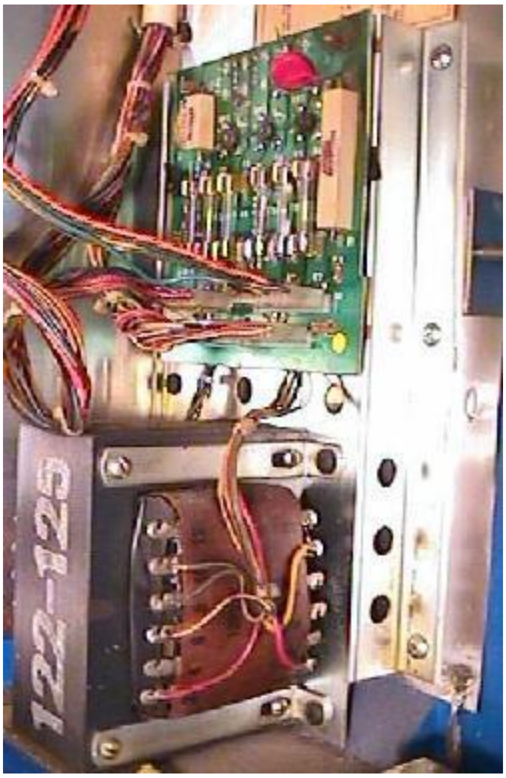


The Line Filter.
The line filter is the next thing connected to the power cord. It's a small silver box that prevents the game from making line noise (which could be "heard" by other products like stereos). Not much to go wrong here, but occassionally these go bad and short.

On/Off Switch.
Next in line is the on/off switch. These too can go bad, but it doesn't happen often. Just before the on/off switch is a service outlet. It's always on, whether the game is switched off or on.

Left: *AS2518-18 Power supply as used in most Bally games until 1981. Stern also used a design identical to this one.*

Right: *AS2518-49 Power supply as used in Kiss, Future Spa, and Space Invaders. Notice the two big heat sinked, metal cased voltage regulators. These don't exist on the AS2518-18 power supply. The AS2518-49 power supply board is exactly like the AS2518-18 board, except for the removal of BR1, which is replaced by these two heat sinked voltage regulators. Also the -49 added one pin to connector J1 (to double up the switch illumination feature lamp line).*



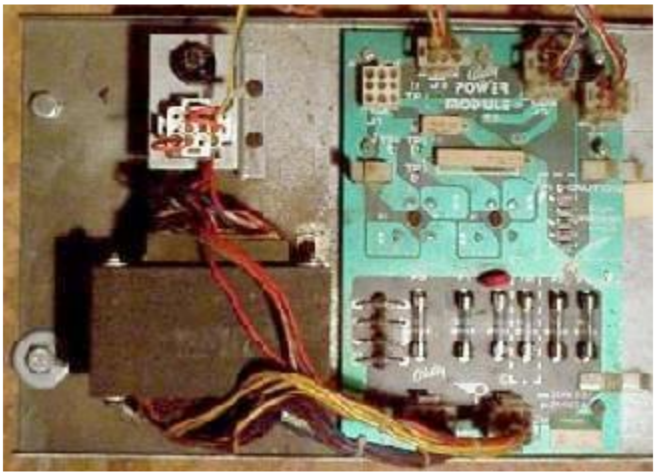
The Rectifier Board.

The rectifier board takes AC voltage from the transformer and converts it to unfiltered DC voltage. Bally used three different rectifier board in thier games from 1977 to 1985. The part number is silk screened right on the printed circuit board.

- AS2518-18 (used from 1977 until 1981, except in Kiss, Future Spa and Space Invaders).
- AS2518-49 (used only in Kiss, Future Spa and Space Invaders).
- AS2518-54 (used in Xenon and later).

Prior to Xenon (late 1980), the actual power supply is in the backbox (head) of the game. It's usually located in the lower right corner (as facing the game). It comprises a large transformer, a silver platform, and a smallish printed circuit board known as the rectifier board. Most of the game fuses are located on the rectifier board (there is usually at least one playfield fuse too).

AS2518-54 Power Supply module, located in the lower cabinet, as used starting in 1981.



How the Power Supply Works.
Power comes into the rectifier board from the line cord at connector J2, pins 6 and 7. It then goes to fuse F6 (3 amp slo-blo), and then to the transformer (primary). The transformer splits the voltage into five different AC voltages. Then these voltages run through their own fuse. Some of the voltages (7.8, 12, 49 volts AC) go to a 200 volt, 8 amp bridge rectifier which converts the AC voltages to DC (+5.4, +11.9, +43 volts DC respectively). The 7.3 volts AC stays AC, and powers the game's general illumination. The 173 volts AC that is used for the displays is converted to 230 volts DC by four 1N4004 diodes (CR1 to CR4).

If there is a AS2518-49 rectifier board, this works identical to the above described AS2518-18 model. The only difference being there's no 7.8 vac and no bridge BR1. Instead, 9.2 vac comes from the transfomer, and is converted to 6.5 vdc by two heat-sinked 200 volt 30 amp voltage regulators. It works exactly the same as the previous model, and has the same pin out (except for one extra pin on J1), but has a beefier +5 volt output.

Header Pins and Connector Pins on the Rectifier Board.
Due to the age of these games, I can almost guarantee that the .156" connector header pins on the rectifier board are at least slightly brown (regardless of the generation of power supply used). If this is the case, these pins are acting like more like resistors than connector pins. These should be replaced with new header pins. And likewise, the female pins in the connector housings should also be replaced. **Make sure both are replaced**! Replacing only the header pins or the housing pins will make the new part brown in a short time (wasting time and money).

Trifurcon Connector Pins.
Molex makes a crimp-on .156" size female terminal pin called a "trifurcon" pin (not available in the .100" pin size). This style .156" pin differs than the "normal" pin; the metal material is more heat resistant, and it has three wiper contacts instead of just one. The more contact points means the female pin "hugs" the male header pin with greater surface area. I highly recommend these. See the connector section for more details.

Check Rectifier J3 Connector Pins 8,17.
On the power supply's rectifier board, connector J3 can often be over stressed and burned. In particular, connector J3 pin 8 (orange wire, +5 volts) and J3 pin 17 (white wire with a brown trace, ground) are often burned (both of these pins go to the Voltage Regulator/Solenoid Driver board). If either of these pins are even slightly brown, both the header pins and the connector pins should be replaced. Trifurcon replacement pins are highly recommended.

Bridge Rectifiers, Diodes, Voltage Rectifiers.
The bridge rectifiers are one of the Bally power supply's weak links. The stock VJ248 bridges (200 volt 8 amps) are just too small to do the job. These will need to be replaced with 25 or 35 amp bridges. The bally rectifier board also uses four 1N4004 diodes CR1 to CR4 for the 173 volts AC used to power the score displays. These do essentially the same thing as a bridge. There isn't much current draw on these diodes, so they usually don't fail. But when replacing these, use 1N4007 or better diodes.

On the AS2818-49 rectifier board, bridge BR1 is replaced with two voltage regulators. These are R712 (NTE6200), which are 200 volt, 30 amp devices. This rectifier board design is heavier duty then the AS2818-18 model.

- BR1 (AS2518-18 only): converts 7.8 vac to +5.5 vdc (through F1). Used for the "switched illumination" (feature lamps).
    - RP1, RP2 (AS2518-49 only): replaced BR1 (as used on AS2518-18) with two voltage regulators, which converts 9.2 vac to +6.5 vdc (through F1). Used for the "switched illumination" (feature lamps).
- BR2: converts 12 vac to +11.9 vdc (through F3). Used for the regulated +5 volts DC to power the logic chips.
- BR3: converts 49 vac to +43 vdc (through F5, uses a varistor too). Used to power all the game's solenoids.
- CR1 to CR4: converts 173 vac to +230 vdc (through F2) using four 1N4004 diodes. Used to power the game's score displays.

The rectifier board as used in AS2518-18.
The bridges are mounted underneath this board.
The three phillips head screws need to be removed to access them. The big red disc capacitor-looking device is a varistor. Note the test points across the top edge.

Left: *The bottom side of the AS2518-18 rectifier board. Note the three small square bridge rectifiers. These will be replaced with larger 25 or 35 amp rectifiers. The one large bridge shown above the installed three is a replacement 35 amp bridge.*
Right: *The bottom side of the AS2518-49 power supply. Note the two small square bridge rectifiers, which will be replaced with larger 25 or*

35 amp rectifiers.

On the AS2518-18 and AS2518-49 rectifier boards, the bridges are mounted on the back of the board, and are bolted to a large metal heat sink. This allows the bridges to run cooler. The phillips head screws on the power supply board hold the bridges to the heat sink. Remove these three screws to remove the board.

Note that the 49 vac that is converted to 43 vdc also has a varistor mounted in it's circuit too.

Power Supply "Test Points" (TP's).
Bally rectifier boards have five "test points" where the proper output voltages can be checked. To do this, the game need to be powered on and in "attract" mode. The best place to pick up ground is at resistor R1, at its lead closest to the fuses (or on rectifier board AS2518-54, on the right side of the resistor). This info applies to all three generations of rectifier boards.

- **TP1** (on AS2518-18) = 5.4 volts DC +/- .8 volts (4.6 to 6.2 volts). Fuse F1, bridge BR1. Used to power the "switched illumination" (feature lamps).
- **TP1** (on AS2518-49) = 6.5 volts DC (5.8 to 7.2 volts). Fuse F1, voltage regulator RP1 and RP2. Used to power the "switched illumination" (feature lamps).
- **TP2** = 230 volts DC, +/- 27 volts (203 to 257 volts). Fuse F2, diodes CR1 to CR4. Used to power the score displays.
- **TP3** = 11.9 volts DC, +/- 1.4 volts (10.5 to 13.3 volts). Fuse F3, bridge BR2. Used to power the regulated +5 volts DC for the game's logic circuits.
- **TP4** = 7.3 volts AC, +/- .9 volts (6.4 to 8.2 volts). Fuse F5. Used to power the general illumination.
- **TP5** = 43 volts DC, +/- 5.4 volts (47.6 to 48.4 volts). Fuse F4, bridge BR3. Used to power all the coils.

If getting a voltage below the above value ranges, that associated bridge rectifier is probably bad and needs to be replaced. If TP4 is out of limits, the transformer may need to be replaced! TP4 is an AC voltage that doesn't get converted to DC, and hence doesn't have a bridge rectifier.

Check the Rectifier Board Fuse Clips (HOT fuses!).

Often the metal clips that hold the fuses in place on the rectifier board fatigue, corrode, and turn brown in color. This can cause a bad connection with the fuse. These fuse clips need to be replaced! They have become hot and are acting like resistors, not connectors. Also these clips can fatigue and not have a good "spring" action to them. This means the clips again don't make good contact with the fuse. There is no fix for this; just replace them!

The high amp fuses on the rectifier board show this problem the most. These fuses will get hot the quickest, and can generate a lot of heat. Once the fuse clips get hot and discolor, they must be replaced to fix this problem.

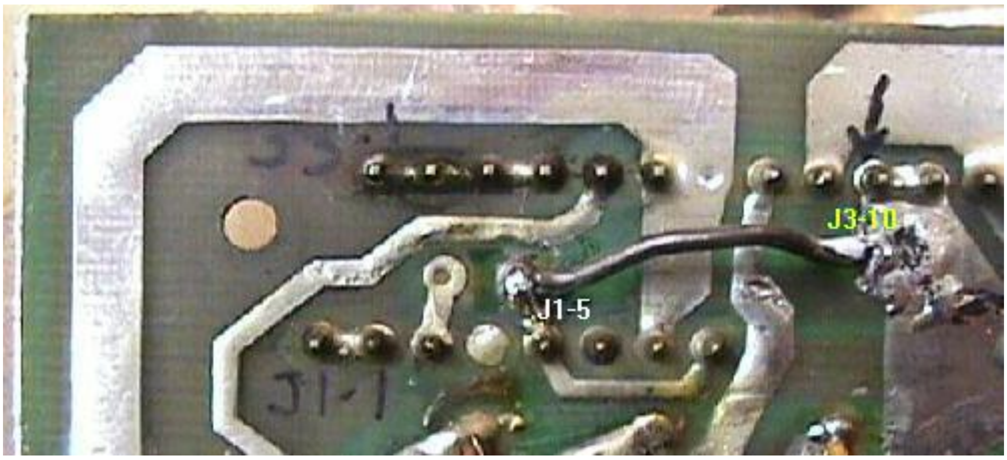
First Upgrade: #47 Light Bulbs instead of #44.
This "upgrade" is actually VERY important! Change ALL the playfield light bulbs from #44 to #47 bulbs. The #47 bulbs consume less power, and put less of a strain on the power supply's transformer, connectors, and bridge rectifier. Sounds ridiculous, but it's true. The difference in amperage is very small, but with 75 of these lamps, it really adds up!

Number 47 lamps are a 150 mA (0.945 watt) lamp, where #44's are 250 mA (1.575 watts) lamp. The difference between the two lamps is 100 mA (.63 watts). If there are 75 of these bulbs, having #44's installed is like adding a 50 watt light bulb to the game. The additional power consumption uses more produces more heat and strain on the connectors and plastic game parts.

Rectifier Board Upgrades for AS2518-18 / AS2518-49 and Stern.
If the game has a Stern or Bally AS2518-18 or AS2518-49 rectifier board (pre-1981), these upgrades need to be done. Note the Stern rectifier board is identical to Bally's AS2518-18 model. This will make the power supply more reliable. Note that after making all these upgrades, one could use an older AS2518-18 power supply in a game calling for the AS2518-49 power supply (they are pin compatible, except for an added pin to double up the switched lamps on connector J1). However the whole power supply must be switched (including the transformer), and not just the rectifier board. Not advisable to switch, but it can be done in a pinch if these modifications are made. Note female connector J1 will have on extra pin that will hang over the edge of the J1 male pins.

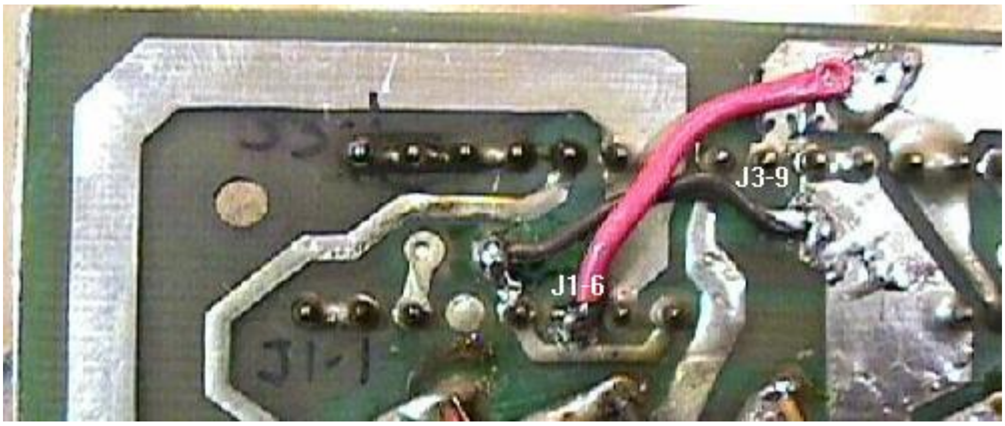
57. Replace ALL the .156" header pins on the rectifier board. Chances are these header pins are brown. Even if just slightly burnt (brown), this means the pins are acting like small resistors. Replace them all with new pins. Sanding the pins and re-tinning them is only a short term fix. Sanding removes the protective plating on these pins, which means they will brown up again. Just replace all the pins and be done with it. When replacing the header pins they are also being re-soldered, which solves another common problem of cracked solder joints on these pins.

Mod 2: adding a jumper from J1-5 to J3-10 on the solder side. Note the convenient plated through holes were used for the wire.



- On the solder side of the rectifier board, add a jumper wire from J1-5 to J3-10. Note there are plated through holes in the circuit board that make this mod very easy. This adds additional area for the 7.3 vac general illumination lines.

Mod 3: adding a jumper from J1-6 to J3-9 on the solder side.

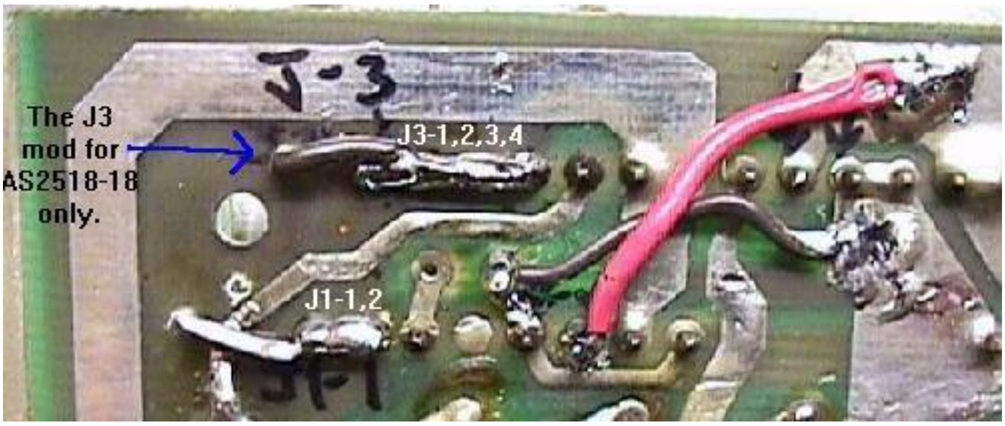


3. On the solder side, add a jumper from J1-6 to J3-9. Since there are no plated through holes here, solder the wire directly to the header pin and the circuit board trace. This adds additional area for the 43 vdc solenoid lines.
4. On the component side, drill a 5/64" hole to the left of the header jack J1. Drill this hole exactly where shown in the picture below, which is to the left of the marking "J1". If a AS2518-18 is being modified, also drill another 5/64" hole to the left of the header jack J3. Drill this hole exactly where shown in the picture below, which is to the left and above the marking "J3". NOTE: Drilling these two holes is optional.

Mod 4 & 5: On the component side a 5/64" hole was drilled next to the marking "J1". On rectifier board AS2518-18 (only), another hole above and next to the "J3" marking on the board was drilled. The drilled holes are optional (the wires can also just wrap around the edge of the board).

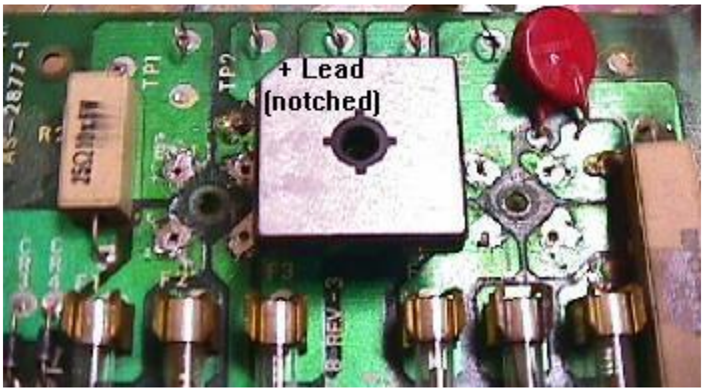
5. On the component side scrape the green solder mask off the surrounding ground trace which the hole(s) goes through. If no hole(s) were drilled, still scrape the green solder mask off the large ground trace, to the side of the header pins (where the hole(s) would have been drilled). Solder wire(s) to this trace and fed it through the drilled hole(s). If no holes were drilled, the wire can instead be fed around the edge of the board. On the solder side, solder the other end of the wire to head pins J1-1/J1-2. This adds additional area for the 7.3 vac general illumination ground lines. For AS2518-18 only, solder the second wire to pins J3-1,2,3,4 on the solder side of the board. This wire add additional ground area for the lamp driver ground.

Mod 4 & 5: On the solder side, the wires go through the drilled holes (or around the edge of the board, if the optional hole(s) are not drilled) and soldered to their respective header pins. The J3 modification is only needed on rectifier board AS2518-18.



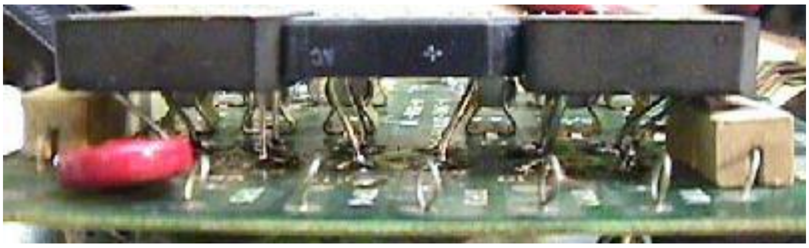
6. Desolder the three (or two, if it is a AS2518-49 rectifier board) bridges from the bottom of the rectifier board.

Mounting the larger 35 amp bridge on the component side of the AS2518-18 rectifier board. The middle bridge must be mounted first! Note the "notch" in the bridge (the "+" lead) is mounted at the top. Add heat sinks to the bridges BEFORE installing them as it's a lot easier (not shown).



7. If it is a AS2518-18 rectifier board (with the three bridges), install a new 25 amp, 200 volt (or higher) wire lead bridge in the **middle** position, on **top** of the rectifier board (originally the bridges were soldered to the bottom of the board). Note the offset lead (and the notch) on the bridge is the "+" lead of the bridge. Install the bridge at least 1/2" off the board to allow good air flow under the bridge. Do not solder the bridge in place yet. Add heat sinks to the bridges before installing them. These may be bought at Radio Shack (part# 276-1363 or 276-1368).

AS2518-18: Notice the "dog leg" bends in the power supply leads to allow these larger bridges to be used. Again note the "+" lead is mounted at the top.

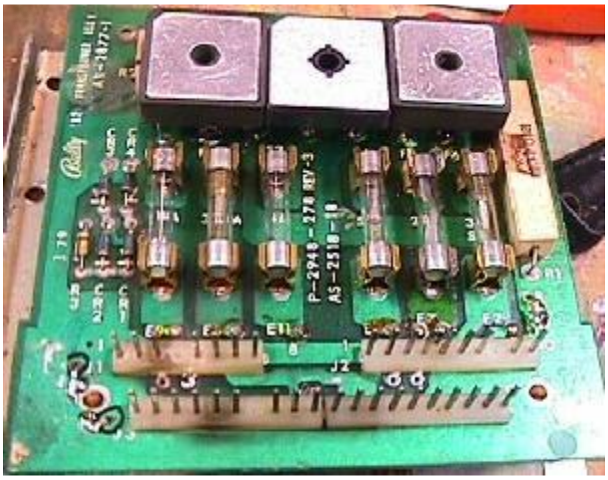


AS2518-49: The "dog leg" bends are less prevalent here because there are only two bridges to install on this rectifier board.

8. Install the remaining bridge(s) (either model rectifier board). To install them, "dog leg" the bridges to get them to fit. It's Ok if the bridge's

metal casing touch. Install the bridges at least 1/2" off the board to allow good air flow underneath. Do not solder the bridges in place yet.

Left: *A top view of the newly installed bridges on a AS2518-18 rectifier board.*
Right: *A top view of the newly installed bridges on a AS2518-49 rectifier board.*



9. Before soldering the bridges in place, it's a good idea to bolt a heat sink to the top of the bridge. This is optional, but highly recommended (see below for more details).
10. After all the bridges are installed, and their placement is good, solder them in. Solder the bridge leads on both the front and back sides of the rectifier board, to ensure good contact.
11. Replace diodes CR1, CR2, CR3, CR4 with new 1N4007 diodes. Make sure to install the new diodes with the band in the same direction! These diodes are used for the high voltage (score displays), and are often heat damaged.
12. Check that resistor R2 (25 ohms 5 watts) is not damaged. Check its value with a multi-meter. This resistor gets quite warm during operation, and can crack. Replace if a value is seen outside 23 to 27 ohms.
13. Check that the correct fuse values are installed in the rectifier board.
14. When installing the rectifier board back onto its plastic standoffs, note the screws and the metal heat sink plate used to bolt the bridge rectifiers to the metal case are no longer needed. These may be discarded.

Install heat sinks BEFORE soldering the bridges in place! (it's a lot easier to do it before). I bought my bridges, heat sinks, and heat sink compound at Radio Shack. The heat sinks are really designed for transistors, but they work well on the bridges too.

Installing Heat Sinks on the Bridges.
John Robertson recommended doing this, and I would agree it is a good idea. Bridges can fail from heat fatique. Installing a heat sink increases the surface area of the bridge, allowing it to cool easier. It really is a good idea as any bridge installed will get hot.

Aluminum transistor heat sinks are available at Radio Shack part #276-1363 or #276-1368. They bolt right to the top of the bridges. The 276-1368 model uses a 4-40 screw (not included). Make sure to buy some heat sink compound (Radio Shack part# 276-1372) too. This aids in the heat transfer from the bridge to the heat sink. It is required! Just spread a thin layer on the top of the bridge before bolting down the heat sink. Get one heat sink per bridge. Note it's a lot easier to install the heat sink BEFORE soldering the bridge in place.

Testing rectifier board upgrade work on the bench. Just hook up 110 volts to connector J2 pins 6 and 7, and the voltages can be tested at the test points. Here we're testing TP2.

Testing Rectifier Board Upgrade Work.
After doing all the previous rectifier board modifications, test your work right on the bench, without installing the power supply back into the game. To do this

requires only a power cord, and two alligator clip wires.

Connect the two alligator clip wires to connector J2, pins 6 and 7 on the rectifier board. Then connect the other end of each aligator clip to a 110 volt power cord. When plugging the line cord into the wall, the power supply will be turned on. Then test the rectifier board's "test points" for proper voltages. The voltages may be slightly different than previously dicussed above, since there is no load on the power supply. No load can cause voltages to vary somewhat. Connect the black (negative) lead of a DMM multi-meter to R1's lead closest to the fuses. This is approximately the readings that should be seen:

- TP1 (AS2518-18): 6.4 volts DC.
- TP1 (AS2518-49): 8.2 volts DC.
- TP2 = 195 volts DC (could be as low as 150 volts).
- TP3 = 13.5 volts DC.
- TP4 = 7.5 volts AC.
- TP5 = 47 volts DC.

If the voltages seen are drastically different than the above, check your work. Also check resistors R1 (600 ohms) and R2 (25 ohms).

Test your work with the power supply installed in the game. Just hook up connector J2 (only!), and leave J1 (playfield power) and J3 (logic board power) disconnected. Turn the game on and check the voltages as described above. Having the J1 and J3 connectors removed will isolate the power supply from the rest of the game.

Rectifier Board Fuses.
Here is a list of the rectifier board fuses. This applies to all generations of Bally power supplies from 1977 to 1985.

- F1 = 10 amp fast-blo (CPU controlled feature lamps)
- F2 = 3/4 amp slo-blo (score display high voltage)
- F3 = 4 amp fast-blo (unregulated +5 volts)
- F4 = 5 amp fast-blo (solenoids, if game has 2 flippers)
- F4 = 6 amp fast-blo (solenoids, if game has 3 flippers)
- F4 = 7 amp fast-blo (solenoids, if game has 4 flippers)
- F5 = 20 amp fast-blo (general illumination lights)
- F6 = 3 amp slo-blo (incoming 120 volts AC line power)

Rectifier Board Fuse Always Blows.
If powering on a game, and the fuse immediately blows, there's a good chance one of the bridge rectifiers is shorted. Try replacing the fuse's associated bridge. Or just do the modification listed above (which replaces the bridges with bigger models).

