

Bally®

ELECTRONIC PINBALL GAMES

REPAIR PROCEDURES

MODULE & COMPONENT REPLACEMENT

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MODULE REPLACEMENT INDEX

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AID, BALLY KIT #485, IS RECOMMENDED FOR USE WITH THIS PROCEDURE.

I. INTRODUCTION

Repair of the electronic game in the game room is by module replacement or cable harness repair. See Figures I and II. The procedures herein facilitate fault localization to the defective lead or module. The game is restored to operating condition by cable repair or by the substitution of a known, good module. Defective modules are returned to a repair station for corrective action.

The repair procedures take advantage of two special test routines designed into the game. The first routine causes the MPU (microprocessor unit) module to examine itself for proper operation on power-up. If the MPU module determines that it is correct, the power-up tune announces that the game is operational. If the MPU module determines that it is not correct, it will not allow game play. The second routine is the Self-(Diagnostic) Test. This routine causes the MPU to exercise each of the other electronic modules. Burned out lamps, defective display modules, solenoids and stuck switches are all quickly located by means of this routine.

A small module, called AID1, is especially useful in determining continuity between modules under actual digital operating conditions. AID1 is a small plug-in module that mates with J5 on the MPU module. The module is available from the Bally Service Department as part of Kit #485.

No special tools or equipment are required by the repair procedure. A volt/ohmmeter, Simpson model 260 (20,000 Ohm/VDC) or equivalent and several test lead jumpers are necessary. The standard tool box compliment of soldering iron hand tools are also required for making cabling and electro-mechanical component repairs. Schematics are helpful, and are required as an aid to troubleshooting.

II. DESCRIPTION OF SELF-(DIAGNOSTIC) TESTS

At power on, the LED on the MPU module flashes once. After a pause, it flashes six more times and goes out. A power-up tune is played to announce game readiness. This indicates proper MPU operating condition and successful completion of the power-up test. If this does not occur, refer to the MPU Diagnostic Table, Section VA, Page 8.

- 1) Pressing the self-test button* inside the door initiates the self-test routine. See Figure III. All switched lamps flash off and on continuously. In case of improper operation, (lamps off, or always on), refer to Lamp Driver Diagnostic Table, Section VB, Page 9.
- 2) Pressing the self-test button again causes each digit on each display to cycle from 0 thru 9, all off, and repeat continuously. Improper operation consists of displays, digits or segments always on or always off. If improper, refer to Display Driver Diagnostic Table, Section VC, Page 12.
- 3) Pressing the self-test button again causes each solenoid to be energized, one at a time, in a continuous sequence. Hold both flipper buttons 'in' during this test. The number appearing on the Player Score displays are the same as the number assigned to the solenoid. The sound of a solenoid pulling-in as a number appears indicates proper operation. The absence of sound is improper. If improper, note the solenoid number and refer to the Solenoid Driver/Voltage Regulator Module Diagnostic Table, Section VD, Page 14. The Solenoid Assembly Identification Table, stapled in the back box, identifies the Solenoid by showing the assigned number and description.
- 4) Pressing the Self-Test button again causes the MPU to search each switch assembly for stuck contacts. If any are found, the number of the first set encountered is flashed on the Player Score displays. The number remains until the fault is cleared. Other numbers may follow if more stuck contacts are present. Note the number on the Player Score displays and refer to the Switch Matrix Diagnostic Table, Section VE, Page 16. The Switch Assembly Identification Table, stapled in the back-box, identifies each switch assembly by showing its assigned number and description. If there are no stuck switches, the number "0" appears in the Match/Ball in Play display. Pressing the Self-Test button eleven more times or turning the power OFF and ON causes the MPU to repeat the power-up test. See II, first paragraph. The game is now ready to play.

* See Figure I.

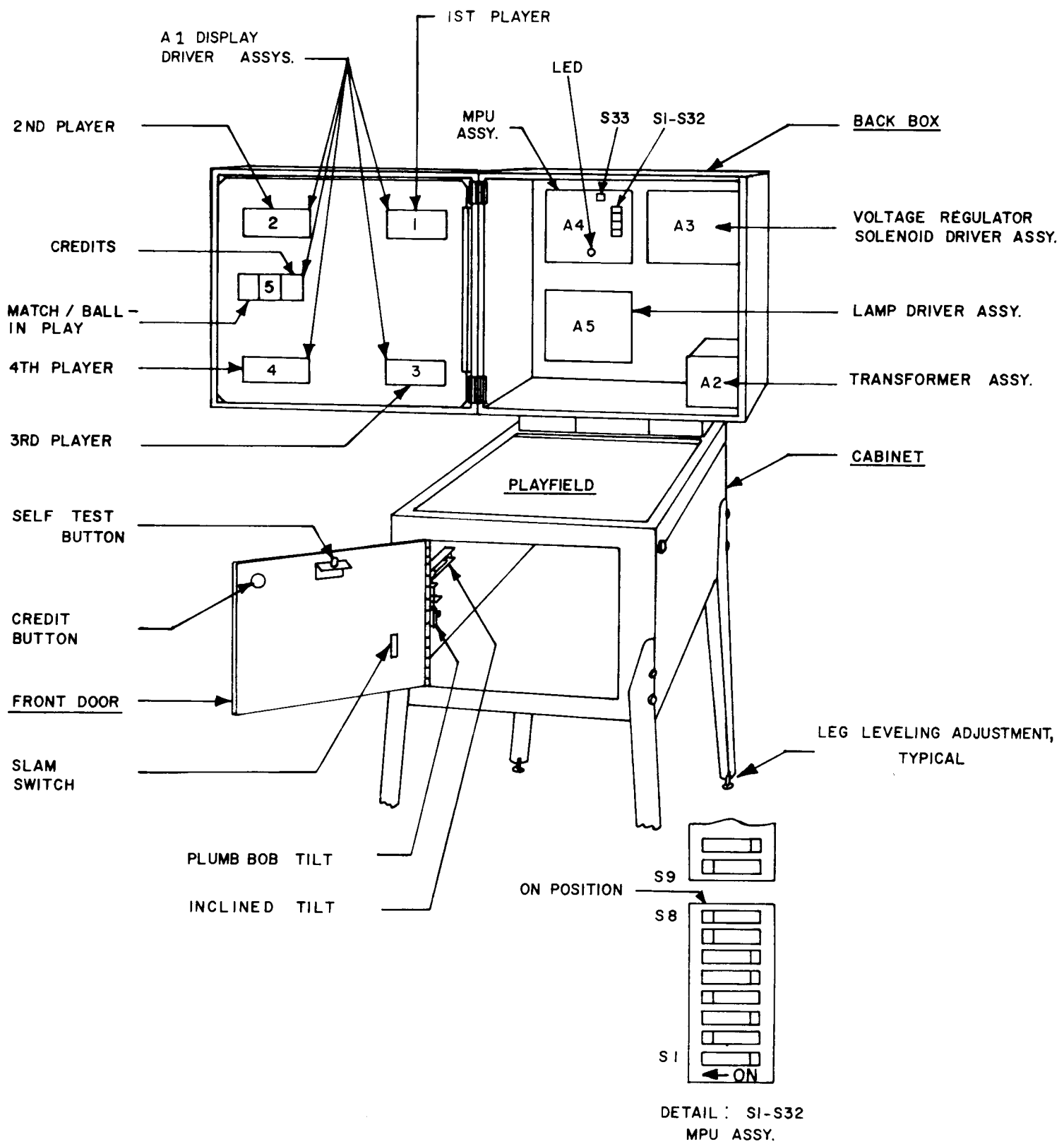


FIGURE I ELECTRONIC PINBALL MACHINE

BLOCK DIAGRAM—ELECTRONIC PINBALL GAME

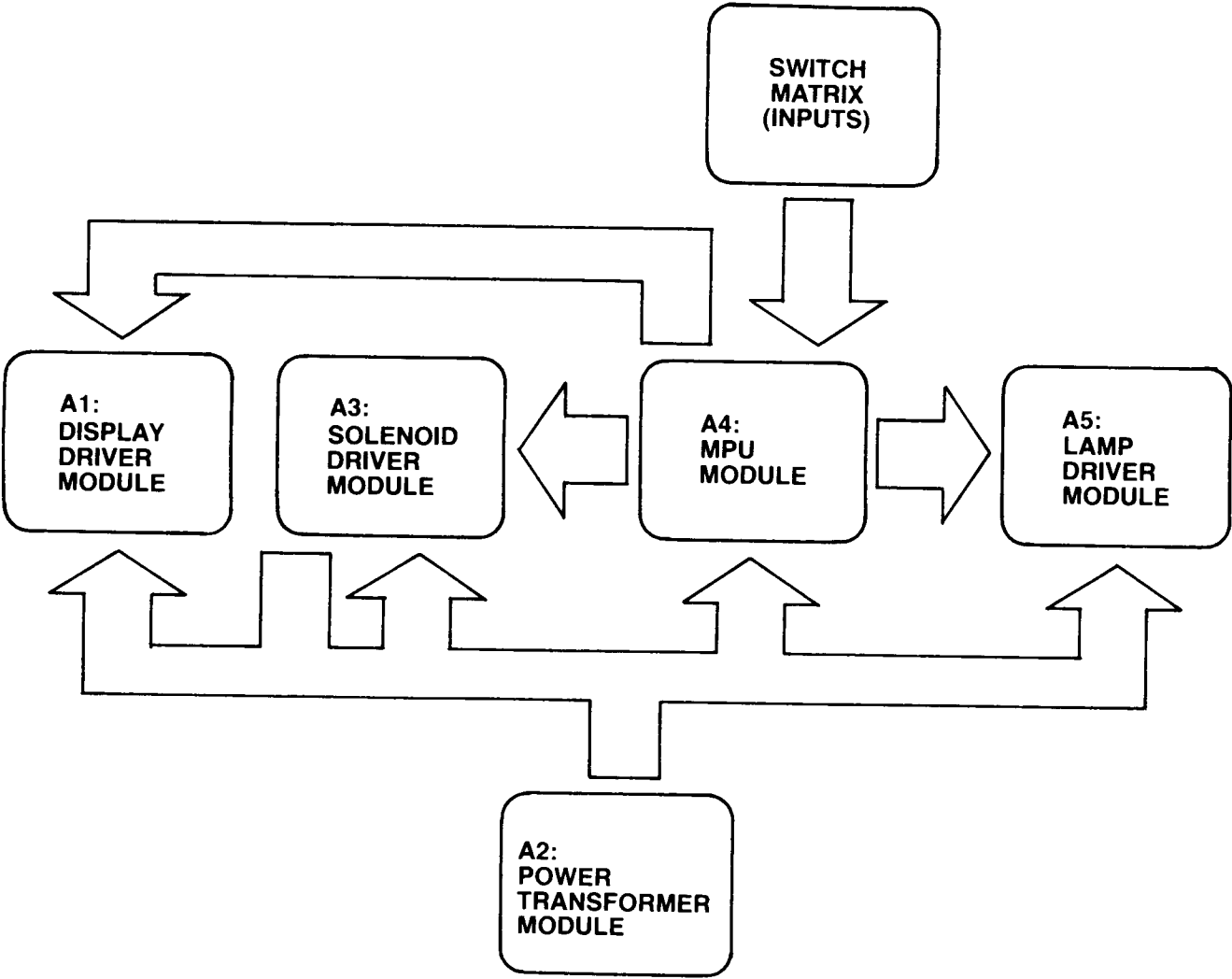


FIGURE II BLOCK DIAGRAM — ELECTRONIC PINBALL GAME

It is recommended that problems be solved in the order in which they appear in the Self Diagnostic Test routine. The reason for this is that the same fault may create misleading symptoms in subsequent test routines.

After successful completion of the Self Diagnostic Test procedure, set the game up for play. Exercise each rollover, thumper-bumper, slingshot, etc., by hand until each switch assembly on the playfield has been checked for proper operation. If actuating a switch assembly results in intermittent or no response, use AID1 and probe (See Section III and VE, Table V) to determine if the switch leaf springs have continuity to the MPU module. If incorrect, work probe back to MPU module until reason for lack of continuity is determined. If the problem is localized to the switch contacts, correct by gently closing them on a clean business card or paper and wiping until they wipe clean. Regap if necessary to $\frac{1}{16}$ ".

III. DESCRIPTION OF AID1 PROGRAM

At any time during steps 1, 2, 3 or 4 of the Self-Diagnostic Test, a troubleshooting AID program can be initiated. Plug in the AID1 module (J5, A4, MPU). Turn on the power. The AID1 program is called from the Self-Diagnostic Test by pressing S33 on the MPU module. When a game is functioning properly, entering into the AID1 program results in all displays, solenoids and switched lamps being turned off. A soft, humming sound will be present.

AID permits signal continuity and adjacent lead short test to be conducted between modules. A test probe in the AID kit is clipped to TP1 on the AID1 module and is placed on the point under test. If signal continuity exists between the point and the MPU module, the LED on the MPU module lights and the humming disappears. If the LED does not light, a fault exists in the circuit. The game schematics and Figures II, III and IV permit isolation of the fault to a module or to the wiring.

When using AID, a noise pulse introduced on the line under test can occasionally cause the MPU to 'jump the track'. If this happens, the humming noise disappears. Turn off the game. Re-enter AID through the Self-Test routine.

IMPORTANT: The only exit from AID to the Self Diagnostic Test or normal operation is by turning the game "OFF" and then "ON" by means of the "ON-OFF" switch. The Self-Diagnostic Test can then be reinitiated by means of the button inside the door. A particular test is reinitiated by pressing the Self-Test button the appropriate number of times. See Figure III.

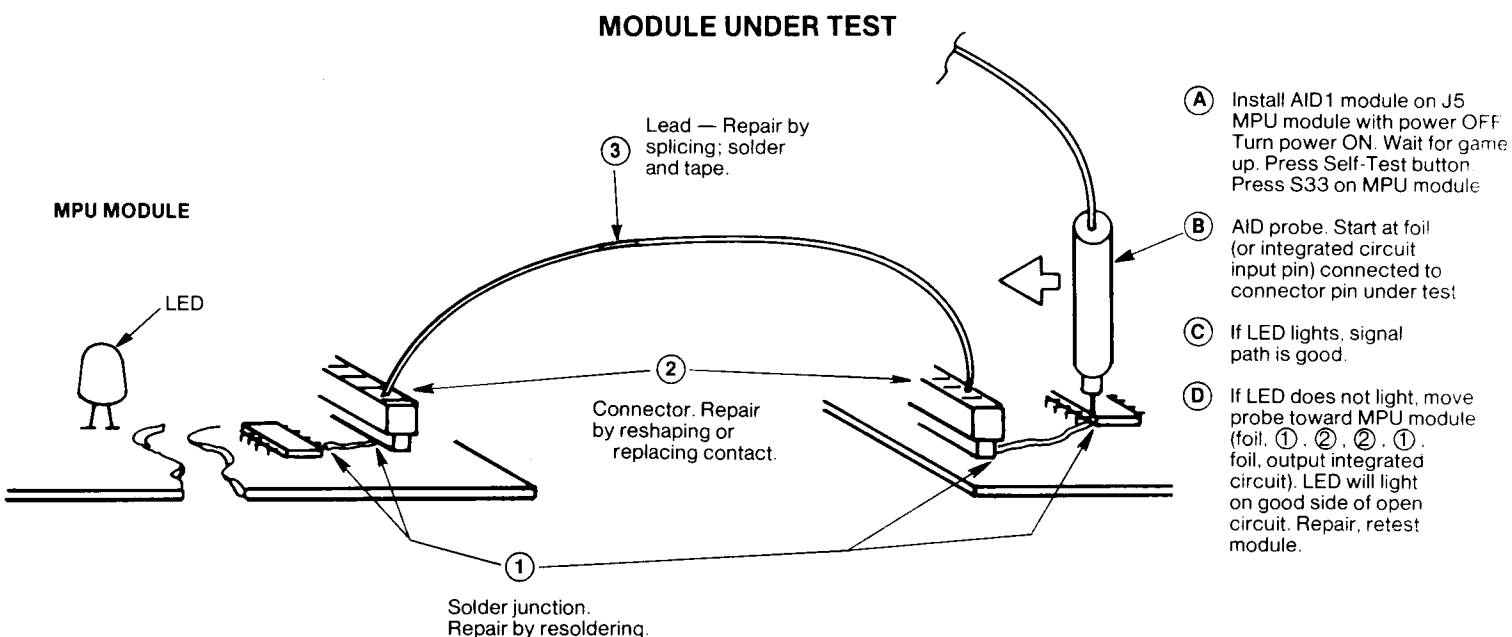
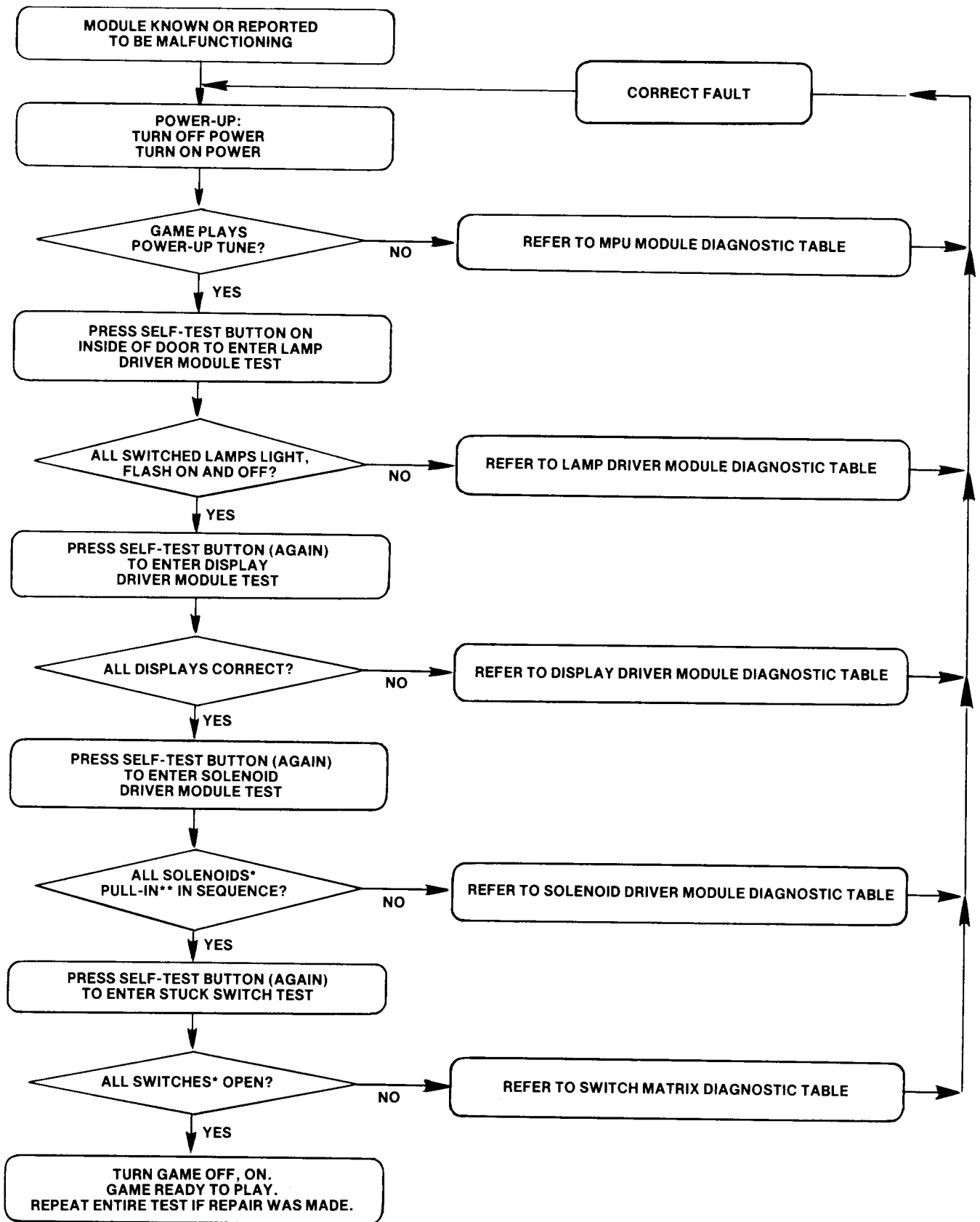


