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

Deze pagina is tot stand gekomen door het aanleveren van technische informatie van duizenden flipperkastliefhebbers en techneuten over de hele wereld.

**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.

**BELANGRIJK:**
**Als je geen ervaring hebt in het repareren van printplaten, dus een goede vaardigheid in solderen hebt kun je dit beter niet zelf proberen.**

**De meeste professionele reparateurs nemen GEEN printplaten aan die door eerdere reparatiepogingen vernield werden (gehacked)**
**Je kunt soldeerwerk en printplaatreparatie in zo'n geval het beste door gespecialiseerde reparateur zoals de Flipperwinkel in Arnhem laten uitvoeren.**

**Speciale dank aan Leon Borré voor het schrijven van testsoftware waarmee het opsporen van fouten flink vereenvoudigd is.**

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# 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.**

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# 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.

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# 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.

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## 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)
  - Strikes and Spares, 6/78 (12,820)

**STERN First Generation with M-100 MPU and "chime" sound:**

- Power Supply identical to Bally's AS2518-18
  - Pinball 7/77 (1,694 SS)
  - Stingray 3/77 (3,066)
  - Stars 3/78 (5,127)
  - Memory Lane 6/78 (2,624)

- 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
- 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

**STERN second Generation with 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)

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)
- Lightning 3/81 (2,350)
- Orbitor One 4/82 (889)
- Cue ??/82 (prototype, never released)
- Lazorlord 10/84 (prototype, never released)

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# 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.

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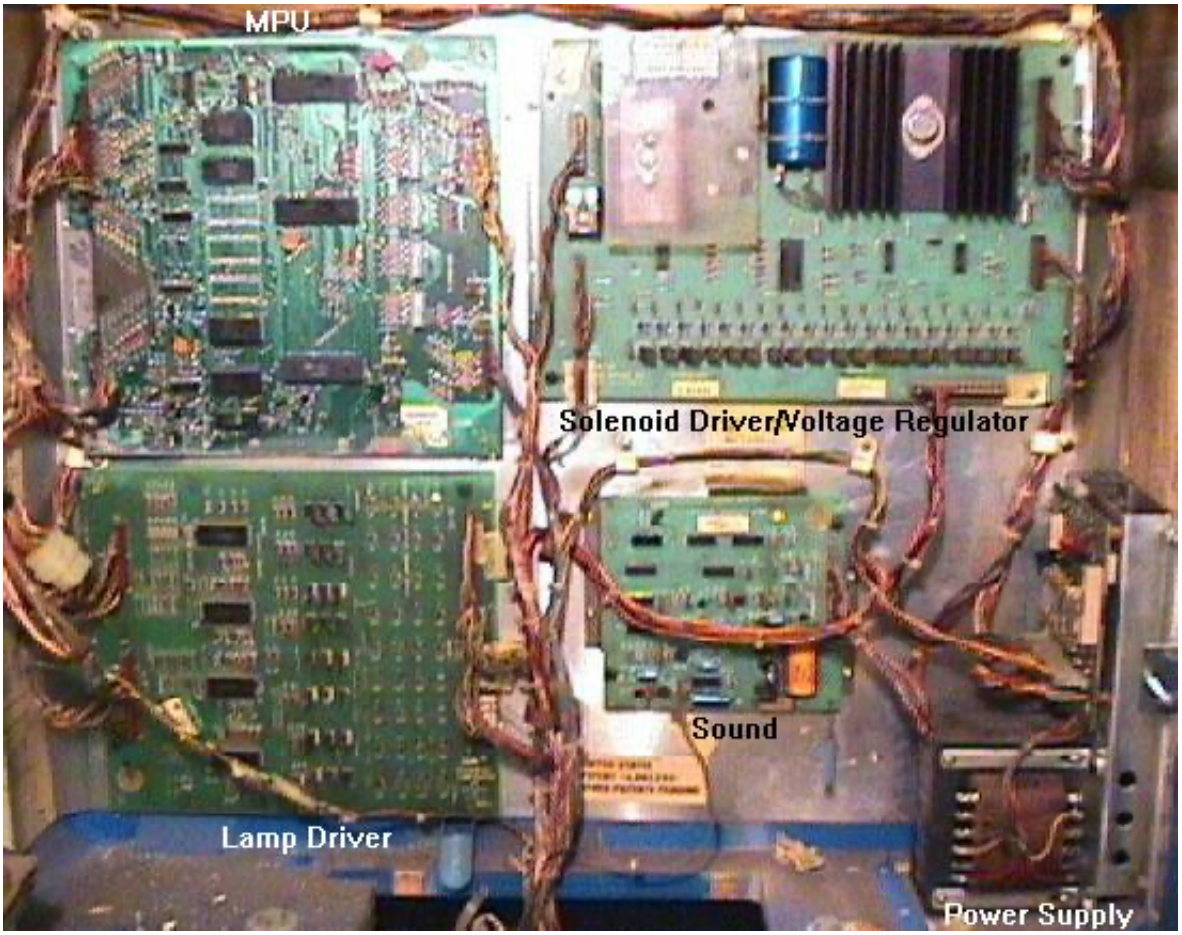
## 1f. Getting Started: The Circuit Boards