- F1 - BR1 (or on AS2818-49, one or both of the voltage regulators RP1, RP2). Used to power the "switched illumination" (feature lamps).
- F2- CR1 to CR4 (four 1N4004 diodes that act like a bridge). Used to power the score displays.
- F3 - BR2. Used to power the regulated +5 volts DC.
- F4 - BR3 (check varistor on the rectifier board too). Used to power the coils.
- F5 - no bridge. Short in the 7.3 volt AC general illumination circut.
- F6 - no bridge. Short in the main 110 volt AC power circuit. Check the varistor and the line filter in the cabinet.

Fuse F5 - General Illumination (G.I.) Fuse Woes.
There isn't much to this circuit, so if fuse F5 blows, this usually means there is a shorted general illumination bulb or socket. This is never a quick or easy fix - you'll have to do quite a bit of looking and eliminating to find the problem.

First, a good idea is to purchase a clip-on circuit breaker. Instead of replacing the F5 fuse for each test "power on", the circuit breaker can be reset and reused. This is great for G.I. problems and saves lots of money on fuses. Just clip the breaker onto the rectifier board's fuse clips with alligator test leads. A mini circuit breaker can be purchased from any lighting store.

To issolate the G.I. problems:

0. Remove connector J1 (playfield) and J3 (backbox) from the rectifier board, leaving J2 (cabinet wiring) connected. Power up. If fuse blows, there is a short in the main cabinet G.I. wiring (probably the coin door lamps).
1. If fuse doesn't blow, remove connector J1 (playfield) from rectifier board, leaving J2 (cabinet) and J3 (backbox) connected. Power up. If fuse blows, there is a short in the backbox GI wiring.
2. If fuse doesn't blow, remove connector J3 (backbox) from rectifier board, leaving J2 (cabinet) and J1 (playfield) connected. Power up. If fuse blows, there is a short in the playfield GI wiring.

Each time plug J1/J2/J3 is removed, that part of the G.I. circuit is removed. What ever plugs are left connected are the wiring sections being tested. If the short is in the cabinet wiring, this is easy to fix. Just examine the coin door lamps. If the backbox wiring is the problem, this too is fairly easy to examine. A very common problem here is the ground braid that connects the head to the backbox. This can bunch up and touch one of the lamp sockets on the back side of the insert (display) panel (when the insert panel is closed). Unfortunately the playfield G.I. is the most troublesome section.

Now that the offending section (playfield!) has been isolated, it is time to further isolate which strand of lamps has the problem. There are two G.I. lines in the game- red/white wires, and orange/green wires. Now find a strand (either one), and de-solder one of the lead wires to the strand (thus taking the strand out of circuit). If there is a double wire (double green, orange, red, white) on the strand, be sure to keep the double wire connected together once it's removed from the strand. This lets other strands "downstream" continue to have power. The basic idea is to disconnect a strand, power up, watch the fuse (or breaker), and repeat until you find the offending strand.

It's never easy or quick to find a problem like this, but this is about the only way to systematically find the short without pulling out every bulb or looking at every socket/wire.

The Playfield Solenoids Don't Work.
First thing to check is the under the playfield fuse might be blown. Next check fuse F4 on the power supply regulator board. Also check it's fuse clip is in good condition with good tension, and is not brown. Now check TP5 (test point 5) on the power supply regulator board. A voltage of about 43 vdc should be seen. If no voltage at TP5, assume the bridge BR3 on this board is bad and replace it.

After getting +43 vdc at TP5, then check connector J1, pin 6 on the power supply regulator board. This brown wire goes directly to the playfield flipper coils. If there is +43 volts at the connector, but not at the brown wire on the flipper coils, there is a problem in the wiring.

Also note +43 volts on some games is used on the early A8 sound board (Lost World to Dolly Parton). A problem on this sound board (or a bad connector there) can cause problems.

If the game is not getting the 7th MPU LED flash, that means +43 volts is missing. After checking all the above, verify there is +43 vdc on the MPU board on the left (connector) side of R113. Now check the right side of R113. If no voltage there, then replace R113 (2k, 1/4 watt) and retest. If still no voltage, there may be battery corrosion damage in this area of the MPU board.

Power Supply AS2518-54 Rectifier Board Upgrades.
The power supply changed for all games Xenon and later. Instead of a bridge to rectify 12 volts AC to +5 volts DC (though bridges are still used for the switched lamps and the solenoid voltages), four individual diodes were used. These diodes can become "leaky" (they normally run somewhat hot). This can cause AC ripple to enter the +5 volts logic circuits, which can cause the game to reset or have other intermittent problems. For games this age, these diodes should be replaced!

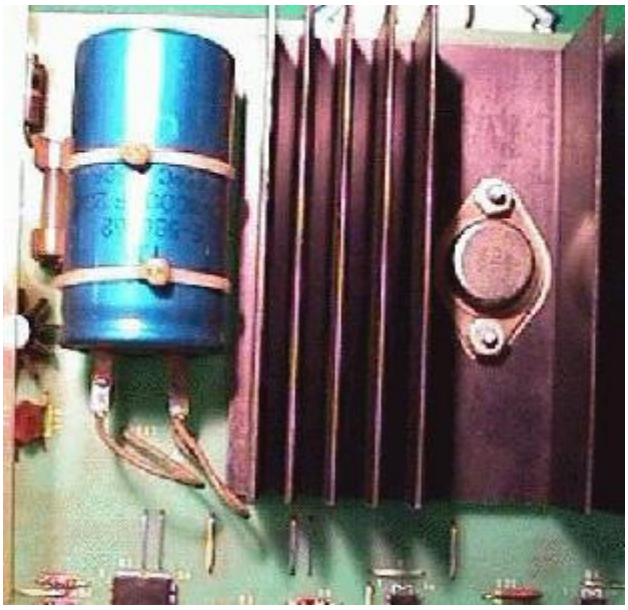
The replacement diodes should be a 6A50 (6 amp, 50 volt or higher) diodes (games Eight Ball Deluxe and later were fitted with this size diodes). Higher voltage diodes can be used too, like a 6A2 or 6A200 (6 amp, 200 volt) or even 6A4 (6 amp 400 volts). Radio Shack sells a decent replacement, part number 276-1661. Also, 1N4004 or 1N4007 diodes could be used, but this is not recommended! The amp rating on 1N4004/1N4007 diodes is only 1 amp, compared to the 6 amp diodes that should be used.

2c. Before Turning the Game On: Upgrading the Voltage Regulator/Solenoid Driver Board.

The voltage regulator board and solenoid driver board takes the DC voltage from the power supply, and smoothes it out. It also has all the transistors that drive the solenoids.

The +5 volt Logic Filter Capacitor.
After power leaves the rectifier board, it goes to the voltage regulator/solenoid driver board. There the +5 DC logic voltage is smoothed using a filter capacitor, known as C23. Capacitors are partly a mechanical device that wear out with time. When "leaky" (the term used when a cap is worn out), they do not smooth the DC voltage properely. When the +5 volts (which powers all the logic boards in the game) is not smooth, this can cause random and unpredictable game problems.

Left: *C23, the 11,000 mfd at 20 volt blue filter capacitor on the voltage regulator/solenoid driver board. Believe me, it needs to be replaced!*
Right: *The bottom view of the C23 filter capacitor. This is about as bad as they get; this capacitor has developed a visible bubbled hole in it just above the positive (red) terminal!*



Filter caps are designed to last about 10 years. So that means ALL Bally games from 1977 to 1985 should have their C23 +5 volt filter capacitor replaced. Replace the filter cap with a higher value than 11,000 mfd, and a higher voltage than 20 volts, if desired, but never lower values. "Computer grade" caps work well and are inexpensive. Digikey also sells a nice 15,000 mfd 35 volt capacitor, part number P6425-ND, for about $7 each. This capacitor is the correct size and well suited for this task. It is the perfect replacement (but is somewhat expensive). I don't suggest going higher than 15,000 mfd though, because it puts unneccesary strain on the bridge rectifier from charging the capacitor when the game is turned on.

A replacement 15,000 mfd at 20 volt cap for C23. Yes it's a bit too long, but the price was right! It is possible to go higher in value (either MFD or volts), but NEVER go lower! Note the replacement date was written right on the capacitor.

Upgrading the Voltage Regulator/Solenoid Driver's Ground.

There is a design problem on the voltage regular and solenoid driver board's ground lines. The ground comes from the power supply to the solenoid driver board, goes through the filter cap and voltage regulator, and then leaves the board through a connector and goes back to the power supply. It then turns around and comes back from the power supply, through the connectors, and back to the solenoid driver board. This puts unnecessary strain on the board's connectors and header pins. It can also give unreliable game play.

For newer (about 1979 and later) Voltage Regulator/Solenoid Driver boards, on the solder side, jump a piece of wire from the negative lead of capacitor C23 (the large filter cap we replaced above), to the trace right below it. This takes the presure off the connectors, stopping pin 10 on J3 on the solenoid board from burning.

On older (pre-1979) Voltage Regulator/Solenoid Driver boards, on the solder side, jump a wire from the negative lead of capacitor C23 (the large filter cap we replaced above) directly to connector J3, pins 18-22 (pins 18 to 22 are all connected together).

NOTE: do NOT do this modification to Baby Pacman's Voltage Regulator/Solenoid Driver boards! Baby Pacman uses a unique version of these boards which is similar, but not exactly the same.

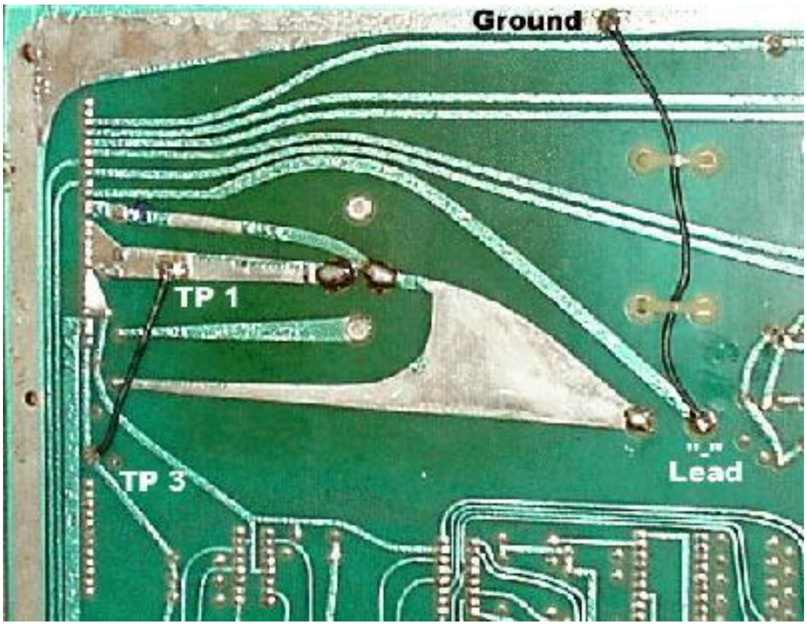
Upgrading the Voltage Regular/Solenoid Driver's +5 volts.
There is also a design problem on the voltage regular and solenoid driver board's +5 volts. Like the ground, the +5 comes from the power supply to the solenoid driver board, goes through the filter cap and voltage regulator, and then leaves the board through a connector and goes back to the power supply. It then turns around and comes back from the power supply, through the connectors, and back to the solenoid driver board. Just like the ground line, this puts unnecessary strain on the board's connectors and header pins. It can also give unreliable game play.

To correct this problem, add a wire from TP1 to TP3. Jump these either on the solder or component side of the board. In the picture above, I jumped them on the component side for clarity. But jumpering on the solder side looks a bit neater. This mod helps saves pins 13 to 25 on J3 on the solenoid board.

NOTE: do NOT do this modification to Baby Pacman's Voltage Regulator/Solenoid Driver boards! Baby Pacman uses a unique version of these boards which is similar, but not exactly the same. Tying TP1 to TP3 will short the unregulated 12 volts to ground.

Left: *On the solder side of a 1979 or later solenoid driver board, jump a wire from the negative lead of C23 to the trace directly below it.*
Right: *On the component or solder side of the solenoid driver board, jump TP1 to TP3.*

The Stern SDU-100 solenoid regulator board, with the modifications. Although the circuit is the same, the board layout is quite different. Shown is the jumper from TP1 to TP3, and the jumper wire from the negative lead of C23 to ground.



Check Voltage Regulator/Solenoid Driver board J3 Connector Pins 10-12 and 13-17.

On the Voltage Regulator/Solenoid Driver board, connector J3 can often be over stressed and burned. In particular, connector J3 pins 10 to 12 (orange wire, +5 volts) and J3 pins 13 to 17 (white wire with a brown trace, ground) are often burned. If any of these pins are even slightly brown, both the header pins and the connector pins should be replaced. Trifurcon replacement pins are highly recommended.

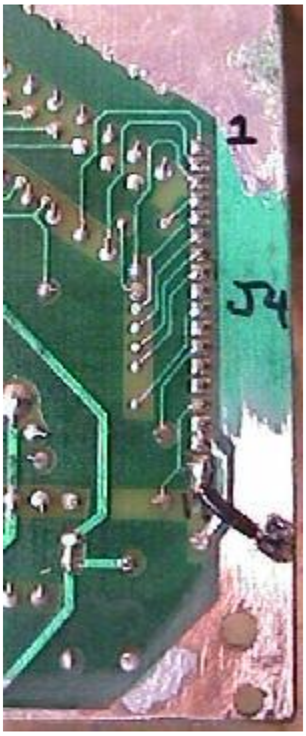
Are Solenoid Driver board AS2518-16 and AS2518-22 Interchangable?

Yes, these two different generations of solenoid driver boards are interchangable. The differences between the two boards are minor. For example, the newer -22 version has an added 8AG 3/16 amp fuse in the high voltage voltage section.

2d. Before Turning the Game On: Upgrading the Ground on the MPU Board.

Bally MPU boards AS2518-17 and AS2518-35 have a very poor connection to ground. The only place that ground from the power supply is connected to logic ground is on the component side of the MPU board. This happens underneath the header pins at J4 pins 18, 19. If the MPU board has been corroded in this area, the J4 header pins can be damaged. The solder joints for the pins can be cracked on J4 from plugging and unplugging the connector, giving a bad ground connection too.

The solder side of a Bally MPU board. The last two pins (18,19) of connector J4 need to be jumped to the large ground trace.



To ensure a good ground contact, add a short insulated jumper wire on the back (solder) side of the board. This jumper should go from J4 pins 18, 19 (the last two pins on the connector) to the ground plane along the edge of the MPU board. Do this on ALL Bally MPU boards encountered, whether they have battery corrosion or not.

Newer Games with Foil Covered Cardboard Ground in the Backbox.
On games such as Eight Ball Deluxe (EBD), Bally used a foil covered cardboard as the ground plane in the backbox, behind the circuit boards. This can cause a couple problems. First, the cardboard can warp and short to the back of the circuit boards. Also, the foil wrapped cardboard can cause an intermittent ground to the circuit boards. The intermittent ground can cause strange problems including score displays which flicker, and flipper that work intermittently.

To fix this, run a wire (daisy chain) to one metal bracket on each of the backbox circuit boards. Then connect this wire to a metal "real" ground in the cabinet. Also make sure the green solder mask on each circuit board is not insulating a circuit board from the metal mounting bracket.

2e. Before Turning the Game On: Ok, So You Didn't Do the Above. You BETTER do This!

Ok, so you're impatient, cheap, or both, and don't want to do the above modifications BEFORE turning the game on. Well if that's the case, at least do this before turning the new (unknown working condition) game on that was just bought!

Remove Connector J1 and J3 from the Power Supply's Regulator Board.
Removing connectors J1 (playfield) and J3 (backbox) from the power supply's rectifier board will disconnect all the power to the game boards. Power the game on and check the voltages at the test points on the regulator board to see if they are correct. This will prevent any damage to the boards if voltages are out of spec. If fuses are blowing on the power supply's regulator board, this also isolates them from the rest of the game. This means it could only be bad bridge rectifier(s) causing the trouble. All the following voltages can vary plus or minus by as much as 10 percent.

- TP1 (AS2518-18): 6.4 volts DC.
- TP1 (AS2518-49): 8.2 volts DC.
- TP2 = 195 volts DC (could be as low as 150 volts).
- TP3 = 13.5 volts DC.
- TP4 = 7.5 volts AC.
- TP5 = 47 volts DC.

If any of these voltages are out, rebuild the power supply as described above.

Remove Connector J4 on the MPU Board.
After doing the above and checking the voltages, reconnect the rectifier board's J1 and J3 connectors. But remove the MPU board's J4 connector. This connector supplies power from the power supply to the MPU board. Power the game on, and again test the voltages to make sure they are Ok.

Check the AC Ripple on the Solenoid Driver Board's C23 Capacitor.
Before connecting the J4 connector on the MPU board, check for AC ripple on the solenoid driver board's big C23 capacitor. This capacitor takes +5 volts DC from the rectifier board, and makes it smooth. If this cap is bad, it will not be giving the MPU board good voltage. To test this, try this:

- Remove connector J4 form the MPU board.
- Turn the game on.
- Put the DMM on AC volts.
- Put the DMM leads on the solenoid driver board's C23 capacitor.

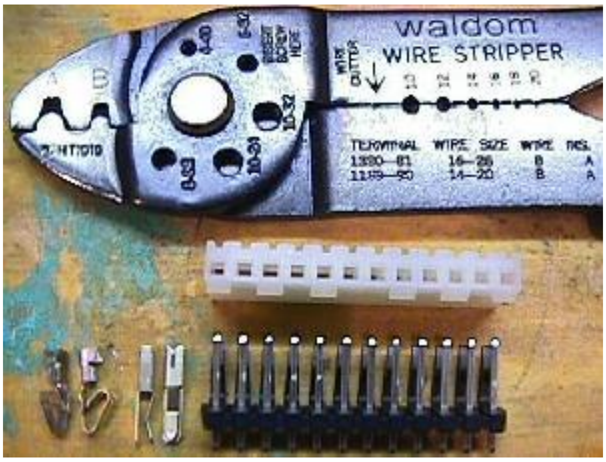
An AC voltage of less than .3 volts should be seen. Any more than that, and C23 is not doing its job, and needs to be replaced. Do this BEFORE you put power to the MPU board! The replacement procedure is described above.

Cut the MPU's Battery off the Board!
If the MPU's battery hasn't already started to leak and corrode the board, consider yourself lucky! Cut that old MPU battery off the board and throw it away. You'll be saving tons of work down the road. The game will work fine without the battery (note some games will default to a different sound pattern, which is held in battery-powered memory). Then later a remote battery holder or a battery back-up capacitor can be installed.

2f. Before Turning the Game On: Connectors.

Connectors are a major problem on any older pinball game, including 1977 to 1985 Bally games. Inspect all connectors for signs of heat damage. If any burnt connectors are found, replace BOTH the board header pins, AND the connector pins. Replace with the same crimp-on variety pins. Don't replace just the header pins or the connector pins. BOTH must be replaced! Otherwise the new part will quickly become tarnished and ruined by the resistance and heat created by the old part.

A crimping tool (top), two different types of pins (left), and a new connector housing and male pins. Note the connector pins; the far left two pins are the crimp-on, single wiper type. The two pins on the right are insulation displacement pins, but with two wipers. It's ideal to use the crimp-on style pin, but with two wipers (not shown).



Connector Pins (Trifurcon type).
Molex makes a crimp-on .156" size female terminal pin called a "trifurcon" pin (not available in the .100" pin size). This style .156" pin differs from the "normal" pin; it has three wiper contacts instead of just one. The more contact points means the female pin "hugs" the male header pin with greater surface area. These are highly recommended. The specs for these pins can be viewed at http://www.molex.com/product/pcb/6838.html. Compares these to the "normal" connector pin specs at http://www.molex.com/product/pcb/2478.html.

Note Molex sells these pins in "strips" or on a "reel". Do NOT buy connector pins this way! Always buy them in "bags" (separated). It's just too difficult to cut them when they are in strips (sharp scissors do work pretty good for cutting them though). If a good job cutting them is not done, the pins will not insert into their plastic housing correctly. Also always get the tin plated version, NOT the gold plated pins.

- .156" Trifurcon pins (three wipers): Molex part# 08-52-0113 (tin plated phosphor bronze) or 08-50-0189 (tin plated brass), for 18 to 20 guage wire. Digikey part# WM2313-ND. Mouser and Competitive Products (#06-2186) also sells these.
- .156" tin pins (one wiper, not suggested): Molex part# 08-50-0106, for 18 to 20 guage wire. Mouser sells these.
- .100" pins: Molex part# 08-50-0114. Digikey part# WM2200-N, and Mouser sells these.

Board Mounted Header Pins.
These are available in several styles. Get the most number of pins available, and cut the header to the size needed. They also come with a "lock" and without

a lock. The lock variety is what will be used the most. Mouser sell these.

- .156" header pins with lock (12 pins), part# 26-48-1125.
- .156" header pins with no lock (12 pins), part# 26-48-1121.
- .100" header pins with lock (12 pins), part# 22-23-2121.
- .100" header pins with no lock (12 pins), part# 22-03-2121.

Connector Housings.
Sometimes the plastic connector housing will need to be replaced too if it is burnt, in addition to the pins within the housing. Get the most number of pins available, and cut the connector to the size needed. Remember though, the connector housing does not influnce how well the connectors actually work.

- .156" black hi-temp housing: Williams part #5792-13384-xx. The "xx" is the number of pins for the housing from "02" to "18". Pinball Resource sell these.
- .156" white housings (12 pins), part# 09-50-3121: Mouser.
- .100" white housings (12 pins), part# 22-01-3127: Mouser.

Polarized Pegs.
A polarized peg is a small nylon plug that go into the connector housing so the housing is "keyed" (plugging it into the wrong board header pin connector is impossible). It is highly recommended to use these when replacing a connector housing. Mouser sells these.

- .156" polarized peg, part# 15-04-0220.
- .100" polarized peg, part# 15-04-9210.

What Connectors Pins are Needed?
Both .100" and .156" connectors are used in Bally/Stern games. The larger .156" connectors are used on the Solenoid driver board, sound board, and score displays. The smaller .100" connectors are used on the MPU board, Lamp driver board, and the Solenoid driver board.

2g. Before Turning the Game On: Setting Free Play.

Checked out the dip switch settings on your 1977 to 1985 Bally or Stern game, and one will notice there is no provision for free play on these games. The best that can be done via the dip switches is to set the first replay to 10,000 points. Then every game the player will probably get at least 10,000 point, so a free credit should be earned with every game. That is about the best/easiest advice for making these games "free play".

There is another solution though without having to put quarters in the game. This procedure outlines how to make the start button also work as a credit button too. When the start button is pressed, it automatically adds a credit, then starts the game (thus removing the just added credit). To do this double up the credit leaf switch with another leaf switch, which will add the credits.

Parts Needed:

- An old leaf switch.
- Fish paper.
- Some wire.

Procedure:

- Set game dip switches so that at least one coin switch is set to one coin/one game (1/1). Set the replay level to a "normal" (factory default) amount. Set the maximum credits to as high as they will go.
- Remove the existing start leaf switch from the inside of the coin door by removing the two screws.
- Unstack the stacked leaf switch and add the additional (two contact) leaf switch. Some of the spacers will probably need to be removed to do this.
- Make sure there's some "fish paper" (insulating paper) between the two switches so they do not touch (short) when the button is pressed! Also make sure the last leaf doesn't touch the metal backing plate (this can cause a bunch of strange and weird operational problems!).
- Re-assemble the leaf switch and install back into the coin door.
- Make sure the newly added switch is activated **first**, before the start switch is activated.
- Attach the two leads of the new leaf switch to the coin switch adjusted in the first step.

Now when the start button is pressed, a credit will first be added, and then the game will start and remove the just-added credit. This works especially great if there is no battery installed (hence unused credits are lost when the game is powered off). Otherwise additional unused credits will pile up from matches and replays, until the maximum credit limit is reached. If this is a problem, the match and replay can be disabled options via the dip switches.

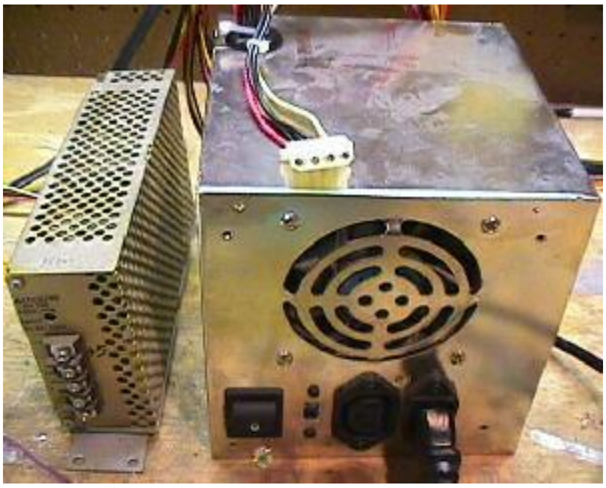
3a. When things don't work: Making a MPU Test Fixture.

If your game is not working, chances are the MPU board is at fault. To fix the board, you'll have work on it on your bench, then install it in the game to test it. I found this too tedious when doing MPU repairs. Instead, I constructed a simple test fixture I would use to test the MPU board right on my workbench.

The J4 MPU Board Connector.
If you don't want to make a work bench test fixture for repairing your Bally MPU board, there is an easy way around this. Assuming your Bally power supply is working correctly in your game, when testing a Bally MPU board, you only need to use connector J4 on the MPU board. The J4 connector is the power connector. With it only attached and a working power supply, you can quickly test your Bally MPU right in the game.

Making a Test Fixture.
To make a test fixture, you will need some sort of power supply that will deliver +5 and +12 volts. You can buy a video game switching power supply (about $25), or you can use an old computer power supply. Either will work fine. Old computer power supplies are plentiful, and often $15 or less, used.

On the left is a video game switching power supply. On the right is a used computer power supply. Either will work fine for a test fixture. Note the computer power supply connector on top of the box is the one that will supply our +5, GND and +12 volts. This plug was used to power drives (hard drive, CD rom, etc). Red is +5, black is GND, and yellow is +12.



In either case, all you need to do is connect the power supply to a wall plug (110 vac), and put aligator clips on the GND, +5 vdc and +12 vdc. That's all you need to power up a Bally MPU board on your workbench!

On a computer power supply, the best way to do this is to use one of the plugs that connected to the computer's hard drive, floppy drive, or CD ROM drive. There are usually at least three of these 4 pin plugs on each computer power supply. These plugs have two black wires, and one red and one yellow wire. The two black wires are ground, the red wire is +5 vdc, and the yellow wire is +12 vdc. I used some crimp-on male connector pins and jammed them into the plug. Then I connected these to aligator clips, which ultimately go to your MPU board.

Using a computer power supply on the workbench to power a Bally MPU board.

On the MPU board, the test points to connect the aligator clips to are:

- TP5 = +5 volts (right next to the battery). Red power supply lead.

- TP4 = GND (opposite end of the board from the battery). Black power supply lead. Don't get this confused with TP1, which is right next to it!
- TP2 = +12 volts (on the same side of the board as the battery; don't get this confused with TP3, which is right next to it!). Yellow power supply lead.
- TP3 = +21.5 volts (right next to TP2). No power supply lead since neither a computer power supply or a switcher supply this voltage.

Once you have your test fixture constructed, you can diagnose Bally MPU problems with the flashing LED on the board easily. Instead of putting the board back in the game to test it, just turn your power supply on and count the flashes!