FIGURE IV USE OF AID PROGRAM IN FAULT LOCALIZATION



*SOLENOID AND STUCK-SWITCH NUMBER IS FLASHED ON CREDIT REGISTER TO AID IN TROUBLESHOOTING.

**HOLD FLIPPER BUTTONS IN DURING TEST.

FIGURE III SELF DIAGNOSTIC TEST

IV. GENERAL

All Diagnostic procedures require that the game be opened to gain access to the parts under test. All electronic modules and some of the switched lamps are in the back box. Access to most solenoids and most of the switched lamps is by raising the playfield.

ALWAYS GOOD PRACTICE

When opening the game for servicing:
Ground yourself by touching braid prior to touching modules.

Visually Inspect

- A) For broken leads.
- B) For over-heated components.

Refer to Diagnostic Table symptoms during Self-Test

Symptom that best describes game fault gives entry point into diagnostic procedure.

Turn-off power*

- A) Before connecting meter leads to measure line voltage.
- B) Before replacing fuses.
- C) Before removing connectors.

Exercise Due Caution When Measuring Dangerous Voltages.

Use grounded element soldering iron when making repairs in game.

Tag defective modules with fault symptoms to facilitate module repair and prevent re-entry into service inventory before repair.

* It must be assumed that the serviceman is familiar with the operation of a volt/ohmmeter. Connecting an ohmmeter to the game with the power on can damage the game, the ohmmeter or both.

V. REPAIR PROCEDURE

- 1) Follow the procedure shown in Figure III and described in Section II.
- 2) When fault is discovered, go to the appropriate Diagnostic Table.
- 3) Correct Fault.
- 4) Repeat Self-Test. When test can be run from start to end without indication of fault, check playfield switch assemblies for proper action as described in II. Corrective action, if necessary, is also given in II. After it has been determined that switch assembly action is correct, the game is ready for customer play.

VA

DIAGNOSTIC TABLE: MPU MODULE A4
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. LED on MPU fails to flash 7X on power-up	
A) + 5 VDC Power Supply incorrect	MEASURE: $5 \pm .25$ VDC at TP1 If incorrect, go to Voltage Regulator Diagnostic Table. MEASURE: 11.9 ± 1.40 VDC at TP2 43 ± 5.4 VDC at TP3
B) Power Supply Incorrect	If incorrect, go to Power Transformer Diagnostic Table.
C) Defective MPU module	If correct, replace MPU module. Repeat Power-Up test. If correct, repeat self-test.

VA
DIAGNOSTIC TABLE: MPU MODULE A4
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE

PROCEDURE

SYMPTOM I. LED on MPU fails to flash 7X on power-up (Cont'd.)

- | | |
|---|--|
| D) Shorted Lead or Shorted module Input | <p>If incorrect*, disconnect connector J1 at MPU module. Repeat Power-Up test.</p> <p>If LED flashes 7X, use Self-Test to enter AID, go to Display Driver module and to Lamp Driver module Diagnostic Tables.</p> <p>If LED does not flash, replace J1 and disconnect J2 and J3. Repeat Power-Up test. LED will flash 7X. Use Self-Test to enter AID. Replace J2 and J3. Go to Switch Matrix Diagnostic Table.</p> |
|---|--|

*MPU module replaced in (C) should be retested in known-good game. If MPU module tests good, return to stock.

SYMPTOM II. MPU fails to play tune on Power-Up (LED flashes 7X on Power-Up)

- | | |
|-------------------------------------|---|
| A) Solenoid Driver module incorrect | Go to Solenoid Driver Diagnostic Table. |
|-------------------------------------|---|
-

VB
DIAGNOSTIC TABLE: LAMP DRIVER MODULE
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE

PROCEDURE

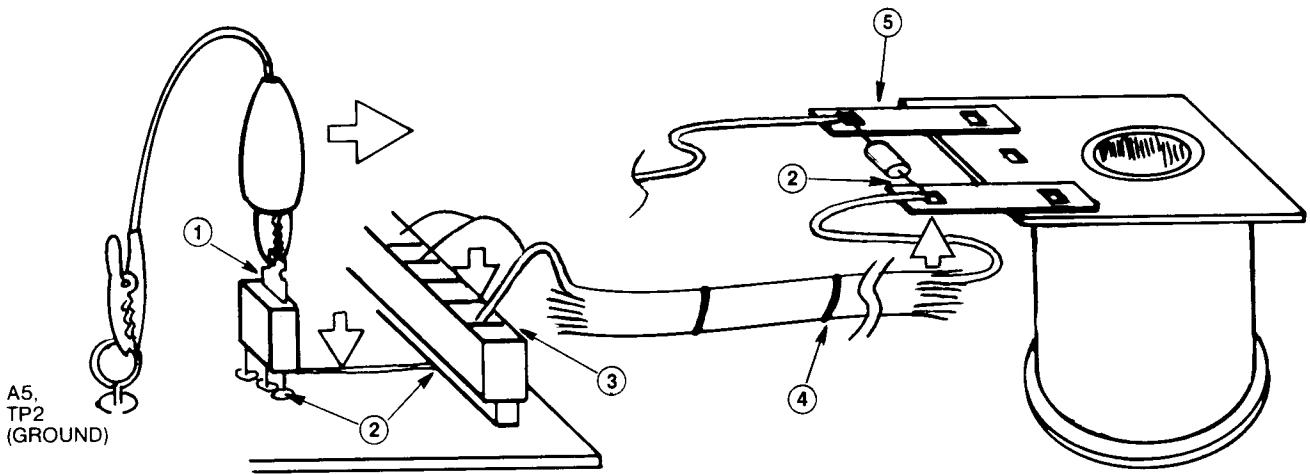
SYMPTOM I. One or Several (but less than 1/4 of total) lamps off.

- | | |
|-------------------------|--|
| A) Burned out bulb | Replace bulb(s). If fault is corrected, repeat Self-Test. |
| B) Defective module | If incorrect, replace Lamp Driver module. If correct, repeat Self-Test. |
| C) Broken Lead(s), etc. | If incorrect*, follow procedure in Fig. V. Repair, repeat Self-Test (Replaced Lamp Driver module can be retested and if good returned to stock.) |

*Module replaced in (B) should be retested in known-good game. If module tests good, return to stock.

SYMPTOM II. All Lamps Off

- | | |
|--|--|
| A) Supply Voltage absent | <p>Measure at lamp common: 5.4 ± .8 VDC. If absent, or out of limits, proceed to Transformer Module Diagnostic Table. Repair, repeat Self-Test.</p> <p>If correct, measure at TP1; Lamp Driver module: 5 ± .25 VDC.</p> <p>If absent, or out of limits, proceed to Voltage Regulator Diagnostic Table, repair, repeat Self-Test.</p> |
| B) Shorted Lamp Strobe line | If correct, remove MPU module connector J1. Use AID1, probe Lamp Strobe line on MPU module, see Table 1. |
| C) Defective MPU module | <p>If LED does not light, replace MPU module. Repeat Self-Test.</p> <p>If LED lights, replace connector J1. Remove connector J4 on Lamp Driver module.</p> |
| D) Pinched, shorted lead(s) in cable harness | If LED does not light, fault is in cable harness. Repair, repeat Self-Test. |
| E) Defective Lamp Driver module | If LED lights, replace Lamp Driver Module. Repeat Self-Test. |



Connect test lead to ground point on board. Ground transistor collector tab, ①, Solenoid Driver module (or SCR anode, Lamp Driver Module). Refer to schematic for game being serviced.

If solenoid pulls-in (or lamp lights), circuit is complete.

If not complete, move alligator clip as shown by arrows until solenoid pulls-in (or lamp lights).

If fault is at solder junction ②, repair by resoldering. If solenoid still does not pull-in, use ohmmeter to check for shorted diode. If defective, replace and repeat self-test.

If fault is at connector pin ③, repair by reshaping or replacing connector contact.

If fault is broken lead in cable ④, repair by splicing, soldering and taping.

If solenoid does not pull-in (or light lamp), use voltmeter at ⑤ to determine continuity to power source (solenoids, $43 \pm 5.4\text{VDC}$; lamps, $5.4 \pm .8\text{VDC}$).

Retest game after completing repairs.

FIGURE V — USE OF GROUNDING LEAD AND VOLTMETER IN FAULT LOCALIZATION: FOR USE WITH LAMP DRIVER MODULE AND SOLENOID DRIVER MODULE TEST PROCEDURES.

VB
DIAGNOSTIC TABLE: LAMP DRIVER MODULE
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM III. Half (or more) lamps always off. Few (one or more) always on.	
Shorted Address Line(s)	Use AID1, remove MPU module connector J1. Probe Lamp Address lines on MPU module. See Table I. Do steps II-C, D, E as required.
SYMPTOM IV. All lamps on, alternating with 1/4, 1/2, 3/4 on or all lamps on continuously.	
Shorted Data Line(s)	Use AID1, remove MPU module connector J1. Probe Lamp Data lines on MPU module. See Table I. Do steps II-C, D, E as required.
SYMPTOM V. A few lamps on; several flicker, others off.	
A) Open Lamp Strobe line	Use AID1, probe Lamp Strobe line at Lamp Driver module foil. See Table I and Fig. IV.
B) Defective Lamp Driver module	If LED lights, replace Lamp Driver module. Repeat Self-Test.

VB
DIAGNOSTIC TABLE: LAMP DRIVER MODULE
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
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SYMPTOM V. A few lamps on; several flicker, others off. (Cont'd.)

- | | |
|-------------------------|---|
| C) Lack of continuity | If LED does not light, see Fig. IV to determine reason for lack of continuity. Repair and repeat Self-Test. |
| D) Defective MPU module | If LED does not light at MPU foil, replace MPU module. Repeat Self-Test. |

SYMPTOM VI. Half or more lamps associated with one or more integrated circuits always off.

Open Lamp Address line(s)	Use AID1, probe Lamp Address lines at Lamp Driver module foil. See Table I, Fig. IV. Do V-B, C, D as required.
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SYMPTOM VII. One Fourth or more lamps always off.

Open Lamp Data line(s)	Use AID1, probe Lamp Data lines at Lamp Driver module foil. See Table I, Fig. IV. Do V-B, C, D as required.
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SYMPTOM VIII. Erratic Operation

Supply Voltage absent (+ 5 VDC)	Do II-A, for 5 volt supply leg only.
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SYMPTOM IX. One or several lamps always on.

A) Defective Lamp Driver module	Disconnect J1, J2 or J3 as appropriate. If Lamp goes out, replace Lamp Driver module. Repeat Self-Test.
B) Pinched, shorted lead(s) in cable harness	If lamp does not go out, fault is in cable harness. Repair, repeat Self-Test.

TABLE I — USE OF AID

SIGNAL	A4-MPU, CONNECTOR J1	PIN	PROBE AT A5, LAMP DRIVER MODULE, CONNECTOR J4	PIN
AD ₀ Lamp Address Line		15		14
AD ₁ Lamp Address Line		14		15
AD ₂ Lamp Address Line		13		16
AD ₃ Lamp Address Line		12		17
PD ₀ Lamp Data Line		16		7
PD ₁ Lamp Data Line		17		6
PD ₂ Lamp Data Line		18		5
PD ₃ Lamp Data Line		19		4
Lamp Strobe #1		11		13

SERVICE HINTS:

- I. AID is used as a means to locate a continuity fault. See Figure IV.
- II. If the LED does not light when probing each of two adjacent leads, it is possible that a solder short exists across the foil. Visual inspection can detect this fault. If present, repair, return module to game and repeat Self-Test.

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE A1*
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. Zeros Flicker	
Supply voltage absent (+ 5 VDC, TP1)	Go to Voltage Regulator Diagnostic Table. Correct fault, repeat Self-Test. If correct, go to VIII.
SYMPTOM II. Display(s) off, one, several or all.	
A) Supply voltage absent (+ 190 VDC)*	Measure at TP2: 190 ± 5 VDC. If absent, or out of limits, go to Voltage Regulator Diagnostic Procedure.
Short or open Display Latch Strobe, line determination	If correct, use AID1. Probe Display Latch strobe lines at MPU foil. See table II.
Open	If LED lights, go to II-E.
Short	If LED does not light, remove MPU module connector J1.
B) Defective MPU module	If LED does not light, replace MPU module. Repeat Self-Test. If LED lights, replace J1. Remove J1 on applicable Display Driver module.
C) Pinched, shorted lead(s) in cable harness	If LED does not light, fault is in cable harness. Repair, repeat Self-Test.
D) Defective Display Driver module	If LED lights, replace module that caused LED to go out. Repeat Self-Test.
E) Blanking Line status determination	Probe Blanking Line at Display Driver foil. See Table II, Figure IV.
F) Defective Display Driver module	If LED lights at foil test point, replace Display Driver module. Repeat Self-Test.
G) Lack of continuity	If LED does not light, see Fig. IV to determine reason for lack of continuity. Repair and repeat Self-Test.
H) Defective MPU module	If LED does not light at MPU foil, replace MPU module. Repeat Self-Test.
SYMPTOM III. Display(s) read '000000', do not cycle 0-9 and off, etc., one, several or all displays.	
Short on Display Latch Strobe line(s)	Remove MPU module connector J1. Use AID1. Probe Display Latch Strobe lines at MPU foil. See Table II. Do steps II-B, C, D as required.
SYMPTOM IV. Incorrect count, all displays. MPU plays power-up tune only after J1 is removed.	
Short on BCD Data Line(s)	Use AID1. Probe BCD Data Lines at MPU module foil. See Table II. Do steps II-B, C, D as required.
SYMPTOM V. Digits missing, all displays. MPU plays power-up tune only after J1 is removed.	
Short on Digit Select Lines(s)	Use AID1. Probe Digit Select line(s) at MPU module foil. See Table II. Do steps II-B, C, D as required.
SYMPTOM VI. Incorrect count, one, several or all displays.	
Open BCD Data Line	Use AID1. Probe BCD Data Lines at Display Driver module foil. See Table II and Fig. IV. Do steps II-F, G, H as required.

*CAUTION: DANGEROUS VOLTAGES ARE PRESENT.

VC

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE A1*
REPAIR LEVEL: MODULE REPLACEMENT (Cont'd.)

CAUSE	PROCEDURE
SYMPTOM VII. Digits missing, one several or all displays.	
Open Digit Select Line(s)	Use AID1. Probe Digit Select Lines at Display Driver module foil. See Table II and Figure IV. Do steps II-F, G, H as required.
SYMPTOM VIII. Displays flicker, one, several or all displays.	
Open Display Latch Strobe line(s)	Use AID1. Probe Display Latch Strobe lines at Display Driver module foil. See Table II and Figure IV. Do steps II-F, G, H as required.
SYMPTOM IX. Segment(s) missing.	
Defective module	Replace module.

*CAUTION: Dangerous voltages are present.

TABLE II — USE OF AID

SIGNAL		A-4-MPU CONNECTOR J1	PROBE AT A1, DISPLAY DRIVER MODULE, CONNECTOR J1
Display Segment	D ₀	25	19
BCD Data	D ₁	26	18
	D ₂	27	17
	D ₃	28	16
Display Latch Strobe		20-24 incl.	15
Display Blanking		10	10
Display Digit Enable	D ₆	6	9
	D ₅	5	8
	D ₄	4	7
	D ₃	3	6
	D ₂	2	5
	D ₁	1	4

SERVICE HINTS:

- I. AID is used as a means to locate a continuity fault. See Figure IV.
- II. If the LED does not light when probing each of two adjacent leads, it is possible that a solder short exists across the foil. Visual inspection can detect this fault. If present, repair, return module to game and repeat Self-Test.