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.*

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## 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)

**Sound module -50:**

- TP1 = +5 vdc
- TP2 =

**Sound module -51:**

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

- 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 -32**

- TP1 = +5 vdc
- TP2 = Ground
- TP3 = +11.9 vdc
- TP4 = +43 vdc
- TP5 = +43 vdc (solenoid return)

Ground

- TP3 = ?
- TP4 = +43 vdc

**Sound Plus module -56 (Xenon):**

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

**Volcalizer module (used with -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 control voltage
- TP7 = AY38912 output
- TP8 = E
- TP9 = TMS5100 output
- TP10 = VMA
- TP11 = TMS5100 clock
- TP12 = Reset

**Sound Module -81 module (Say it again)**

- TP1 = Ground
- TP2 =
- TP3 =
- TP4 =
- TP5 =
- TP6 =
- TP7 =
- TP8 =
- TP9 =
- TP10 =
- TP11 = +11.9 vdc
- TP12 = +11.9 vdc
- TP13 = +4 to +8 vdc

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

* 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)

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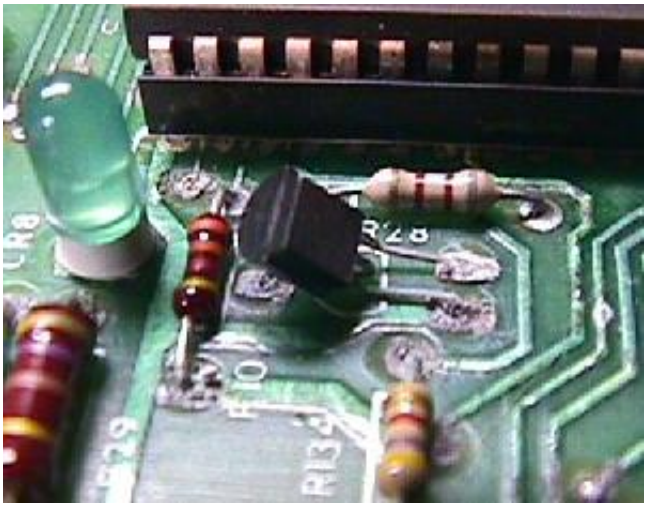
## 2a. Before Turning the Game On: Removing the MPU Battery and Fixing Corrosion.

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.

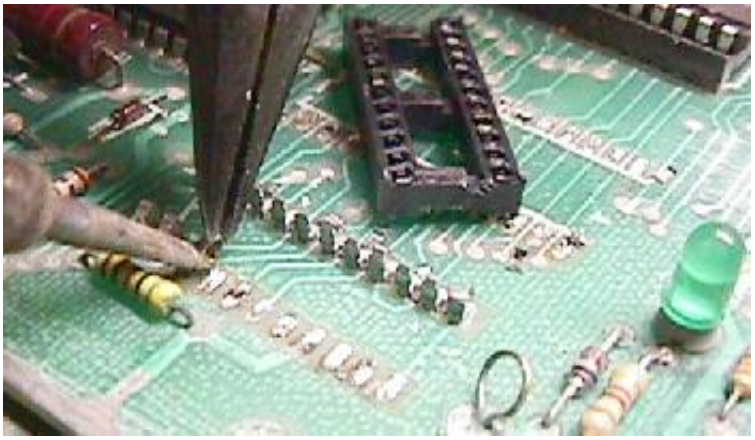
- **Tip for desoldering corroded solder:** Often solder becomes so grey/black it can't be heated and desoldered. First try adding some new solder. If that does not work, take a Dremel tool with a tiny wire wheel to the grey/black solder joints.
- Hand sand all green/gray areas with 100 or 150 grit sandpaper. 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.*

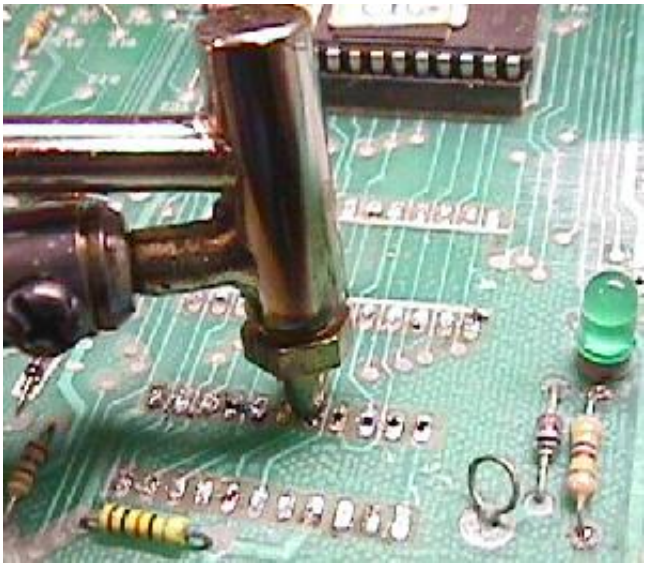


**Step 3:** Desolder the MPU board chip holes. Using a desoldering iron (Radio Shack $10), desolder the holes. It may be easier to desolder the solder joints from the back (non-component) side of the board because the corrosion is usually less there, and the solder will melt better. Sometimes new solder 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.