Warning!!
Be careful when you hook up the voltages to your MPU board. If you short +12 volts to +5 volts (for example), you will probably destroy all the chips on the MPU board! Also be careful when you hook up +12 volts to TP2. It is VERY easy to short TP2 to TP3. This may damage the MPU board too! (Unlikely, but let's not risk it). So be careful, and double check your connections before you turn the power supply on.

To get the last flash from the MPU board, 20 to 25 volts DC is needed at test point TP3 on the MPU (or put a temporary alligator jumper wire from chip U12 pin 3 to U14 pin 14). This can be done by purchasing an inexpensieve 25 volt transformer and bridge rectifier. I screwed this make-shift power supply to a board for easier use.

The Last LED Flash (missing voltage at TP3).
Using the above jig to power a MPU on your workbench will NOT get the last MPU LED "flash" in the power-on sequence. This happens because there is no +43 volts DC present (as used for the solenoids) on the MPU board, which has a circuit to detect this voltage. For most games, this means only getting 6 of the 7 total flashes (for a working MPU). The exception to this is Baby Pacman and Granny and the Gators, which only get 5 of the 6 total flashes. And since the last flash is not achieved, the board won't go into full attract mode.

There are *two* ways to solve this problem. The first is to trick the MPU board into thinking the 43 volts is present. To do this, put a temporary jumper wire on the MPU board, connecting chip U12 pin 3 to chip U14 pin 14. This can be done easily with an alligator jumper wire, connecting the top leg of resistor R23 (leg closest to chip U12) to the top leg of resistor R17 (leg closest to TP3). This is certainly the easiest approach.

The other solution is more realistic, but involves some parts (a transformer and a bridge rectifier). Radio Shack sells a 120 volt AC to 25 volt AC transformer (#273-1366) for $6 that works well for this. They also sell a 25 amp 50 volt bridge (#276-1185) for about $2.70, which is also needed.

To wire this up, connect the two black transformer wires that are together on one side of the transformer to a 120 volt power cord. The remaining three wires (two yellow, one black) on the other side of the transformer are the output. Connect the two yellow wires to the AC terminals of the bridge. The black (center tap) transformer wire you won't use. The bridge should have a label signifying at least one AC lead. The second AC lead is diagonal or across from the labeled lead.

The J4 connector of the MPU board. Notice the TP3 and TP2 test points at the upper right corner of this picture. The R113 resistor takes the +43 volts from J4 pin 15 and lowers it to +21.5 volts at TP3.

Another lead on the bridge should be labeled "+". This is the positive DC voltage output lead. The lead opposite or diagonal to this terminal is the negative DC lead. Connect the "+" lead to the MPU's test point TP3 (which is right next to TP2). Connect the negative bridge lead to ground (TP4) on the MPU board.

The output from the bridge will be about 25 volts DC. 43 volts DC is not needed because this connects 25 volts to the MPU board's TP3 test point, which is looking for 21.5 volts DC. What happens is the 43 volts DC comes from the rectifier board and goes to MPU connector J4 pin 15. Then the 43 volts goes through resistor R133, which lowers the voltage to 21.5 volts. Then a "zero crossing" voltage detection circuit looks for that 21.5 volts. If present, a working MPU board will flash the last time. If the voltage is missing, there is no last LED flash.

So instead of supplying 43 volts to connector J4 pin 15, we just skip resistor R133 and connect our 25 volt DC power supply directly to TP3. It's pretty easy to get a 25 volt transformer, but getting a 43 to 50 volt transformer is more difficult. The zero crossing circuit will work fine if you supply 25 volts DC (instead of 21.5 volts) to test point TP3.

The voltage supplied above with the transformer and bridge gives 25 volts DC to test point TP3. This DC voltage is NOT smoothed with a filter capacitor! This is done for a reason. The original Bally power supply doesn't filter this voltage, and for good reason. The zero crossing circuit requires the DC voltage "ripple" to work!

(Re-)Booting a MPU Board with the Test Fixture.
After connecting the test fixture to the MPU board, simply turn the power supply on and count the LED flashes. To **re-boot** the MPU board, simply short together (with a screwdriver blade) pins 39 and 40 of the U9 CPU. This will quickly reset the CPU, and the flash sequence will start over, without having to turn the power supply off.

3b. When things don't work: Fixing the MPU (LED flashes and the such).

I am assuming if your MPU board had any battery corrosion, that you have fixed it (see the Removing the MPU Battery and Fixing Corrosion section). Fixing a MPU board with corrosion is like a dog chasing its tail; a never ending path of frustration. Corrosion can cause intermittent problems. Take care of the corrosion first before trying to fix a MPU board.

Fixing a Bally MPU board, generally speaking, is one of the easiest game boards you will ever repair. The reason for this, is Bally uses a "LED flash test". The green LED (light emitting diode) lamp is right next to the battery on the MPU board. As the MPU board boots, it does self diagnostics. For each diagnostic test the MPU board runs, it flashes the LED when that diagnostic is complete. If a diagnostic fails, the boot up process stops, and the LED stops flashing. There are a total of 6 or 7 LED flashes during the boot-up process. This makes determining MPU board problems fairly easy.

First Step: Count the LED Flashes.
The first step in fixing a non-working game is to count the LED flashes. On a working MPU board, when you turn the game on, the LED should "flicker" (a very faint and quick flash), and then flash seven times (only six times on Baby Pacman or Granny and the Gators). If the board does not do this, the internal diagnostics have determined a problem. At this point you should remove the board from the game, and hook it up to your test fixture (which you made above in the Making a MPU Test Fixture section). Working on your MPU board on a workbench is much easier than trying to fix it, and then test it in the game itself.

The Last Flash.
If you game does the initial flicker, and then follows with all the flashes but the last flash (flash number seven, or flash six on Baby Pac/Granny), check your +43 volt solenoid power F4 fuse on the rectifier board before proceeding. This last flash verifies that the game has +43 volts for the solenoids. If it doesn't (the F4 fuse is blown), the game won't boot and won't finish the flash sequence.

No Flashes: the LED is Permanently On.
If you turn your Bally game on, and the LED stays on continually, this is one of the hardest problem to fix on these boards. A stuck on LED can be caused by any (or all!) of the following:

- The reset circuit is damaged (after all, it's in the battery corrosion area!). This includes transistors Q1 and Q2 (both 2N3904), Q5 (2N4403), and diodes CR5 (1N4148 or 1N914) and VR1 (1N959B or 1N4738A).
- The program ROM (read only memory) at U6 is bad.
- The ROM jumpers are incorrectly set for the U6/U2 ROMs installed.
- The U9 CPU microprocessor is bad.
- The U11 PIA (peripheral interface adapter) is bad.
- ANY of the sockets for chips U6, U9, U11 are bad.

The first and last points are probably the most common problems.

Go "Bare Bones" (What to Remove for the first "Flicker").
To get the initial flicker out of the MPU board's LED, you only need three chips on the MPU board. These three chips are U9 (the CPU), U11 (PIA) and U6 ROM (except on some Stern games, which also require the U2 and/or U5/U6 ROMs). Remove all other socketed chips! Once you get the initial flicker out of the MPU board, then you can re-install the other removed chips.

The Reset Circuit.
If the reset circuit is damaged, the MPU board will never start, and the LED will stay on at power up. Since the reset circuit is in the "corrosion zone", it is often damaged from battery corrosion. The reset circuit holds pin 40 (reset) of the U9 CPU low until +5 volts is "stable", and then sets pin 40 high (telling the CPU it can start the boot up process). While the reset section is holding pin 40 of the CPU low, the LED will be on. This is one part of the initial "flicker" seen when a working Bally board is first powered on.

Here's what to try first:

- With the MPU board OFF, Put a logic probe or DMM set to DC volts on pin 40 of the U9 CPU. The logic probe will be "low" (or the DMM at zero volts).
- Power the MPU board on.
- In just an instant, the U9 CPU Pin 40 should go "high" on the logic probe, or about 4.75 to 5.5 volts on the DMM. Repeat this for U9 pin 2, which also should also go high.

If the above happens, the reset circuit is probably working fine. If pin 40 of the CPU is low and never goes high, there is a problem with the reset circuit. Since pin 40 never goes high, the CPU will never start the boot process, and the LED will stay on.

Here's some other stuff to try:

- With the MPU board powered on and pin 40 of the U9 CPU high (4.75 to 5.5 volts), short the junction of resistors R1 and R3 to ground. To do this, find the junction where resistors R1 and R3 connect together. With the MPU board on, use a wire and short this junction to ground (TP4).
- U9 CPU pin 40 should now go low to zero to .5 volts while the R1/R3 junction is grounded.

The above procedure is simulating what the reset circuit is meant to do. If shorting the junction of R1 and R3 does not pull U9 Pin 40 from high to low, then there is a problem with the reset circuit. Most likely there is a problem with Q1 (2N3904), Q2 (2N3904) and/or Q5 (2N4403). Replace them all (they are cheap!) and repeat the above procedure. Also check/replace diode CR5 (1N4148 or 1N914). Finally check/replace diode VR1, which is a 1N959B (1/2 watt) or 1N4738A (1 watt), 8.2 volts (note VR1 is mis-labeled in the manual as "1N9598"). If you still can't get U9 CPU pin 40 to go low, there is some other problem in the reset circuit (corroded traces?).

Here are some other points to check. Turn the MPU board on and test:

- U9 pin 3 = 2.4 volts
- U9 pin 36 = 2.6 volts
- U9 pin 40 = 4.75 to 5.5 volts

- U9 pin 5 = 2.8 volts

If the above voltages check out, then the reset section is probably working correctly. This means your problem probably lies with chips U6, U9 or U11 (or their sockets), or incorrect MPU board jumpers.

A Reset Trick (LED stuck On) - Adding a Capacitor.
If having problems with the reset (LED stuck on), try shorting together (with a screwdriver blade) pins 39 and 40 of the U9 CPU. This will manually reset the CPU, since reset pin 40 gets set low by ground, pin 39. Essentially, the screwdriver blade is doing what the reset does. So if the flashes start and proceed, there is a problem with the reset section of the MPU board.

It could be the +5 volts is not stablizing within the "window" the CPU expects (about 50ms). To make the reset window longer, try putting a 470 mfd electrolytic capactor in the reset section (on the solder side of the MPU board). Solder the positive leg of this cap to the collector (top leg) of Q1. Then solder the negative leg of the cap to ground (the emitter of Q1). This will increase the reset timing length. Now test the MPU board. If the MPU board works and continues with the flashes, the +5 volts was just not getting "stable" in the 50ms window (there could be a power supply problem, probably with the large 5 volt rectifying capacitor on the driver board).

One note about this added reset capacitor. Since the 470 mfd cap increases the reset timing (the time pin 40 of the CPU is held low), the initial "flicker" may not longer be a "flicker". The LED will stay on longer (because the reset is longer), making the "flicker" more of a "flash".

If for some reason the $4.50/$10 is too much money, here are the typical parts needed for reset section repair:

- Q1,Q2 - Transistor, 2N3904
- Q5 - Transistor, 2N4403
- VR1 - Diode type 1N4738A, Zener, 8.2V (alternate for 1N9598)
- CR8 - Light Emitting Diode, Green.
- CR5,CR7 - Diode, Switching. 1N4148
- CR44 - Diode, Rectifier. 1N4004 (or better)
- C1,C2 - Capacitor, 820pF, Axial Ceramic.
- C5 - Capacitor, 4.7uF, Radial Tantalum.
- C3,C13,C80 - Capacitor, 0.01uF, Axial Ceramic.
- R1,R3,R24,R28 - Resistor, 8.2K, 1/4W, 5%
- R2 - Resistor, 120K, 1/4W, 5%
- R11 - Resistor, 82, 2W, 5%
- R12 - Resistor, 270, 1/4W, 5%
- R16 - Resistor, 2K, 1/4W, 5%
- R17 - Resistor, 150K, 1/4W, 5%
- R29 - Resistor, 470, 1/2W, 5%
- R107 - Resistor, 3.3K, 1/4W, 5%
- R112 - Resistor, 1K, 1/4W, 5%
- R134 - Resistor, 4.7K, 1/4W, 5%
- R140 - Resistor, 20K, 1/4W, 5%

Using a Dallas/Maxim DS1811 in the Reset Section.
There is also another way to fix the reset section. This involves using the new Dallas/Maxim Semiconductor D1811 reset chip (TO-92 package). This single reset chip should replace a whole bunch of the stock reset components on a Bally MPU (I am working on exactly what can be removed!) This inexpensive

Dallas device looks like a transistor, but is really a three leg chip in a TO-92 transistor package (I also show how to use this same reset chip on Gottlieb System80 MPU boards in the Gottlieb System80 Repair Guide). Click here or here (PDF, more info) for the specs on this chip.

The Dallas DS1811 comes in three TO-92 flavors of "normal reset threshold":

- DS1811-15 = 4.13v
- DS1811-10 = 4.35v
- DS1811-5 = 4.62v

Probably the best one to order is DS1811-10.

The DS1811 is installed with pin 1 going to /RESET (Q5's leg closest to resistor R11), pin 2 to +5 volts, and pin 3 to ground. In the future I will be adding more information on what reset components can be removed installing the Dallas DS1811. If the MPU board boots fine by shorting pins 39 and 40 of the U9 CPU, installing this part may be the "quick fix" to your reset problems. Also the benefit of removing many of the stock reset components on boards with battery corrosion certainly helps.

There is a side affect of the changed reset circuit: Since the Dallas DS1811 increases the reset timing (the time pin 40 of the CPU is held low) from about 50ms to 150ms, the initial "flicker" may not longer be a "flicker". The LED will stay on longer (because the reset is longer), making the "flicker" more of a "flash".

A "Good" U6: EPROMs, Masked ROMs, and Jumpers.
If the LED is stuck on, next give yourself the advantage of knowing that at least the program jumpers match the type of Game ROMs being used (EPROMs, Masked ROMs, etc.). Jumper are discussed in the Game ROMs, EPROMs, and Jumpers section below. Basically these jumpers tell the MPU board what type, size, and how many game ROMs are being used on the MPU board. Bally did this as a convenience factor; if you wanted to use an older MPU board in a newer game (that had a larger program and hence larger or more ROMs), you could. All you needed was to change the jumpers. It also allowed you to use the board with EPROMs (erasable, programable read only memory), or factory created "masked" ROMs. The factory masked ROMs are black with numbers screened on them. These are not re-programable, and must be used in the game they are intended for. EPROMs on the other hand, can be re-programmed and re-used (if you have an EPROM programmer, which costs about $150 and can connect to your computer). An accurate jumper chart is mandatory here and a basic knowledge of how to recognize the different types of ROMs is also a plus.

U6 is the program ROM chip which contains the code for the boot-up diagnostics (and on some Stern games, U2 and/or U5/U6 ROMs are also required for the initial "flicker"). If you don't have a good U6, and don't have the MPU jumpered properely for that U6/U2, the diagnostics can't even start to run. If you don't have an EPROM programmer to make your own U6 EPROM, contact Tom Callahan and order the ROMs needed for your particular game. Make sure you plug them into the sockets correctly (notch oriented correctly) when you install them. Also make sure you have the jumpers set correctly for the type of ROMs you are installing.

Don't Change the MPU board's ROM jumpers unless you have to!
If the U6/U2 ROM jumpers are incorrectly set on your MPU board, this can cause a locked-on MPU board LED. For this reason, I suggest not changing the MPU

board jumpers until getting the intial flicker from the LED. If the jumpers are changed, TWO problems could exist instead of just one! If not sure if the U6 ROM is good, try and install a known good ROM of the same type (or test the U6 ROM in another game). This way the board jumpers don't need to be changed.

Using 2532 EPROMs instead of 9332 Masked ROMs.
If the game in question is a later Bally game with 9332 masked ROMs, these can be changed to 2532 EPROMs with NO jumper modifications! This can be handy and convenient if the original black 9332 masked ROMs need changing, but the repair person doesn't want to mess with the jumpers.

A "Good" U9 and U11.
These two chips MUST also be good to get your MPU board to even start to work. The diagnostics won't even start to run if you don't have a good CPU chip at U9. Also a good PIA chip at U11 is required.

If your LED is locked on, and the reset circuit is working (see above), I would next invest in a new 6800 CPU for U9, and a new 6821 PIA for U11. Y

What Chips are Required to Get the MPU "Unlocked"?
The only socketed chips that are required to get the MPU board to do its first flicker, are a working U6 (program ROM), U9 (the CPU), and U11 (a PIA). Of course this assumes the reset circuit is working properely. All other socketed chips can be removed until the board becomes "unlocked" and does its first flicker.

How Can I Ensure I have good U6, U9 and U11 Chips?
I keep a working MPU board around, and plug the unknown chips (one at a time!) into the working MPU. Then I power the MPU on and see if it still works. This works best for me, but you may not have a good MPU spare laying around.

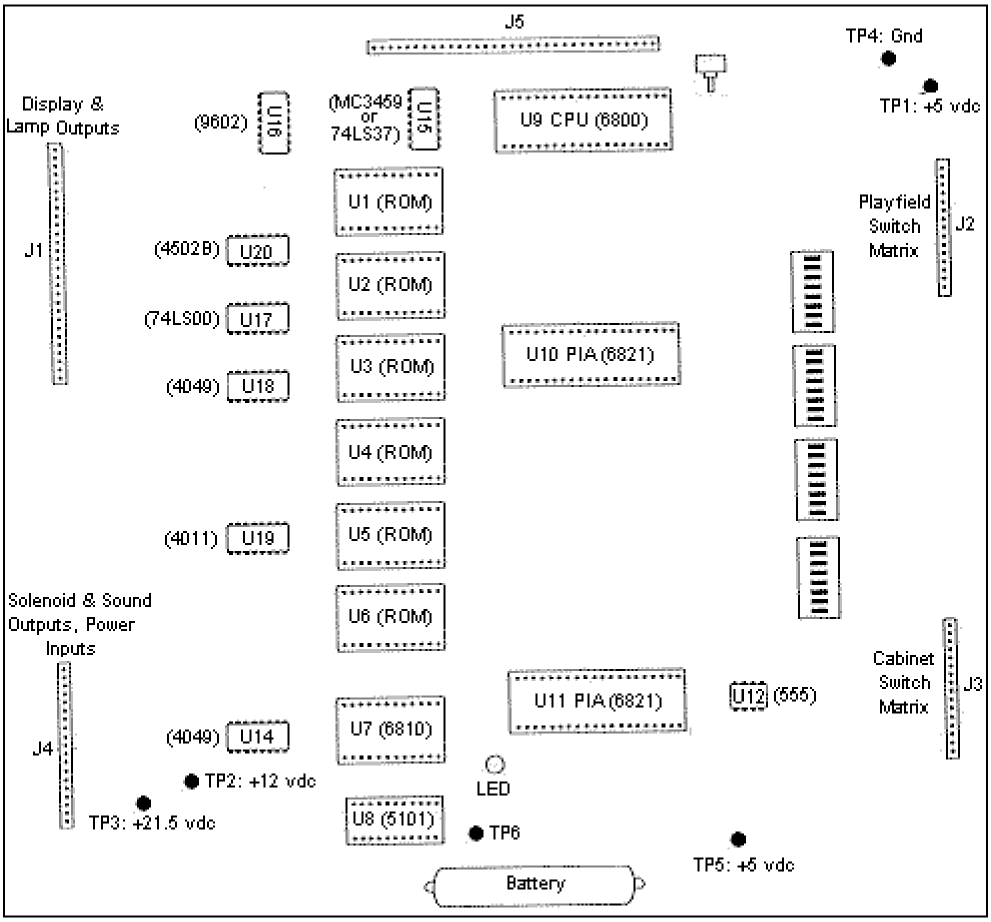
If you have no spare working MPU, make sure you buy some new U9 (6800 CPU) chips and U11 (6820 PIA) chips from Jameco. They are inexpensive and worth keeping "in stock". And get a set of known good EPROMS (U6/U2) too. You can buy these from Tom Callahan if you don't have an EPROM programmer

Good Chip Sockets (replace the "brown" sockets!).
If the sockets that U6, U9 and U11 plug into are "bad", nothing will make the LED start flashing until this is fixed. If your sockets are the "brown" variety, or have the brand name "SCANBE" or "RS" impressed in the sockets, replace ALL of them! These types of sockets are known to be troublesome. Another approach to replacing these problem sockets is to plug a new machine pin socket into the problem socket, then plug the chip into the new socket. This is a good temporary solution until you get the MPU board working. Then you can later replace the old bad sockets with new machine pin sockets. Using your DMM, buzz-out the chip legs to the under side of the MPU board to make sure the sockets are good. Note: do NOT get gold plated sockets! These react with the different metal in the chip legs, and can cause intermittent problems. Also remember that U11 is in the "corrosion zone". This means this socket could have easily been affected by battery corrosion.

Re-seating the Chips.
Sometimes fixing a MPU board can be as easy as taking all the socketed chips out, and re-seating them into their sockets. It's worth a try, as it only take a minute (and costs nothing). Sometimes bad connections can be rectified by doing this. Make sure when you plug the chips back in, that ALL the legs go into the socket and that the chip notch is oriented in the correct direction (a

common neophyte error). Plugging a chip in "backwards" usually destroys it. If re-seating the chips does work, this usually means the sockets will need replacing. If the problem keeps coming back, I would suggest replacing the socket(s) in question.

Component layout on the Bally MPU.



The LED is Still Locked On.

If the U6, U9, U11 chips and sockets are known to be good, the reset section tests good, and the board is jumpered correctly, you should be getting at least a initial flicker from the LED. The inital flicker indicates these three chips are good, and that the MPU has started its boot-up process (a good sign!). Remember, on some Stern games, a good U2 and/or U5/U6 ROMs chip are also needed to get the intial flicker.

If the reset section is working, get a head start and put in your own "known good" U9, U6 and U11 (and re-jumper the board if necessary). This will usually get at least a flicker out of the LED. If the LED is still locked on, here's some other things to test:

Reset Section Components to Replace:

- If the zener diode VR1 (1N959B or 1N4738A, 8.2 volt) on the MPU board is bad, the LED will remain on.
- If the reset transistors Q1 (2N3904) and Q5 (2N4403) are damaged, the LED will remain on. As a general rule, it's always a good idea to replace these inexpensive transistors.
- If diode CR5 (1N4148 or 1N914) is bad, the LED will remain on.
- If transistor Q2 is bad, it could leave the LED on (regardless of what the

MPU is doing!).

After the Reset Section is Rebuilt, try this:

- If your CPU board has brown sockets, or sockets labeled "SCANBE" or "RS", you may want to replace ALL the sockets. These sockets are known to be problematic. An alternative to replacement is to plug a machine pin socket into the problem socket, then plug the chip into the new socket. This is a good temporary solution until you have the MPU board working.
- Measure the voltage at the CPU board. Even if you are using your test fixture, measure the voltage right at the chips to verify. The +5 line should be 4.8 to 5.2 volts DC. Check the power at the required socketed chips (U6, U9, U11). This will tell you if power is getting through the board to the chips
    - U6, U2 (ROM): +5 = pin 24, GND = pin 12
    - U9 (CPU): +5 = pin 8, GND = pin 1 or 21
    - U11 (PIA): +5 = pin 40, GND = pin 1
    - U8 (5101): +5 = pin 22, GND = pin 8
    - U7 (6810): +5 = pin 24, GND = pin 1

  You don't really need to check the +12 at the board. If the LED is lit, you know the +12 volts is already present.

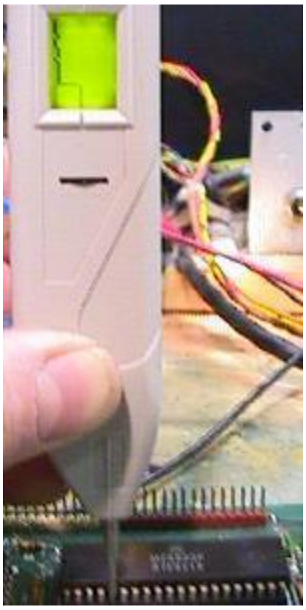
- Using a logic probe, check U9 (CPU) pin 2 and pin 40. They should be high. Pin 40 is the Reset line, and this pin will start LO at initial power-on (for about 50 ms), and then go HIGH. As you turn the power on, the logic probe's Lo LED should light briefly, then the Hi LED should turn on and stay on. If there is no intial LO followed by about 4.5 volts at pin 40, the "valid power" reset circuit in the lower left corner of the board is at fault. The reset section's job is to hold the CPU pin 40 Lo until the +5 volts stablizes, and then allow pin 40 to go high to 4.5 volts. If pin 40 stays low, the board will never reset, and the LED will stay locked on. Most likely there is corrosion damage to transistors Q1 (2N3904), Q2 (2N3904), and Q5 (2N4403). Also check diode CR5 (1N4148 or 1N914). Replace all of these if you suspect them as bad.
- If U9 CPU pin 40 is high (about 4.5 volts), then jump the junction of R1 and R3 to ground. Now check U9 CPU pin 40 again. This pin should be low (about .5 volts). This is simulating what the reset section does at power-on. If jumping R1/R3's junction to ground does not give .5 volts at U9 pin 40, there is still a problem with the reset section. Try replacing the reset transistors Q1 (2N3904), Q2 (2N3904), and Q5 (2N4403). Also check the diode CR5 (1N4148 or 1N914). To do this, put your DMM on diode setting. You should get a reading of .3 to .6, and reading of null (zero) when the leads are reversed. Or again, install one of Ed's reset section rebuild kits (which includes all the reset parts needed).
- Using a logic probe, make sure chip U9 (the CPU), pins 3 and 36, 37 are "pulsing". These are the "clock" signals. If you don't have a logic probe, put your DMM on these pins and you should get about 2.5 volts (the average of the pulsing waveform). If you don't have a pulse or about 2.5 volts, suspect chips U15 (MC3459L or 74S37) and U16 (9602 or NTE9602). Also sometimes the C14 and/or C15 (470 pf) capacitors have failed. However the most common cause is a bad U15.
- Check that U9 (CPU) pin 2 is high (+5 volts). This is the Halt signal on the CPU. If it's not HIGH, check for a broken or missing resistor at R135 or a short on the J5 connector.
- Using a logic probe, check that U9 (CPU) pin 5 is pulsing (or use your DMM and you should get about 2.8 volts). This is the VMA (valid memory

address), and is an output from the CPU. If it's not pulsing, the CPU is not running! It could be a bad U9 chip, or some fault on the address and/or data lines cause U9 to "crash". Watch U9 pin 5 on the logic probe after turning the power off and then back on. You should see it pulse for a second or two before stopping. If any CPU output pin is shorted, this can cause the CPU to crash.