CAUSE	PROCEDURE
SYMPTOM I. All solenoids deenergized.	
Supply voltage(s) absent	Measure at TP3: + 5 ± .25 VDC. If absent, or out of limits, go to Voltage Regulator Diagnostic Table.
SYMPTOM II. Flipper solenoids do not respond to button (deenergized).	
A) Open circuit (Specific cause to be determined)	Ground collector of transistor Q15 at metal tab. If relay K1 pulls in, push flipper buttons.
B) Lack of continuity	If flipper(s) do not pull in, determine reason for lack of continuity between buttons, module, flippers and power source. Trace leads and see Figure V. Flipper button switch contacts and end of stroke switch contacts should be adjusted and or burnished as required. Repair and repeat Self-Test.
C) Defective Relay K1	If K1 does not pull in, replace module. Repeat Self-Test. Remove connector J4. Use AID1. Probe J4, Pin 8.
D) Defective Solenoid Driver module	If LED lights, replace Solenoid Driver module. Repeat Self-Test.
E) Lack of continuity	If LED does not light, see Fig. IV to determine reason for lack of continuity. Repair, repeat Self-Test.
F) Defective MPU module	If LED does not light at MPU foil, replace MPU module. Repeat Self-Test.
SYMPTOM III. Continuous duty solenoid does not pull-in.	
A) Open output circuit	Ground collector of solenoid Driver Transistor at metal tab (Ex: Q19). If solenoid does not pull-in, determine reason for lack of continuity. (See Fig. V.), repair and repeat Self-Test.
B) Defective Solenoid Driver module	If solenoid pulls-in, replace Solenoid Driver module A3. Repeat Self-Test.
C) Input problem	If solenoid does not pull-in, remove connector J4. Use AID1, Probe appropriate pin on J4, (8, 9, 10 or 11). Do steps II-D, E & F.
SYMPTOM IV. Momentary duty solenoids do not pull-in.	
A) Lack of continuity	Ground collector of Drive Transistor at metal tab (Ex: Q1). See schematic for game being serviced. If solenoid does not pull-in, see Figure V. Repair and repeat Self-Test.
B) Defective Solenoid Driver module	If solenoid pulls-in, replace solenoid Driver module. If fault is corrected, repeat Self-Test.* If incorrect, use AID1, probe Solenoid Bank Select line at Solenoid Driver module foil. See Figure IV and Table III. Do steps II-D, E, F as required.
SYMPTOM V. One half or more of impulse solenoids do not pull-in.	
Use AID1, probe Momentary Solenoid Data lines at Solenoid Driver module foil. See Fig. IV. Do steps II-D, E, F as required.	

* If incorrect, return module to stock.

CAUSE	PROCEDURE
SYMPTOM VI. Flippers energized continuously.	
Stuck Flipper Button assembly	Repair or replace flipper button switch assembly. Repair by burnishing contacts. Replace switch assembly if contacts badly burned. Reset contact gap to 1/16".
SYMPTOM VII. One (or up to four) Momentary solenoid(s) energized continuously. See Note. Half (or more) do not pull-in during Self-Test or Continuous Duty solenoid energized continuously. (Special Case: Flippers can be used on tilt and game over.)	
A) Pinched, shorted lead(s) in cable harness	Remove connector J4. If solenoid(s) deenergize, repair cable harness, reconnect connector J4, repeat Self-Test.
B) Defective Solenoid Driver module	If no fault is found in cable harness, replace Solenoid Driver module. If solenoid(s) deenergize, repeat Self-Test.
C) Defective MPU module	If solenoids do not deenergize*, replace MPU module. If solenoid(s) deenergize, repeat Self-Test.
D) Pinched, shorted lead(s) in cable harness	If solenoid(s) do not deenergize*, fault is in cable output harness, J1, J2, J3 or J5. See schematic for game being serviced. Repair, repeat Self-Test.

NOTE: Momentary solenoids are not designed for continuous operation. Limit troubleshooting to the following cycle: One minute on, five minutes off. If damaged by overheating, they must be replaced before returning game to operation.

*If incorrect, return module to stock.

TABLE III — USE OF AID

SIGNAL	A4-MPU CONNECTOR J-4 PIN	PROBE AT A3 SOLENOID DRIVER MODULE CONNECTOR J4, PIN
(PB ₀) Momentary	4	6
(PB ₁) Solenoid	3	5
(PB ₂) Data	2	4
(PB ₃)	1	3
PB ₄	5	11
PB ₅ Coin Lock Out	6	9
PB ₆ Flipper Disable	7	8
PB ₇	8	10
CB ₂ Solenoid Bank Select	10	7

SERVICE HINTS:

- I. AID is used as a means to locate a continuity fault. See Figure IV.
- II. If the LED does not light when probing each of two adjacent leads, it is probable that a solder short exists across the foil. Visual inspection of the MPU and Solenoid Driver modules can detect this fault. If present, repair, return module to game and repeat Self-Test.

VE

DIAGNOSTIC TABLE: SWITCH MATRIX
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. Number appears on Player Score Displays during Stuck-Switch test.	
Stuck Switch	Refer to Switch Assembly Identification Table, stapled in back-box. Locate Switch Assembly on playfield (coin switch, Self-Test and Credit button switches are on door. Repair or replace switch assembly. All contacts are used at low current levels. They are gold plated to prevent corrosion. Burnishing can break the finish and is NOT recommended. If cleaning is necessary, close the contacts on a clean business card or stiff paper. Draw the card between the contacts several times until they wipe clean. Regap to 1 / 16" contact separation. Repeat Self-Test.

NOTE: If several switches are stuck, the Self-Test routine will display the lowest numbered switch assembly only. Repeating the Self-Test after clearing one assembly allows the game to display the number of the next lowest numbered, stuck-switch assembly. Repeat the above procedure. When all switch assemblies are cleared, the stuck switch test ends by flashing '0' on the Match/Ball in play display.

VF

DIAGNOSTIC TABLE: VOLTAGE REGULATOR A3*
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. + 5 VDC absent at module under test.	
A) Lack of continuity	Measure TP1: $5 \pm .25$ VDC. If voltage is present and within limits, use voltmeter to determine reason for lack of continuity between modules. Repair and repeat Self-Test. If absent, measure TP5: 11.9 ± 1.4 VDC. If absent, go to Power Transformer Module Diagnostic Table. If voltage at TP5 is correct, replace Voltage Regulator module.
B) Defective Voltage Regulator module	If voltage at TP1 is now correct, repeat Self-Test. If incorrect, remove J4, MPU, J4, Lamp Driver module and J1, Display Driver module(s). If voltage at TP1 is incorrect, repair pinched, shorted leads in cable harness. If it is correct, reconnect J4 MPU module.
C) Defective MPU or Lamp Driver or Display Driver module	If voltage at TP1 is incorrect, replace MPU module. If correct, repeat for Lamp Driver module and each of the five Display Driver modules, one at a time. Replace module that causes voltage at TP1 to go out of limits. Repeat Self-Test.

SYMPTOM II. + 190 VDC absent at Display Driver module under test.*

A) Lack of continuity	Measure TP2: 190 ± 5 VDC. If voltage is present and within limits, use voltmeter to determine reason for lack of continuity between modules. Repair and repeat Self Test. If voltage at TP2 is not correct or absent, measure TP4: 230 ± 27.4 VDC. If voltage at TP4 is incorrect, go to Power Transformer Module Diagnostic Table. If voltage at TP4 is correct, and voltage at TP2 was incorrect, but not absent, go to Step E.
-----------------------	---

*NOTE: Voltage Regulator is part of Solenoid Driver/Voltage Regulator module.
 CAUTION: Dangerous voltages are present.

VF

DIAGNOSTIC TABLE: VOLTAGE REGULATOR A3*

REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM II. + 190 VDC absent at Display Driver module under test. * (Cont'd.)	
B) Defective fuse	If voltage at TP4 is absent, replace fuse F2 on Power Transformer module. If fuse does not blow, repeat Self-Test. If fuse blows, turn off power. Remove connector J3. Use an ohmmeter to measure J3, pin 8 on cable end of connection to ground. If J3, pin 8 is shorted, disconnect Display Driver module connectors A6 J1, one at a time.
C) Defective Display Driver module	If short is removed, replace last Display Driver module disconnected just before short disappeared. Replace Voltage Regulator module, check fuse F2, Power Transformer module and replace if necessary. Reconnect all connectors to Display Driver modules. Recheck connector J3, pin 8. If J3, pin 8 is shorted, continue disconnecting Display Driver module connectors, J1 until faulty module is located. When short is removed, repeat Self-Test.
D) Cable short	If short is not removed by disconnecting connector J1 from all Display Driver modules, short is in cabling. Trace lead to locate and remove short. Reconnect all connectors to Display Driver modules. Recheck connector J3, pin 8. If J3, pin 8 is shorted, repeat (C), from previous page. If short is corrected, replace Voltage Regulator module, check fuse F2, Power Transformer module and replace if necessary. Reconnect all connectors, repeat Self-Test.
E) Defective module	If TP2 is incorrect, replace Voltage Regulator module. Repeat Self-Test.

*NOTE: Voltage Regulator is part of Solenoid Driver/Voltage Regulator module.
CAUTION: Dangerous voltages are present.

TABLE V — VOLTAGE DISTRIBUTION

	VOLTAGE REGULATOR MODULE A3	MPU MODULE A4	LAMP DRIVER MODULE A5	DISPLAY DRIVER MODULE A1	POWER TRANSFORMER MODULE A2
+ 5VDC	J3-13/J3-25 J3-14, 15 J3-16 J3-17	— J4-16, 17 — —	— — J4-3 —	— — — J1-20	— — — —
+ 11.9VDC	J3-11 J3-12	J4-12 —	— —	— —	— J3-8
+ 43VDC	J3-5	J4-15	—	—	J3-12
+ 190VDC*	J3-8	—	—	J1-1	—
+ 230VDC	J3-6	—	—	—	J3-5
GND	J3-10 J3-3 J3-18, 19 J3-20 J3-21, 22 —	— — J4-18, 19 — — —	— — — — — J1-1, 2, 11, 12	— — — J1-13 — —	J3-17 J3-18 — — J3-15, 16 J3-3, 4, 14

DIAGNOSTIC TABLE: POWER TRANSFORMER MODULE A2
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE

PROCEDURE

SYMPTOM I. Voltage absent or incorrect at remote module (ex: MPU J4-15, + 43 VDC)

- | | |
|---------------------------|---|
| A) Continuity fault | <p>Measure at TP1: 5.4 ± .8 VDC.
 TP2: 230. ± 27.4 VDC.
 TP3: 11.9 ± 1.4 VDC.
 TP4: 7.3 ± .9 VAC.
 TP5: 43. ± 5.4 VDC.</p> <p>If correct, use VOM to determine reason for lack of continuity between modules and correct fault. See Fig. VI and Table VI. Repeat Self-Test.
 If incorrect, (out of limits, but not zero), measure line voltage at transformer across input leads. A variation of ± 10% is acceptable. (ex: A 115VDC nominal line can measure 103.5 to 126.5 VAC.)</p> |
| B) Incorrect line voltage | If incorrect, steps must be taken to correct supply line voltage at location. |
| C) Defective module | If line is correct, replace module. Repeat Self-Test. |

SYMPTOM II. Voltages absent at all remote modules.

- | | |
|---------------------|--|
| A) Blown fuse | <p>If line voltage is absent at transformer, (across input leads), replace fuse <i>F6, 3 amps, slow blow</i>. Repeat Self-Test.
 If fuse holds, log failure for future reference and return game to use. If F6 blows again, disconnect J1, J2, J3. Replace F6. Turn on power. If F6 blows, replace Power Transformer module, repeat Self-Test.</p> |
| B) Cable short | <p>If F6 does not blow, disconnect all remote module power connectors. See Table V, Page 17. Replace connectors J1, J2, J3, Power Transformer module, one at a time.
 If F6 blows, short exists in cabling. Repair, repeat Self-Test.</p> |
| C) Defective module | Replace remote module power connectors one module at a time. Replace remote module that causes F6 to blow. Replace F6. Repeat Self-Test. |

SYMPTOM III. Voltage absent — at TP5, or TP2, or TP4, or TP1, or TP3.

- | | |
|----------------------------|--|
| Blown fuse F4 (5A) | Disconnect connector J1, J2, J3 (TP5) |
| Blown fuse F2 (3/4A) | Disconnect connector J3 (TP2) |
| Blown fuse F5 (20A) | Disconnect connector J1, J2, J3 (TP4) |
| Blown fuse F1 (10A) | Disconnect connector J1, J3 (TP1) |
| Blown fuse F3 (4A) | Disconnect connector J3 (TP3) |
| Defective module | <p>Replace fuse:
 If fuse blows, replace Power Transformer module, repeat Self-Test.
 If fuse does not blow, disconnect associated remote module connectors as applicable, see Table VIA.</p> |
| A) Cable short | <p>Turn on power.
 Replace Power Transformer module connectors J1, J2 and J3 one at a time.
 If fuse blows, short exists in cabling. Repair, repeat Self-Test.
 For F1 and F5 faults, locate short in general illumination or switched lamps circuitry common. Repair, repeat Self-Test.</p> |
| B) Defective Remote module | Replace Remote module connectors one at a time. See Table VIA. Replace remote module that causes fuse to blow. Replace fuse, repeat Self-Test. |

VF

DIAGNOSTIC TABLE: POWER TRANSFORMER MODULE A2

REPAIR LEVEL: MODULE REPLACEMENT

TABLE VI — POWER DISTRIBUTION CIRCUITRY

FROM A2, CONNECTOR, PIN #	TO MODULE, CONNECTOR, PIN #	FUNCTION
J2-6		A.C. LINE, HIGH
J2-7		A.C. LINE, LOW
J2-10		A.C. LINE, CONDUIT (SYSTEMS GROUND)
J3-5	A3J3-6	+ 230 VDC TO VOLTAGE REGULATOR
J3-18	A3J3-3	+ 230VDC RETURN (GROUND)
J3-16	A1J1-13	+ 190VDC RETURN (GROUND)
J3-8	A3J3-11, 12	+ 11.9VDC TO VOLTAGE REGULATOR
J3-2	A3J3-10	+ 11.9VDC RETURN (GROUND)
J3-15	A3J3-21, 22	+ 5VDC RETURN (GROUND)
J1-5, 8	PLAYFIELD	7.3VAC GENERAL ILLUMINATION
J1-1, 2	PLAYFIELD	GENERAL ILLUMINATION RETURN
J2-1	CABINET	7.3VAC GENERAL ILLUMINATION
J2-5	CABINET	GENERAL ILLUMINATION RETURN
J3-10, 11	BACKBOX	7.3VAC GENERAL ILLUMINATION
J3-1, 2	BACKBOX	GENERAL ILLUMINATION RETURN
J1-7	PLAYFIELD	5.4VDC FEATURE LAMP BUS
J1-1, 2	PLAYFIELD	GROUND
J3-6	BACKBOX	5.4VDC FEATURE LAMP BUS
J3-3, 4, 14	BACKBOX	SWITCHED ILLUMINATION RETURN
J1-6	PLAYFIELD	+ 43VDC SOLENOID BUS
J1-2	PLAYFIELD	GROUND
J2-2	CABINET	+ 43VDC SOLENOID BUS
J2-9	CABINET	SOLENOID RETURN
J3-9	A3J3-5	+ 43VDC TO FLIPPER RELAY A3K1
J3-12	A4J4-15	+ 43VDC ZERO CROSSING INPUT TO MPU
J3-13	BACKBOX	+ 43VDC SOLENOID BUS
J3-19	BACKBOX	SOLENOID RETURN

TABLE VIA — FUSE, TEST POINT, CONNECTOR LIST

POWER TRANSFORMER MODULE			REMOTE MODULE(S)	
FUSE	TEST POINT	CIRCUIT	TEST POINT	CONNECTORS
F1 (10A)	TP1	+ 5.4VDC	COMMON	FEATURE LAMPS
F2 (3/4A)	TP2	+ 230VDC	A3 TP4	A3 J3-6
F3 (4A)	TP3	+ 11.9VDC	A3 TP5	A3 J3-11, 12
F4 (5A)	TP5	+ 43VDC	A4 TP3	A4 J4-15
F5 (20A)	TP4	+ 7.3VAC	COMMON	GENERAL ILLUMINATION