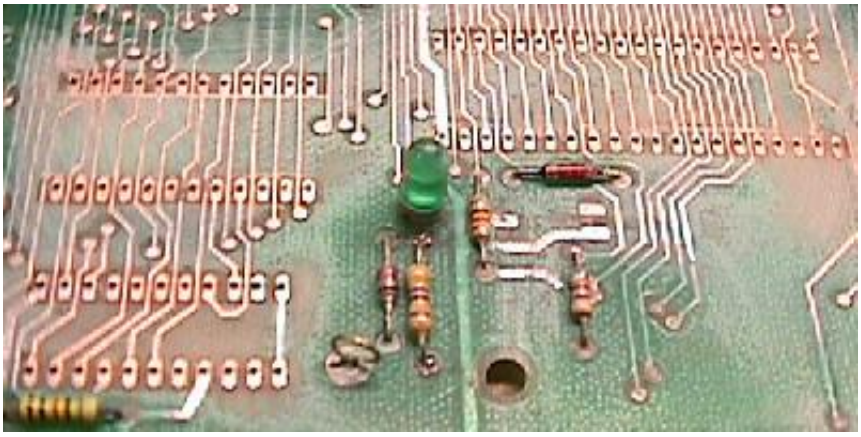
**Step 5:** Examine the DIP switches for corrosion. Any corrosion around the DIP switches can cause these switches to short together, giving all kinds of strange switch matrix problems.

*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.*



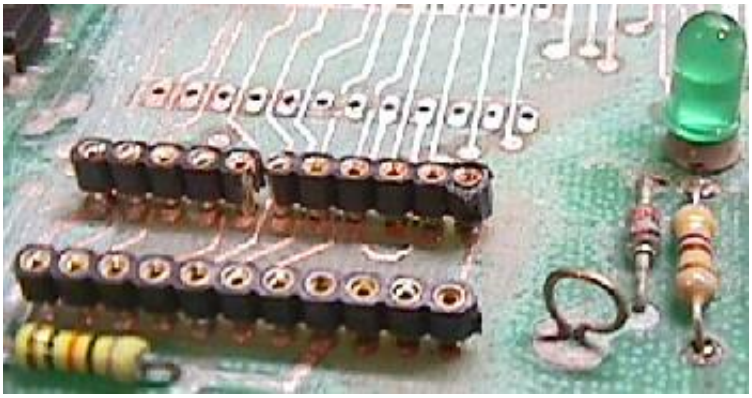
**Step 7:** Wash the board in a 50/50 solution of white vinegar and water (as descibed above).

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

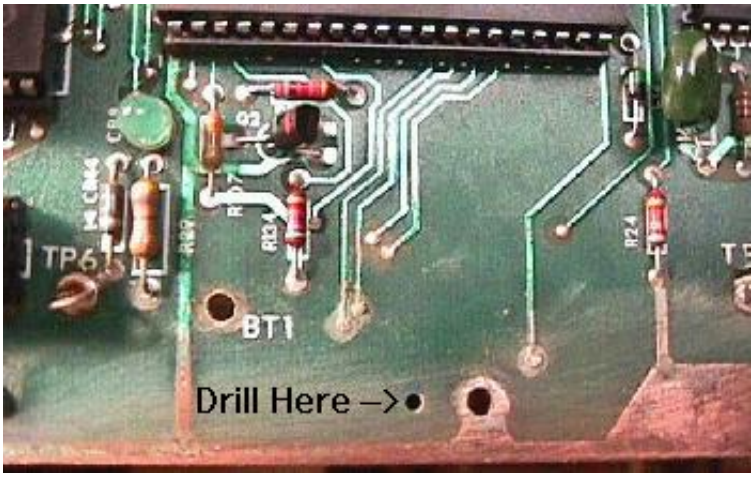
**Step 9:** Replace any damaged traces on the board. For large (thick) traces (like the ground rail surrounding the outside of the board), use desoldering braid. For small traces, use wire wrap wire. For medium traces, use stranded 24 guage wire. Use rosin soldering flux (Radio Shack) to help solder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