Left: *Chip U9 (CPU), pin 3. Note pins 36, 37 will have the same signal pattern too. This is the clock signal.*

Middle: *Chip U9 (CPU), pin 40 and pin 2. Should be a straight line "high", except initially at power-on.*

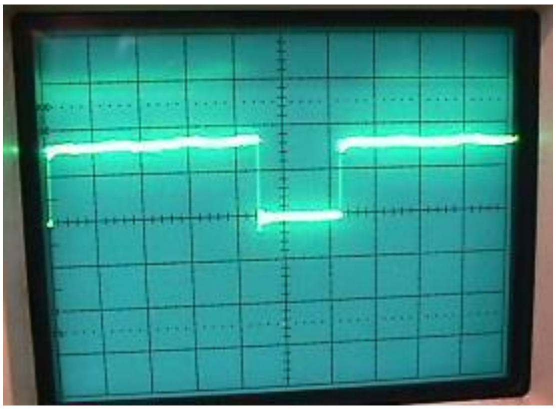
Right: *Chip U9 (CPU), pin 5. This is the Valid Memory Address line.*

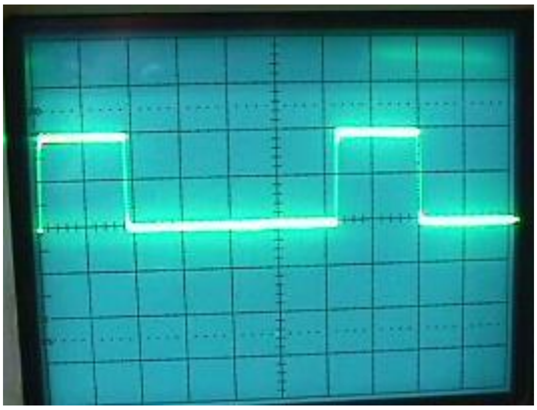


- Trace the VMA signal through its path. Using a logic probe, test the following path. You should get a pulsing signal at all points while the game is in attract mode (or when the MPU is on the bench in your test fixture):
    1. U9 pin 5 (VMA line on the CPU): Pulse
    2. U19 pin 8 (input to U19): Pulse
    3. U19 pin 9 (input to U19): HIGH
    4. U19 pin 10 (output from U19): Pulse
    5. U14 pin 11 (input to U14, about 1.3 volts measured with a DMM): Pulse
    6. U14 pin 12 (output from U14): High Pulse
    7. U15 pin 4 (input to U15): Pulse
    8. U15 pin 5 (input from U16 pin 10): Pulse
    9. U15 pin 6 (output from U15): Pulse
    10. U15 pins 1, 2 (input to U15 again; both pins tied together): Pulse
    11. U15 pin 3 (output from U15, about 1.8 volt measured with a DMM): Pulse

Tracing the above, you can see where the signal runs astray. Replace the suspected component. U15 (MC3459L or 74S37) seems to be the component that fails the most here, followed by U14 then U19.

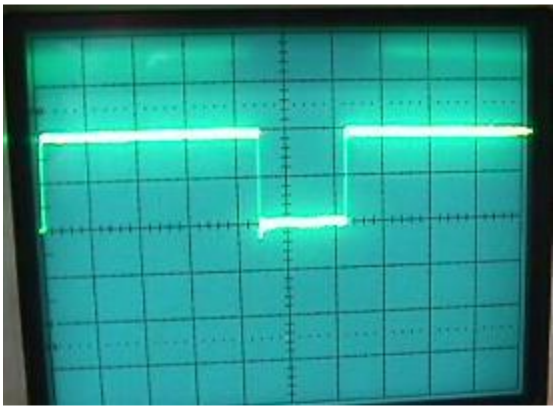
Left: *U9 (CPU) pin 5, and U19 pin 8 look* ***Right:*** *U19 pin 10, and U14 pin 11 look* *like this.* | *like this.*

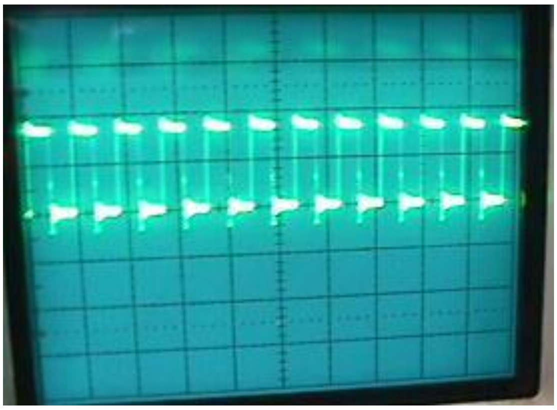




Left: *U14 pin 12, and U15 pin 4 look like this.*

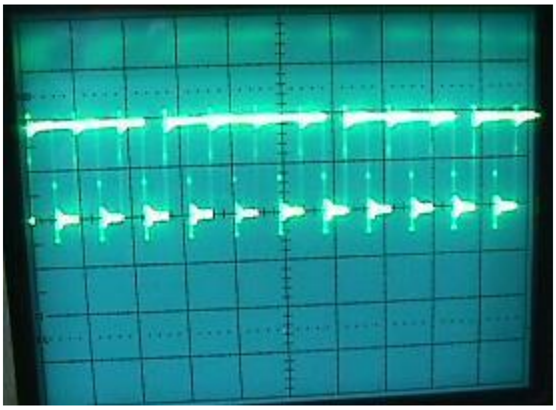
Right: *U15 pin 5.*





Left: *U15 pin 6, and U15 pins 1 and 2 look like this.*

Right: *U15 pin 3.*



- Check U9 (CPU) address and data lines with your logic probe for pulsing signals. This includes pins 9 to 22, 24 (address lines, pin 24 is only used if 2732 EPROMs installed) and pins 26 to 33 (data lines).
- If the PIA at U11 is bad (or its socket is bad), all the above pulses can be present and acting correctly. Yet the LED will still be stuck on. This PIA is right in the "corrosion zone", so make sure the U11 socket and chip are in good shape.
- If C23 on the solenoid driver board is not filtering the +5 volts effectively, this can cause the MPU to lock and leave the LED on (see

Upgrading the Voltage Regulator/Solenoid Driver Board for details on this).
- If Q20 (the +5 voltage regulator) on the Solenoid Driver board is bad, the LED will remain on.

If you've gotten to this point, and the MPU's LED is still staying lit, you may want to consider sending the board out for repair.

Strengthen the Reset Signal by Replacing Caps C14 and C15.
The two capacitors at C14 and C15 (470 pfd) should also be replaced. If these capacitors are weak, the reset signal will not be as crisp and strong. This is very apparent if you have a scope.

Was there Work Done on Chips U15 and U16?
If chips U15 or U16 were worked on, suspect problems. Even though these chips are not directly involved in the reset circuit, there are very fragile traces which travel underneath the U15/U16 sockets. If someone replaced these chip and/or sockets, these traces could be damaged. Using a ohm meter and check for continuity on all of these traces (this may require removing the U15/U16 sockets; always replace these sockets with strip socket headers, so the traces maybe seen and worked on easily in the future).

More on the RESET Signal and a Locked-on LED.
A major part of the reset circuit is transistor Q1, and there is an easy way to test it. As we learned above, when the game is first turned on, the reset line (pin 40 of the U9 CPU) goes low for just a moment, then sticks high. You can similate a reset by shorting the ground junction of resistors R1 and R3. This will force a reset in a good MPU board. As you do this, watch pin 40 of U9 with your logic probe. It should go low for a moment, then stick high. If it doesn't, try replacing Q1 (2N3904). If Q1's collector doesn't go to about 4 volts DC when R1/R3 junction is grounded, then Q1 is bad.

Q5 gets Cooked by R11, and the Game Re-boots Intermittently.
Another strange problem relates to transistor Q5 (2N4403). This transistor is also part of the reset circuit (along with Q1), and is located right below R11, an 82 ohm 2 watt power resistor. The problem here is resistor R11 gets HOT, and is sometimes touching Q5. The heat is transfered to Q5, and this can cause the MPU board to suddenly stop running, and reboot the game. To fix this, provide an air gap between Q5 and R11. You should also probably replace Q5 too. If you replace R11, make sure you leave some "air" between R11 and the MPU board.

The Game only Starts up "sometimes".
If the MPU only starts up properely "sometimes", replace Q1 and Q2 (both 2N3904), Q5 (2N4403), VR1 (1N959B or 1N4738A) and CR5 (1N4148 or 1N914). These transistors and diodes need to be in perfect working order for the MPU to boot reliably.

LED Still Locked On: MPU Board Signals.
If having play problems with an otherwise working MPU, check all the chip's signals with a logic probe, and cross reference them to this chart. If a signal is other than shown below, check the schematic. If it's an input line to the chip, the device that feeds that pin is probably bad. If it's an output line from the chip, the chip itself is probably bad.

All the following signals are with the MPU board in "attract" mode, and a MPU -35 loaded with Kiss 2732 EPROM's at U2 and U6. Because these signals are with the game in attract mode, this chart won't help much if your MPU is in some

other state.
Key:

- H = Logic High (+5)
- L = Logic Low (GND)
- P = Pulse
- HP = High Pulse (signal is mostly high but pulsing)
- LP = High Pulse (signal is mostly low but pulsing)
- X = No signal

Chip	Pin/Signal	
U16 (9602)	L 1	16 H
	LP 2	15 L
	H 3	14 LP
	P 4	13 H
	H 5	12 P
	P 6	11 H
	P 7	10 P
	L 8	9 P

Chip	Pin/Signal	
U15 (MC3459)	P 1	14 H
	P 2	13 P
	P 3	12 P
	P 4	11 P
	P 5	10 P
	P 6	9 P
	L 7	8 P

Chip	Pin/Signal	
U20 (4502)	P 1	16 H
	P 2	15 L
	P 3	14 P
	L 4	13 HP
	LP 5	12 HP
	P 6	11 LP
	LP 7	10 P
	L 8	9 LP

Chip	Pin/Signal	
U17 (7400)	P 1	14 H
	P 2	13 P
	P 3	12 P
	P 4	11 P
	P 5	10 P
	P 6	9 P
	L 7	8 HP

Chip	Pin/Signal	
U18 (4049)	H 1	16 X
	P 2	15 P
	P 3	14 P
	P 4	13 X
	P 5	12 P
	P 6	11 P
	HP 7	10 H
	L 8	9 L

Chip	Pin/Signal	
U19 (4011)	HP 1	14 H
	HP 2	13 P
	P 3	12 P
	P 4	11 P
	H 5	10 P
	HP 6	9 H
	L 7	8 P

Chip	Pin/Signal	
U14 (4049)	H 1	16 X
	P 2	15 LP
	P 3	14 HP
	P 4	13 X
	HP 5	12 P
	HP 6	11 P
	P 7	10 HP
	L 8	9 P

Chip	Pin/Signal	
U12 (555)	L 1	8 H
	HP 2	7 P
	HP 3	6 P
	H 4	5 H

Chip	Pin/Signal	
U2 (ROM)	P 1	24 H
	P 2	23 P
	P 3	22 P
	P 4	21 P
	P 5	20 P

Chip	Pin/Signal	
U6 (ROM)	P 1	24 H
	P 2	23 P
	P 3	22 P
	P 4	21 P
	P 5	20 P

P 6	19 P
P 7	18 L
P 8	17 P
P 9	16 P
P 10	15 P
P 11	14 P
L 12	13 P

Chip	Pin/Signal	
U7 (6810)	L 1	24 H
	P 2	23 P
	P 3	22 P
	P 4	21 P
	P 5	20 P
	X 6	19 P
	P 7	18 P
	P 8	17 P
	P 9	16 P
	P 10	15 P
	P 11	14 P
	P 12	13 P

Chip	Pin/Signal	
U10 (6820)	L 1	40 H
	P 2	39 HP
	P 3	38 HP
	P 4	37 HP
	HP 5	36 P
	P 6	35 P
	P 7	34 H
	P 8	33 P
	P 9	32 P
	HP 10	31 P
	HP 11	30 P
	HP 12	29 P
	HP 13	28 P
	HP 14	27 P
	HP 15	26 P
	HP 16	25 P
	HP 17	24 P
	LP 18	23 P
	LP 19	22 P
	H 20	21 P

P 6	19 P
P 7	18 P
P 8	17 P
P 9	16 P
P 10	15 P
P 11	14 P
L 12	13 P

Chip	Pin/Signal	
U8 (5101)	P 1	22 H
	P 2	21 P
	P 3	20 P
	P 4	19 P
	X 5	18 P
	P 6	17 H
	P 7	16 P
	L 8	15 P
	P 9	14 P
	P 10	13 P
	P 11	12 P

Chip	Pin/Signal	
U11 (6820)	L 1	40 HP
	HP 2	39 LP
	H 3	38 HP
	P 4	37 HP
	P 5	36 P
	P 6	35 P
	P 7	34 H
	P 8	33 P
	P 9	32 P
	H 10	31 P
	H 11	30 P
	H 12	29 P
	H 13	28 P
	H 14	27 P
	L 15	26 P
	H 16	25 P
	H 17	24 P
	L 18	23 P
	H 19	22 P
	H	21 P

Chip	Pin/Signal	
U9 (6800)	L 1	40 H
	H 2	39 L
	P 3	38 L
	HP 4	37 P
	P 5	36 P
	H 6	35 L
	L 7	34 P
	H 8	33 P
	P 9	32 P
	P 10	31 P
	P 11	30 P
	P 12	29 P
	P 13	28 P
	P 14	27 P
	P 15	26 P
	P 16	25 LP
	P 17	24 P
	P 18	23 LP
	P 19	22 P
	P 20	21 L

The LED is Always OFF, and Never Comes On.
This can be caused by a lack of +12 volts getting to the LED, or the LED could be dead. A dead LED happens quite a bit actually. But first trace the +12 volts:

- TP2: should have +12 volts.
- R29: should have +12 volts on both sides of this 1/2 watt 470 ohm resistor.
- Q2: should have +11 volts on the leg closest to U11 (PIA). <-- CLAY CHECK THIS.
- Q2: Cross the two legs that are next to each other with a screw driver. The LED should come on.

If +12 volts is at the above three points (or at least two of them), the LED is probably bad. If you have the above voltages, cross the two adjacent legs of Q2 together with a screw driver. This should light the LED. If it doesn't, and the above voltages exist, replace the LED.

Ok, the MPU's LED "Flickers": What's Next?.
At this point you have an "unlocked" MPU board. By "unlocked" I mean you get the intial LED flicker upon power-on. This tells us that U6, U9 and U11 are good, and the CPU is "running". Now the MPU will test the other components on the board. So at this point, you should have all the other socketed chips like U7, U8, U10, U2, etc (if you removed them) back in the board. The U6 ROM will continue to run its diagnostics on the other components on the MPU board and will FLASH when each of its tests are COMPLETED. What follows is a description of these flashes (or lack of them), and what they mean.

The MPU Diagnostic LED Flash Sequences Explained.

1st Brief Flicker:
The Fakers Guide: If the LED briefly flickers on power-up, U6 (ROM), U9 (CPU), U11 (PIA), the reset components, and +5 volts DC are good (remember some Stern games also require the U2 and/or U5/U6 ROMs for the first flicker). If the LED locks on, one of these components (or some other supporting components

such as the MPU's Q1, Q2, Q5, VR1, or C23, Q20 on the solenoid driver board) are bad (see above). Also the traces connecting these components together could be bad (battery corrosion!).

Techno Guide: On power-up, the U9 CPU chip requires +5 volts DC be applied before the reset line is allowed to swing from 0 to +4.8 volts. It also requires the presense of a two-phase, non-overlapping clock pulse. If these conditions are met, and if the U9 CPU chip itself is good, the LED on the MPU board briefly flickers.

The brief flicker indicates the operation is proper. The MPU has gone out to memory and obtained the starting address of the self-test from memory. The flicker indicates that it then went to that address and started to execute the self-test program.

The Valid Power Detectors circuit on the U9 CPU works with the +5 volts DC regulator Q20 on the solenoid driver board. This prevents the reset line from going high until +5 volts DC is proper at the U9 CPU chip. Q20 is supposed to go into regulation when +7.5 volts DC is applied to its input. This means that when the game is turned on, and a sufficient time (milliseconds) has passed so that C23 on the solenoid driver board has charged, Q20 switches into regulation. This supplies +5 volts DC to the MPU board.

Q1 on the MPU board (in the valid power detector circuit) does not allow the CPU chip to turn on immediately. The zener diode VR1, in series with the base of Q1 delays application of the reset voltage until C23 charges. At this point, Q1 and Q5 on the MPU board go into conduction, and the reset line at the MPU is caused to go high. Only then is the U9 CPU chip "on".

The importance of the Valid Power Detection circuit can be appreciated when the following fact is known; should the reset line be allowed to go high before the +5 volts is applied and proper, or should the +5 volt supply fail and go out of regulation, the U9 CPU chip can jump out of the program. The reason this happens is that the U9 CPU goes out to the program memory bank U1-U6 for instructions. The logic levels are wrong because the +5 volts is not proper. The MPU misinterprets the data, jumps out of the program, and executes this misinterpreted program! The U9 CPU is now like a train that has left the tracks, and it can end up anywhere. The difference is that a train will eventually stop. But the U9 CPU may continue as long as the clock circuit continues to run.

If the U9 CPU jumps out of the program, it is said to be in "run away". While it is mis-interpreting the program, it invariably overwrites the Bookkeeping function in U8 and the scratch pad RAM. An indication of a "run away" would be false data in bookkeeping. Probable cause is a faulty Q20 or C23 (or both) on the solenoid driver boared, or a leaky zener diode VR1 on the MPU board.

First Flash:
The Fakers Guide: No first flash means one of the game program ROMs U1 to U6 is bad. Could be a mis-jumpered board, or a bad ROM chip at U1 to U6.

Techno Guide: the U9 CPU chip next goes out to the program ROM's (read only memory) U1 to U6. It tests each chip in the bank, in accordance to how the MPU board is jumpered. When it finds the bank is correct, it flashes the LED for the first flash. A fault in the U1 to U6 ROM chips is indicated by the absense of the first flash.

The U9 CPU tests each ROM chip's function like this: in a game with ROM chips

U2 and U6 (typical), the CPU first goes to U2. It fetches the first byte in U2, and adds it to the second byte in U2. It will add to this sum the third byte in U2. This continues until all bytes in the chip have been added up. If the sum of all the bytes is "0000 0000", the U9 CPU proceeds to U6 and repeats this process. If U6 has a sum of "0000 0000", the U9 CPU causes the LED to flash the first time. Fault in either U2 or U6 is indicated by the absence of the first flash.

The contents of each ROM chip have byte locations called checksums, reserved for this test routine. There is one checksum byte reserved in each 512 bytes of ROM memory. The game programmer at Bally must insert a btye with the proper value in each checksum byte location to force each 512 byte checksum to equal "0000 0000".

During the life of an electronic game, if a ROM chip U1 to U6 fails by so much as a single bit, it will be detected during this CPU test. The CPU will not continue until the defective ROM chip is replaced.

Second Flash:
The Fakers Guide: no second flash means U7 (6810) is bad.

Techno Guide: The U9 CPU chip goes out to the U7 RAM and erases the contents of the first byte (U7 is a 128 byte scratch pad memory). It then tries to read back the word "0000 0000" (indicating erased). If it can read it back, it adds "1" and continues. 256 tries later, it writes the word "1111 1111". If it can read it back, it has determined that the first byte in U7 is good. It repeats this process for each of the 128 bytes of RAM in U7, one at a time. If at the end of this 256 x 128 (=32,768) tests, each time the CPU writes, it can read the same word back, the CPU cause the LED to flash a second time.

Note the pause between the first and second flashes. This is the CPU doing 32,768 tests to the RAM at U7 and repeats the process.

Third Flash:
The Fakers Guide: no third flash means U8 (5101) is bad.

Techno Guide: The U9 CPU goes out to U8 (CMOS 5101 RAM) and makes a copy of the contents of the first half byte. It does this because U8 is battery supplied, non-volatile memory where the bookkeeping functions are stored. It then erases the contents of the first half byte, and tries to read back the word "0000 xxxx". If it can read it back, it adds "1" to the previous word (giving "0001 xxxx"). It continues to write and read until it reaches the word "1111 xxxx". When this is done successfully, the CPU restores the original contents to the first byte located in U8. It then makes a copy of the contents of the second byte, and repeats the process. It does this for the entire 256 bytes, one at a time. If at the end of the 256 x 16 (=4096) test, each time the CPU writes and reads the same word correctly, the CPU caused the LED to flash a third time.

Fourth Flash:
The Fakers Guide: no fourth flash means U10 (6821 PIA) is bad.

Techno Guide: The U9 CPU chip now tests the first 6821 PIA chip. There are two of these chips on the MPU board, which are identical and interchangable. The test for both is the same.

To determine if a PIA chip is good, the U9 CPU does the following:

15. The CPU accesses, by means of input RS0, RS1, CS0, CS1 and CS2 each of the two full byte registers used to store the port initialization information. If does this, one register at a time. After it completes the first register, it repeats for the second. It goes through 256 tests similar to that used to check each byte in U7 (second flash). If each time the CPU writes a word into the register, it can read the same word back, it continues to test until completion.
16. The CPU accesses, by means of input RS0, RS1, CS0, CS1 and CS2, each of two full byte registers used as data output registers when PA0 to PA7 and PB0 to PB7 are used as outputs. It does the same type of test on each register as described just above. Again if no faults are found, the test is continued until completion.
17. The CPU then accesses, by means of input RS0, RS1, CS0, CS1 and CS2, the two ports CA2 and CB2. The port is initialized as an output. The port is then written into to see if it can store a "1" and then a "0".

A total of 4 x 256 + 4 (=1028) test steps are required to test the PIA chip. However, there are internal buffer amplifiers used with the PB0 to PB7 output registers and CB2 port register which can not be tested by the CPU. Access is only to the register; if the buffer is open, it does not interfere with the registers ability to be written into and read from by the CPU. It is this uncertainity that reduces the accuracy of these test to 99.5%.

Fifth Flash:
The Fakers Guide: no fifth flash means U11 (6821 PIA) is bad.

Techno Guide: Same test is performed on U11 as was performed on U10. See above.

Sixth Flash*:
The Fakers Guide: no sixth flash means either PIA U11 (6821) is bad, or U12 (555) timer is bad.

Techno Guide: The U9 CPU chip monitors PIA2, port CA1 (U11). If transitions from high to low are detected, the CPU decides the Display Interrupt Generator is working. If U12, a 555 timer, or any associated circuit component fails, the CPU will not flash the LED the sixth time.

* Note on Baby Pacman and Granny and the Gators, this flash step is skipped and not tested.

Seventh Flash:**
The Fakers Guide: no seventh flash means PIA U10 (6821) is bad, or there is no +43 volts DC for the solenoids (power transformer fuse F4 is probably blown), or U14 is bad.

Techno Guide: The U9 CPU chip monitors PIA1 port CB1 (U10). If transistion from high to low are detected, the CPU decides that the zero crossing detector is working. If U14 fails and the CB1 line is stuck high or low, the test will also fail. The zero crossing detector circuit input is the +43 volts DC line that is used for the solenoids. If the fuse in that line (F4 on the power transformer module) is blown when the game is turned on, the CPU will not flash the LED the seventh time.

** Note on Baby Pacman and Granny and the Gators this flash is the final flash. These games only had six flashes instead of seven.

Game Initialization.
The U9 CPU chip now initializes the two PIA's U10 and U11, assigning to each port its role as either an input or an output, as required. It then clears out U7 (6810 RAM). Now the CPU takes a picture of the settings of fixed switches S1 to S32 on the MPU board. It stores this "picture" in memory in chip U7. The CPU next jumps to a routine which turns on the "Game Over" feature light, lights the "Ball in Play" light, and the "Credit Indicator" light if there are credits stored in memory. It resets the drop targets and activates the saucer kickers or any kicker associated with a playfield device that can trap the ball and keep it out of the outhole. It then energizes the coin lockout solenoid to allow the game to accept coins (unless the credit maximum was met). Playfield and backbox feature lights associated with and appropriate to animation effects are turned on. With the game tested and initialized, the CPU now divides its time between monitoring momentary switches for closure (coin switch, credit button) and updating displays (lamps and score registers).

Problems/Solutions with the Seventh Flash.
If fuse F4 is blown on the solenoid board, the seventh flash will not occur. But what if there is a problem on the playfield which is forcing this fuse to blow (stopping the final LED flash on the MPU board, hence stopping your MPU diagnostics)?

The easiest way to deal with this is to remove the solenoid connectors from the solenoid driver board to the playfield. These connectors are on the left side of the solenoid driver board, and the one connector at the bottom right of the board too. This should allow the F4 fuse to be replaced, and the completion of the MPU booting process.

To help find the playfield coil that is causing the F4 fuse to blow, replace the connectors one at a time on the solenoid driver board (with the game off), and reboot the game. This will help issolate the bad coil.

Another thing to try: remove the under-the-playfield coil fuse, and replace fuse F4. If F4 does not blow, then one of the coils under the playfield is somehow shorted or staying energized (and blowing the solenoid driver F4 fuse). If fuse F4 still blows, there is either a problem with the backbox knocker, or the cabinet coin door lockout coil, the solenoid bridge rectifier (on the rectifier board), or the rectifier board's varister.

Also try removing connectors J1 and J3 from the rectifier board (this moves the solenoid power back a step further, not allowing it to get any further than the rectifier board). Replace fuse F4 on the solenoid driver board, and turn the game on. If the fuse still blows, the solenoid bridge rectifier (on the rectifier board) or the rectifier board's varister is probably at fault.

If it is a coil under the playfield, check the coils to see which one energizes when the game is powered on. Or disconnect a wire on each solenoid, and re-attach each wire, one at a time, until the fuse blows. At this point it could be the coil, coil diode, or coil driver transistor at fault.

Still No Seventh Flash - Other Things to Check.
First check TP3 and make sure there is 21 volts DC (of course this assumes fuse F4 is not blown on the solenoid board). If there is still no seventh flash, here are some other things to check. Remember all the components mentioned below are in the battery corrosion area.

- Check resistor R17 (150k). If this resistor goes open, or is not making good contact the circuit board, there will be no 7th flash. This resistor commonly fails.

- Check resistor R16 (2k).
- Check resistor R18 (1.5 meg).
- Check diodes CR52 and CR49 (1N4148 or 1N914).

If there is still no seventh flash, the last thing to check is chip U14 (4572).

MPU Boots Fine, but after Turning Off and Immediately back On, The MPU board is Locked.
Game is turned on and works fine. Then the game is turned off, and within a few minutes, turned back on. But the MPU board's LED is locked on, and will not (flicker) boot. The reset section of the MPU board has been rebuilt, as described in this document.

The first thing to suspect is MPU battery corrosion in the reset circuit. Inspect the board for any damage due to corrosion. The problem may be the reset line stays high from the battery power. When the battery is discharged enough, the game will restart. This can happen from the two 8.2k resistors (R1, R3) at the bottom of the MPU board. Other resistors in the reset section should be checked too (R2, R112, R120, R140, R139, R138, R140, R12, R11).

Seven Flashes Constantly Repeats.
The MPU boots and gets to the 7th flash, then start all over and repeats the seven flashes, then starts all over and does it over and over. This can happen from a bad 6810 RAM at U7. Or possibly a bad socket at U7.

3c. When things don't work: Game ROMs, EPROMs, and Jumpers - the Basics

Bally started using the improved -35 MPU board from 1979 to 1985. The later -35 MPU board can be used for ANY game from 1977 to 1985. The difference between the new -35 MPU and the early -17 MPU is mostly how the game ROMs are used and addressed (though the manufacturing and the type of sockets in the earlier -17 boards is also considered inferior to the -35 MPU boards). This section will address general concepts that are used on both the -17 and -35 (and -133) MPU boards.

Bally has provided us with about 35 different "jumper" locations on the -35 (and -133) MPU board, and about ten on the -17 MPU. This was done to handle all the different game ROM (read only memory) chip configuations, for all the different games. Depending on supply and demand for certain ROM chips, Bally pretty much had all the bases covered. They could use any combination of ROM types and sizes to fit their needs.

Important: Before you Change any Jumpers!!
It is EXTREMELY important that you have a working MPU board **before** you change any jumper locations! If you MPU board currently has ROMs in it, get it working first before you play with the jumpers. If you have your MPU board jumpered incorrectly for the game ROMs installed, the diagnostic LED light will stay on and the board will not power-up. So it is absolutely important that the jumpers are correct for the ROMs installed. Get your MPU board working first before proceeding.