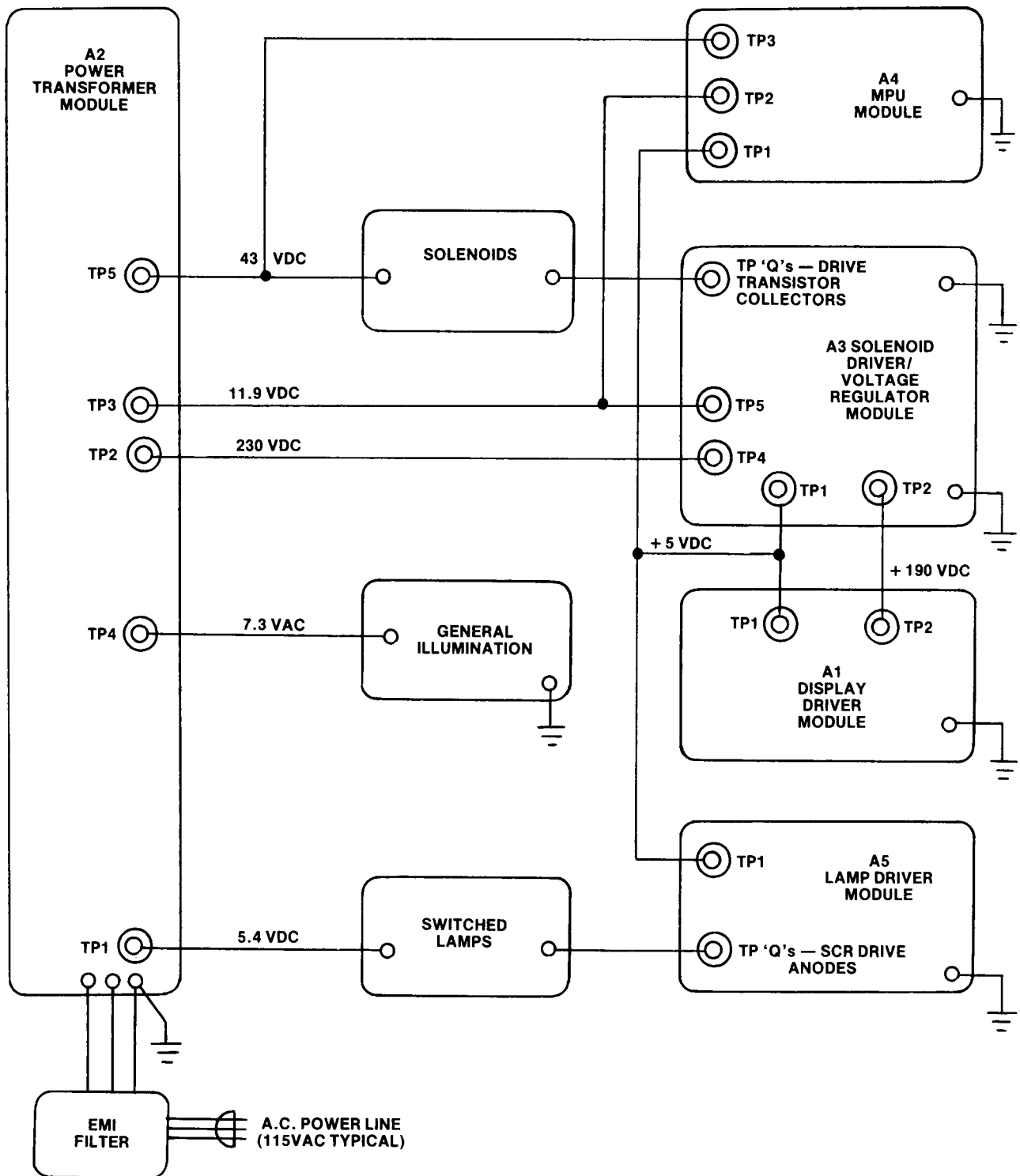


FIGURE VI POWER DISTRIBUTION DIAGRAM

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AID, BALLY KIT #485, IS RECOMMENDED FOR USE WITH THIS PROCEDURE.

I. INTRODUCTION

The procedures contained herein are written for use by the Service Center that cannot justify the purchase of the fully automated module test equipment available from Bally. The procedures allow fault localization, analysis and repair in an organized, direct manner. It is necessary to read, understand, and follow the procedure step-by-step until a cause for the problem is determined and the remedy for the problem, as given in the procedure, is put into effect. The few minutes spent to read and understand the procedure will prevent problems and save time.

Repair of each of the five types of electronic modules used in the games is accomplished by using a known good game as a test-bed. (See Figures I & II). The procedures, when used with a set of module schematics, facilitate fault localization to the defective component. Repair is accomplished by standard electronic module repair practices. A stock of replacement components is necessary. The specific memory (ROM/PROM) chips used for each different game must also be stocked. An AID Kit is required by the procedures. The modules AID mate with J5 on the MPU module. The Kit is available from the Bally Service Department. Order AID, Bally Kit #485. No other special tools or equipment are required.

II.

The repair procedures take advantage of the two test routines designed into the game. These are the MPU Self-Test and the Self-Diagnostic Test.

- A) The MPU Self-Test occurs on power-up. The MPU module examines itself for proper operation. The MPU goes thru a sequence where it does a check-sum on its read-only memory bank, exercises its read-write memory bank, exercises each peripheral input/output port, examines its inputs for the presence of line voltage zero crossings, and for the presence of display interrupts. If all is proper, the MPU module flashes the LED seven times* and announces play-readiness with the game-up tune. If, at any point in the test, performance standards are not met, the test is stopped. The game will not play until repairs are made. Counting the number of flashes that occur on power-up is used for fault localization on the MPU module.

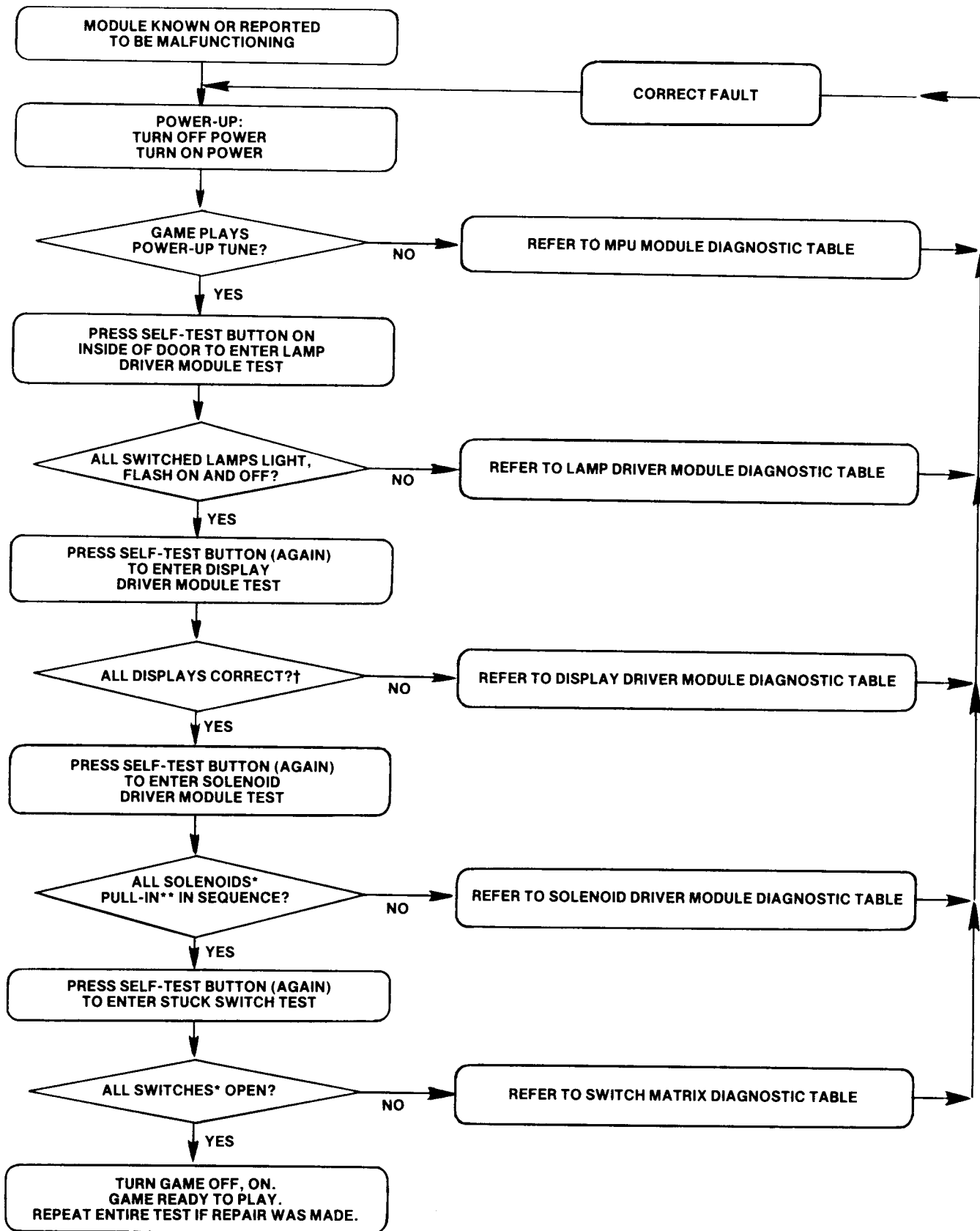
In a known 'good game', this test is a measure of the MPU modules' ability to perform. In a defective game, the test results can be misleading if certain output lines are shorted to ground. It is necessary for purposes of the test procedures herein that the game used as a test-bed is known to be good.

- B) The Self-Diagnostic Test is a routine that causes a known-good MPU module to 'exercise' each of the three other types of electronic modules. *The symptoms that arise when a defective module is tested are listed in each of the module diagnostic tables* as a means to fault localization to the defective component. Different portions of the test are associated with each of the three types of modules. A flow chart for the complete test is given in Figure III. The chart illustrates the sequence of the Self-Diagnostic Test. Instructions for entering into the appropriate portion of the test are given in the figure. See Figure 1 for location of Self-Test button on door.
- C) The AID Kit, Bally Kit #485 extends the usefulness of the Self-Diagnostic Test to locate defective components. The AID modules are plugged into J5 on the MPU module before turning the power on.

AID1 is entered from the Self-Diagnostic Test by pressing S33 on the MPU module. AID1 permits on-module signal *continuity* and *functional* checks under digital operating conditions. The test probe is clipped to TP1 and is placed in the circuit under test as detailed in the module diagnostic tables. The LED on the MPU module lights if operation in the circuit is proper. The tables detail the corrective action to be taken if the LED does not light.

When a properly operating game is in the AID1 mode, all switched incandescent display lamps and the digital display panels on the Display Driver Module are off. A soft, humming sound may be heard. It is normal for the sound to stop as the probe is placed in various circuits in the game.

*The LED flash sequence is flicker/flash, pause, flash 6X and turn "OFF".



† ALL DISPLAY COUNT 0-9 INCL., CONTINUOUSLY.
 * SOLENOID AND STUCK-SWITCH NUMBER (SEE IDENTIFICATION TABLES IN BACK BOX) IS FLASHED ON MATCH/BALL IN PLAY DISPLAY TO AID IN TROUBLESHOOTING.
 ** HOLD FLIPPER BUTTONS IN DURING TEST.

FIGURE III SELF-DIAGNOSTIC TEST

IMPORTANT: The only exit from AID1 to the normal operating game routines is by way of the ON-OFF switch. Simply, position the toggle to "OFF" and then again to "ON". Normal games routines or the Self-Diagnostic Test routine are then available.

AID2 is used during trouble shooting of the MPU module. It is plugged into J5 before power is turned ON. It is used to detect bus line faults on the address, data and Read/Write lines as discussed in the MPU module diagnostic tables.

III. SERVICE HINTS, GENERAL:

- A) VISUAL INSPECTION prior to servicing can often minimize service time requirements. Inspect modules for overheated components, swollen capacitors and physically damaged parts.
- B) Schematics and parts lists are essential to module servicing. Component reference designations made in the diagnostic procedures are the same as those used on the schematics and in the parts lists. Solenoid and switch assembly reference numbers are given in the tables stapled in the backbox.
- C) No special tools are required for servicing. A 20,000 Ohm/Volt meter, Simpson Model 260 or equivalent, jumper-leads, and hand tools (including a grounded element soldering iron) are considered standard servicing tools.
- D) *Read all of the Module Symptoms* in the Module Diagnostic Table before attempting to make a diagnosis. Study the symptoms presented by the defective module. Follow the procedure associated with the most applicable symptom description in the Module Diagnostic Table.
- E) Make a record of all bookkeeping functions before using AID1. When using AID1, a noise pulse induced on the line under test can occasionally cause the MPU to 'jump the track'. If this happens, turn off the game, and reenter AID1 through the Self-Test routine.
- F) The MOS and CMOS devices used in the modules are susceptible to damage from static discharge. Ground yourself, your workbench and the module under repair. Touching the ground braid in the game or the conduit in the work area frequently is a good practice. Use a grounded element soldering iron to make repairs.
- G) Clip out defective transistors and integrated circuits not in sockets to facilitate removal and prevent damage to the printed circuit boards.
- H) Use care not to flex printed circuit boards. Damage to foil or plated through holes can result from careless handling.

NOTE: It is assumed that the technician knows how to use an ohmmeter and that he knows that the power must be turned off before attempting to do so. It is further assumed that the technician can exercise proper caution when using a voltmeter to measure the line voltage and the high voltage in the Display Driver and Solenoid Driver/Voltage Regulator modules.

The procedures given herein are not all-inclusive. Faults such as intermittent operation due to poor solder joints must be left to the technicians ingenuity to discover.

MPU MODULE A4
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PARTS LIST

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	AS-2518-17 MPU MODULE (LESS PROM/ROM)	40

MPU MODULE A4

GENERAL

An MPU Self-Test occurs on power-up. Positioning the ON-OFF switch on the game to the "ON" position initiates the test. Successful completion of the test is indicated by seven flashes* of the LED (Light Emitting Diode) on the module. Figure A4-1 directs the serviceman to the proper entrance point in the diagnostic table for less than seven flashes. It is necessary to read, understand, and follow the procedure step-by-step until a cause for the problem is determined and the remedy for the problem, as given in the procedure, is put into effect. The few minutes spent to read and understand the procedure will prevent problems and save time later.

During certain steps in the procedure, it is necessary to determine the condition of the address, data & read/write lines (bus). Each line is examined for the following faults: Inputs 'stuck' high or low (shorted to ground), shorts to adjacent leads and continuity between devices on the bus. The procedure also examines the status (good or failed) of several decoding integrated circuit inverters, buffers and gates on the A₉-A₁₂ address lines. To accomplish this testing with the use of a voltmeter, bus lead connection points are provided by means of J5. Continuity between devices on the bus is ascertained by the use of Table A4-1 (or the schematic) and a voltmeter.

An AID2 module, used to locate bus line faults on MPU address, data and read/write lines is included in the AID Kit, part #485, available from Bally, or may be made by the user. (Fig. A4-2)

The AID2 module is connected before the game is turned on. It is used to ground the HALT line. When the game is turned on, the address, data and read/write bus lines all go to a high impedance state and the VMA line goes low. In this state, the clip lead on the resistor COMmon can be used to make all bus lines high (clip to +5 V) or low (clip to GND). When high, continuity to the pins of any device on the bus can be read with a voltmeter. Lines 'stuck' low due to a failed device become 'visible' to the voltmeter. When the clip is connected to ground, lines 'stuck' high due to a failed device also become 'visible'.

The GND is used to find adjacent lead shorts. The resistor COMmon lead is connected to +5 V. The GND lead is connected to each resistor, one position at a time. With the lead on a given resistor, a short to an adjacent line will result in a reading of Zero on the adjacent line. All other lines will read approximately +5 VDC.

Visual inspection can usually locate solder-splash adjacent line shorts. Removal of socketed integrated circuits one at a time locates failed devices on the line.

The MPU Self-Test is supplemented by the PIA 'B' Port procedure given in A4-IX. This procedure MUST be performed each time an MPU Module is tested. See Figure A4-1. Successful completion of the MPU Self-Test does not guarantee that the MPU module is good. Successful completion of both the MPU Self-Test and the PIA 'B' Port procedure, however, does mean that the MPU module is good. The AID1 module is used in this procedure.

*The flash sequence is flicker/flash — pause and then 6 more flashes. The LED is turned 'off' after the seventh flash.

MPU-MODULE-TEST SERVICE HINTS

- A) Voltages shown on schematic are typical operating voltages after the power-up MPU Self-Test is complete. They are dynamic in nature and represent the voltmeters response to a digital information flow at a particular point in the game program. Voltage at the output of a failed device will differ from the voltages shown. The voltages shown on the schematic are, therefore, a useful trouble shooting aid and must be used for reference.
- B) The trouble shooting procedures are slanted towards ease of maintenance. If either of two devices could be the cause of malfunction, and one is soldered into the circuit and the other is inserted in a socket, the procedure will advise substitution of the socketed device first. See Caution.