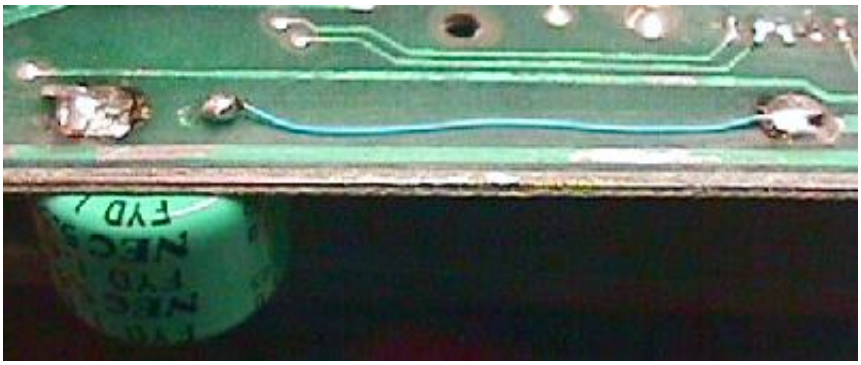
**New Battery**
To replace the original battery, add a remote three "AA" battery pack and a 1N4001 diode (banded diode end first connected to the pcb "+" pin, and the non-banded end connected to the positive lead of the battery pack). The diode is used so the recharging circuit doesn't try to charge 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.

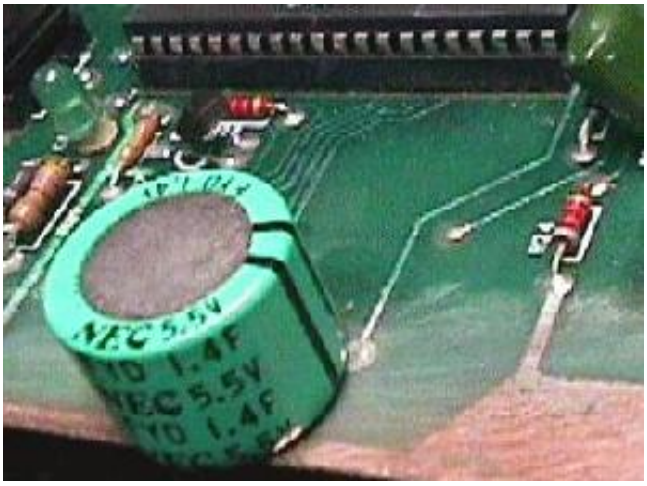
**Installing the Memory Back-Up Capacitor.**
After removing the battery and addressing any board corrosion, install the memory back-up capacitor. Drill a hole for the second lead of the back-up cap, just to the side of the negative battery lead (see picture above). Then mount the cap in the board, and 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.*



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## 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!

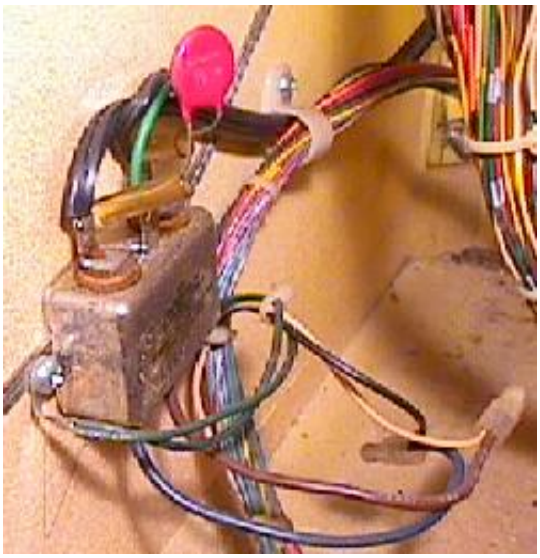
There are three different version of the Bally electronic rectifier board. The most common is AS2518-18 (which is identical to the rectifier board used in Stern games too). This is the most troublesome design, and will require some upgrades. The least common is AS2518-49, and was only used on Kiss, Future 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.

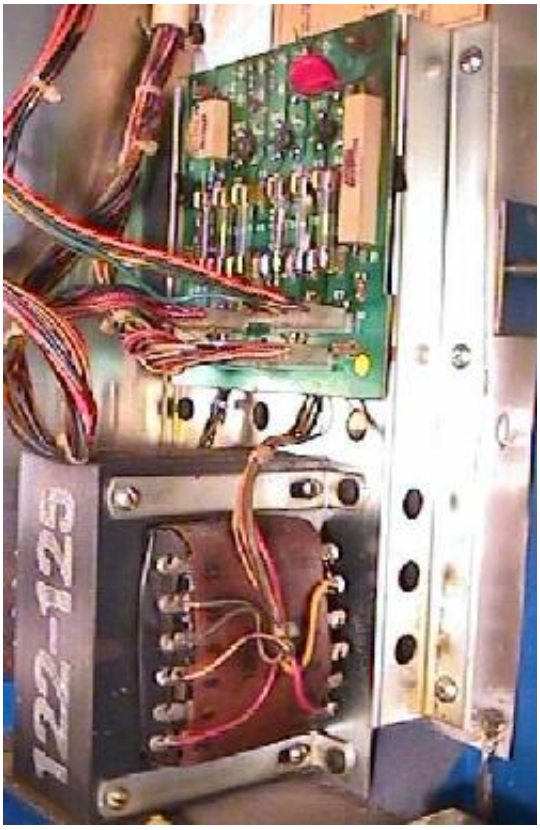
*The red varistor and the line filter, as found in the cabinet of a Bally game.*