Which MPU board Is It: -17 or -35 or -133? (How to Tell!)
Of course Bally silkscreen the MPU part number (AS-2518-17 or AS-2518-35 or

AS-2518-133) right on the MPU board. But sometimes due to battery corrosion, etc, the part number can not be read. It is important to know which board is being worked on, as the game ROM/EPROM jumpers are different.

Basically there are two flavors of MPU board: the -17 or -35 (the -133 is really a -35 board with R113 changed to a diode CR52). The easiest way to tell which board is to examine connector J5. On a -17 MPU board, this connector will have 32 pins (including the removed "key" pin). On a -35/-133 MPU board, J5 will have 33 pins (including the removed "key" pin).

Bally/Williams' Jumper Information.
Though I personally don't recommend or use it, here is a link to the information that (recently) Williams posted about the original Bally board jumpers. You may find this information helpful (though personally I don't). It lives at **ballyrm1.htm**.

Masked ROMs versus EPROMs.
If you are repairing a game, you may be replacing the original masked (black) ROMs. These ROMs, as they get old, break very easily. In particular their pins tarnish and/or break off. The black tarnish is silver oxide, which is caused by oxygen and moisture in the air, and dis-similar metal electrolytic action between the silver plated pins and the tin plated sockets. The black oxide doesn't conduct well, and this can make the ROMs stop working correctly. They are not available any more, but they can be replaced with EPROMs.

EPROMs are basically the same as masked ROMs, but have a small cyrstal window on top of the chip. If UV (ultra-violet) light is shined through this window, the chip can be erased and re-programmed. An EPROM programmer is necessary to re-program an EPROM. These attach to your computer (though there are some stand alone ones too), and can "burn" a blank EPROM with a game's program code. After the EPROMs are burned, a sticker is placed over their window to prevent light from erasing them. EPROMs are the best replacement for your old and tired black masked ROMs.

Chances are if you are doing any repairs to a Bally MPU board, and you need new game ROMs, you will be installing EPROMs. EPROMs are available blank from many sources. But you need to have them "burned" first before you can use them.

The two chips on the left are the black "masked" ROMs.
All masked ROMs used in these Bally games are known as "9316"
EPROMs can be 2516, 2716, 2732, or 2532. The last two numbers identifies the size of the ROM (16k or 32k bits of program data). Masked ROMs are only usable in the game they were designed for. Note how their legs are tarnished black. The two chips on the right are EPROMs. Note the "window" which allows them to be erased, and re-programmed. Also note how the EPROM's legs are not tarnished. You can just read the notation on the one EPROM as "2532".

The Program Code that Lives inside the ROMs.
The memory inside each ROM or EPROM is the heart of your game. It contains the power-on diagnostics, the switch matrix, the game rules, and the coil assignments, among other things. Each model of pinball game has different program code that must be installed only in the game it is designed for. The program code is stored (burned) in your game's ROMs or EPROMs.

The Jumpers.
Each kind and size of ROM chip has its own set of enable and address requirements. To allow a board to use any type or size ROM that Bally had in stock, jumpers were used on the MPU board. It also provides a way to take a MPU board out of a newer game, and put it in an older game (and only have to change the jumpers and the game ROMs).

The wide array of jumpers Bally provides is very confusing. Some games use just one ROM at U6. Others use three ROMs at U6, U2, and U1. The size and type of these individual chips can change too.

What Type and Size are My ROM chips?
Before you can change a MPU board's jumpers to another game (or for new EPROMs), you need to know the type and size of chips you are installing. If you are installed Masked ROMs, these are all 9316 (16k bits of data) or 9332 (32k bits of data). If you are installing EPROMs, you need to read the markings on the EPROM. They will say what type and size of EPROM you have. They will be 2516, 2716 (both 2516 and 2716 are the same type of 16k bit EPROM), 2532, or 2732 (32k bit EPROMs). Note the jumpers for 2532 and 2732 EPROMs are different, as these chips have different pin assignment (but the jumpers for 2532 EPROMs and 9332 ROMs are the same, which is the ONLY sharing of masked ROM and EPROM jumpers). This is unlike 2516 EPROMs and 2716 EPROMs, which are identical and have identical jumpers.

What if I don't have an EPROM Programmer?
You can also buy the above EPROM chips already programmed in 2732 format (or any other size) from Flipperwinkel.nl

Using 2532 EPROMs instead of 9332 Masked ROMs.
If the game in question is a later Bally game with 9332 masked ROMs, these can be changed to 2532 EPROMs with NO jumper modifications! This can be handy and convenient if the original black 9332 masked ROMs need changing, but the repair person doesn't want to mess with the jumpers.

What Do the Masked ROMs Chip Numbers Mean?
If the game in question uses original black masked ROMs, there are numbers on the ROMs that denote information about the chip. This information is can be seen by clicking **ballyro2.htm**, where the ROM numbers are sort numerically. Another page located at **ballyrom.htm** shows the same information, but sorted

by game name. Also shown are the original jumper settings.

Note the higher -xx number means a later revision. In the case of the U6 chips, that revision is important, as generally a game can not be run with the "wrong" U6 part. But for the U1/U2 chips, it usually means a later version of the same game (and all the chips must be of the "correct" revision to match the others, though there's not always a good way to know what that is).

As an example, Lost World uses "720-28" for U6. But then the other chips should all be "729-xx", with the latest revision being "729-33" at U1, and "729-48" at U2. If the game has an earlier version, they would have some other numbers after "729-". But note there can be no mixing of old and new versions!

3d. When things don't work: -35/-133 MPU Game ROMs, EPROMs, and Jumpers.

Important: Before you Change any Jumpers!!
It is EXTREMELY important that you have a working MPU board **before** you change any jumper locations! If the MPU board currently has ROMs in it, get it working first before playing with the jumpers. If the MPU board is jumpered incorrectly for the game ROMs installed, the diagnostic LED light will stay on, and the board will not power-up. So it is absolutely important that the jumpers are correct for the ROMs installed. Get the MPU board working first before proceeding.

Also of course, make sure the board being worked on is a AS-2518-35 (or AS-2518-133) MPU (remember the -133 is really a -35 board with R113 changed to a diode CR52). The easiest way to tell (besides looking at the silkscreened part number on the board!) is to examine connector J5. On a -35/-133 MPU board, J5 will have 33 pins (including the removed "key" pin).

Max out ROM Memory on the -35 MPU to use 2732 EPROMs.
Jumpering is not a big problem until the MPU's ROM chips begin to fail, and MPU boards are shifted from game to game. An MPU board can only be jumpered so many times before the traces and jumpers start to lift and strip off the board. So instead of custom jumpering a board to a particular set of ROMs, the best idea is to maximize the board to use the largest EPROM size, and cater the EPROMs themselves to the board (instead of the other way around).

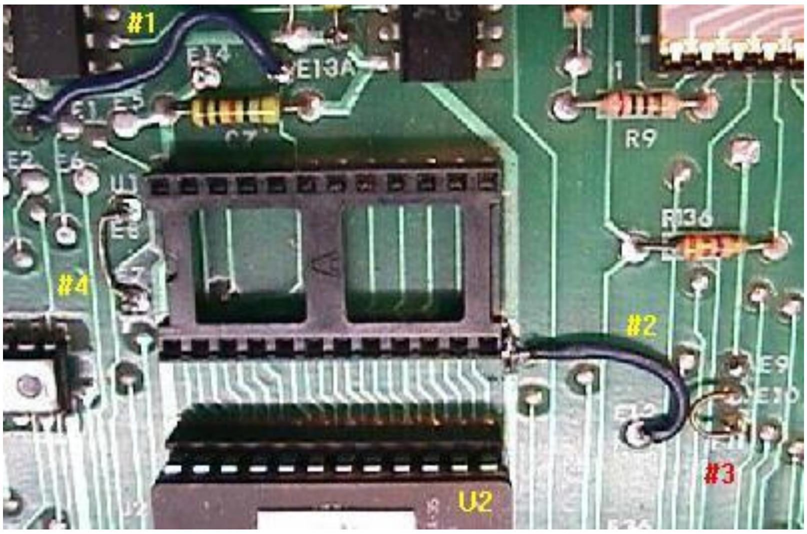
This really makes sense as the largest EPROMs that will fit the -35 MPU board are 2732's, which are commonly and cheaply available. For this reason, the Bally ROM code has been re-formated to fit this size EPROM. The original program size and code is still available from Williams at www.pinball.wms.com/tech/roms.html. But I highly suggest you down load the ZIP file bly2732.zip instead, as it contains all the Bally ROMs for all games from Freedom (1977) to Cybernaut (1985), and has been converted to 2732 format. Only Baby Pacman and Granny and the Gators ROMs are missing from this file. Using these files will allow you to use a -35 MPU board for ANY Bally game from 1977 to 1985.

One set of Jumpers for a -35 MPU using 2732 EPROMs.

For the -35 MPU board, using all 2732 for ANY game has the advantage of just one set of jumpers. Just download the above file and expand it, and burn your game into 2732 EPROMs. Then jumper your -35 MPU board like this:

1. Jump E4 to E13a
2. Jump E12 to GND (large GND trace next to the ROM sockets)
3. Jump E7 to E8
4. Jump E10 to E11
5. Jump E31 to E32
6. Jump E16a to E29
7. Jump E33 to E35

Jumpers around the U1 socket, for using two 2732 EPROMs:
Jumpers E4 to E13a (top blue wire), E12 to GND (right blue wire),
E7 to E8 (middle left), and E10 to E11 (lower right).



Jumpers around the U6 socket, for using two 2732 EPROMs:
E16a to E29, E33 to E35, and E31 to E32.

If you don't want to convert your game to 2732 format, you can also use these jumpers for other types of ROMs in your -35 MPU board.

Using 2532 EPROMs instead of 9332 Masked ROMs.
If the game in question is a later Bally game with 9332 masked ROMs, these can be changed to 2532 EPROMs with NO jumper modifications! This can be handy and convenient if the original black 9332 masked ROMs need changing, but the repair person doesn't want to mess with the jumpers.

The "Mother" Source for Jumper Info.
All the following jumper information came from several sources. The primary source is, of course, the original MPU board schematics. There were also two secondary sources too. First was Williams web site, located at http://www.pinball.wms.com/tech/bally_read1st.txt

Bally -35 MPU Jumpers				
U2 ROM	**U6 ROM**	**U1 ROM**	**MPU Board Jumpers in numberic order**	**Cuts**
9316	**9316**	**9316**	1-4,2-6,7-8,9-11,12-36,13-15,16a-19,31-32,33-34	
2716		**2716**	1-5,2-4,7-8,10-12,16a-18,31-32,33-35	
74S474	**74S474**	**2716**	1-3,2-6,9-11,12-36,13-15,16a-18,31-32,33-35	
2532 or 9332	**2532 or 9332**		4-12, 7-8, 10-11, 13a-14, 16a-34, 29-33, 31-32	cut 13-15
2532 or 9332	**2732**		4-12,7-8,10-11,13a-14,16a-29,31-32,33-35	cut 13-15
9316	**9316**		2-6,7-8,9-11,12-36,13-15,16a-17,31-32,33-34	
9316	**2716**	**9316**	1-4,2-6,7-8,9-11,12-36,13a-19,16a-18,31-32,33-35	cut 13-15
2716	**9316**		1-5,2-4,7-8,10-12,11-29,13a-14,16a-19,31-32,33-34	cut 13-15
2716	**2716**		1-5,2-4,7-8,10-12,11-29,13a-14,16a-18,31-32,33-35	cut 13-15
2716	**2716**	**2716**	1-5,2-4,7-8,10-12,11-25,13a-14,16a-18,31-32,33-35	cut 13-15
2716	**9316**	**2716**	1-5,2-4,7-8,10-12,11-25,13a-14,16a-19,31-32,33-34	cut 13-15
2716	**2532 or 9332**	**2716**	1-5,2-4,7-8,10-12,11-25,13a-14,16a-34,29-33,31-32	cut 13-15
2732	**2716**		4-13a, 7-8, 10-11, 12-GND, 16a-18, 31-32, 33-35	cut 13-15
2732	**2732**		4-13a, 7-8, 10-11, 12-GND, 16a-29, 31-32, 33-35	cut 13-15
U2 ROM	**U6 ROM**	**U1 ROM**	**MPU Board Jumpers in numeric order**	**Cuts**

The first three rows of this table are commonly found factory ROM jumpers.
Stuff to remember:

- Bally uses a preceding "E" on all jumper numbers. Yes, the "E" has been left out above to save some space in the chart.
- The "dash" between the numbers is the "jump". That is, "1-4" means a jumper from E1 to E4.
- Remove any jumpers not shown above for a given configuration. If it's not mentioned above for your ROM set up, you don't need that jumper!
- Don't trust other Bally jumper charts! The above chart is "the one to use" (using Bally published jumper charts can lead to problems).
- You must know the ROM device type installed at each ROM location. The Bally part number (often printed on the ROM) does not help.
- BLACK masked ROMs, as used in many Bally games, are entirely black and usually have some white part numbers printed on them. These are

known as 9316 masked ROMs.

- EPROMs, on the other hand, have a small clear "window" on their top, often with a sticker over the window. The sticker is there for a reason; it prevents UV light from entering the EPROM's clear window (this is how an EPROM is erased! so keep the sticker on the window). EPROMs are labeled as to their size (i.e. "2716").
- The most common EPROMs used on Bally MPU boards are 2716, 2532 and 2732 EPROMs.
- ROMs and EPROMs are game specific. Each game has its own custom set of ROM computer code, stored on that game's ROMs (or EPROMs).
- Some EPROM part numbers are interchangable. For example, 2532 EPROMs, 9332 masked ROMs, and 8332 masked ROMs all use the same jumper setting. But a U2 2532 EPROM from a Kiss game is NOT interchangable with a U2 9332 EPROM from a Strikes and Spares! This also applies to the 16 bit masked ROMs too. That is, 9316 masked ROMs, 8316 masked ROMs, and 8516 masked ROMs all use the same jumper settings. But again a U2 9316 ROM from a Kiss game is NOT interchangable with a U2 8316 ROM from a Strikes and Spares!

Freedom and Night Rider ROM Information.
These two games used a strange set of ROMs at U1 and U2. These are 74S474 or 7461 (512 byte) ROMs at U1 and U2, and a 9316 or 2716 (2K byte) at U6. The Williams tech web site at www.pinball.com states that a U1 2716 EPROM and a U6 2716 EPROM can be used for these two games (and provides the ROM files for download, and the jumper settings for the -35 MPU board, which are shown above).

Note I have also tested both games with 2732 EPROMs at U2 and U6 on a converted -17 and -35 MPU boards (as documented above). This does in fact work fine for both Freedom and Night Rider.

E13, E15 Mistaken Jumper Locations.
There are two jumper pads near the lower right hand corner of the U2 ROM socket labeled "E13" and "E15". There are also two vias (plated through holes) just a little bit further to the right, which are actually closer to the "E13" and "E15" labels. The vias are completely unrelated to the labeled jumper pads. Be careful when using these jumpers that you don't confuse the vias with the jumper pads. They are both round plated through holes, but the jumper pads are a bit bigger.

3e. When things don't work: -17 MPU Game ROMs, EPROMs, and Jumpers (and Stern M-100).

Important: Before you Change any Jumpers!!
It is EXTREMELY important that you have a working MPU board **before** you change any jumper locations! If the MPU board currently has ROMs in it, get it working first before playing with the jumpers. If the MPU board is jumpered incorrectly for the game ROMs installed, the diagnostic LED light will stay on, and the board will not power-up. So it is absolutely important that the jumpers are correct for the ROMs installed. Get the MPU board working first before proceeding. If the ROMs are suspect as bad, and the MPU board is set up for 9316 ROMs (most -17 boards are), see the section below, "Making an Adapter to use Two 2716 EPROMs in an Unmodified -17 MPU board that is Jumpered for 9316 ROMs". This will allow the use of two new 2716 EPROMs to replace the failed 9316 ROMs, without any MPU board modifications or new jumper settings.

Also of course, make sure the board being worked on is a AS-2518-17 MPU. The easiest way to tell (besides looking at the silkscreened part number on the board!) is to examine connector J5. On a -17 MPU MPU board, this connector will have 32 pins (including the removed "key" pin).

Bad -17 MPU Board Sockets (Brown/Scanbe/RS sockets).
If your -17 MPU board is using tan/brown sockets, or socket that have "SCANBE" or "RS" impressed on them, it is advised you change the sockets. These older sockets are very troublesome and cause many intermittent problems. A quick alternative to replacement is to plug a machine pin socket into the brown socket. This is a temporary fix, but should work well enough until you can get the board working, and later replace the sockets).

Jumpers used on the Early -17 MPU (and Stern M-100).
The 1977 to 1979 Bally -17 MPU boards aren't as versatile as the newer -35 boards. They have limited ROM space, which means they can't be used in the newer 1979 to 1985 games. This can all be rectified, but will require some cutting and jumping of traces on the -17 MPU board.

There are only a few jumper choices on the -17 MPU board. The following jumpers only apply for the early 1977 to 1979 Bally -17 MPU board. Note the configuration that uses a U1 ROM only existed for the first two Bally games, Freedom and Night Rider.

Bally -17 and Stern M-100 MPU Jumpers				
U1 ROM	**U2 ROM**	**U6 ROM**	**MPU Board Jumpers in numeric order**	**More Stuff**
2716		**2716**	See below	Used only on Freedom/Night Rider. (2716 ROM files from WMS site)
74S474 (or 7461)	**74S474 (or 7461)**	**2716/9316**	Unknown	Used only on Freedom/Night Rider.
	9316	**9316**	1-2, 3-4, 6-7, 8-10	Most games shipped with this configuration.
	2716	**9316**	1-2, 3-4, 6-7, 8-10	must also cut and jumper (see below)
	2716	**2716**	1-2, 3-4, 6-7, 8-10	must also cut and jumper (see below)
	2732	**None**	6-7, 8-10	must also cut and jumper (see below)
	2732	**2732**	1-2, 3-5, 6-7, 8-10	must also cut and jumper (see below)

Stuff to remember:

- Bally uses a preceding "E" on all jumper numbers. Yes, the "E" has been left out above to save some space in the chart.
- The "dash" between the numbers is the "jump". That is, "1-4" means a jumper from E1 to E4.
- Remove any jumpers not shown above for a given configuration. If it's not mentioned above for your ROM set up, you don't need that jumper!

- You must know the ROM device type installed at each ROM location. The Bally part number (often printed on the ROM) does not help.
- BLACK masked ROMs, as used in many Bally games, are entirely black and usually have some white part numbers printed on them. These are known as 9316 masked ROMs (though Freedom and Night Rider can also use 74S474 or 7461 masked ROMs).
- EPROMs, on the other hand, have a small clear "window" on their top, often with a sticker over the window. The sticker is there for a reason; it prevents UV light from entering the EPROM's clear window (this is how an EPROM is erased! so keep the sticker on the window). EPROMs are labeled as to their size (i.e. "2716").
- ROMs and EPROMs are game specific. Each game has its own custom set of ROM computer code, stored on that game's ROMs (or EPROMs).
- Some EPROM part numbers are interchangable. For example, 2532=9332=8332. But a U2 2532 EPROM from a Kiss game is NOT interchangable with a U2 9332 EPROM from a Strikes and Spares!

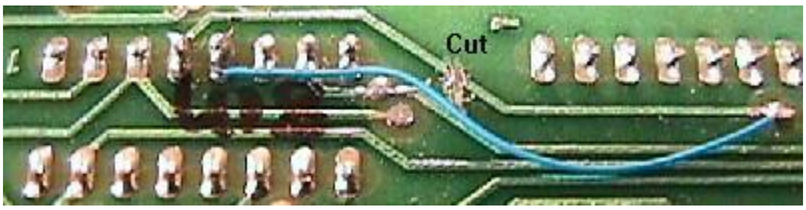
2716 in U2, 9316 in U6 on a Bally -17 or Stern M-100 MPU board.
In addition to the jumpers listed above (1-2, 3-4, 6-7, 8-10), you must also make the following cuts and jumps to use this configuration.

9. On the componet side of the -17 board, cut the trace from U2 pin 18 to U3 pin 18. Best place to do this is where the trace passes between sockets U2 and U3. Use your DMM set to continuity to help figure out the trace to cut.
10. On the solder side of the -17 board, run a jumper from U2 pin 18 to U17 pin 11.
11. On the solder side of the -17 board, cut the trace going to U2 pin 21.
12. On the solder side of the -17 board, run a jumper from U2 pin 21 to U2 pin 24.

2716 in U2, 2716 in U6 on a Bally -17 or Stern M-100 MPU board.
In addition to the jumpers listed above (1-2, 3-4, 6-7, 8-10), you must also make the following cuts and jumps to use this configuration.

13. Make sure jumpers E1-E2, E3-E4, E6-E7, and E8-E10 are in place.
14. On the solder side of the -17 board, cut the trace leading to U18 pin 4.
15. On the solder side of the -17 board, connect U18 pin 5 to the trace you cut above from pin U18 pin 4. It's easiest to run the wire from U18 pin 5 to the via ("trace thru dot") that connects to this trace.
16. On the solder side of the -17 board, cut the trace leading to U2 pin 21.
17. On the solder side of the -17 board, cut the trace leading to U6 pin 21.
18. On the solder side of the -17 board, run a jumper from U2 pin 21 to U2 pin 24.
19. On the solder side of the -17 board, run a jumper from U6 pin 21 to U6 pin 24.

When using 2716's at U2/U6 or a single 2732 at U2, you need to make this modification at chip U18: cut the trace going to pin 4, and connect pin 5 to the cutaway trace's via ("trace thru dot").



Single 2732 U2 on a Bally -17 or Stern M-100 MPU board.
This modification combines the two original 9316 ROMs at U2 and U6 into one single 2732 EPROM at location U2. This works only for the early 1977 to 1979 games.

To combine the original 9316 (or 2716) U2 and U6 ROM computer files into a single 2732 U2 ROM file, use this DOS command:

```
COPY /B U2ROM.716 + U6ROM.716 U2COMBO.732
```

Make sure you use the "/B" option in the copy command, as shown above. This binary copy command will combine the two files into one.

In addition to the jumpers listed above (6-7, 8-10), you must also make the following cuts and jumps to use this configuration.

1. Make sure jumpers E6-E7 and E8-E10 are in place.
2. Remove any jumpers at E3-E4, and E1-E2.
3. On the solder side of the -17 board, find U18 pin 4. Follow this trace to the via ("trace thru dot"). Cut the trace near the via.
4. On the soider side of the -17 board, run a jumper from the via ("trace thru dot") that was seen above to U18 pin 5. It's easiest to run the wire from U18 pin 5 to the via ("trace thru dot") that connects to this trace. This connects U18 pin 5 to U2 pin 18.
5. On the componet side of the -17 board, find U2 pin 13 (top right hand corner). Slightly higher and to the right is a via ("trace thru dot") with a trace going straight down. Cut this trace to separate the via from this trace.
6. On the component side of the -17 board, run a jumper from the above via ("trace thru dot") to jumper pad E4. This connects jumper pad E4 to U2 pin 21.
7. On the component side of the -17 board, notice the large GND trace that runs to the right of the ROM sockets. To the right of the U2 ROM socket, scrape the green solder mask from this large GND trace and jump a wire from this GND trace to the jumper pad E3. This connects U2 pin 20 to ground.

Converting a Bally -17 or Stern M-100 to a Bally -35 MPU, using a 2732 in U2 and 2732 in U6.
This modification allows a Bally -17 or Stern M-100 MPU board to be used on any Bally game up to 1985. It doubles the amount of ROM space the older MPU board can use, and essentially makes a Bally -17 or Stern M-100 MPU board a Bally -35 MPU board. Note you can not use a -35 Bally board in a Stern games requiring a M-200 MPU (these boards have two 5101 RAMs instead of one as used on a Bally -35 MPU).

In addition to the jumpers listed above (1-2, 3-5, 6-7, 8-10), you must also make the following cuts and jumps to use this configuration.

8. Make sure jumpers E1-E2, E3-E5, E6-E7, and E8-E10 are in place.
9. Double check jumper E3 connects to E5.
10. On the solder side of the -17 board, cut the trace that runs to U2 pin 21.
11. On the component side of the -17 board, cut the trace that runs to U2 pin 18. Best place to do this is where the trace passes between sockets U2 and U3. Use your DMM set to continuity to help figure out the trace to cut.
12. On the solder side of the -17 board, jump a wire from U2 pin 18 to U2 pin 12.
13. On the soider side of the -17 board, jump a wire from U2 pin 21 to U9 (CPU) pin 24.
14. On the solder side of the -17 board, cut the trace that runs to U6 pin 21.
15. On the component side of the -17 board, cut the trace that runs to U6 pin 18. Best place to do this is where the trace passes between sockets U6 and U5. Use your DMM set to continuity to help figure out the trace to cut.

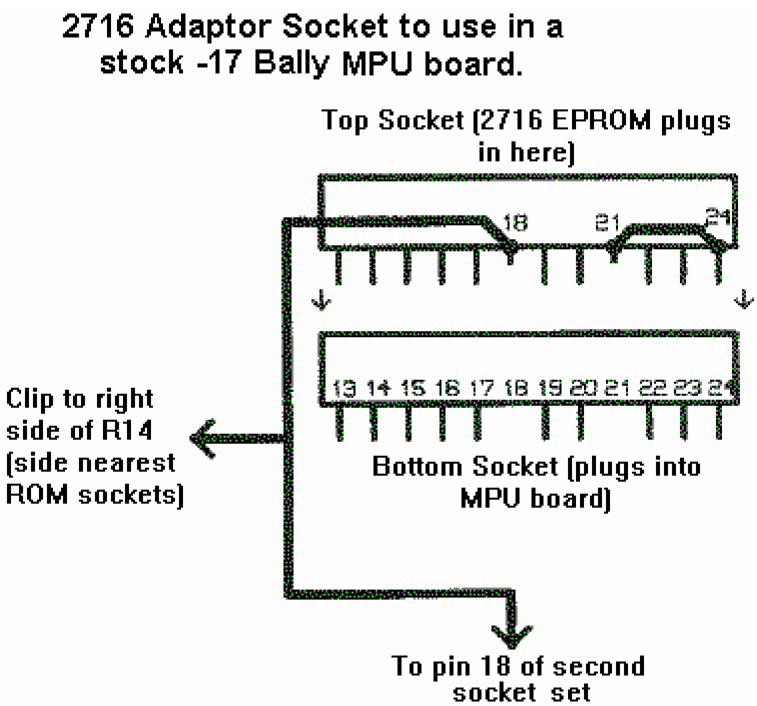
16. On the solder side of the -17 board, jump a wire from U6 pin 18 to U6 pin 12.
17. On the solder side of the -17 board, jump a wire from U6 pin 21 to U2 pin 21 (this connects both U2 and U6 pins 21 to U9 pin 24).
18. On the solder side of the -17 board, cut the trace that runs to U17 pin 2.
19. On the solder side of the -17 board, cut the trace that runs to U18 pin 4.
20. On the solder side of the -17 board, jump a wire U17 pin 2 to U18 pin 4.

Making an Adapter to use Two 2716 EPROMs in an Unmodified -17 MPU board that is Jumpered for 9316 ROMs.

This is a great adapter to have around when working on a -17 board that you don't want to modify. It will allow you to use a pair of 2716 EPROMs on a stock, unmodified -17 MPU board. This allows testing of the board without making any cuts or jumps.