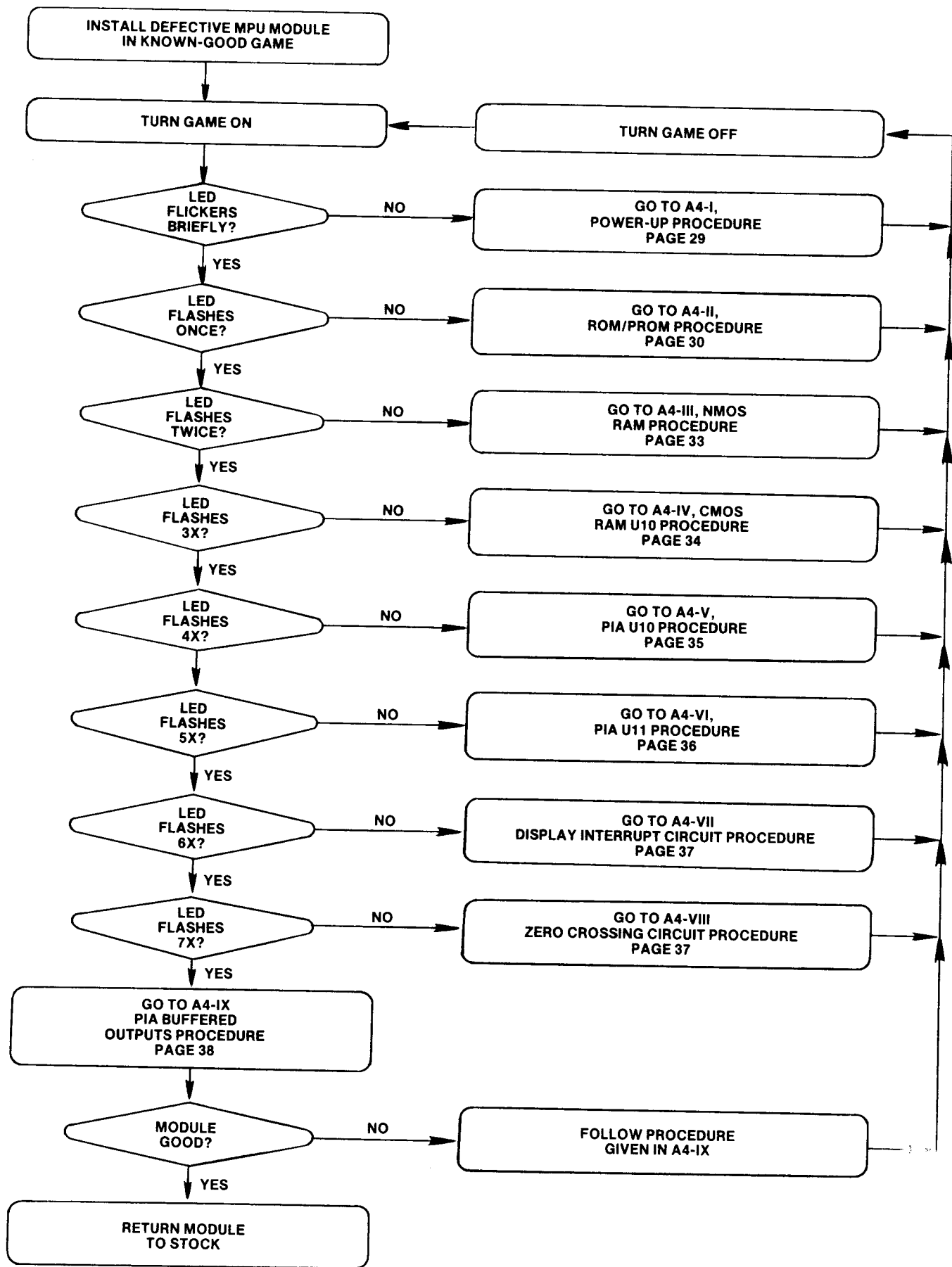
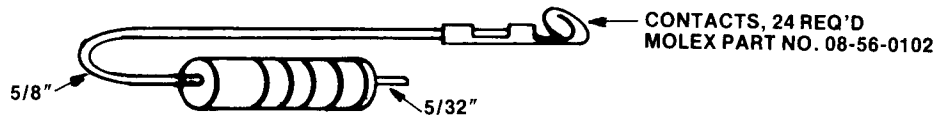
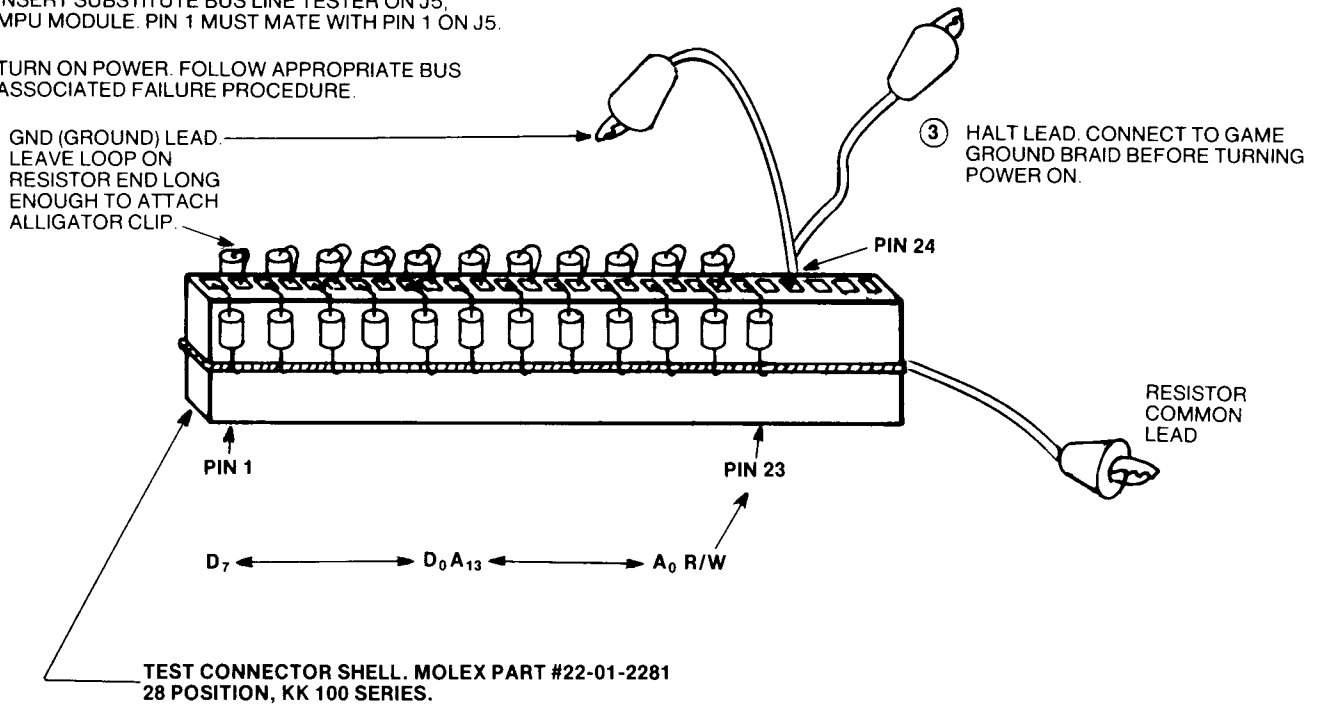


FIGURE A4-1 MPU MODULE TEST FLOW CHART

INSTRUCTIONS:

- ① TURN OFF POWER.
- ② INSERT SUBSTITUTE BUS LINE TESTER ON J5, MPU MODULE. PIN 1 MUST MATE WITH PIN 1 ON J5.
- ④ TURN ON POWER. FOLLOW APPROPRIATE BUS ASSOCIATED FAILURE PROCEDURE.



RESISTOR/CONTACT DETAIL
ALL RESISTORS 1.2 K Ω , 1/4 WATT, 23 REQ'D

FIGURE A4-2 SUBSTITUTE FOR AID2, MPU MODULE BUS LINE TESTER

- C) When substitution of a socket mounted device with a known-good replacement does not solve the problem, the device removed should be set aside and retested later in a known-good module. See Caution. If the device tests good, it should be returned to stock. If bad, it is recommended that several leads be cut off before discarding to mark the device as defective.
- D) A part number is on each ROM (or PROM), U1-U6 incl., used in the game. Each ROM (or PROM) can only be replaced with a ROM (or PROM) with an identical part number. Failure to do so will cause improper game operation.
- E) It is assumed that the repairman will turn off the power before using an ohmmeter, removing or inserting an integrated circuit or initiating repairs.

CAUTION: MOS AND CMOS integrated circuits are damaged by static charges. It is good practice to ground yourself to the braid in the game before removing or inserting an integrated circuit, to conduit-ground your work surface (bench) and tools. A grounded element soldering iron is also necessary.

DIAGNOSTIC TABLE: MPU MODULE — A4-I, POWER-UP PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM IA: LED always off (does not flash on Power-up).	
A) Power supply line fault on module	Measure at TP2: $+ 11.9 \pm 1.4$ VDC. If correct, go to B). If absent, measure $+ 11.9 \pm 1.4$ VDC at A3, TP5, Voltage Regulation/Solenoid Driver module.
Open on $+ 11.9$ VDC line	If present, locate and repair open between connector and TP2 on MPU module. Retest module.*
Short on $+ 11.9$ VDC line	If absent, fault should be visible, such as a solder splash caused during repair. Locate and remove short, replace fuse F6, Power Transformer module. Retest MPU module.*
B) Power supply line fault on module	If 11.9 VDC is present, measure at A4, TP1: $+ 5 \pm .25$ VDC. If correct, go to C). If absent, measure 5 volts at A3, TP1, Voltage Regulation/Solenoid Driver module.
Open $+ 5$ VDC line	If present at A3, TP1, locate and repair open between connector and TP1 on MPU module. Retest module.*
Short on $+ 5$ VDC line	If absent at A3, TP1, use standard trouble shooting techniques to locate short on $+ 5$ volt distribution circuit on MPU module. Socketed integrated circuits can be removed one at a time to locate fault. See CAUTION note in Service Hints.
C) Fault in LED circuit	If voltage at TP1 is correct, remove U11 and retest module.* If LED lights, replace U11 and retest module. If LED does not light, check Q2 and CR8 for proper operating voltages. Replace Q2 or CR8 as appropriate and retest module.*
SYMPTOM IB: Erratic Game operation. LED on continuously. Lamps flash or flicker, Solenoids pull-in, dropout. Displays may be energized.	
Fault on BUS line	CAUTION: Turn game OFF. Continuous operation of impulse solenoids causes permanent damage. Disconnect Solenoid Driver/Voltage Regulator module input connector A3-J4. Do procedures A4-II, Symptom IIA page 30.
SYMPTOM IC: LED "ON" continuously	
A) Fault in clock circuit or clock buffers	Measure at U9, pin 3: 2.4VDC and at U9, pin 36: 2.6VDC ($\phi 1$ and $\phi 2$, clock circuit). If correct, go to IC), step B). If absent, measure the voltages as shown on the schematic at U16, pins 4, 5 and 10. If correct, go to line below 'Open Capacitor.' If incorrect, check C14 and C15 with an ohmmeter by unsoldering and lifting one lead.
Shorted capacitor	If C14 or C15 is shorted, replace and retest module.* If C14 & C15 are not shorted, replace U16.
U16 defective	If voltages at pins of U16 are now correct, retest module.*
U15 defective	If voltages at pins of U16 are still incorrect, replace U15. If correct, retest module.*
Open capacitor	If incorrect after replacing U15, replace C14 and C15. Retest module.* If voltages at U16, pins 4, 5 & 10 are correct, remove U9 from the socket.
U9 defective	If voltages at U9 socket, pins 3 & 36 are now correct, replace U9 & retest module.*
U15 defective	If voltages at U9, pins 3 & 36 are not correct, replace U15. Reinsert U9 and retest module.*

* If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-I, POWER-UP PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM IC: LED "ON" continuously (Cont'd.)	
B) Fault on or affecting $\overline{\text{Reset}}$ line	Measure on $\overline{\text{Reset}}$ line, U9, pin 40: 4.8VDC (Approx.). If correct, go to IC), Step C). If absent, use schematic and voltmeter to verify proper operation of Valid Power Detector circuit, VR1, Q1, and Q5. Collector of Q5 should read 4.8VDC.
Defective component in Valid Power Detector Circuit	If defective component is located in Valid Power Detector circuit, replace component and retest module.* If Valid Power Detector circuit voltages agree with schematic, but $\overline{\text{Reset}}$ line is low, remove U8, U9, U10 and U11, one at a time, from their sockets.
U8, U9, U10, or U11 defective	If voltage at U9 socket, pin 40 goes to 4.8VDC, last integrated circuit removed was defective. Replace and retest module.*
Open on $\overline{\text{Reset}}$ line	If voltage at U9, pin 40 is still not correct, check for continuity between Q5, U8, U9, U10 & U11. If incorrect, determine reason for lack of continuity. Repair, retest module.* If continuity is correct, check $\overline{\text{Reset}}$ line (U9, pin 40) to ground with an ohmmeter.
Short on $\overline{\text{Reset}}$ line	If line is shorted to ground, locate and remove short. Reinsert U8, U9, U10 and U11. Retest module.*
C) Fault on $\overline{\text{HALT}}$ line U9 defective	If $\overline{\text{Reset}}$ line is correct, measure at U9, pin 2: 4.95VDC ($\overline{\text{HALT}}$). If incorrect, replace U9 and retest module.*
D) Fault on VMA line	If $\overline{\text{HALT}}$ line is correct, measure at U9, pin 5: 2.8VDC (VMA line). If incorrect, toggle on-off switch several times. Observe VMA line. If initially correct and then incorrect, go to (F), below.
U9 defective	If incorrect, replace U9, retest module.* If still incorrect, go to (E) below.
E) Fault in VUA- ϕ 2 circuit	If VMA line is correct, use voltmeter and schematic to verify proper operation of VUA- ϕ 2 circuit, U14D, U19B, U15C and D. If incorrect, locate and replace defective component in VUA- ϕ 2 circuit, retest module.*
F) Fault on BUS line	Do A4-II, Symptom IIA.

DIAGNOSTIC TABLE: MPU MODULE — A4-II, ROM/PROM PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM IIA: LED flickers briefly on Power-up.	
A) Fault in memory bank. U1, 2, 3, 4, 5 or 6 or U7 or 8 defective	If LED does not flash, replace U1-6, U7, and U8, one package at a time. Repeat Power-up sequence after each substitution. CAUTION: Each ROM or PROM must be replaced with a part with an identical part number. If LED flashes 7X, last integrated circuit replaced is defective. Retest module.*
B) Fault in PIA U10 or U11	If LED does not flash, remove and replace U10 and U11, one package at a time. Repeat Power-up sequence after each substitution. If LED flashes 7X, U10 or U11 is defective. Retest module.*
C) U9 failure to execute	If LED does not flash, remove and replace U9. Repeat Power-up sequence. If LED flashes 7X, U9 is defective. Retest module.*

*If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-II, ROM/PROM PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM IIA: LED flickers briefly on Power-up. (Cont'd.)	
D) BUS associated failure	If LED does not flash, go to A4-II, BUS-Associated Failure Procedure.
SYMPTOM IIB: LED flickers briefly, goes off and then comes on continuously. Erratic operation: Lamps flash or flicker, solenoids pull-in, drop out.	
Fault on BUS line	Do A4-II, BUS-Associated Failure Procedure.

A4-II. BUS-ASSOCIATED FAILURE PROCEDURE, PROM/ROM TEST

- 1) Turn off Power. Install AID2 module on MPU connector J5.
 - 2) Connect the resistor COMMon lead to GND loop on the AID2 module. Turn on Power.
 - 3) Probe resistor loops A₀ thru A₁₃, D₀ thru D₇ and R/W on AID2 with a voltmeter. All loops must read 1.2 volts or less. (At this point in the test, devices U1-11 have been replaced and are known to be good.)
If correct, go to 5.
If a line reads greater than 1.2 volts, check for a solder splash to an adjacent, high lead on the module. If a solder splash is found, repair, remove AID2, retest module.*
 - 4) Address lines A₉, ₁₀, ₁₁, and ₁₂, the VUA-φ2' and the R/W line have logic gate inputs connected to them. A₉, ₁₀, ₁₁, ₁₂, VUA-φ2' and R/W are associated with U17; A₉, ₁₁, ₁₂ and R/W with U18; A₉ and ₁₂ with U19.
If address lines A₉, ₁₀, ₁₁, ₁₂ or the R/W line do not have a solder splash, remove the associated integrated circuit(s) from the line (clip out part). Replace part(s), remove AID2, retest module.*
 - 5) Connect resistor COMMon lead to the + 5 V. loop on AID2.
 - 6) Probe resistor loops A₀ thru A₁₃, D₀ thru D₇ and R/W on AID2 with a voltmeter. All loops must read 4 volts or more. If a line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. Repair, remove AID2, retest module.*
 - 7) Repeat step 4, above. If good, go to step 8.
 - 8) Connect the GND lead to D₇ on AID2. Probe D₆-D₀, A₁₃-A₀, R/W incl. on AID2 with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted to D₇ by a solder splash. Repair, remove AID2, retest module.*
- NOTE:** A₁₂ could be shorted to VUA-φ2' if U17A were defective. If shorted, A₁₂ reads 1.8 VDC. Replace U17. Remove test connector, retest module.*
- 9) Repeat step 8 for GND lead connected to each of D₆-D₀, A₁₃-A₀, R/W, one at a time. If shorted adjacent leads are found, repair, remove AID2 and retest module.*
 - 10) Disconnect the GND lead. Use Table A4-1 and a voltmeter. Check bus line continuity as follows:
 - A) Read 4 VDC or greater at U9, pins 9-20, 22, 23 and 26-34 incl. Absence of a reading means lack of continuity. If lack of continuity exists, repair, remove AID2, retest module.*
 - B) Repeat readings (4 volts or greater) at U1, pins 1-11, 13-17 and 23. Temporarily connect TP1. 1k Ω pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U1, pin 18 as 1.8 VDC. Remove test lead. Read pins 19 and 20 as 4 VDC or greater.
If any of the voltage readings are absent, repair the lack of continuity or failed logic device U17, 18 or 19, remove AID2, retest module.*

*If LED flashes 7X, do A4-IX.