**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).*

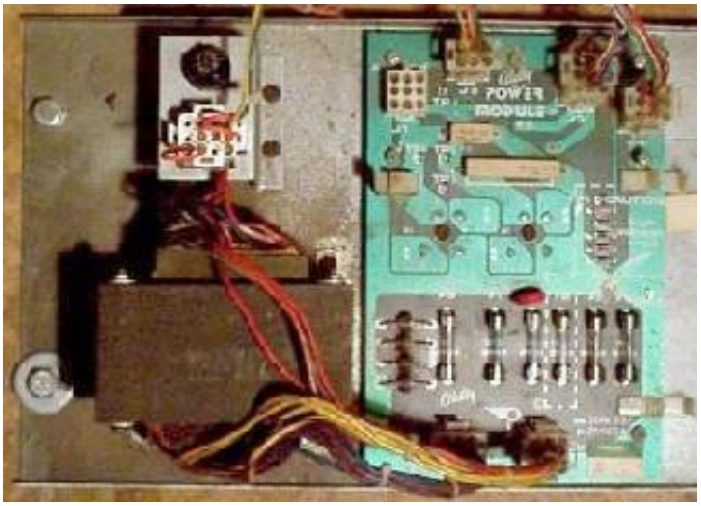



**The Rectifier Board.**
The rectifier board takes AC voltage from the transformer and converts it to unfiltered DC voltage. Bally used three different rectifier board in thier games from 1977 to 1985. The part number is silk screened right on the printed circuit board.

- 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.

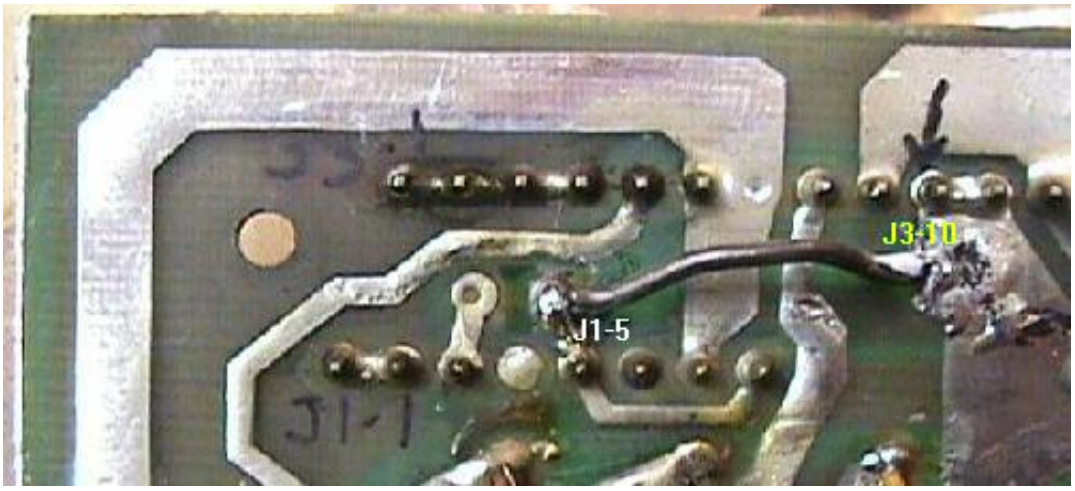
**First Upgrade: #47 Light Bulbs instead of #44.**
This "upgrade" is actually VERY important! Change ALL the playfield light bulbs from #44 to #47 bulbs. The #47 bulbs consume less power, and put less of a strain on the power supply's transformer, connectors, and bridge rectifier. Sounds ridiculous, 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.