Basically it takes four good quality (machine pin) 24 pin sockets, and sandwiches two of them together. There are a couple pins that need to be cut, and a couple jumper wires added (see the diagram below):

- On two of the 24 pin sockets, jump pins 21 and 24 together with some wire.
- On the two sockets you modified above, solder a four inch wire to pin 18. Then solder the sockets' pin 18 wires together, and attach a test clip to this wire too.
- On the two sockets you modified above, cut pins 18 and 21 short so they won't plug into anything.
- Plug the two modified sockets into the other two unmodified sockets. Make sure pins 18 and 21 do not contact the unmodified sockets. To be double sure this happens, you can cut pins 18 and 21 off the bottom sockets too.
- Plug the 2716 EPROMs for U2 and U6 into the two modified sockets.
- Plug the sandwiched sockets and EPROMs into the MPU board at positions U2 and U6.
- Connect the test lead coming off pin 18 of the two modified sockets to the right side of R14 (the side nearest the ROM sockets).



Freedom and Night Rider ROMs and Jumper Notes.

These two games used a strange set of ROMs at U1 and U2. These are 74S474 or 7461 (512 byte) ROMs at U1 and U2, and a 9316 or 2716 (2K byte) at U6. The Williams tech web site at www.pinball.com states that a U1 2716 EPROM and a U6 2716 EPROM can be used for these two games (and provides the ROM files for download, and the jumper settings for the -35 MPU board).

If using a -17 MPU with a U1 2716 EPROM and U6 2716 EPROM, there are some other cuts and jumps required:

- Cut the trace from U1 pin 18 to U2 pin 18.
- Cut the trace from U1 pin 21 to jumper pad E7.
- Connect U1 pin 21 to U1 pin 24.
- Connect U1 pin 18 to U17 pin 11.
- Connect U1 pin 22 to U2 pin 22.

Note I have tested both games with 2732 EPROMs at U2 and U6 on a converted -17 MPU board (as documented above). This does in fact work fine for both Freedom and Night Rider.

Bally's chart for ROMs in a -17 MPU board (U1,U2,U6 are all 9316 ROMs).

FO-597

FIGURE 3

MEMORY COMBINATIONS AND JUMPERS
FOR USE WITH
MPU AS-2518-17 (F.O. 597 MODIFIED)

GAME NAME, NUMBER	U1	U2	U6	JUMPERS REQUIRED
FREEDOM #1066-E	E-720-8	E-720-10	E-720-7	E1-E2, E3-E4, E12-E7, E14-E15
NIGHT RIDER #1074-E	E-721-21 ~~E-721-12~~ PROM	~~E-721-13~~	E-720-20	E1-E4, E-3-E-4, E-12-E-13, ~~SAME AS FREEDOM~~ E-14-E-11, E-6-E7
EVEL KNIEVEL #1094-E		E-722-17	E-720-20	E1-E2, E3-E4, E12-E13, E14-E11, E7-E6
EIGHT BALL #1118-E		E-723-17	E-720-20	SAME AS EVEL KNIEVEL
POWER PLAY #1120-E		E-724-25	E-720-20	SAME AS EVEL KNIEVEL
MATA HARI #1104-E		E-725-21	E-720-20	SAME AS EVEL KNIEVEL
STRIKES & SPARES #1135-E		E-740-16	E-720-20	SAME AS EVEL KNIEVEL
BLACKJACK #1092-E		E-728-32	E-720-20	SAME AS EVEL KNIEVEL
LOST WORLD #1119-E	E-729-39	E-729-40	E-720-28	SAME AS EVEL KNIEVEL
SIX MILLION DOLLAR MAN #1138-E	E-742-5	E-742-6	E-720-30	SAME AS EVEL KNIEVEL

NOTES: 1) Jumpers between E- tie points not specifically listed for a given game should be disconne

2) Additional memory combinations are possible. To use original memory tables for Freedom thru Blackjack with a modified MPU, add E12-E7 and E14-E15 to required jumpers. Combinations using U5 not permitted.

3f. When things don't work: Stern M-200 MPU Jumpers (using a Stern M-200 in a Bally Game).

The Stern M-200 Board: The Universal Soldier.
Having a Stern M-200 MPU jumpered for 2732 EPROMs is like having a universal soldier. This MPU board, with the correct EPROMs installed, will work in any Bally or Stern game from 1977 to 1985. Having it jumpered for "universal" 2732 EPROMs is the trick. For example, all the Bally game ROM code have been converted to this format (click here to download all the ROM files). As discussed above, using the original 9316 (or 2716) U2 and U6 ROM files can be combined into a single 2732 U2 ROM file, using this DOS command:

```
COPY /B U2ROM.716 + U6ROM.716 U2COMBO.732
```

Make sure you use the "/B" option in the copy command, as shown above. This binary copy command will combine the two files into one.

If a Stern game uses four 9316 or 2716 ROMs at U1/U2/U5/U6, these can easily be converted to two 2732 EPROMs at U2/U6 using the above copy command.

Keep in mind the Stern M-200 MPU uses a second 5101 RAM on this board (which is ignored by the Bally firmware). Because of this extra RAM, Stern games 1980 and later will only work with a Stern M-200 MPU (you can't put a Bally MPU in). The earlier Stern M-100 or Bally -17 or -35 MPU will not work in these later Stern games. So even though you can put a M-200 in a Bally game, it is a waste (to Stern collectors!), because the supply of M-200 MPU's is pretty low compared to Bally -17, -35 and -133 MPU's, which will work in any Bally game.

The Clock Speed Jumpers.
If you are using the newer Stern M-200 MPU in any Bally game or older Stern game (that originally had a M-100 MPU), you may need to remove two jumpers. These two jumpers are E32-E33 and E34-E35. Removing these two jumpers will lower the clock speed of the M-200 to run in the Bally or older Stern games. Frankly, leaving the faster clock speed (leaving E32-E33 and E34-E35 in place) is usually fine on Bally games. When using the Stern M-200 in a Bally game, the start-up reset sequence may run faster (especially if jumpers 32-33 and 34-35 are left in place). Also the extra 5101 RAM at U13 is not needed for the Bally games and may be removed (the Bally ROM software does not use this chip).

Stern M-200 MPU Jumpers				
U1 ROM	U2 ROM	U5 ROM	U6 ROM	MPU Jumpers in numeric order
None	2732	None	2732	1-2, 4-5, 13-15, 24-25, 16-18, 32-33, 34-35
2716	2716	2716	2716	2-3,5-7,9-10,13-14,16-18,19-21,23-25,27-28,29-30,32-33,34-35
None	2716	None	2716	2-3, 5-7, 13-14, 16-18, 23-25, 32-33, 34-35
9316	9316	9316	9316	1-5,2-6,8-9,12-13,16-18,19-20,22-25,26-28,29-31,32-33,34-35

Stern M-200 and the 5101 RAM chips (boot up problems).
The Stern M-200 MPU board uses two 5101 RAM chips (instead of just one like Bally and Stern M-100 MPU boards). When buying 5101 chips, the standard speed rating on this chips is 300 ns. This works fine for Bally and M-100 MPU's, but the Stern M-200 (which runs at a higher clock speed) requires a faster 5101

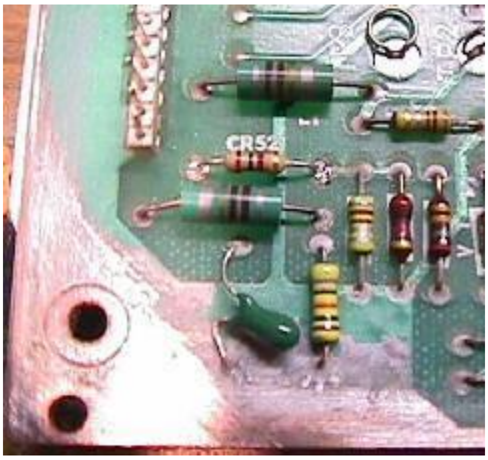
RAM chip, at 100 ns. The faster 100 ns chip is labeled as 5101-1, and the slower 300 ns chip is labeled as 5101-3. If you use the slower 5101-3 RAM chip in a Stern M-200 MPU board, the board may not boot up correctly; you can get the seventh LED flash, but the game just doesn't work right. Often this can be indicated by the game audits and high scores, where a number (like '74') is continually repeated in all the audits or high scores. Remember, if using a M-200 MPU in a Bally game, the second 5101 RAM at U13 can be removed (the Bally ROM software does not use this chip).

3g. When things don't work: Converting a -133 MPU (Baby Pacman) to a -35 MPU

In 1982 Bally changed their -35 MPU board very slightly to work in the combination pinball/video games Baby Pacman and Granny and the Gators. If you want to use this MPU in other pinball games, you need to convert it to a -35 MPU.

Converting the Baby Pacman -133 MPU is very easy do. Just replace the 1N4148 diode at CR52 with a 2k 1/4 watt resistor. This was the only change made. This diode is on the lower left corner of the MPU board, next to connect J4. On the original -35 MPU, this resistor is labeled R113, not CR52.

Links: *a Baby Pacman -133 board that was converted to a -35 board. Note the 2k resistor installed in place of "CR52".*



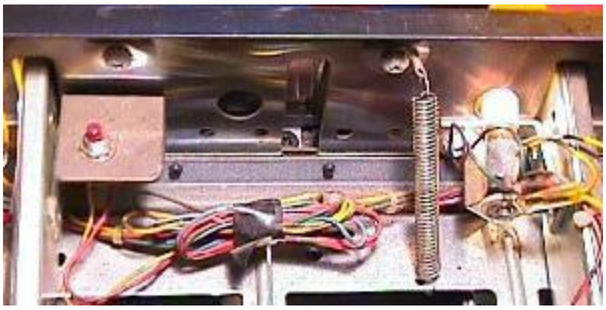
You may also need to re-jump the board for the ROMs you will be using (typically Baby Pacman came with a 2732 U2 EPROM, and a 2532 U6 EPROM).

Converting a -35 MPU to a -133 MPU for use in Baby Pacman.
If you have a pinball -35 MPU that you want to put into a Baby Pacman game, this of course is easy too. Just remove the 2k resistor R113 and replace it with a 1N4148 or 1N914 diode. The non-banded side of the diode connectors to the J4 header pin 15 (diode band goes towards capacitor C1).

3h. When things don't work: the Built-in Diagnostics/Bookkeeping.

If you game "boots" correctly and goes into attract mode, you can use the built-in diagnostics for the game. This is done by pressing the red test switch mounted inside the coin door. Here's what happens each time the test button is pressed:

The red self-test diagnostic button inside the coin door.



1. The first test is for all switched feature lamps; they will flash off and on continuously. You can check for burnt bulbs, lights that are never on, or lights that are always on (lamp driver board problems).
2. The second test is for the score displays. Each digit on each score display will cycle from 0 to 9, and repeat continuously. Broken diplays will have digits or segments always on or always off.
3. The third test is the solenoid test. Each solenoid will be energized, one at a time, in a continous sequence. Holding both flipper buttons "in" during this test will display the solenoid number being tested on the score display. Correct operation is indicated by the sound of a coil pulling in as its number appears on the display. If a coil makes no sound, note the coil number on the display and check out that coil. The game manual will tell you which coil the solenoid number correspond to.
4. The fourth button push is the sound card test (only on games equipped with one, Lost World and later; "chime" games do not have this test). A tune will be played repeatedly. Improper operation (no sound or distorted sound) can easily be heard.
5. The last test is the switch test. The MPU will search each switch for stuck contacts. If any are found, the switch number of the first stuck switch is flashed on the score display. Additional switches will be flashed until the last stuck switch is found. The last switch number will remain until the fault is cleared. Then the previous stuck switch is displayed. If no stuck switches are found, the number zero appears in the Match/Ball in Play display.
6. After the diagnostic test, the game will go into bookkeeping and adjustments mode. Each press of the red button will display a bookkeeping ID number, and the its value. Refer to your game manual for a description of each ID number. Note some 1982 and later Bally games also have some game adjustments available in addition to the bookkeeping. Again, see your game manual.

To exit the test mode, turn the game off and then back on.

3i. When things don't work: Locked-on or Not Working Coils (Solenoid Driver board).

If a coil is locked on (Burning! Turn the game off!) or doesn't work, there are several tests you can perform to isolate the problem. But first you should know the sequence of events in energizing a coil:

- The MPU is told (by a playfield switch or other trigger) to fire a coil.
- The MPU turns on, for just a moment, a solenoid transistor on the solenoid driver board. This completes the power path to ground for the particular coil.
- The coil fires.

There are a series of steps you should take when a coil is not working properely, which we will outline below.

If a Coil is Locked On.
Generally, this is caused by a solenoid driver transistor that is shorted on. If a coil is locked on, turn the game off immediately (otherwise you'll be replacing more than a bad transistor!). Then follow these steps:

- Check the manual's schematics to figure out which transistor controls the coil in question. This information is on the Solenoid Driver/Voltage Regulator schematic page.
- Look at the connector in the center of the schematic. There the coil name/description will be listed.
- Follow this line back to the first "Q" (transistor) that intersects this line. Write down the transistor number (for example, "Q13"). Also write down the diode number behind it ("CR13"), and the chip number that drives this transistor ("U3"), and the pins of the chip (pins 11, 12). Also note the pin number that connects to the diode (pin 12). All these components could be damaged (but generally it's just the transistor).

Now that you know the transistor in question, you can test it.

Other Coil Diagnosing Techniques.
Another technique is to remove the solenoid connectors from the solenoid driver board to the playfield. These connectors are on the left side of the solenoid driver board, and the one connector at the bottom right of the board too.

To help find the playfield coil that is troublesome, replace the connectors one at a time on the solenoid driver board (with the game off), and reboot the game. This will help issolate the bad coil.

Another thing to try: If fuse F4 blows, there is either a problem with the backbox knocker, or the cabinet coin door lockout coil, the solenoid bridge rectifier (on the rectifier board), or the rectifier board's varister.

Also try removing connectors J1 and J3 from the rectifier board (this moves the solenoid power back a step further, not allowing it to get any further than the rectifier board). Replace fuse F4 on the solenoid driver board, and turn the game on. If the fuse still blows, the solenoid bridge rectifier (on the rectifier board) or the rectifier board's varister is probably at fault.

Finally, disconnect a wire on each solenoid, and re-attach each wire, one at a time, until the F4 fuse blows. At this point it could be the coil, coil diode, or coil driver transistor at fault.

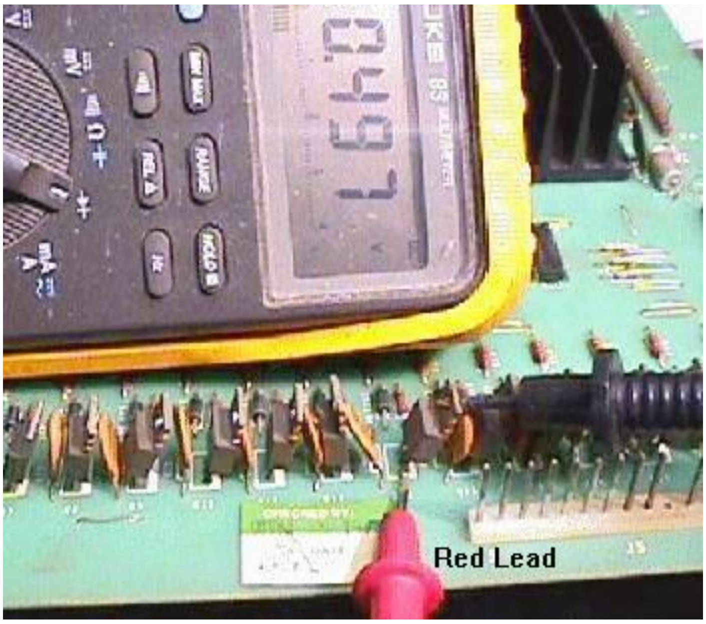
Testing the Solenoid board Transistors, Game Off.
The transistors on the solenoid driver board are very easy to test. This is done with the game off. You can remove the solenoid driver board, or leave it installed in the game. Using your DMM set to the "diode" setting, do the following:

- Turn the game off.
- On the component side of the board, put the black lead of your meter on the metal tab of a driver transistor.
- Put the red lead of your meter on the center lead of a transistor. Your meter should read zero.

- Put the red lead of your meter on either outside lead of a transistor. Your meter should read in the .3 to .6 volt range.
- Put the red lead of your meter on the other outside lead of the transistor. Your meter should again read in the .3 to .6 volt range.

If your meter reads anything outside the .3 to .6 range, replace that transistor.

Testing a solenoid driver board transistor. The black lead of the DMM is on the transistor's metal tab. The red lead is put on either outside lead, one at a time. The meter should read in the .4 to .6 range.



Testing a Solenoid board Transistor, Game On.
If a coil is not locked on, you can test it's solenoid driver board transistor with the game on and in "attract" mode.

- Attach an alligator wire and clip to ground in the backbox.
- Momentarily touch the other end of the alligator clip to the metal tab on a solenoid driver board transistor.
- The coil that is driven by that transistor should fire.
- Optionally, you can also momentarily touch your ground wire to the solenoid board "U" chip; the pin that does NOT connect to the diode. This will also fire the coil.

If the coil doesn't fire, and the transistor tested properely in the above steps *"Testing the Solenoid board Transistors, Game Off"*, you have either a blown playfield fuse or a broken wire/connector.

To test for a broken solenoid wire or connector pin, do this:

- Turn the game off.
- Put an alligator clip on the coil lug that the NON-banded side of the diode connects to.
- Connect the other end of the alligator clip to one of the test leads on your DMM.
- Set your DMM to continuity ohms setting.
- Refer to the manual and find the "J" connector number and pin number that the solenoid in question connects to on the solenoid driver board.
- Touch the other lead of your DMM to this "J" connector pin on the solenoid driver board.

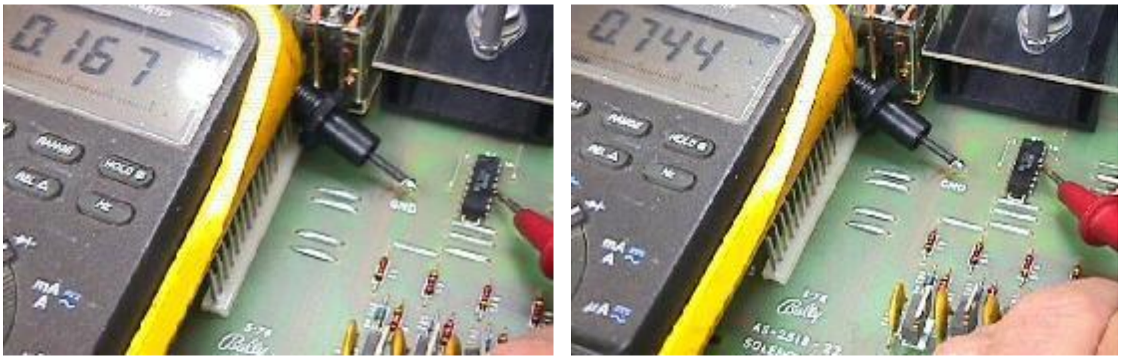
You should get about 0 ohms. Note if you are testing to the wrong conector pin, you will get about 30 ohms.

Driver Transistor Tested Good, but Coil is still Locked On.
The driver transistor may be OK, but the 1N4004 diode behind it could be bad. Since we wrote down the diode that is behind the driver transistor (in the above steps), refer to that to get the diode number. Here's how to test it:

- Turn the game off.
- Remove the Solenoid driver board from the game.
- Put your DMM on diode setting.
- On the component side of the board, put the DMM leads on the 1N4004 diode. You should get a reading of .4 to .6 volts.
- Reverse the leads, and you should get the same reading you got in the previous step.
- BEST METHOD: remove one lead of the diode from the driver board, and retest. In one direction you should get a zero (null) reading.

If you get any other value, replace the 1N4004 diode.

Test the pre-driver CA3081 transistor chip. The picture on the left is testing the transistor pin that connects to the diode.



Now we need to test the chip that drives the diode and driver transistor. This chip is a CA3081 (NTE916) transistor array. Basically it's several transistors packaged in a chip format. This is known as the "pre-driver transistor pack". You can test this too:

- Turn the game off.
- Remove the Solenoid driver board from the game.
- Put your DMM on diode setting.
- On the component side of the board, put the black lead of your DMM on the GND test point just to the left of the U1 chip.
- Put the red lead of your DMM on the two pins of the pre-driver chip (one at a time) that you noted above.
- For the pin that connects to the 1N4004 CR diode, you should get a reading of .1 to .2 volts.
- For the other pin, you should get a reading of .7 to .8 volts.
- Reverse the DMM leads (red lead now on GND). You will get the same .1 to .2 volt reading for the pin that connects to the CR diode. The other pin will read 1.1 to 1.3 volts. Note this test is far less conclusive than the first test with the black lead on GND.

If you get any other meter readings, replace the pre-driver CA3081 (NTE916) chip.

Replace the Coil Diode.

If you had ANY problems with a coil being locked on, ALWAYS replace the coil diode. This diode prevents a "backlash" of current going to the solenoid driver board when the magnetic coil is shut off. This diode is easily damaged and can cause damage to your solenoid driver board if bad. Always make sure you install the new diode with the diode band on the "power" lug of the coil. The power lug is usually the lug with two wires going to it (because the power is daisy chained from coil to coil).

Testing for Power at the Coil.
If a coil doesn't work, and the transistor is good, test for power at the coil. Do this with the game on and in attract mode, and the playfield lifted.

- Put your DMM on DC voltage (100 volt range).
- Put the black lead on the metal side rail (ground) of the game.
- Put the red lead on either terminal of the coil. It should read about 43 volts. On flipper coils, any of the three terminals should also read about 43 volts.

If you are missing voltage at the coil, check for a broken wire/connector, or blown playfield fuse (see below). Remember the power wires are "daisy changed" together. So a break in the power wire in a previous coil will cause the coils further down the line to not work.

Testing a Coil.
You can also test a coil for proper operation. With the game on and in attract mode, and the playfield lifted, try this:

- Connect one end of a alligator clip and wire to the metal side rail of the game.
- Momentarily touch the other end of the alligator clip to the coil's terminal with the **non-banded side of the diode** connected to it.
- The coil should fire.

Note if you accidentally touch the banded side of the diode to ground, you will probably blow a fuse.

If the coil doesn't fire, you have a damaged coil or no power at the coil. Look for a broken wire going to the coil's terminal. You can also test the resistance of a coil. A good coil should be in the 3 to 15 ohm range.

The Over-Looked Under-Playfield Solenoid Fuse.
Often your Bally game will boot fine and start a game. The flippers work, but no other solenoids on the playfield work. This can often be caused by a blown under-the-playfield solenoid fuse.

If you run the solenoid diagnostic test and the coin lock-out coils, the flipper relay, and the knocker all work, and nothing else works, a dead under the playfield fuse could be the problem. Since the game boots OK, we know the +43 volt fuse on the rectifier board is OK (if this fuse was blown the MPU board won't "flash" the seventh time).

The under the playfield solenoid fuse is usually located on the right hand side by the flippers. Usually it's a 1 amp slo-blo fuse. If this fuse keeps blowing, you have a solenoid problem on the playfield somewhere. This can be caused by a shorted coil, a bad coil diode, or a broken (and shorted) coil wire. A shorted and locked on driver transistor is probably NOT your problem.

If the playfield fuse keeps blowing, there is another procedure you can try to isolate the problem as a last resort. Turn the game off and disconnect the "pull down" wire from EVERY coil under the playfield. The pull down wire is the single wire on each coil, and connects to the NON-banded side of the coil's diode (the power side connects to the banded side of the diode's coil lug). Then power the game on (the fuse should not blow!). Now re-connect each wire to its respective coil. When the fuse blows, you've found your problem coil/diode.

Coil TroubleShooting - More Ideas.
Here's some other ideas on coil problems.

No Coils Work.

- Check TP5 on the power supply for 43 volts. If no voltage, check fuse F4 on the power supply.
- Check solenoid driver board for +5 volts at TP3 on the driver board. If no voltage here, check for a broken jumper on connector J3 from pin 13 to pin 25.

Only the flippers work.

- Check 1 amp slow blow fuse underneath the playfield.
- Check for a broken wire from the above fuse. There should be a brown wire going from the under the playfield 1 amp fuse to the flipper coil.

Flippers work and just some coils.

- Under the playfield, check for a broken yellow wire from coil to coil. This is the coil power wire, and it daisy chains from one coil to another. A break in this wire will stop power from getting to coils "down stream".
- A problem with the connection between connectors J4 of the MPU board and J4 of the solenoid driver board. If one line is missing, coils 1 to 4 will not work.

Power supply board coil power distribution.

- J1 pin 6 = brown wire to flipper coils.
- J1 pin 9 = to solenoid driver board J3 pin 5 (flipper relay).
- J2 pin 2 = to chime unit (in early games) or knocker coil (in later games), and coin lockout coils in all games.
- J2 pin 13 = to backbox knocker on early games.
- J3 pin 12 = to MPU board connector J4 pin 15.

3j. When things don't work: Locked-On or Not Working Feature Lights (lamp driver board)

Bally's lamp driver and auxiliary lamp driver boards stayed pretty consistant from 1977 until 1989 (when Bally produced its last game, before being taken over by Williams). These procedures should work on all Bally lamp driver boards from their inception until their end in 1989.

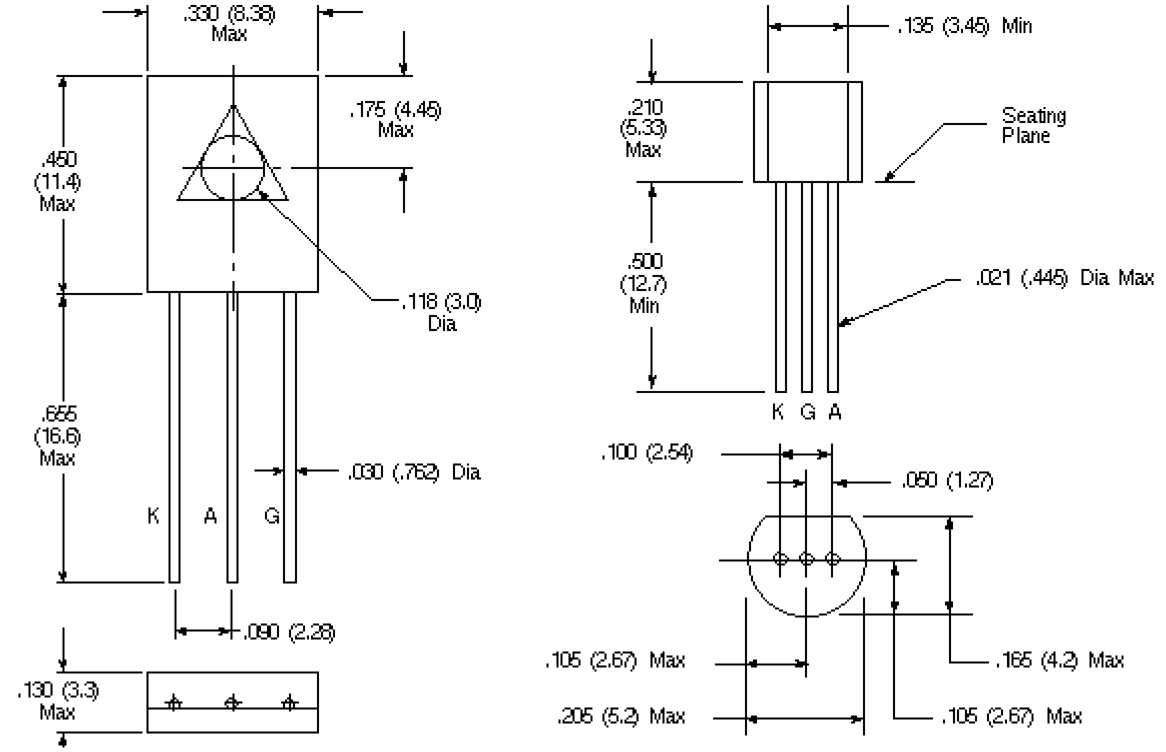
If a feature light is continually on, or is never on, you can test the lamp driver board for a component problem. Assuming the wiring is intact, chances are good that the lamp's driving component(s) are bad. This is especially true if a lamp is always on. The internals to the driving components have probably shorted on, leaving the lamp continually on.