TABLE A4-1 BUS-ASSOCIATED FAILURES

BUS LINE UNDER TEST	CPU-		ROM/PROM, PINS					RAM
	U9, PIN	U1	U2	U3	U4	U5	U6	U7, PIN
A ₀	9	8	8	8	8	8	8	23
A ₁	10	7	7	7	7	7	7	22
A ₂	11	6	6	6	6	6	6	21
A ₃	12	5	5	5	5	5	5	20
A ₄	13	4	4	4	4	4	4	19
A ₅	14	3	3	3	3	3	3	18
A ₆	15	2	2	2	2	2	2	17
A ₇	16	1	1	1	1	1	1	15
A ₈	17	23	23	23	23	23	23	—
A ₉	18	21	21	19	19	21	21	10
A ₁₀	19	19	19	21	21	19	19	11
A ₁₁	20	20	20	20	20	20	20	12
A ₁₂	22	—	—	—	—	—	—	14
D ₀	33	9	9	9	9	9	9	2
D ₁	32	10	10	10	10	10	10	3
D ₂	31	11	11	11	11	11	11	4
D ₃	30	13	13	13	13	13	13	5
D ₄	29	14	14	14	14	14	14	6
D ₅	28	15	15	15	15	15	15	7
D ₆	27	16	16	16	16	16	16	8
D ₇	26	17	17	17	17	17	17	9
R/W	34	—	—	—	—	—	—	16
A ₁₂ -(VUA-φ2')	—	18	18	18	18	18	18	—
VUA-φ2'	—	—	—	—	—	—	—	13

BUS LINE UNDER TEST	NON	I/O	I/O
	VOLATILE RAM U8, PIN	PIA U10, PIN	PIA U11, PIN
A ₀	4	36	36
A ₁	3	35	35
A ₂	2	—	—
A ₃	1	22	—
A ₄	21	—	22
A ₅	5	—	—
A ₆	6	—	—
A ₇	7	24	24
D ₀	—	33	33
D ₁	—	32	32
D ₂	—	31	31
D ₃	—	30	30
D ₄	9, 10	29	29
D ₅	11, 12	28	28
D ₆	13, 14	27	27
D ₇	15, 16	26	26
A ₁₂ -A ₉	—	23	23
A ₉ -A ₁₂ -VUA-φ2'	19	—	—
RESET	17	—	—
VUA-φ2'	—	25	25
R/W	20	21	21
A ₁₃	—	—	—
HLT	—	—	—
R/W	18	—	—

A4-II. BUS-ASSOCIATED FAILURE PROCEDURE, PROM/ROM TEST (Cont'd.)

- C) Repeat (B) for U2-U6 incl. The bar over 21 (or 19 or 20, see table A4-1) requires that the resistor COMMon on AID2 be temporarily connected to the GND loop. Read 4 VDC or greater. Repair lack of continuity. Remove AID2, and retest module.*
- D) Read 4 VDC or greater at U10, U11, pins 21-24, 26-33, 35 and 36. Absence of a reading means lack of continuity. If lack of continuity exists, repair, remove AID2, retest module.*
- E) Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at end that goes to J5). Read U10, U11, pin 25 as 1.8 VDC. Repair lack of continuity. Remove AID2, and retest module.*

DIAGNOSTIC TABLE: MPU MODULE — A4-III, RAM PROCEDURE, NMOS
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM III. LED flashes once on Power-Up.	
A) Fault in R/W memory — U7 defective	Replace U7. If LED flashes 7X on power-up, replaced integrated circuit is defective. Retest module.*
B) U9 failure to execute U9 defective	If LED flashes once on Power-Up, replace U9. If LED flashes 7X on Power-Up, retest module.*
C) U10 or U11 defective	If LED flashes once on power-up, replace U10, U11 one at a time. If LED flashes 7X on power-up, U10 or U11 was defective; retest module.*
D) BUS associated failure	If LED flashes once on power-up, go to A4-III, BUS-Associated Failure Procedure.

A4-III. BUS-ASSOCIATED FAILURE PROCEDURE, RAM TEST

- 1) Turn off power. Install AID2 on MPU connector J5.
- 2) *Connect the resistor COMMon lead to GND loop on the AID2 module. Turn on power.*
- 3) Probe R/W resistor loop on AID2 with a voltmeter. The loop must read 1.2 volts or less. (At this point in the test, devices U7, 9, 10 and 11 have been replaced.)
If the line reads greater than 1.2 volts check for a solder splash to an adjacent, high lead on the module. Repair, remove AID2, retest module.*
- 4) If the R/W line does not have a solder splash, remove the associated integrated circuit U18 from the line (clip out part). Replace part, remove AID2, retest module.*
- 5) *Connect resistor COMMon lead to the + 5 V. loop, AID2.*
- 6) Probe R/W resistor loop on AID2 with a voltmeter. The loop must read 4 volts or more. If the line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. Repair, remove AID2, retest module.*
- 7) Repeat step 4, above. If good, go to step 8.
- 8) Connect the GND lead to R/W on AID2. Probe D₇-D₀, A₁₃-A₀ incl., on AID2 with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted to R/W by a solder splash. Repair, remove AID2, retest module.*
- 9) Disconnect the GND lead. Use Table A4-1 and a voltmeter. Check bus line continuity as follows:
 Read 4 VDC or greater at U7, pins 2-9, 11, 12 and 14-23, incl. Absence of a reading means lack of continuity. Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U7, pin 13 as 2.2 VDC. Absence of a reading means lack of continuity. Remove test lead. The bar over 10 (see table A4-1) requires that the resistor COMMon on AID2 be temporarily connected to the GND loop. Read 4 VDC or greater. Absence of a reading means lack of continuity.
 If lack of continuity exists, repair, remove AID2, retest module.*

* If LED flashes 7X, do A4-IX.

**DIAGNOSTIC TABLE: MPU MODULE — A4-IV, RAM PROCEDURE, CMOS
REPAIR LEVEL: COMPONENT REPLACEMENT**

CAUSE	PROCEDURE
SYMPTOM IV. LED flashes twice on power-up.	
A) Fault in R/W memory U8 defective	Replace U8. If LED flashes 7X on power-up, integrated circuit is defective. Retest module.*
B) U9 failure to execute U9 defective	If LED flashes twice on Power-up, replace U9. If LED flashes 7X on power-up, retest module.*
C) U10 or U11 defective	If LED flashes twice on power-up, replace U10, U11, one at a time. If LED flashes 7X on power-up, U10 or U11 was defective; retest module.*
D) BUS associated failure	If LED flashes twice on power-up, go to A4-IV, BUS-Associated Failure Procedure.

A4-IV. BUS-ASSOCIATED FAILURE PROCEDURE, RAM TEST

- 1) Turn off power. Install AID2 module on MPU connector J5.
- 2) *Connect the resistor COMmon lead to GND loop on the AID2 module.* Turn on power.
- 3) Probe R/W resistor loop on AID2 with a voltmeter. The loop must read 1.2 volts or less. (At this point in the test, devices U8, 9 and 10 have been replaced.) If the line reads greater than 1.2 volts, check for a solder splash to an adjacent, high lead on the module. Repair, remove AID2, retest module.*
- 4) If the R/W line does not have a solder splash, remove the associated integrated circuitry U18 from the line (clip out part). Replace part, remove AID2, retest module.*
- 5) Connect resistor COMmon lead to the + 5 V. loop on AID2.
- 6) Probe R/W resistor loop on AID2 with a voltmeter. The loop must read 4 volts or more. If the line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. Repair, remove AID2, retest module.*
- 7) Repeat step 4, above. If good, go to step 8.
- 8) Connect the GND lead to R/W on AID2. Probe D₇-D₀, A₁₃-A₀ incl., on AID2 with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted to R/W by a solder splash. Repair, remove AID2, retest module.*
- 9) Disconnect the GND lead. Use Table A4-1 and a voltmeter. Check bus line continuity as follows:

Read 4 volts or greater at U8, pins 1-7, 9-17, 20 and 21. Read pin 19 as 2.6 VDC. The bar over $\overline{R/W}$ at 18 (see table A4-1) requires that the resistor COMmon on AID2 be connected to the GND loop. Read 4 VDC or greater.

If any of the voltage readings are absent, repair the lack of continuity or replace the failed logic device U8 or associated logic devices U17, U18 or U19; remove AID2, retest module.*

* If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-V, PIA U10 PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM V. LED flashes 3X on Power-up.	
A) Defective I/O circuit U10 defective	Replace U10. If LED flashes 7X on Power-up, retest module.*
B) U9 failure to execute U9 defective	If LED flashes 3X on Power-up, replace U9. If LED flashes 7X on Power-up, retest module.*
C) Fault on output line Defective capacitor or shorted line	If LED flashes 3X on Power-up, remove U10, use schematic and ohm-meter to check output lines at U10 socket, pins 2-9, for shorts to ground. If shorted capacitor or solder-splashed line is found, replace/repair. Retest module.*
D) Fault on input line	If output lines are correct, go to A4-V, BUS-Associated Failure Procedure.

A4-V. BUS-ASSOCIATED FAILURE PROCEDURE, PIA U10 TEST

- 1) Turn off power. Install AID2 module on MPU connector J5.
- 2) Connect the resistor COMMon lead to the + 5 V. loop on the AID2 module. Turn on power.
- 3) Use Table A4-1 and a voltmeter.
 - A) Read 4 VDC or greater at U10, pins 21-24, 26-33, 35 and 36 incl. Absence of a reading means lack of continuity. If lack of continuity exists, repair, remove AID2, retest module.*
 - B) Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U10, pin 25 as 1.8 VDC. Remove test lead.

If any of the voltage readings are absent, repair the lack of continuity or failed logic device U17, remove AID2, retest the module.*

*If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-VI, PIA U11 PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM VI. LED flashes 4X on Power-up.	
A) Defective I/O circuit U11 defective	Replace U11. If LED flashes 7X on Power-up, retest module.*
B) U9 failure to execute U9 defective	If LED flashes 4X on Power-up, replace U9. If LED flashes 7X on Power-up, retest module.*
C) Fault on output line	If LED flashes 4X on Power-up, use ohmmeter and schematic to check output lines at U11 socket, pins 2-9 for shorts to ground. If shorted capacitor or solder-splashed line is found, replace/repair. Retest module.*
D) Fault on input line	If output lines are correct, go to A4-VI, BUS-Associated Failure Procedure.

A4-VI. BUS-ASSOCIATED FAILURE PROCEDURE, PIA U11 TEST

- 1) Turn off power. Install AID2 module on MPU connector J5.
- 2) Connect the resistor COMmon lead to the + 5 loop on the AID2 module. Turn on power.
- 3) Use Table A4-1 and a voltmeter.
 - A) Read 4 VDC or greater at U11, pins 21-24, 26-33, 35 and 36 incl. Absence of a reading means lack of continuity. If lack of continuity exists, repair. Remove AID2, retest module.*
 - B) Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U11, pin 25 as 1.8 VDC. Remove test lead.

If any of the voltage readings are absent, repair the lack of continuity or failed logic device U17, remove AID2, retest the module.*

*If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-VII, DISPLAY INTERRUPT CIRCUIT PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM VII. LED flashes 5X on Power-up.	
A) Fault in interrupt circuit	Use Ohmmeter to affirm continuity between U9, pin 4 and U11, pins 37 & 38. Measure from U9, pin 4 to ground to check for short.
Open or shorted line	If incorrect, repair open or short condition. Retest module.* If correct, replace U11.
U11 defective	If LED flashes 7X on Power-up, retest module.*
B) U9 failure to execute	If LED flashes 5X on Power-up, replace U9.
U9 defective	If LED flashed 7X on Power-up, retest module.*
C) Fault in interrupt generator circuit	If LED flashed 5X on Power-up, check voltage at U12 against voltages shown on schematic.
Open line	If correct, use ohmmeter to determine reason for lack of continuity to U11, pin 40. Repair, retest module.* If voltages at U12 are incorrect, replace U12.
Defective U12	If LED flashes 7X on Power-up, retest module.*
Defective capacitor	If LED flashes 5X replace C16 and C17. Retest module.*

DIAGNOSTIC TABLE: MPU MODULE — A4-VIII, (LAMP AND SOLENOID INTERRUPT)
REPAIR LEVEL: COMPONENT REPLACEMENT

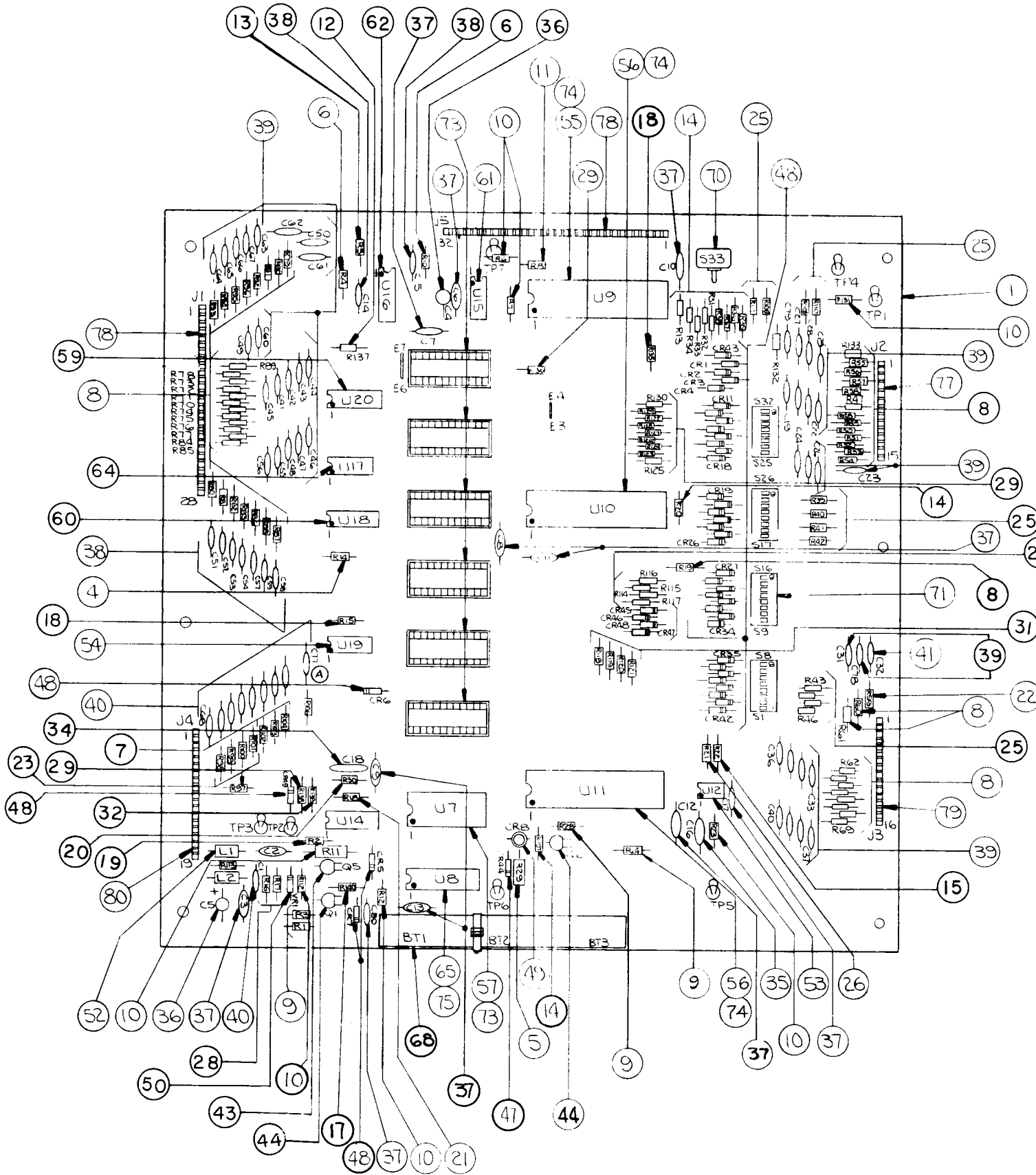
CAUSE	PROCEDURE
SYMPTOM VIII. LED flashes 6X on Power-up.	
A) Fault in interrupt circuit	Use Ohmmeter to affirm continuity between U11, pins 37 and 38 and U10, pins 37 and 38 and U9, pin 4.
Open line	If incorrect, repair open circuit and retest module.* If correct, replace U10.
Defective U10	If LED flashes 7X on Power-up, retest module.*
B) Fault in Zero Crossing Detector circuit	If LED flashes 6X on Power-up, use schematic and voltmeter to check operation of Zero Crossing Detector circuit U14. Measure .25VDC at U14, pin 4, & U14, pin 15; 4.5VDC @ U14, pin 10 & U14, pin 14.
Open or shorted line	If correct, use ohmmeter to determine reason for lack of continuity to U10, pin 18. Repair, retest module.*
U18 or U19 defective	If incorrect, change U14 -or-
Open or shorted line	Determine reason for lack of continuity to input connector, as appropriate. Voltage at TP3, if proper, reads 21.5 ± 2.7 VDC. Repair, retest module.*

* If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-IX, PIA OUTPUTS PROCEDURE
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM IX. LED flashes 7X on Power-up. Game operation improper.	
A) Fault in PIA U11 buffered output circuit	<p>Turn game OFF. Connect AID1 to J5 on MPU. Turn power ON. Put game in Self-Test mode of operation. Use AID1 and schematic. Probe output connector and pins listed. LED lights to indicate proper operation.</p> <p>Remove connector A3J4, Solenoid Driver module. Probe A4J4, pins 1-8 and 10 incl.</p>
U11 defective Open or shorted output line	<p>If correct, replace A3J4, go to B).</p> <p>If incorrect: If U11 was not replaced during previous testing, replace U11. Repeat test on J4.</p> <p>If correct, proceed to B).</p> <p>If incorrect, determine reason for short or open on line. Repair, retest module.</p>
B) Fault in PIA U10 switch Matrix buffered output circuit	<p>Probe J2, pins 8-15 and J3, pins 9-16 incl.</p> <p>If correct, go to C).</p> <p>If incorrect: If U10 was not replaced during previous testing, replace U10. Repeat test on J2, J3. If correct, proceed to C). If incorrect, determine reason for short or open on line. Repair, retest module.</p>
C) Fault on buffered display blanking line (CA2)	<p>Probe J1, pin 10.</p> <p>If correct, go to D).</p>
Open line	<p>If incorrect, probe U19, pin 4. If correct, determine reason for lack of continuity. Repair and retest module.</p>
U10 defective	<p>If U19, pin 4 is incorrect, and U10 has not been previously changed, replace U10. Retest module.</p> <p>If correct, go to D).</p>
U20, 14 or 19 defective	<p>If incorrect, use voltmeter, voltages shown on schematic, to localize fault to U20, U14 or U19. Repair, retest module.</p>
D) Fault on Display Latch Strobe buffered lines	<p>Probe J1, pins 20-24.</p> <p>If correct, go to E). If incorrect: NOTE LINE.</p>
Open line	<p>Probe U20 outputs, pins 2, 5, 7, 9 and 11, as appropriate.</p>
U10 and U11 defective	<p>If correct, determine reason for lack of continuity. Repair, retest module.</p> <p>If incorrect, and U10 and U11 were not replaced in previous testing, remove U10 and U11. Replace and retest module.</p>
U20 output defective	<p>If incorrect, replace U20, retest module.</p>
E) Open line, PIA non-buffered outputs	<p>Probe J2, pins 1-5; J3, pins 2, 3; J1, pins 1-7, 12-19 and 25-28.</p> <p>If incorrect, determine reason for lack of continuity. Repair, retest module.</p> <p>If correct, return module to stock.</p>