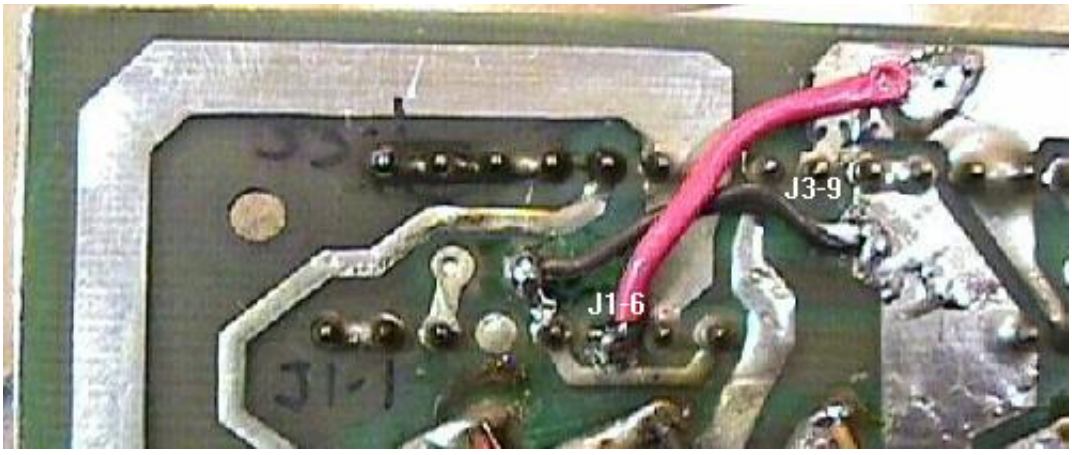
1. Replace ALL the .156" header pins on the rectifier board. Chances are these header pins are brown. Even if just slightly burnt (brown), this means the pins are acting like small resistors. Replace them all with new pins. Sanding the pins and re-tinning them is only a short term fix. Sanding removes 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.*




2. 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.*

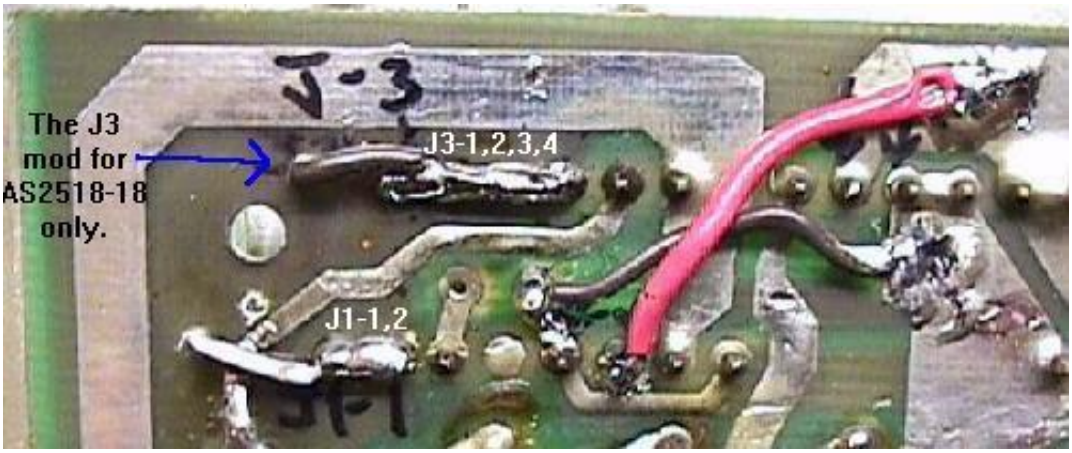



3. On the solder side, add a jumper from J1-6 to J3-9. Since there are no plated through holes here, solder the wire directly to the header pin and the circuit board trace. This adds additional area for the 43 vdc solenoid lines.
4. On the component side, drill a 5/64" hole to the left of the header 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).*

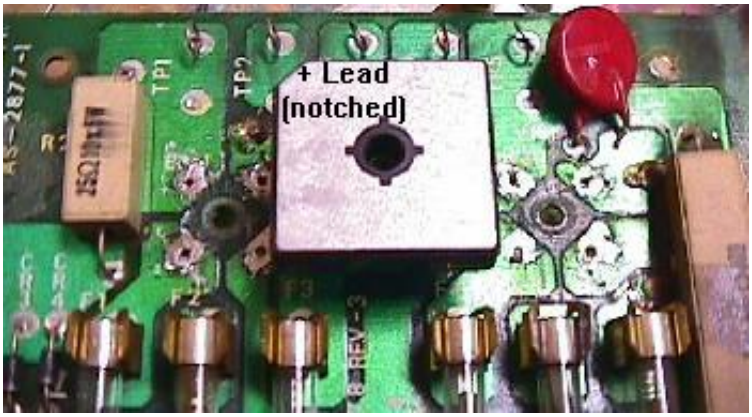

5. On the component side scrape the green solder mask off the surrounding ground trace which the hole(s) goes through. If no hole(s) were drilled, still scrape the green solder mask off the large ground trace, to the side of the header pins (where the hole(s) would have been drilled). Solder wire(s) 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.*