All Bally electronic pinball games until Williams bought them out in 1989 used SCR's (Silicon Controlled Rectifiers) to drive feature lamps. SCR's are different than transistors. Instead of a collector, base and emitter like a transistor, they have a cathode, anode and a gate (abbreviated C, A, G respectively, though sometimes the "C" is abbrevated as "K"). Each gate is driven by a CD4514 CMOS decoder output. All SCR cathodes are connected to the feature lamp ground. Each SCR anode is connected to a unique feature lamp.

There are two different SCR's used for lights on the lamp driver board: the larger MCR106-1, and the smaller 2N5060. They serve the same function, just the larger MCR106-1 can handle more current (and sometimes lights two lamps, while the smaller 2N5060 can only light one lamp). There is also a CD4514 CMOS decoder that drives the lamps. Sometimes these go bad too.

Bally does not use a lamp matrix to drive the feature lamps. There is a separate SCR that drives each feature lamp.

Specs for the two styles of SCRs used in Bally games.
Left: *the SCR106-1.* ***Right:*** *the 2N5060.*

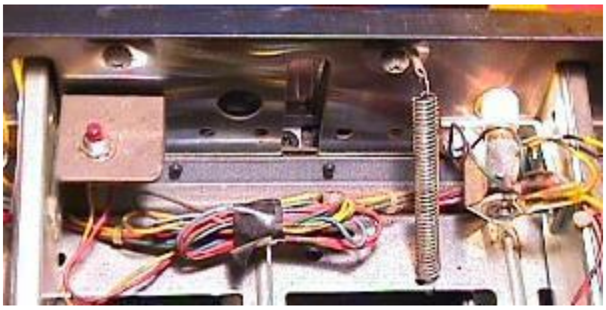


SCR106-1 (NTE5411 to NTE5416) Specs **2N5060 (NTE5400 to NTE5406) Specs**

Nieuw thyristoren kun je gewoon bij de Flipperwinkel kopen.

Testing the Lamp Driver SCR's, game On.
If a lamp is permanently stuck on, this procedure won't tell you anything. A lamp that is always on is generally caused because its SCR has internally shorted. Replace the SCR.

The Bally red test switch, just inside the game's coin door.



Assuming the game powers on, you can test a non-working lamp's SCR's to see if it's working (this assumes you have checked the bulb, the lamp socket, and the wiring to the lamp socket).

- While the game is on and in "attract" mode, press the Self-Test button inside the coin door ONCE. This should put the game into the "Flash All Feature Lamps" test (check your game manual if it does not).
- Note which feature lamps are NOT working. Write them down. You will need this information if several lamps that connect to the same decoder don't work. A decoder has likely failed if 4, 8 or 12 lamps (multiples of 4) are not working.
- Check the manual's schematics to figure out which SCR controls the lamp(s) in question. This information is on the Lamp Driver schematic page.
- Look at the connectors at the right of the schematic. There the lamp name/descriptions will be listed.
- Follow this line back to the first "Q" (SCR) that intersects this line. Note the SCR number (for example, "Q8"). If the schematic lists a "**" next to the SCR, this means it's a MCR106-1. Otherwise it's a 2N5060. Also note the chip that drives this SCR ("U1"). Both these components could be damaged (but generally it's just the SCR).
- Write down the "Q" number and the lamp name on some paper. Also write down the driving decoder "U" chip number.
- If 4, 8 or 12 lamps that all connect to a single decoder don't work, suspect the decoder "U" chip as faulty.
- Press the game's test switch again to take the game out of lamp test mode. The display test will probaby come up. Leave the game here, as all the playfield lamps should now be turned off.
- Connect an alligator test lead wire to ground. The bare braided wire in the bottom of the back box works well for this.
- Touch the other end of the test lead to the ANODE of the SCR in question. On the large SCR, the metal tab is the anode. On the smaller SCR, it's the lower right leg. To make sure, the pinout for the small SCR's is silk screened on the board for a few selected SCR's. You are looking for the lead marked "A".
- If the lamp does NOT light when the anode is grounded, the problem is NOT on the lamp driver board. Most likely you have a wiring problem, a bad lamp socket, or a bad bulb.
- If the lamp DOES light when the anode is grounded, the problem probably lies with the SCR. Replace it and see if that fixes the problem. If not, suspect the "U" decoder chip that drives that lamp.

Testing the Lamp Driver SCR's, game Off.
You can also check the lamp driver board's SCR's using your DMM, set to the diode setting.

- Check the manual's schematics to figure out which SCR controls the lamp(s) in question. This information is on the Lamp Driver schematic page. Write down the SCR's "Q" number.

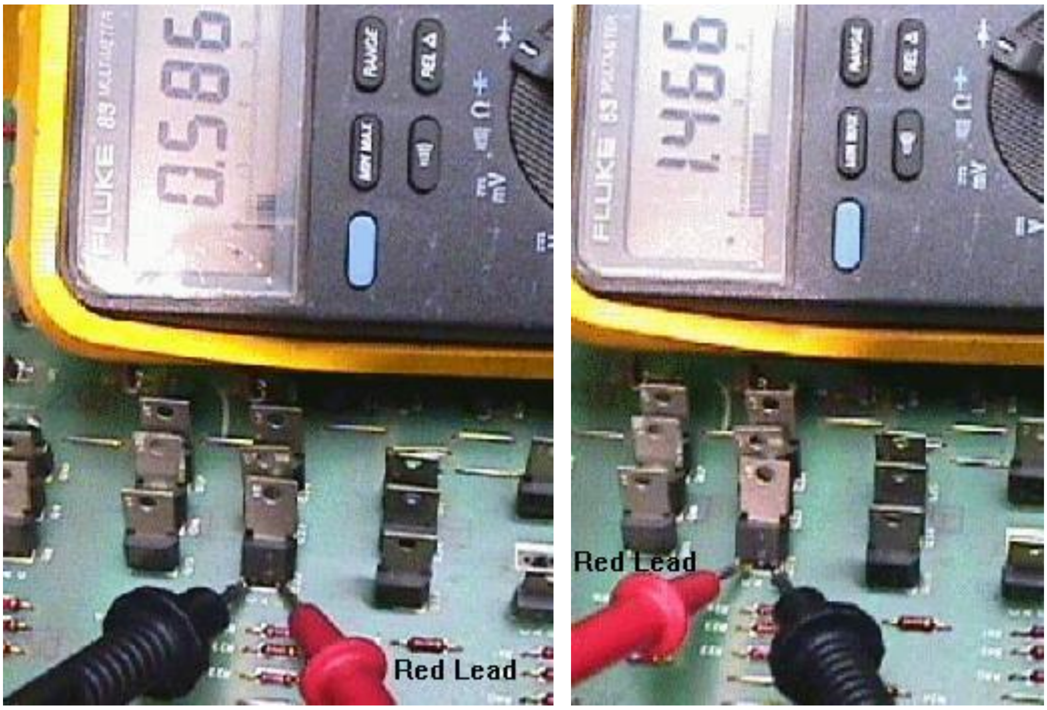
- Look at the connectors at the right of the schematic. There the lamp name/descriptions will be listed.
- Follow this line back to the first "Q" (SCR) that intersects this line. Note the SCR number (for example, "Q8"). If the schematic lists a "**" next to the transistor, this means it's a MCR106-1. Otherwise it's a 2N5060. Also note the chip that drives this SCR ("U1"). Both these components could be damaged (but generally it's just the SCR).
- You can remove the lamp driver board, or leave it installed in the game. Use your DMM set to the "diode" setting.

MCR106-1 Lamp Driver SCR test:

- Put the black lead of your meter on the outside "cathode" leg (labeled "C") of the SCR.
- Put the red lead of your meter on the outside "gate" leg (labeled "G") of the SCR. Your meter should read .4 to .6 volts.
- Swap the meter leads. Now the meter should read 1.4 to 1.6 volts.

If your meter reads anything outside the values above, replace that MCR106-1.

Testing the large MCR106-1 lamp driver SCR.



2N5060 Lamp Driver SCR test:

- Put the black lead of your meter on the "cathode" leg (labeled "C") of the SCR.
- Put the red lead of your meter on the center "gate" leg (labeled "G") of the SCR. Your meter should read .4 to .6 volts.
- Swap the meter leads. Now the meter should read 1.4 to 1.6 volts.

If your meter reads anything outside the values above, replace that 2N5060.

Testing the small 2N5060 lamp driver SCR.

3k. When things don't work: Solenoid Expander board Problems.

Starting with Eight Ball Deluxe, Bally started designing games that had more solenoids than transistors to drive them on the solenoid driver board. To allow more coils to be used in the game, Bally came up with a "Solenoid Expander Board". This board is a solenoid multiplexer; it allows a single transistor on the solenoid driver board to drive two different devices, instead of just one.

The solenoid expander board's main component is a relay. This relay connects to four different coils. When the relay is pulled in, two of the four coils can be activated by the solenoid driver board's transistors. When the relay is at rest, the other two of the four coils can be activated by the solenoid driver board's transistors.

The real trick to the solenoid expander board is how its relay is pulled in. A relay is basically a solenoid with switches. To activate a solenoid you normally use a transistor on the solenoid driver board. But wait! We're trying to SAVE transistors on solenoid driver board because we're running out of them to drive all the coils on the game.

So instead of using a solenoid driver board transistor to activate the solenoid expander board's relay, a LAMP driver SCR (silicon controlled rectifier) is used on the lamp driver board! This allows the lamp driver board to control which two of the four coils can be controlled by the solenoid driver board's transistor.

The solenoid expander board and its accompanying 555 lamp.

Another way to look at it is this: think of two transistors on the solenoid driver board, say transistors 11 and 12. These normally control two coils (call them coils 11 and 12). But now transistors 11 and 12 control FOUR coils (coils 11a, 11b, 12a, 12b). When the lamp driver board's SCR activates and pulls in the solenoid expander board's relay, the solenoid driver transistors 11 and 12 control coils 11b and 12b. When the lamp driver board and solenoid expander board's relay are at rest, the solenoid driver transistors 11 and 12 control coils 11a and 12a. Note all four coils can not be activated at the same time.

It's also important to note that the solenoid expander board usually controls little used coils. Stuff like the outhole kicker or drop target reset coils. These coils are used far less than say slingshot or pop bumper coils. So if your outhole kicker solenoid is acting up, the expander board may be the cause.

The Solenoid Expander Board's Partner.
The other strange thing about the solenoid expander board is its partner; a lamp! The solenoid expander board is located under the playfield, and right next to it is a lamp. This lamp is VERY important, and it must have a good light bulb installed for the solenoid expander board to function properely.

The reason for the lamp is this; the solenoid expander board has a MOC3011 opto-isolator that actually turns the relay on. However this device doesn't draw enough current for the SCR on the lamp driver board to activate it. To solve this problem, an actual lamp is installed next to the solenoid expander board. This lamp is also connected to the lamp driver board's SCR. The combination of this lamp and the solenoid expander board's MOC3011 gives the lamp driver board's SCR enough current draw for it to work reliably.

Testing the Solenoid Expander Board.
The easiest way to test the solenoid expander board is to use the built in feature lamp diagnostics. After the game is turned on and in attract mode, press the red test button inside the coin door once. This will activate the feature lamp test. All the playfield lamps will turn on and off. The solenoid expander boards relay should also click on and off. If you lift the playfield you should see the solenoid expander board's relay pull in. You should also see the lamp next to the solenoid expander board turn on and off.

If you heard the relay buzz instead of click on and off, this means there is a problem. See the list of problems below to fix this.

Problems with the Soleniod Expander Board.
If the solenoid expander board buzzes in the above test, this indicates a problem. Also it is important to remember that every coil that connects to the solenoid expander board has TWO diodes; one "normal" diode across the coil lugs, and another diode in series with the power wire going to the coil! If this diode set up is mis-wired, a diode is reversed, missing or broken, you will have problems. Here are some other things to consider too:

- Header pins on the solenoid expander board may have cracked solder joints. Re-flow these header pin solder joints.
- The lamp under the playfield next to the solenoid expander board may be burned out. Replace with a new lamp. Without this lamp, there isn't enough load for the SCR on the lamp driver board to activate the solenoid expander board's relay.
- The lamp driver board's SCR that controls the solenoid expander board may have failed. See Locked-On or Not Working Feature Lights (lamp driver board) section for details on how to test the SCR.
- The 6.5 volts provided by the power supply's rectifier board BR1 bridge may be failing. The 6.5 volts DC provided by BR1 powers the feature lamps. If this voltage is low, the solenoid expander board's relay may not function correctly.
- The power supply's rectifier board R2 resistor (25 ohms 5 watts) may be broken or open. Check it with your DMM set to ohms.
- Connector pins on the power supply's rectifier board may be burned or tarnished. This will create resistance which will lower the 6.5 volts DC provided to the lamp driver board. If this voltage is low, the solenoid expander board's relay may not function correctly.
- Diode on the solenoid expander board's relay may be broken or missing.
- In-series diode going to the power lug of the coil may be broken, missing or reversed.
- Diode across the lugs of the coil may be broken, missing or reversed.
- Switch contacts on the solenoid expander board's relay may be pitted and may need to be filed (or the relay replaced).
- The solenoid expander board's MOC3011 opto-isolator may be bad. Replacements are available from Jameco (part #95020), or replace with NTE3047.

Testing the Transistors and Coils Driven by the Solenoid Expander board.
If the solenoid expander board's relay is working properely, you can test the devices it controls using this test:

- Check the schematics to see which transistor number is controlled through the solenoid expander board.
- Turn the game on and let it boot.
- Press the red test switch once to put the game into diagnostic feature lamp test.
- Using an alligator clip test wire, attach one end to the ground strap in the backbox.
- Touch the other end of the alligator clip test wire to the metal tab on the solenoid driver board's transistor you identified in the first step above.

If you leave the transistor's metal tab grounded while the game is in the feature lamp diagnostic test, the two coils controlled by the above transistor should turn off and on with the feature lamps.

3L. When things don't work: Auxiliary Lamp Driver board Problems.

Left: *the earlier style AS2518-43 Auxiliary Lamp Driver board.*

Right: *the later style AS2518-52 Auxiliary Lamp Driver board.*

On Bally games with special backbox lighting (Space Invaders, Xenon, and many others), Bally used an auxiliary lamp driver board to run these lights. This saves the lamps on the lamp driver board for use on the playfield. This auxiliary board isn't much different than the lamp driver board itself. It used SCR (silicon controlled rectifiers) just like the lamp driver board. It uses only MCR106-1 devices (no 2N5060 SCR's).

If a lamp is locked on or not working that is controlled by the auxiliary lamp driver board, the procedure for testing and replacing its SCR on the auxiliary lamp driver board is the same as the lamp driver board. Please see lamp driver board section above for more details.

3m. When things don't work: Switches and the Switch Matrix.

All electronic pinball machines use a technique to read switches called a "switch matrix". Problems with the switch matrix can be difficult to diagnose. The matrix consists of eight rows and eight columns. This makes a checkerboard type pattern with 64 individual switch (or squares). So instead of 64 wires going to 64 switches, there are only 8+8=16 wires going to all the switches.

Bally identifies the switches in the switch matrix starting with row zero, column zero as switch "1". The rest of the switches in column 0 are numbered 2 through 8. If you look at the schematic it can appear some switches are missing. But most of these "missing" switches are the cabinet switches, which are not shown on the schematics. This includes the ball roll tilt, the plumb bob tilt, and some other cabinet switches.

Stuck Switches.

If a switch is stuck, first remove all the balls from the playfield (to open the trough switches). Also if a switch gets closed as you lift a playfield up, put a piece of tape between the switch contacts to prevent closure. This especially happens on spinner targets.

Put the game into its switch test. On games with sound cards (Lost World and later), this means pressing the red self-test button inside the coin door FIVE times. For chime games prior to Lost World you only press the test button four times. Note the switch number shown in the display. This will be the last switch "bad switch" in the list. Use your game manual to find the actual playfield location of the switch. Clear this switch first, then the next "bad switch" will be shown on the display. Your job isn't over until there are no more switch numbers shown in the display.

Switch Capacitors - Stuck Switches and Chattering Pop Bumpers.
The most common stuck switch problem relates to the capacitor on playfield switches. Note all playfield switches have a capacitor, but most do. Often these capacitors short, leak, or just break off. With the game on and in switch test, cut one end of the capacitor and see if the number goes away on the display in switch test. If so, the capacitor will need to be replaced. If the number doesn't go away, then reconnect the capacitor, as this wasn't the problem (check the switch diode next, in the same manner).

Note Bally never sent out a service bulletin telling operators to "clip the caps". Many operators did this though to get their game working. Bally only suggested clipping the caps to trouble shoot a stuck switch problem.

Bally used really cheap switch capacitors that failed prematurely. This probably happened because of the high power industrial soldering irons used on the assembly line. The caps used for the switches were actually made for circuit boards. As a result the high powered soldering irons on the assembly line weakened the cap's internal insulation, causing it to leak (not function reliably). This could result in a stuck switch indication. The other problem was the capacitors' leads were weakened from the high powered soldering irons. This caused the caps to break off the playfield switches.

Chattering pop bumpers is another problem caused by bad switch capacitors. A failing switch cap across the pop bumper switch is very common (due to vibration of the bumper), and can cause the switch to "bounce". This will can make the pop bumper fire more than once. Cut the cap off the pop bumper, and see if that fixes the problem. But make sure to replace the capacitor. It is there to help the game detect quick switch closures, and effectively makes the pop bumpers play better (more sensitive).

The switch capacitors are .05 mfd, 16 volt (or greater), ceramic disc, non-polarized.

Non-Working Switches.
There can be a few reasons for a missing switch in the switch test diagnostics. If it is only one switch, it could simply be a broken wire or dirty switch contacts. If it's more than one, it could be a broken wire at the top of that switch string. Switches are "daisy chained" together. That is, a row or column wire runs to the first switch in the series, then continues along to the next. If the wire is broken, all the switches behind that break can be affected.

Connectors can also be a problem. All switches run to the MPU board's J2 connector (upper right hand corner). Connector pins can break, or the wire inside the connector can break.

Switch Diodes - Stuck and Flakey Switches.
Just as the switch capacitors can fail, so can the switch diodes. Though not as common a problem, these small diodes can quite often fail or work intermittently. Unlike the switch capacitor, every switch must have a diode. If the diode is missing or fails, the switch will not work correctly.

Switch diodes are 1N4148 (or 1N914), which are known as fast "switching" diodes. Also a 1N4001 or 1N4004 can be used in a pinch. And it does matter which way the band of the diode is installed!

With the game off, you can test a switch diode by unsoldering one lead of the diode, and use your DMM (set to diode setting), and test the diode. In one direction you should get .4 to .6 volts. Reverse the leads and you should get a null or zero reading.

You can also test a diode with the game on and in switch test mode. Do this by jumping the two switch wires together (before the diode). If the switch registers in the self-test, the diode is bad.

What are the Diodes for?
The diode on each switch isolates that switch from the other switches in the switch matrix's column. The diodes "steer" the signal in one direction only. A shorted, broken, leaky or missing diode can havoc in the switch matrix. A broken diode would cause a switch to never be "seen" by the MPU (a broken wire will cause this too!). A shorted diode will violate a switch's uniqueness, and allow the switch strobe signal to show up at the wrong times, and for the wrong switches! Leaky diodes can act some of the time like a shorted diode, and other times be OK. This is the hardest diode problem to locate, but luckily doesn't happen too often.

Using diodes allows the switch matrix to use only 16 wires for 64 switches. The matrix is made up of 8 rows and 8 columns, allowing for a total of 64 switches. But a problem exists in Bally's design; they don't use diodes on every switch!

The reason Bally did this was they felt diodes were not needed on the coin mech switches. Since a coin mech switch would only be activated by itself (and never during game play with the playfield switches), they were un-needed. Also some early Bally electronics game playfield switches are also missing diodes. These were omitted because it was thought the ball could only activate one switch at a time.

Missing Diodes: the Problem.
If any of the switches without diodes get stuck closed (for whatever reason), this sends a constant signal to the MPU which totally confuses it. This can cause all kinds of other random game play problems. Bally finally reconized this problem, and put diodes on ALL switches by the mid-1980's. If your game is missing any switch diodes, I recommend you install a 1N4148 or 1N914 diode on the switch. Orient the band on the diode as it is installed in the other switches.

Switch Matrix Problems caused by the Coin Door Credit Button.
The start (credit) button is insulated from the grounded coin door with a piece of gray "fish paper". This paper stops the start switch from being permanently grounded. Often this paper gets worn, ripped or torn. This will cause the start button's entire switch strobe (row) to be grounded. This can make your Bally/Stern game do some weird stuff!

If your game has been broken into and the coin door pried open, the start button's fish paper can be easily damaged and causing a switch matrix problem.

For example, one strange problem seen from the start button being permanently grounded was the player one display always showed the same information as the credit/ball display. If the start button gets grounded, other strange game behavior can happen too like a confused game that just won't play right.

If you think the start button may be causing a problem, turn the game off and unplug the coin door's connector plug. Then turn the game back on and see if that clears the problem.

Switches as Interpretted by the MPU.
When a switch is closed, a row and column is crossed. This information goes to the MPU through the wiring harness to the MPU connector J2. Then the U10 PIA chip interprets this signal and directs it to the U9 CPU. Now scoring or other game conditions occur.

The information can get sent to the MPU properely, but a corroded MPU board can mis-direct the information. If acid damage gets underneath connector J2, this can cause havoc. Also connector J3, which at pins 2 and 3 are the shared strobe signals from J2, can be shorted together from corrosion damage and cause more havoc.

MPU Board DIP Switch Problems.
There is another area where the switch matrix can go crazy. This is at the MPU board's 32 mini DIP switches. These switches too have diodes, but if one diode goes bad, the DIP switches can be mis-interpretted, and this can cause havoc in the switch matrix.

If you suspect the MPU board's DIP switches as a problem, just turn them all OFF. This essentially removes them from the switch matrix. Then the DIP switch's diodes can be individually tested using your DMM (set to the diode setting). With the game off, you should get a reading of .4 to .6 for each diode, and when the DMM leads are reversed, a zero or null reading.

Multi-Ball Games and what is Required to Start a Game.
Some Bally multi-ball games require ALL the pinballs to be in the right place before a game will start. If a pinball is stuck or missing, often the game will not start. Sometimes a wire coming off the trough switch can also cause this problem. In either case the game appears to be broken, when the fix is really just unsticking a ball or re-attaching a trough switch wire. Here are the games that are effected by this:

Multiball Games that Won't Play Because of Switch Trouble			
Game	**Balls**	**Symptoms**	**Trouble Switches**
Centaur	5	All zeros on; flickering displays.	#01 Ball Trough #4 #02 Ball Trough #5 #08 Outhole (starts with #01 or #02)
Elektra	2	Won't start; displays blank.	#01 Outhole #02 Left/Right of Outhole (starts with #1 or #2)
Embryon	2	Will always start regardless	#05 Left/Right of Outhole #08 Outhole

Fathom	3	Won't start; displays blank.	#01 Outhole #02 Left of Outhole #1 #03 Left of Outhole #2 (starts with 1&2 or 1&3)
Fireball II	3	Won't start; displays blank.	#01 Outhole #02 Left of Outhole #03 Left of Outhole #18 Right of Outhole
Vector	3	Won't start; displays Ok.	#01 Left of Outhole #2 #02 Left of Outhole #1 #03 Outhole
Xenon	2	Won't start; displays blank.	#02 Ball Release #1 #28 Ball Release #2
Game	**Balls**	**Symptoms**	**Trouble Switches**

The above switches can be checked in diagnostic switch test. On games with sound cards (Lost World and later), this means pressing the red self-test button inside the coin door FIVE times. For chime games prior to Lost World you only press the test button four times. If the above switches are mis-read by the MPU, this can cause a game to not start, more than one ball being served to the shooter lane, no multi-ball, or some other strange behavior.

3n. When things don't work: High Voltage Section Problems.

The high voltage section of the Solenoid driver board supplies high voltage to the gas score display tubes to light them.

Adjust the High Voltage down to +170 Volts DC.
Bally and Stern games from 1977 to 1985 have an adjustable high voltage potentiometer ("pot") on the Solenoid driver board. This pot is located in the upper left corner of the board, beneath capacitor C26, and to the left of capacitor C23. This pot allows you to adjust the voltage going to the score displays for optimum voltage. Bally recommends this voltage be adjusted to +190 volts DC. But for increased display life, it's best if you adjust the voltage to +170 volts, or as low as +155 volts. Brightness generally won't be effected since there is a minimum voltage required for the gas inside the score displays to glow. Set your high voltage to whatever value it takes to adequately light all of your score displays, then turn it up just a few volts higher. Keeping this voltage as low as possible will greatly extend the life of these gas display tubes, and the display drive circuits.

The high voltage adjustment pot on the Solenoid driver board.

How do I measure the High Voltage?
The high voltage can be measured on the solenoid driver board. Put your DMM on DC volts, and put one lead on the solenoid driver board's TP-2 test point. Put the other lead on ground. This will measure the output high voltage from the solenoid driver board.

Exception to the +170 volt High Voltage Rule.
When installing brand NEW score displays, it may require the full +190 volts DC to light the displays for the first few hours. After the new displays become "seasoned", you can back the voltage down to +170 volts or lower.

High Voltage Warning.
WARNING! The high voltage circuit contains a large capacitor at C26 which can retain high voltage at dangerous levels. This capacitor will bleed off this high voltage to a relatively safe level after the game has been off for a few minutes. Note this voltage can also be dangerous to the integrated circuits on the solenoid driver board. If you short this cap accidently to the logic circuit, it can ruin those components.

Rebuilding the High Voltage Section.
If your high voltage section of your Solenoid driver board is not working, you may need to rebuild it. This is pretty easy to do, and fairly inexpensive. But you should install ALL the parts mentioned below. The design of this circuit was very simple to keep costs low. There is no protection against multiple part failures. Often the parts in this section fail in pairs. So just replacing one will burn out the new part in a short order. So replace all the parts in this circuit to ensure reliability.

High Voltage Rebuild Parts Needed.

- 2N3584 transistor at Q21 (250 volts, 2 amp, TO-66 NPN).
- (2) 2N3440 transistors at Q22, Q23 (250 volts, 1 amp, TO-39 NPN).
- 1N5275A zener diode at VR1 (140 volts, 1 watt).
- 1N4004 diode at CR21 (400PIV, 1 amp).
- 3/16 amp fast blow fuse at F1.
- 22k ohm 1/2 watt resistor at R51.
- 1.2k ohm 1/4 watt resistor at R55.
- 82k ohm 1/2 watt resistor at R56.
- 8.2k ohm 1/4 watt resistor at R54.
- 390 ohm 1/4 watt resistor at R52.