AS-2518-17 MPU MODULE



A4: MPU MODULE COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A4 (see note 1)	AS-2887-XXXX	MPU Module Complete. See page 39.
2	A4 (see note 2)	AS-2518-17	MPU Module less Program Memory, U1-6 incl.
3-32	See Schematic		Resistors, See schematic for value.
34	C18	E-00586-0019	Capacitor, .05 MFD, 100V
35	C16	E-00586-0023	Capacitor, 1 MFD, 100V
36	C4, C5	E-00586-0073	Capacitor, 4.5 MFD, 25V
37	C3, C6-C13, C17	E-00586-0065	Capacitor, .01 MFD, 500V
38	C14, C15, C79, C41-C67	E-00586-0067	Capacitor, 470 PFD, 1kv
39	C19-C31, C78, C33-C40	E-00586-0069	Capacitor, 390 PFD, 1kv
40	C1, C2, C68-C77	E-00586-0075	Capacitor, 820 PFD, 1kv
41	C32	E-00586-0077	Capacitor, 3000 PF, 1kv
43	Q5	E-00585-0023	Transistor PNP (MPS-3702)
44	Q1, Q2	E-00585-0031	Transistor (2N3904)
47	CR44	E-00587-0006	Diode (IN4004)
48	CR1-CR7, CR11-CR43, CR45-CR48	E-00587-0014	Diode (IN4148)
49	CR8	E-00679	LED (Green)
50	VR1	E-00598-0008	Diode Zener (8.2V, IN9598)
52	L1, L2	E-00604-0003	Inductor, 22 Micro Hy.
53	U12	E-00620-0004	Timer (555)
54	U19	E-00620-0005	Quad 2 Input (4011)
55	U9	E-00620-0028	MPU I.C. (6800)
56	U10, U11	E-00620-0029	PIA I.C. (6820)
57	U7	E-00620-0030	RAM I.C. (6810)
59	U20	E-00620-0032	HEX Buffer I.C. (14502B)
60	U14, U18	E-00620-0033	HEX Inverter (4049B)
61	U15	E-00620-0034	Quad Memory Driver (MC3459L)
62	U16	E-00620-0035	Dual Monostable (9602)
64	U17	E-00620-0041	Quad 2 Inputs (74L00N)
65	U8	E-00620-0042	RAM (C MOS, P5101L-3)
68	BT1, BT2, BT3	E-00628-0002	Battery
70	S33	E-00658-0001	Push Button Switch
71	S1-S8, S9-S16, S17-S24, S25-S32	E-00677	DIP Switch
73		E-00712	24 Pin Socket
74		E-00712-0001	40 Pin Socket
75		E-00712-0003	22 Pin Socket
77	J2	E-00715	15 Pin Wafer Connector
78	J4, J5	E-00715-0004	28 Pin Wafer Connector
79	J3	E-00715-0017	16 Pin Wafer Connector
80	J1	E-00715-0018	19 Pin Wafer Connector
81	J5	E-00715-0023	4 Pin Wafer Connector

NOTE 1:

When ordering, fill in dash number. For example, AS-2887-1: FREEDOM, AS-2887-2: NIGHT RIDER, AS-2887-3: EVEL KNIEVEL

NOTE 2:

Order replacement memory chips U1-U6, by specifying game, socket and part number stamped on chip.

LAMP DRIVER MODULE A5 PROCEDURAL STEPS

- I. The Lamp Driver module part of the Self-Test energizes each of the sixty lamp driver output circuits on the module. The game used as a test bed, however, may not have a lamp assigned to each of the output circuits. If it does not, the following procedure can be followed:
 - A) *Use the Lamp Driver module part of the Self-Test. If faults are found, use the symptoms to select a repair procedure.* Restore the module to operating condition by following the procedure.
 - B) Use the test bed game schematic. Make a list of the Lamp Driver circuits that did not have lamp loads.
 - C) The LED on the MPU module is used as a substitute for a lamp load. If the circuit under test is good, the LED will flash on and off just as the lamps in the test bed game do. Access to the anode of the first Lamp Driver SCR on the list is available at J1, J2 or J3. Refer to the Lamp Driver module schematic. Insert a 3/4" piece of solid wire (ex: a resistor lead clipping) into the connector contact position to be tested. Connect a test lead from TP6 on the MPU module to the piece of wire.
 - D) Repeat A.
 - E) Repeat C and A for each of the remaining Lamp Driver circuits on the list.* Return the module to stock or repair, as required.
- II. Lamp Bank Extender modules can be tested in the test bed game.

If the game has provision for a Lamp Bank Extender, insert the module in its proper place and conduct the Lamp Driver module part of the Self-Test. The procedure above must be followed to test unused outputs.

If the game does not have provision for a Lamp Bank Extender module, insert it in the Lamp Driver position. Connect J4, cable harness to J4 on the module, J2 to J2. Testing is the same as for the game with provision for the module. Unused outputs can also be tested. Lamp assignments are given on the test bed game Lamp Driver module schematic.

*Connecting a lamp-loaded SCR anode to TP6 causes the LED to flicker, alternating between bright and dim.

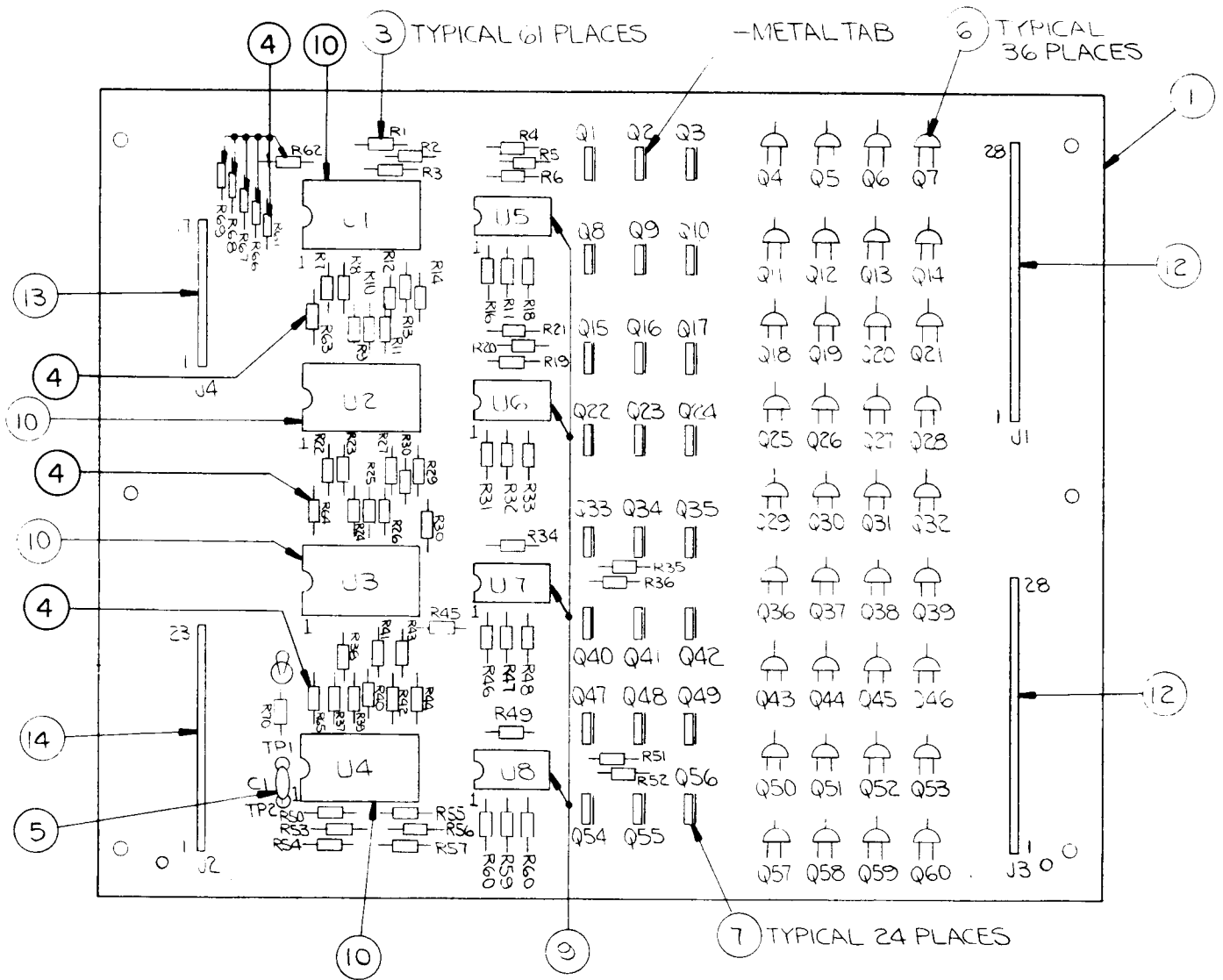
DIAGNOSTIC TABLE: LAMP DRIVER MODULE, A5
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. Lamp always off.	
A) Defective SCR	Use jumper to connect pull-up resistor at TP3 (R70, 2k Ω) to gate of SCR (silicon controlled rectifier). (Ex: Q10) If lamp does not turn on, replace SCR. Retest module.
B) Defective buffer amplifier	If lamp turns on and buffer amplifier (Ex: U5) is used, replace buffer. Retest module. If fault is not corrected, go to step "C".
C) Defective integrated circuit	If lamp turns on and no buffer amplifier is used (Ex: Q1) or if changing buffer did not correct problem, replace associated integrated circuit (Ex: U1). Retest module.
SYMPTOM II. Lamp always on.	
A) Defective SCR	Use jumper to ground (TP2) SCR gate (Ex: Q10). If lamp does not go out, replace SCR, retest module. If lamp goes out and buffer amplifier (Ex: U5) is used, use jumper to ground buffer amplifier input.
B) Defective buffer amplifier	If lamp does not go out, replace buffer amplifier, retest module.
C) Defective integrated circuit	If lamp does go out, replace associated integrated circuit (Ex: U1). Retest module.
SYMPTOM III. Half or more of lamps associated with one or all integrated circuit(s) flicker or always off.	
A) Open address line	Use AID1, probe pins 2, 3, 21 & 22 (U1, U2, U3 or U4). If LED does not light, use schematic to determine reason for lack of continuity. Repair, retest module.
B) Defective integrated circuit	If LED lights, replace appropriate integrated circuit (U1, U2, U3 or U4). Retest module.
SYMPTOM IV. One fourth (or more) of total lamps, all associated with one (or several) integrated circuit(s) always off.	
A) Open data line	Use AID1. Probe pin 23 of fault associated integrated circuit(s). If LED does not light, determine reason for lack of continuity. Repair, retest module.
B) Defective integrated circuit	If LED lights, replace appropriate integrated circuit (U1, U2, U3 or U4). Retest module.
SYMPTOM V. A few lamps on, several flicker, others off, associated with one or all integrated circuit(s).	
A) Open strobe line	Use AID1. Probe pin 1 of fault associated integrated circuit(s). If LED does not light, determine reason for lack of continuity. Repair, retest module.
B) Defective integrated circuit	If LED lights, replace appropriate integrated circuit (U1, U2, U3 or U4). Retest module.

DIAGNOSTIC TABLE: LAMP DRIVER MODULE, A5
REPAIR LEVEL: COMPONENT REPLACEMENT (Cont'd.)

CAUSE	PROCEDURE
SYMPTOM VI. Half or more lamps always off alternating with a few always on.	
A) Shorted address line due to defective integrated circuit	Use AID1. Probe pins 2, 3, 21 & 22. Hold probe on line that does not light LED. Cut foil associated with line that does not light LED close to integrated circuit, one at a time until LED lights. Replace integrated circuit, repair foil cuts with jumper wire and solder. Retest module.
SYMPTOM VII. One fourth of lamps always on.	
A) Shorted data line due to defective integrated circuit	Replace integrated circuit associated with one fourth lamps always on. Retest module.
SYMPTOM VIII. All lamps off except four (4). (one per integrated circuit.)	
A) Shorted lampstrobe line due to defective integrated circuit	Repeat procedure VI for U1, U2, U3, U4, pin 1.
SYMPTOM IX. MPU does not flash LED on power-up.	
A) Short on + 5VDC line Defective capacitor C1	Remove capacitor C1. Measure + 5VDC at TP1. If correct, discard and replace C1. Retest module.
B) Defective integrated circuit	If incorrect, repeat foil cutting procedure, Symptom VI for U1, 2, 3, 4, pin 24.
SYMPTOM X. All lamps off, or erratic operation, no voltage at TP1.	
+ 5VDC supply voltage absent	Use voltmeter to determine reason for lack of continuity. Repair, retest module.

AS-2518-14 LAMP DRIVER MODULE



A5: LAMP DRIVER MODULE COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A5	AS-2518-14	Lamp Driver Module, Complete
3	R1-R60, R70	E-00105-0237	Resistor, 2k Ω , 5%, 1/4W
4	R61-R69	E-00105-0256	Resistor, 2.2M Ω , 1/4W
5	C1	E-00586-0065	Capacitor, .01 MFD, 500V
6	Q4-Q7, Q11-Q14, Q18-Q21, Q25-Q32, Q36-Q39, Q43-Q46, Q50-Q53, Q57, Q58	E-00585-0014	SCR, 2N5060
7	Q1-Q3, Q8-Q10, Q15-Q17, Q22-Q24, Q33-Q35, Q40-Q42, Q47-Q49, Q54-Q56	E-00585-0029	SCR, MCR106-1
9	U5-U8	E-00620-0007	I.C., Buffer, CD4050AE
10	U1-U4	E-00620-0037	I.C., Decoder, 14514B
12	J1, J3	E-00715-0004	28 Pin Wafer Connector
13	J1	E-00715-0013	17 Pin Wafer Connector
14	J4	E-00715-0014	23 Pin Wafer Connector

DISPLAY DRIVER MODULE A1 PROCEDURAL STEPS

CAUTION

- I. Before inserting module in game, probe the 190 VDC circuit to ground, TP2 to TP3, with an ohmmeter. Clear shorts, if present, *before* inserting module in game. Shorts on the 190 VDC supply line can cause failure of the Solenoid Driver/Voltage Regulator module, A3.
- II. High voltages are present in the display panel driver circuits (+ 190 VDC) on this module. Exercise due caution when servicing.
- III. Careless or accidental probe slips that short the + 190 VDC circuit to ground or to the + 5 VDC or logic circuits can cause failure of the Solenoid Driver/Voltage Regulator module (A3) and MPU module (A4). It is recommended that a standard or needle tipped probe similar to the AID probe be used to perform voltage checks. Alligator clip leads are to be avoided unless special precautions are taken.

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE, A1
REPAIR LEVEL: COMPONENT REPLACEMENT

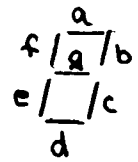
CAUSE	PROCEDURE
SYMPTOM I. Mottled, Uneven or dim display.	
Display at end of useful life	Replace Display Panel.
SYMPTOM II. Digit Fails to light.	
A) Lack of continuity	Use AID1 probe junction of base resistor (R2, 4, 6, 8, 10 or 12, as appropriate) and connector. If LED does not light, determine reason for lack of continuity. Repair, retest module.
B) Defective Digit Driver Transistor	If LED lights, turn game off, then on, enter Display Driver Self-Test. Ground collector (Ex: junction of Q6, R11) of level shifter transistor.* If digit does not light, replace digit driver transistor (Ex: Q12). Retest module.
C) Defective level shifter transistor	If digit lights, replace level shifter transistor. Retest module.
SYMPTOM III. Digit brighter than adjacent digits (Digit always on).	
A) Defective level shifter transistor (Ex: Q6)	Use AID1 to effectively ground base of level shifter. Carefully connect jumper lead from TP2 (+ 190VDC) to base of digit driver transistor. If digit turns off, replace level shifter transistor. Retest module.
B) Defective digit driver transistor	If digit does not turn off, replace digit driver transistor. Retest module.

* To prevent damage to Display Panel due to overheating, Limit Time Jumper is in circuit to 60 seconds or less. TP3 is a convenient ground point.

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE, A1
REPAIR LEVEL: COMPONENT REPLACEMENT (Cont'd.)