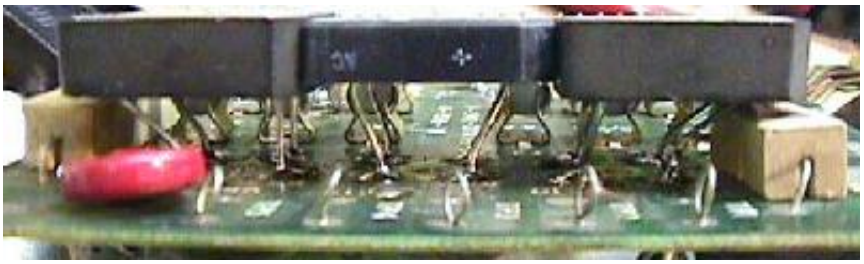

6. Desolder the three (or two, if it is a AS2518-49 rectifier board) bridges from the bottom of the rectifier board.

*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.*

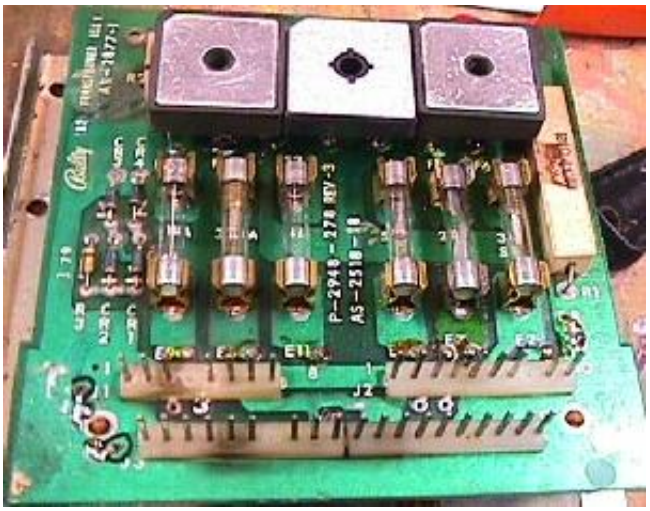


*AS2518-49: The "dog leg" bends are less prevalent here because there are only two bridges to install on this rectifier board.*

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:

1. 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).
2. 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.
3. 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.

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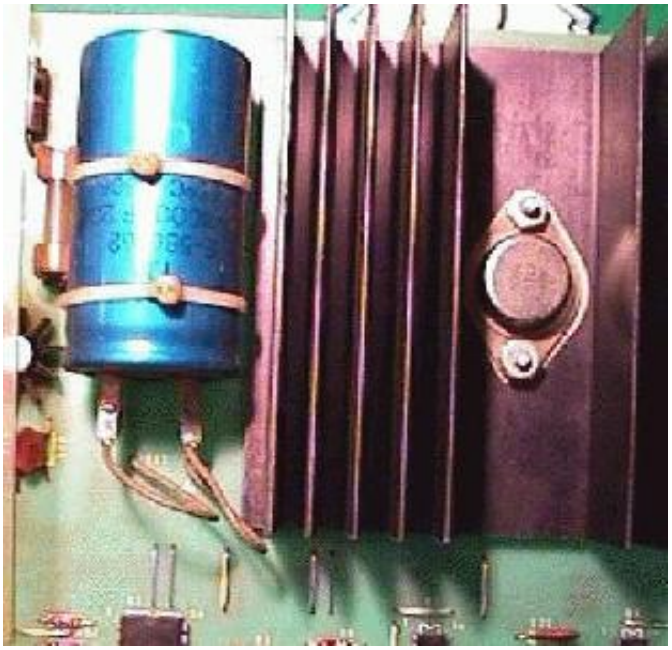
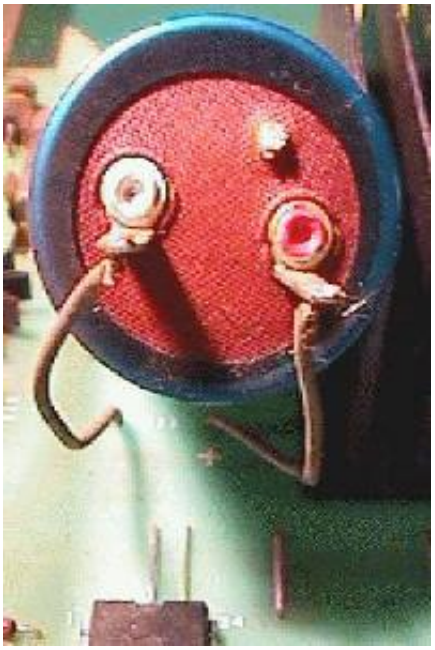
## 2c. Before Turning the Game On: Upgrading the Voltage Regulator/Solenoid Driver Board.

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.

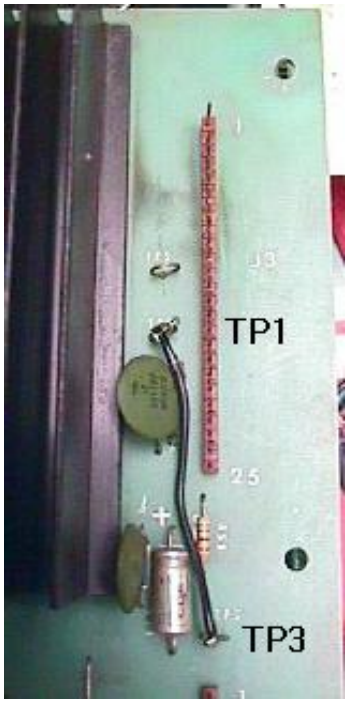
**Upgrading the Voltage Regular/Solenoid Driver's +5 volts.**
There is also a design problem on the voltage regular and solenoid driver board's +5 volts. Like the ground, the +5 comes from the power supply to the solenoid driver board, goes through the filter cap and voltage regulator, and then leaves 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.