- 100k ohm 1 watt resistor at R35.
- (2) .01 mfd 400 vdc metal polyester capacitors at C27, C28.
- 25k ohm potentiometer PC mount at RT1

You can probably get away with not replacing all the resistors. But make sure you check them all with your DMM. If more than 5% out of spec, replace. It is very common for a resistor to go open in this circuit. Remember to install the new resistors and transistors slightly above the circuit board to allow a good air flow. Re-use any transistor spacers from the old transistors; they help prevent solder shorts. Definately replace all the transistors and diodes and capacitors specified above, regardless if they test good.

Replacement for the 2N3584 Transistor.
Often the high voltage 2N3584 transistor just can't be found. If your high voltage section is showing really high voltage (like 230+ volts), often the 2N3584 and the 2N3440's have failed. The 2N3440's are easy to get. So what can be used to replace the hard to get 2N3584?

There is a replacement transistor, the BUX84. This transistor has a TO-220 style case (instead of a TO-66 case). You may need to enlarge the heat sink's base/emitter holes to make sure there is plenty of clearance for the new BUX84's base and emitter leads. You can also cut off the BUX84's collector (center) lead. You can do this because the BUX84's metal tab, which bolts to the circuit board, will provide the transistor's collector connection. Remember to also insulate the heat sink from the transistor's (collector) metal tab. Use a nylon washer between the transistor's metal tab and the heat sink. Also use a small piece of heat shrink tubing to go over the bolt that holds the transistor to the heat sink.

Testing Your Work.
After the new parts are installed, set the high voltage adjustment pot to the minimum value (turn all the way to the left, counter-clockwise). If the solenoid driver board is the later design, do NOT install the the solenoid driver high voltage fuse!

Now turn the game on and measure the high voltage at TP2 on the solenoid driver board. Now adjust the voltage to +170 volts (or lower, if you can).

Now turn the game off and wait a minute or two for the voltage to bleed off. Re-install the solenoid driver board's 3/16 amp fuse at F1.

Finally, turn the game back on and press the red test button switch inside the coin door twice to run the display test. Let this test run for a few minutes, and make sure all the displays work properely. Check the high voltage again at the solenoid driver board's TP2 to verify everything is Ok.

The "Short" High Voltage Fuse.
The fuse used on the AS2518-22 solenoid driver board for the high voltage section is a smaller 8AG fast blo 3/16 amp style fuse. These are sometimes difficult to find in the smaller 8AG style. If you can't find this fuse, you can solder in a normal 1 1/4" fuse length fuse holder, and use the easier to get 3AG (1.25") fuse.

Replacing the small .75" 8AG fuse with a larger 1.25" fuse. If you can't find a 3/16 amp .75" 8AG fuse, you can solder in a normal size fuse holder in it's place (or bend the existing fuse clip, as described below). The larger 1.25" *long fuses are much easier to find.*

Another alternative is to bend the fuse clip slightly to accomodate the longer 3AG (1.25") fuse. This can be done by pinching the right angled ends of the stock fuse holder straight. These right angled ends stop a longer fuse from fitting in the smaller fuse holder. When the ends are bent back, the longer 3AG (1.25") fuse fits in the stock holder quite well.

Note the earlier AS2518-16 solenoid driver board does not have this fuse. Also the earlier solenoid driver board AS2518-16 (without the fuse) is directly interchangable with the later AS2518-22 solenoid driver board (with the fuse).

3o. When things don't work: Score Displays Replacement and Fixes.

The score displays on these older Bally games can be very tempermental. Here are some tips to help keep them running.

Display Missing One Digit.
If one digit is missing on a 6 digit score display, this can often be caused by a failed resistor. An open resistor at R1, R3, R5, R7, R9 or R11 (on 6 digit displays) are often the problem. If one is found bad (using your DMM set to ohms), replace them all!. They are all 100k ohm resistors. Replace with 1/2 watt versions, instead of the factory installed 1/4 watt size. When installing the new resistor, make sure to leave them slightly above the circuit board for better air flow. Also clean off all the black soot that is attracted to the displays with a 2 inch paint brush.

A 6 digit Bally display and circuit board.

Dim Score Displays.
Sometimes the score displays can seem dim. This is often caused by resistors on the score display circuit board. There are many resistors on this board. Test them with your DMM to make sure they are have correct values. Also make sure the header pins and connector pins on the score display board are clean and bright. If they are not, this adds resistance which dims the displays. To correct this, the pins must be replaced. Also sometimes the header pins can have cracked solder joints on the score display circuit board too. Resolder these to correct this problem.

Bally and Stern Display Units - Interchangable?
Six digit Bally and Stern display units are indeed interchangable. But the seven digit displays are not! But you can modify a Bally or Stern 7 digit display to work in either game.

To do this, jump together pins 11 and 12 of the Bally or Stern 7 digit display with a short piece of wire. This will allow either 7 digit display to work in either game. There is one problem with this, because the Stern display circuit board is deeper than a Bally board. To make this work, you must remount the tray-like mounting bracket on the other side of the backbox door. If you are using a Bally 7 digit display in a Stern game, be careful of shorting the circuit board to the metal bracket since the board will not reach the rubber support buttons at the rear of the bracket.

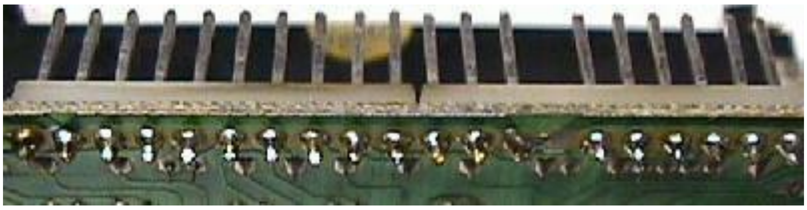
Finally, the Stern 7 digit display units do not have the circuitry to drive the commas in the display tube. So if installed in a Bally game, the Stern 7 digit display will never show any commas. If a Bally 7 digit display board is installed in a Stern game, the commas will show up! This happens because the commas are generated on the display board and is not part of the data sent by the MPU.

Flickering Displays.
Flickering displays can often be attributed to cracked solder joints or a broken lead on a component. Here are some things to check:

- Pin 36 on the display glass.
- R21, R22, R29.
- Q17.
- U1 pin 13.

Often reflowing the solder joints on these components will fix the flickering problem. Also reflow ALL the header pin solder joints. These crack easily from plugging and unplugging the cable.

The header pins on a score display circuit board.
These often need resoldered to fix flickering displays.



MPU board problems causing Score Display Problems.
If data from the MPU board is not properely sent to the score displays, this can cause a display not to work. Often the culprit is chip U20 on the MPU board. Move the score displays to a different player to isolate and make sure the problem does not lie within the score glass itself.

Test Counting Sequence Out of Numeric Order.
If during the score display internal test, the counting sequence is strange (i.e. 0,1,0,1,4,5,4,5,8,9 instead of 0,1,2,3,4,5,6 etc), there could be a problem with one of the address lines not being read correctly. If the problem moves when you swap displays, this means the MPU board is not the problem. Often the resistors R49 to R53 (20k) can be the problem (should be within 5% of 20k ohms), but also check for cracked solder joints at the header pins (a VERY common problem). The interesting thing is a bad display can affect the other displays. You may have to issolate the displays to find the bad one by plugging them into the game (with the game off) one at a time, and then running diagnostics.

Replacing a Score Diplay Tube.
Score display tubes don't last forever. With time and usage, the displays often "outgas". There is no way to fix this short of replacing the glass display tube. Here's how to do it:

- Cut the pins on the old score display tube. Do NOT try and save the old glass! The circuit board is what you are trying to save, not the (bad) glass.
- Remove the old tube's pins from the circuit board. Do this by heating each cut pin, and pulling it out with needle nose pliers. Then use a solder sucker to remove the old solder from the circuit board holes.
- Install the bottom mounting bracket if it was removed for cleaning!
- Feed the new display tube pin into the circuit board starting at one end of the board. This is easiest if all pins are straight first.
- When all the pins have been inserted, carefully bend the tube pins to produce a strain relief bend in all of the pins. This takes a bit of practice so that all the pins don't slip out of the holes in the circuit board! This is very important because as the display tube heats up, the tube can fail where the pins enter the glass if there isn't good strain relief.
- Check display tube alignment before soldering. The bottom plastic display bracket must be installed to check this. If you screw this up, the score digits may not be fully visible through the backglass score windows! Compare your new display to an existing display to make sure things are correct.
- After aligned, gently clamp the tube in place with 2 wooden clothes pins.
- Tack solder the display pins at each end of the circuit board. Re-check alignment.
- Solder all the display tube pins to the circuit board. Make sure the pads are soldered good on both sides of the circuit board. Inspect for any

shorts between two pins.

- Clip off the excess display pin leads.
- Inspect again for shorts.
- Put two marble sized dabs of silicon adhesive on the circuit board on both ends of the display glass. Do NOT fully glue the glass to the circuit board!
- Put a big dab of silicon on the display tube's "nipple". This will protect it from breaking and ruining the glass.
- Let the silcon dry overnight and re-install the display.

3p. When things don't work: Sound Board Problems.

The sound board discussed here is the Bally "Squawk and Talk" (S&T) board, as used in most of their talking games.

Bad Speaker?
This happens more often than you think. A bad speaker, or a speaker with one broken lead can drive you crazy thinking the sound problem is a lot more complicated. Check the speaker first before proceeding.

Distorted Sound and Humming.
Dried out capacitors on the S&T board is the major cause. The biggest offenders are the final filtering capacitors at C16 and C22. These are 4.7 mfd 25 volt caps, but they should be replaced with 6.8 mfd 16 volts (or higher volts). Here's are the caps to replace:

- C16, C22 (4.7 mfd, but replace with 6.8 mfd 16 volt)
- C19, C24, C25, C28, C31, C34, C42 (1.0 mfd 25 volt)
- C15 (10 mfd 16 volt)
- C36, C43 (2.2 mfd 25 volt)
- C25, C34 (1 mfd 25 volt)

Make sure you install all the above electrolytic caps in the right "direction". They are polarized, and there should be a "+" on the circuit board to help installation.

As a last resort, replace C14 (4700 mfd 25 volts). There generally is no need to replace the big caps at C27 (100 mfd 16 volt), C29 (470 mfd 16 volt), and C34 (4700 mfd 25 volt). Though these are tempting to replace, they are rarely the problem.

If replacing the above caps doesn't solve your sound problem, it can also be caused by a bad U7 PIA chip. This controls execution of speech via the TMS5200 speech chip. You can swap U7 and U11 (same chip) to see if this makes any difference. If it does, that means U7 is probably bad.

Also check the TMS5200 chip at U8 for oxidation on the chip legs, or a poor connection in the socket. This too can cause faulty speech. Sand off any oxidation on the chip legs and reinstall.

Another thing to try is swaping the PIA chips on the MPU board at U10 and U11. Also a bad potentiometer on the S&T board can cause bad speech problems.

Don't forget to check for cracked solder joints on the back of connector J1 on the Squawk and Talk board. This too can cause speech problems.

Checking Your Work.
There is a test button on the S&T board. Note this button is NOT "debounced",

and when pressed it makes multiple closures (the switch was not debounced as a cost savings). This can cause the CPU on the S&T board to lock up. Sometimes the S&T board will "stutter" and then lock up. To clear this, turn the game off, and then back on and wait for the game to re-boot. There is no way to avoid the test button bouncing other than luck. The S&T board's self test button should produce several speech phrases, followed by a long single "sound". Then the board will re-boot itself.

Squawk and Talk LED Flashes.

The S&T has a series of LED power-on flashes much like the MPU does. Here's a description of the flashes.

First Flicker.
Fakers Guide: No flicker means a bad U5, flakey U15, leaky C1, open R1, leaky CR1, or bad U17.
Techno Guide: On power up, U1 requires +5 volts to be applied before the reset line is allowed to go high. If this condition is met, the LED does a quick "flicker". At power-on, C1 slowly charges via R1. The voltage across C1 is monitored by U15. When it reaches 1.7 volts DC, U15 take the reset line high. Diode CR1 across R1 provides a quick discharge path for C1 in the event the +5 momentarily disappears.

First Flash.
Fakers Guide: No first flash means a bad U6, U15 or U17.
Techno Guide: The U1 chip tests the U6 RAM. It attempts to write then read back all 256 patterns in each of the 128 scratch pad RAM memory locations. If U1 completes the 256 x 128 = 32,768 tests, the LED is flashed.

Second Flash.
Fakers Guide: No second flash means PIA U7 is bad.
Techno Guide: The U1 chip now tests the first PIA U7. Each of the two PIA chips U7 and U11 are interchangable. The test is the same for both. If it determines the two PIAs are good, the U1 chip performs some test. This includes testing each of the two full byte port initialization registers, testing the two full byte I/O registers, and testing the CA2 and CB2 ports. If all checks out, the LED is flashed.

Third Flash.
Fakers Guide: No third flash means PIA U11 is bad.
Techno Guide: The same test above is performed on PIA U11.

Fourth Flash.
Fakers Guide: No fourth flash means sound generator U12 is bad.
Techno Guide: The U1 chip performs a test on the sound generator chip U12. The U12 chip is controlled by PIA U11. If the sound chip passes the LED is flashed the fourth time. A bad PIA at U11 can also cause no fourth flash! Or a bad connection between the three chips U1 (microproocessor), U7 (PIA), and U12 (sound generator).

Fifth Flash*.
Fakers Guide: No fifth flash means speech chip U8 is bad. (NOTE: Some games, namely Fathom, will not have a fifth flash! See the explaination below.)
Techno Guide: The speech generator U8 chip requires an initialization sequence at power-on. Since the chip is a "slow" device, there is an acknowledgement signal from the speech chip to the U7 PIA. Every time a write to the speech chip is done, the speech chip acknowledges. The U7 PIA attempts to send 9 bytes of initialization data to the speech chip, one at a time, waiting for

acknowledgement. If it is sucessful, the speech chip is considered functional and the LED is flashed the fifth time. A bad PIA at U7 can also cause no fifth flash! Or a bad connection between the three chips U1 (microproocessor), U7 (PIA), and U8 (speech chip).

***No Fifth S&T Flash on Fathom (and some other games).**
Fathom does not use the AY-8912 PSG (Programable Sound Generator) chip at U12 (and has the EE jumpers installed on the S&T board indicating it is not used). Because of this, only *four* flashes of the S&T LED will be seen (after the initial power-on flicker). This is normal and correct. Disassembly of the self-test ROM code for Fathom reveals there are only four calls to the LED flash routine instead of five.

Normal Operation.
The S&T accepts address signals from the MPU to select one of the sound or speech signals stored in memory. It then plays the request by controlling the sound generator chip U12, or the D/A converter U10 for sounds, or the speech generator chip U8 for speech. The S&T is notified of a sound/speech request by an interrupt from the MPU.

Power Needs.
The S&T requires several voltages for operation. A +12 vdc at 3 amps (unregulated) is required for the LED, VR1, and audio amplifier U18. Also +5 vdc is required for the remaining components, and comes from 6.3 vdc through VR2. Also -5 vdc is needed for the speech generator chip, and also comes from the 6.3 vdc input voltage.

Audio Control.
The S&T generates speech via the U8 chip. Commands and speech data are passed to this chip through U7 PIA. The speech chip uses the information it receives to control an electronic vocal tract that produces a speech signal across R14. This signal contains unwanted high frequencies that are removed in a low pass filter through U13, C19, C20, C21, R11, R15, R16, R27 and R81. The filtered speech signal is mixed with an optional off-card audio signal and is given to the speech voltage controlled amplifier (VCA). The output of the speech VCA is fed into the U18 power amplifier (8 watts).

The Squawk and Talk in Technical DETAIL!
Clive Jones wrote and excellent technical document on exactly how the Squawk and Talk works. If you wish to read this document, go to **squawk.htm**.

No Sound and Loud Buzz from Speakers.
This isn't always a complicated problem. Sometimes no sound and/or loud buzzing from the speakers can be as simple as a bad ground to the sound board. Check the Molex connectors, and make sure the ground wires are making good contact to the sound board.

3q. When things don't work: Miscellaneous Problems and Fixes.

These are a number of strange problems and solutions that people have mentioned to me.

- *"On my Eight Ball Deluxe (EBD), the score displays would flicker during attract mode, and a bit during game play. Also occasionally the flipper would cut out, or the flipper enable relay would chatter. I did all the*

suggested power supply and solenoid board modifications in this document too."
The problem turned out to be a bad ground path. The later Bally games used a foil covered cardboard as the grounding method for all the backbox boards. In this case, the foil was not consistently making a good ground to the MPU board. Also the green masking on the back of the MPU board was preventing the board from touching the mounting bracket, so the ground mod in this document did not help. To fix this, wires were run from one mounting bracket on each board to a true ground. Also the green solder mask was scraped from the circuit boards around the mounting bracket. Also make sure the "earth-ground-cable" going to the backbox is connected.

- *"On my Elecktra, the player one display does not work."*
  The backbox "earth-ground-cable" was mistakenly not connected. Attaching this cable fixed the problem.
- *"On my Centaur I recently changed the battery because the game wouldn't remember previous credits. After installing the battery, I went to the self-test button to turn the background sound back on. When I pressed the self-test button, it cycled through the game tests. But the next time I pressed the button to go to the bookkeeping functions, the displays went blank and the game locked up. The game boots just fine and gets seven LED flashes too."*
  What has happened is the memory in the 5101 RAM has become corrupt. Replacing the 5101 will fix this problem. Alternatively, you can try grounding all the pins together on the existing 5101. Sometimes that works too.
- *"My Bally game works fine except for the flippers. They do nothing. All fuses are Ok, as are the flipper EOS switches."*
  This is a very common problem. There is a relay on the solenoid driver board that turns on the flippers during a game. The power to this relay is through brown jumper wires between two header pins, adjacent to the relay. If one of the wires break, comes loose, or their solder points go cold, the flippers will no longer work. On the back side of the solenoid driver board, look for the two brown wires and resolder them to the connector header pins.
- *"How do I reset the replay values and high scores?"*
  This can be done by pressing the red button on the MPU board when the game is powered on. Note this is the button on the MPU board, not the red (self-test) button inside the coin door!
- *"I changed the battery or 5101 RAM on my MPU board, and now the game's sound doesn't work; I only get "chime" sounds, where before I got electronic sound."*
  On some 1982 to 1985 Bally games, there are several different types of "sound themes" available. These are kept in memory and not set by a DIP switch. If you change the battery on your MPU board, the game will default to the chime sound. See your game's manual for details on how to change to another sound theme.
- *"My Centaur powers on but does not finish 'booting'."*
  Centaur is a multi-ball game that requires all balls to be in the ball trough and the ball trough switches working before it will finish its power-on.
- *"All playfield solenoids don't work."*
  First thing to check is the under the playfield fuse might be blown. Next check fuse F4 on the power supply regulator board. Also check it's fuse clip is in good condition with good tension, and is not brown. Now check TP5 (test point 5) on the power supply regulator board. You should get about 43 vdc. If no voltage at TP5, assume the bridge BR3 on this board is bad and replace it.
  After getting +43 vdc at TP5, then check connector J1, pin 6 on the

power supply regulator board. This brown wire goes directly to the playfield flipper coils. If you have +43 volts at the connector, but not at the brown wire on the flipper coils, you have a problem in the wiring. Also note, +43 volts on some games is also used on the early A8 sound board (Lost World to Dolly Parton). A problem on this sound board (or a bad connector there) can cause problems.
If your game is not getting the 7th MPU LED flash, that means +43 volts is missing. If you have checked all the above, verify you have +43 vdc on the MPU board on the left (connector) side of R113. Now check the right side of R113. If no voltage there, then replace R113 (2k, 1/4 watt) and retest. If still no voltage, you probably have battery acid damage in this area on the MPU board.

- *"A playfield target feature lamp won't turn off."*
  A bad SCR on lamp driver board, or bad capacitor on the switch that activates the lamp.
- *"Only even numbered score displays show numbers."*
  A bad 5101 on the MPU board can cause this.
- *"No game credits shown in the credit display."*
  There is a DIP switch setting to turn this back on!
- *"Player one display always displays the same information that's in the credit/ball display."*
  Maybe a problem with the start button! The start button has a piece of "fish paper" (insulating paper) behind the last leaf. This stops the switch leaf from touching the metal support behind the switch. The fish paper had torn, and allowed the switch blade to touch the metal (grounded) support. This has the effect of grounding a row or column of the switch matrix. This will cause all kinds of strange problems! A new piece of fish paper, and the player one display worked fine.
- *"My Bally game boots with 7 LED flashes, but I just can't start a new game, even though I have credits."*
  Again, if the grey insulating fish paper on the coin door's start button is worn, ripped, or damaged, this will ground that entire switch matrix strobe (row). This can cause all kinds of strange game behavior.
- *"All four of the 7-digit score displays on a 1980 Xenon have the same problem; the first digit and the comma right after it are all dimly lit and visible whenever the displays are on."*
  Try disconnecting the score display modules one by one and see if the problem goes away. If so it's related to one of the score display units. If this doesn't correct the problem, most like the problem is the MPU board. Check the MPU board's J1 connector for a poor connection. Also U20 or it's associated components like U11 PIA could be faulty. Try swapping U10 and U11 and see the problem changes. Also check the +190 volts at the display board and make sure it is indeed from 155 to 190 volts.
- *"Game starts but won't serve the ball to the shooter lane."*
  Make sure there are enough balls in the ball trough, and that all the ball trough switches are working. If that is not the problem, chances are this game uses a "solenoid expander board". This board multiplexes a solenoid driver board transistor so it drives TWO coils instead of one. If the solenoid expander board develops a problem, certain coils may not work. See the section titled Solenoid Expander Board section above for more details.
- *"The wrong coil activates."*
  Make sure you have the correct game ROM software installed in the MPU board. Aside from that, chances are this game uses a "solenoid expander board". This board multiplexes a solenoid driver board transistor so it drives TWO coils instead of one. If the solenoid expander board develops a problem, the wrong coils can be activated instead of the correct coil. See the section titled Solenoid Expander Board section above for more

details.

- *"Coil will not work, yet transistor check out good, and there's power at the coil."*
  Bad or flakey connector on the solenoid driver board.
- *"Can't get the last flash from the MPU (Star Trek)."*
  Solenoid fuse on the rectifier board was good, but a bad diode on the sound board lowered the solenoid voltage enough to prevent the MPU from flashing the last time.
- *"Solenoids fire "out of order" in the diagnostic test mode."*
  Bad PIA on the MPU board. Try swapping U10 and U11 and see if the problem changes. If so, U10 or U11 are bad.
- *"Game boots up and everything is "slow" (power up tune is half speed, and there's a delay from when the ball hits a bumper until it scores)."*
  Check all passive components that connect to U12, the 555 timer chip. For example, capacitor C16 can go bad and slow the 555 timer frequency, and increase the service interrupt period. This will "slow" the game down.
- *"I am working on a Mr/Mrs Pacman, and I notice the GI (general illumination) lamps flash on and off at certain times during attract mode, but does not come on during game play."*
  To make the GI lamps flash on and off, Bally used a Triac bolted to the power supply board in the cabinet. The triac is cycled by the GI lamp flasher board mounted under the playfield. This flasher board is similar to a solenoid expander board. The output of a lamp SCR driver is used to drive a MOC3011 opto coupler that drives the Triac. As with the solenoid expander board, a dummy 555 lamp is connected to the SCR output on the flasher board to insure there is enough current draw to drive the MOC3011. Most likely this 555 bulb is burned out, and causing your problem. Also check the flasher board for bad (cracked or cold) solder connections. Check all the cable connections to the triac too. Lastly you can replace the MOC3011 chip.
- *"My Xenon won't run with the sound card and vocalizer plugged in. If I unplug the vocalizer from the sound card, and the sound card plugged in, the game works fine (but no sound)."*
  Probably a problem with bad capacitors or a bad voice ROM on the volcalizer board. Also check the 3 vertically mounted diodes in the lower right corner of the vocalizer board. When these go bad the diodes run hot and the game has hum and noise. If you replace the diodes, also replace the voltage regulator to the left of them.
- *"My Mati Hari displays are strobing wildly. I swapped in a known good driver board, but no change. These displays do not strobe in another game. Game works and plays perfectly otherwise. What is wrong?"*
  Connector J1 in the upper left corner of the MPU board could be the problem. Make sure there are no cracked solder joints on the MPU board's J1 connector header pins. This problem could also be related to the rate the displays are being updated. It could be a bad capacitor in the MPU's circuitry for the U12 (555) chip, perhaps the "big green" capacitor.
- *"My Bally Space Invaders continues to blow the 20A Fuse for the GI on the Rectifier Board and I'm stumped. It doesn't blow the fuse iimmediately it usually does it shortly after game play begins. Are there any components on the Rectifier Board that may be making it short out? If so what?"*
  This is never an easy problem. Break the GI lamp circuits down into sections and isolate the problem that way. Maybe start by disconnecting GI to the backbox, to the cabinet, and/or to the playfield. Eventually you should be able to isolate which part of GI is at fault. Once you've localized it, start disconnecting different portions of the GI circuits on the components in question (playfield, cabinet, backbox). Keep in mind there

are two GI lines- red/white, and green/orange. Each one usually runs a couple of lines of bulbs on playfield/backbox. Just start disconnecting a wire from individual lines until problem goes away, then you've got it narrowed down even further. The problem could be shorted wires or sockets, to wires swapped (red to white and vice-versa), even a #44 bulb that had a filament wire sticking out of the bottom of it that was just long enough to short out against the side of the bulb socket when it was installed (this is why I personally like to replace light bulbs with the power on, so you can immediately see a problem bulb). There really aren't any components on the rectifier board that control the GI circuit, unless it's a short on the back side of the board or something. All that really is in the GI circuit on the rectifier board is the 20A fuse. GI power comes off the transformer and goes through fuse. Then it goes to the various pins on J1, J2, and J3, and the test point. Just look for wires rubbing, solder splash on traces/pins on back of board, etc. Of course, if this was the case, then the fuse would still blow even when J1 and J3 were disconnected from the rectifier board. If this isn't happening, then keep looking elsewhere in the game- backbox, playfield, cabinet (coin door), etc.

- *"When I turn on my Stern game with a M-200 MPU board, the game will energize coils, blink the lamps, and the displays will count 1,2,3,etc real fast. What is the problem?"*
  If all 32 DIP switches on the Stern M-200 MPU board are in the OFF position, the Stern MPU is designed to go into diagnostic test mode at boot-up. So either all your DIP switches are off, or PIA U10 is bad and telling the CPU that all the switches are open (off).
- *"My Stern Sea Witch with a M-200 MPU has a problem where it will not boot on occassion. Also the bookkeeping and high score reset button has no effect. There is no MPU board corrosion, and the reset section of the MPU has been totally replaced."*
  This person solved their problem by replacing the U9 6800 CPU chip. Apparently the NMI (non-maskable interupt) circuit inside the CPU chip was damaged, maybe by static from a poorly grounded coin door. This CPU problem did not show itself immediately, and let the MPU board function for the most part. The non-functioning reset switch was the give-away here, since this switch connects to the NMI circuit on the CPU chip.
- *"My Baby Pacman's playfield GI {General Illumination} lights do not come on when the pinball mode starts, why?"*
  The playfield GI lamps are controlled by a Triac, so the lamps can be switched on and off (as the game moves from video to pinball and back to video modes). There is a small driver board which holds the Triac. This board is connected to a switched lamp SCR on the lamp driver board. If all the switched lamps do not work (fuse?), or the SCR on the lamp driver board has failed, the playfield GI lamps will never turn on.