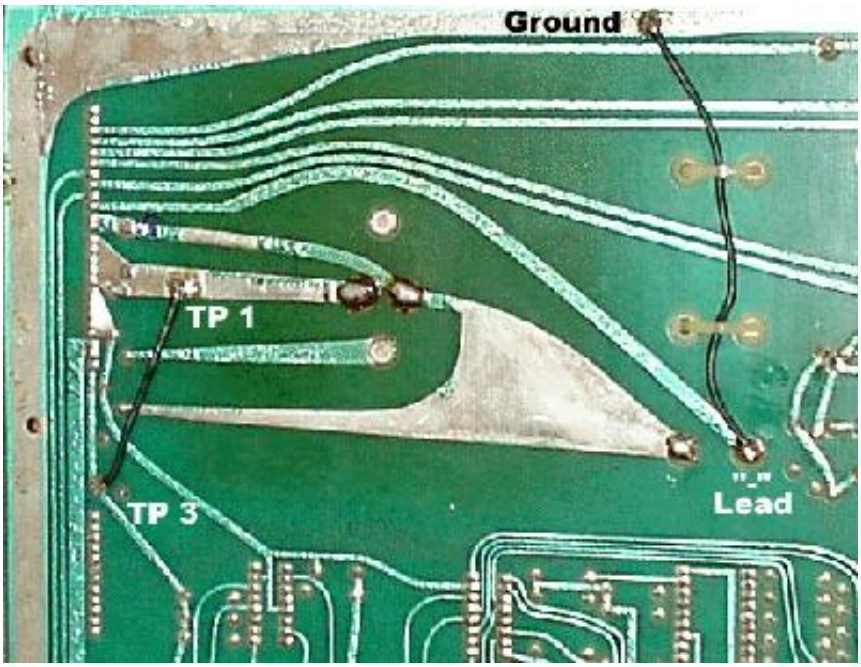
NOTE: do NOT do this modification to Baby Pacman's Voltage Regulator/Solenoid Driver boards! Baby Pacman uses a unique version of these boards which is similar, but not exactly the same. Tying TP1 to TP3 will short the unregulated 12 volts to ground.

***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.

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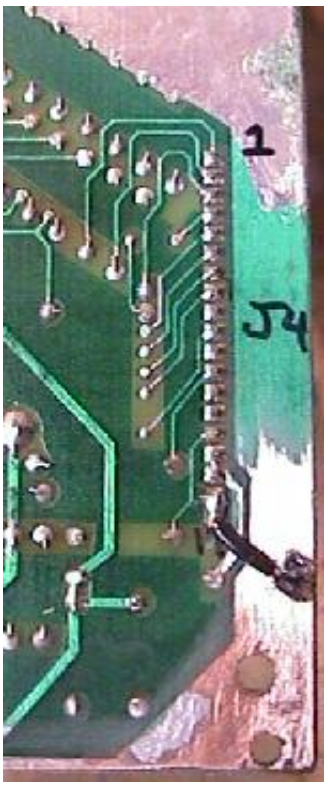
## 2d. Before Turning the Game On: Upgrading the Ground on the MPU Board.

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.

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## 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.

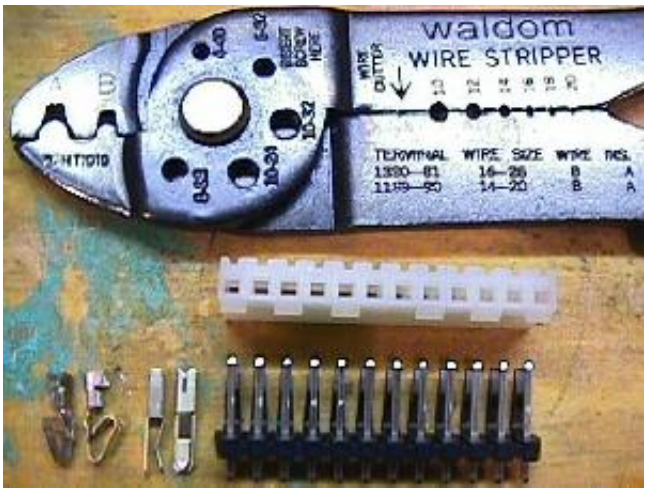
An AC voltage of less than .3 volts should be seen. Any more than that, and C23 is not doing its job, and needs to be replaced. Do this BEFORE you put power to the MPU board! The replacement procedure is described above.

**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.

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## 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.

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* Go to the Bally Repair Guide Part 2
* Go to the Bally Repair Guide Part 3