CAUSE	PROCEDURE	
SYMPTOM IV. Segment always ON. (See Table "A")		
A) Defective segment driver transistor	Use AID1. Probe base, segment driver transistor (Ex: Q13). If LED lights, replace transistor, retest module. If LED does not light, measure voltage at base of segment driver transistor.	
B) Defective segment driver transistor & Integrated Circuit U1	If greater than +5 VDC (Ex: +110 VDC) replace transistor and U1 segment decoder. Retest module.	
C) Defective Integrated circuit U1	If +5 VDC, replace U1. Retest module.	
SYMPTOM V. Segment Always OFF. (See Table "B")		
A) Defective segment driver transistor	Use AID1. Probe base, segment driver transistor (Ex: Q13). If LED lights, replace transistor. Retest Module. If LED does not light, unsolder and remove base lead of transistor from foil on board. Probe foil. If LED lights, replace segment driver transistor. Retest module.	
B) Defective Integrated Circuit U1	If LED does not light, replace U1, segment decoder. Retest module.	
SYMPTOM VI. Display Count is improper.		
A) Ex: 1,1,3,3,5,5,7,7,9,9,- or 2,3,2,3,6,7,6,7,-,-,- or 4,5,6,7,4,5,6,7,-,-,- or 8,9,-,-,-,-,-,8,9,- or etc.	A) Lack of continuity	Use AID1. Probe address inputs at U1, pins 2, 3, 4 & 5. If LED does not light, determine reason for lack of continuity to connector. Repair, retest module. If LED lights, replace U1. Retest module.
	B) Defective Integrated Circuit U1	
B) Ex: 0,0,2,2,4,4,6,6,8,8,- or 0,1,0,1,4,5,4,5,8,9,- or 0,1,2,3,0,1,2,3,8,9,- or 0,1,2,3,4,5,6,7,0,1,- or etc.	A) Short on Address Line	Use AID1. Probe address inputs at U1, pins 2, 3, 4, & 5. If short exists between foil traces, repair, retest module.
	B) Defective Integrated Circuit U1	If short does not exist between traces, replace U1. Retest module.
SYMPTOM VII. No Display or digits flicker.		
A) Open on +5 VDC Supply Line	Measure $5 \pm .25$ VDC at TP1 and at U1, pin 16. If absent, determine reason for lack of continuity. Repair, retest module.	
B) Open on +190 VDC Supply Line	If +5 present, measure 190 ± 5 VDC at TP2. If absent, check connector for 190 VDC. If present, determine reason for lack of continuity. Repair, retest module.	
C) Short on +190 VDC Supply Line	If absent, replace C2. Retest module.	
D) Defective Integrated Circuit U1	If 190 VDC is present in step "B", replace integrated circuit U1. Retest module.	

TABLE "A" — SEGMENT ALWAYS ON



COUNT	a	b	c	d	e	f	g
0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

TABLE "B" — SEGMENT ALWAYS OFF

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE, A1
REPAIR LEVEL: COMPONENT REPLACEMENT (Cont'd.)

CAUSE

PROCEDURE

SYMPTOM VIII. Arcing Between Digits.

- | | |
|------------------------------|---|
| A) Defective Zener Diode VR1 | Measure voltage across Zener Diode. If voltage is 190 VDC or 0 VDC, replace zener, retest module. |
| B) Defective Display Panel | If voltage is 110 ± 11 VDC, replace display panel. Retest module. |

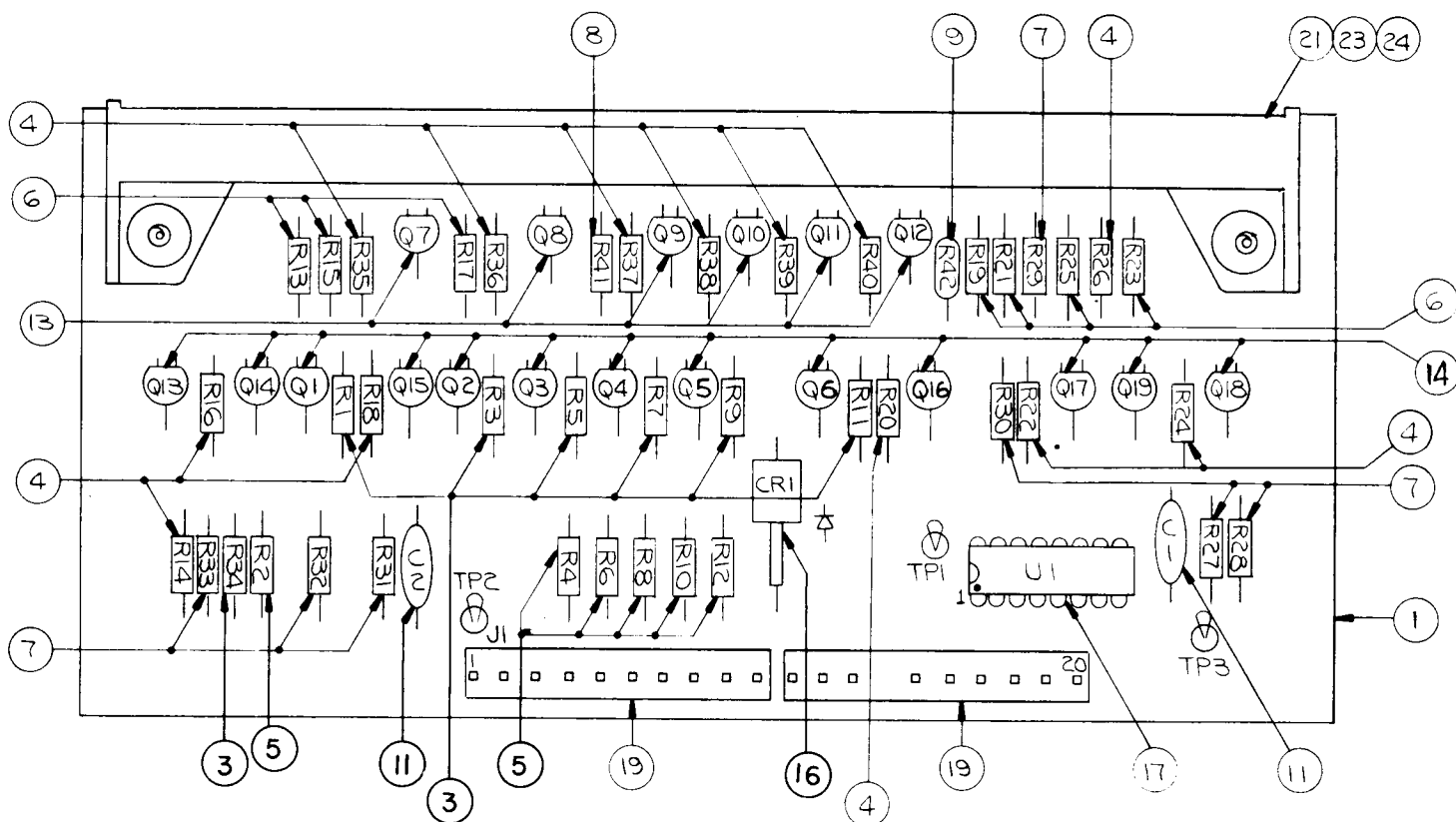
SYMPTOM IX. MPU does not flash LED on Power-up.

- | | |
|------------------------------------|---|
| Short on + 5 VDC line | Remove C1 from Module. Test with Ohmmeter. |
| A) Defective capacitor C1 | If defective, discard. Replace C1, retest module. |
| B) Defective Integrated Circuit U1 | If good, return C1 to module. Replace integrated circuit U1. Retest module. |

SYMPTOM X. MPU flashes LED once, briefly, on power-up. Game ready condition cannot be attained.

- | | |
|-----------------------|---|
| Short on address line | Disconnect connector J1. Power-up game. Use AID1. Carefully reconnect connector J1. Go to Symptom VI. |
|-----------------------|---|

AS-2518-15 DISPLAY DRIVER MODULE



A1: DISPLAY DRIVER MODULE COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A1	AS-2518-15	Display Driver Module, Complete
3	R1, R3, R5, R7, R9, R11, R34	E-00105-0226	Resistor, 100K, 1/4W
4	R14, R16, R18, R20, R22, R24, R26, R35-R40	E-00105-0227	Resistor, 300K, 1/4W
5	R2, R4, R6, R8, R10, R12	E-00105-0228	Resistor, 9.1K, 1/4W
6	R13, R15, R17, R19, R21, R23, R25	E-00105-0229	Resistor, 1.5K, 1/4W
7	R27-R33	E-00105-0230	Resistor, 1K, 1/4W
8	R41	E-00105-0231	Resistor, 39K, 1/4W
9	R42	E-00105-0271	Resistor, 240K, 1/4W
11	C1, C2	E-00586-0065	Capacitor, .01 MFD, 500V
13	Q7-Q12	E-00585-0032	Transistor, 2N5401
14	Q1-Q6, Q13-Q19	E-00585-0033	Transistor, MPS-A42
16	CR1	E-00598-0007	Zener Diode, 110V, 1W, IN3045A, IM110Z.S10
17	U1	E-00620-0038	I.C. Decoder, 14543B
19	J1, J2	E-00715-0011	10 Pin Wafer Connector
21	DS1	E-00680	Digital Display Panel
23		P-02399	Display Mounting (Top)
24		P-02399-0001	Display Mounting (Bottom)

SOLENOID DRIVER/VOLTAGE REGULATOR MODULE A3

INDEX

PROCEDURAL STEPS

+ 5 VDC Regulator related problems	Page 51
+ 190 VDC Regulator related problems	Page 52
Solenoid Driver related problems	Page 53

- I. High voltages are present in the + 190 VDC regulator circuit on the module. Exercise due caution when servicing.
- II. Damage can result to the MPU module due to improper operation in the + 5 VDC regulator circuit. Disconnect MPU module connector J4 before turning on power to test Solenoid Driver/ Voltage Regulator module. If voltage at TP1 is correct ($+ 5 \pm .25$ VDC), connector on MPU module may be connected. If voltage at TP1 is incorrect, leave MPU module connector off until proper operation is attained.
- III. The Solenoid Driver module part of the Self-Test energizes each of the nineteen solenoid driver output circuits on the module. The game used as a test bed, however, may not have a solenoid assigned to each of the output circuits. If it does not, the following procedure can be followed:
 - A) Use the Solenoid Driver module part of the Self-Test. If faults are found, use the symptoms to select a repair procedure. Restore the module to operating condition by following the procedure.
 - B) Use the test bed game schematic. Make a list of the Solenoid Driver circuits that did not have Solenoid loads.
 - C) The LED on the MPU module is used as a substitute for a solenoid load. If the circuit under test is good, the LED can be made to flash on and off in the test bed game. Access to the collector of the first solenoid driver transistor on the list is available at J1, J2, J3 or J5. Refer to the Solenoid Driver module schematic. Insert a 3/4" piece of solid wire (ex: a resistor lead clipping) into the connector contact position to be tested. Connect a test lead from TP6 on the MPU module to the piece of wire.
 - D) Repeat A.
 - E) Repeat C and A for each of the remaining Solenoid Driver circuits on the list. Return the module to stock or repair, as required.
- IV. Solenoid Bank Extender modules can be tested in the test bed game.

If the game has provision for a Solenoid Bank Extender insert the module in its proper place and conduct the Solenoid Driver module part of the Self-Test. The procedure above must be followed to test unused outputs. If the Game does not have provision for a Solenoid Bank Extender module, insert it in the Solenoid Driver position. Connect J4, cable harness to J4 on the module, J2 to J2. Testing is the same as for the game with provision for the module. Unused outputs are also to be tested. Solenoid assignments are given on the test bed game Solenoid Driver module schematic.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR* MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, + 5 VDC REGULATOR CIRCUIT

CAUSE	PROCEDURE
SYMPTOM I. * No regulation. Input TP5 and output TP1 are equal (+ 11.9 VDC).	
Defective integrated circuit Q20	* Replace Q20, voltage regulator. Measure voltage at TP1. If $+ 5 \pm .25$ VDC, replace MPU module connector. Retest module.
SYMPTOM II. No output at TP1. TP5 normal (11.9 VDC).	
A) Defective capacitor C36	Remove connector contact, J3, pin 25. If TP1 is $+ 5 \pm .25$ VDC, replace C22, .01Mf, reinsert contact, retest module.
B) Defective integrated circuit Q20	If TP1 is 0 VDC, replace Q20, retest module.
C) Defective capacitor C25	If TP1 is still 0 VDC, replace capacitor C25, 0.1Mf, retest module. Q20, replaced in step "B" may be retested and, if good, returned to stock.
SYMPTOM III. Module blows fuse F6 on transformer module.	
A) Defective capacitor C23	Disconnect one lead of capacitor C23, 11,700Mf. Discharge capacitor with screw driver. With ohmmeter set to Rx 100, capacitor takes about 50 seconds to charge (0-∞). If capacitor reads short after 50 seconds, replace and retest module.
B) Defective capacitor C24	If C23 checks good, unsolder one lead of C24, 2Mf. Discharge capacitor with screw driver. With Ohmmeter set to Rx 10,000, capacitor reads about 100,000 ohms. If capacitor reads short, replace and retest module.
C) Defective integrated circuit Q20	If capacitor is good, resolder. Replace Q20, retest module.
SYMPTOM IV. MPU module does not flash LED, play tune on power-up. Voltage at TP1 Low, out of limits ($5 \pm .25$ VDC).	
A) Defective capacitor C23	Disconnect one lead of capacitor C23, 11,700Mf. Discharge capacitor with screw driver. With ohmmeter set to Rx 100, capacitor takes about 50 seconds to charge (0 to ∞). If capacitor charges rapidly, replace and retest module.
B) Defective integrated circuit Q20	If C23 checks good, reconnect lead. Replace Q20. Retest module.

*Disconnect MPU module connector J4 before testing module. Turn on power. If voltage at TP1 is greater than + 5 VDC, correct problem before connecting MPU module connector. Failure to observe this procedure can result in damage to MPU module.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, + 190 VDC REGULATOR CIRCUIT

CAUSE	PROCEDURE
SYMPTOM I. $V_{IN}(TP4) = V_{OUT}(TP2)$.	
Defective Zener or pot wiper not making contact	At cathode of zener diode VR1 (wiper on pot) measure: 140 ± 14 VDC. If voltage is present, but high, use ohmmeter to determine condition of zener diode.
A) Defective Zener, overheated resistors	If zener reads open, both directions, replace, retest module. If zener diode checks good, go to step C.
B) Defective pot	If Voltage is absent at wiper on pot, spray clean or replace pot. Retest Module. If 140 ± 14 VDC is present at wiper on pot, measure approximately + 1.5 VDC at base of Q23, feed back amplifier.
C) Defective transistor Q23	If voltage at base is 0 VDC, and R55 ($1.2k \Omega$) is good, replace Q23, retest module. If voltage at base is 1.5 VDC (approx.) or if R55 is open, measure voltage at collector of Q23. If voltage is 230 VDC, disconnect all display driver modules. CAUTION: Failure to do so can damage Q21, Q22. Use jumper to short Q23 collector to ground, measure voltage at TP2. Remove jumper quickly to prevent damage to R7 ($22k \Omega$).
D) Defective transistor Q23	If voltage at TP2 went to 0 VDC, and returned to 234 VDC, replace Q23. Retest module. If fuse blew, unsolder and lift one end of C27. Check C27 with ohmmeter.
E) Shorted capacitor C27	If C27 is shorted, replace C27, R55 and Q23 and retest module. If C27 is good, resolder C27.
F) Defective transistors Q21, Q22 and Q23	Replace Q21, Q22, Q23, R55 and fuse and retest module.
G) Defective diode CR21, transistors Q21, Q22, Q23	If fuse did not blow, unsolder one lead of diode CR21. Measure CR21 diode with an ohmmeter, both directions. If diode is shorted, replace diode, Q21, Q22, Q23 and R55. Retest module.
H) Defective transistors Q21 and Q22	If diode is good, replace Q21, Q22, Q23 and R55. Retest module.
SYMPTOM II. $V_{OUT}(TP2) = 20$ VDC or less.	
A) Defective Zener diode VR1	At wiper on pot (cathode of zener diode VR1) measure 140 ± 14 VDC. If voltage is absent, check zener diode with an ohmmeter. If zener is shorted, replace zener. If R58 ($8.2k \Omega$) and pot are damaged, replace. Retest module. If zener diode is good, measure voltage at collector of Q23: 193 VDC. If voltage is 1.5 VDC, disconnect one end of C28. Check C28 with ohmmeter.
B) Defective capacitor C28	If C28 is shorted, replace C28 and R7 ($22k \Omega$). Retest module.
C) Defective transistor Q23	If C28 is good, replace transistor Q23 and R7 ($22k \Omega$). Retest module.
D) Defective transistors Q21 and Q22	If voltage at collector, Q23 is correct, replace transistors Q21 and Q22. Retest module.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, + 190 VDC REGULATOR CIRCUIT (Cont'd.)

CAUSE	PROCEDURE
SYMPTOM III. V_{IN} out of limits, below 206 VDC.	
Defective capacitor C26, 160Mf, 350 WVDC	Replace capacitor. Retest module.
SYMPTOM IV. Module blows fuse.	
Defective capacitor C26, 160Mf, 350 WVDC	Replace capacitor. Retest module.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, SOLENOID DRIVER CIRCUITS

CAUSE	PROCEDURE
SYMPTOM I. Solenoid does not pull-in.	
	Use jumper to connect TP6 pull-up resistor (120 Ω) to base of solenoid driver transistor (Ex: Q2). If solenoid pulls-in, go to Step I-C).
A) Defective Solenoid Driver Transistor	If solenoid does not pull-in, use voltmeter at transistor collector. If meter reads 43 ± 5.4 VDC, replace solenoid driver transistor. Retest module.
B) Lack of continuity	If voltage not present, use voltmeter to determine reason for lack of continuity to connector. Repair, retest module.
C) Defective Integrated Circuit U1, U3, U4	Use jumper to ground the base of transistor driver (U1, U3 or U4, as appropriate). If solenoid does not pull-in, measure voltage (DC) at collector-diode junction, transistor driver. If voltage at collector is 0 VDC, replace U1, U3 or U4 as appropriate. Retest module.
D) Defective diode (Open)	If solenoid does not pull-in and voltage at collector is 5 VDC, replace diode (Ex: CR2), retest module.
E) Lack of continuity (Solenoids not driven) from U2)	If solenoid pulls-in and is not associated with U2 determine reason for lack of continuity to input connector J4. Repair, retest module.
F) Defective integrated Circuit U2	If solenoid pulls-in and is associated with U2, replace U2. Retest module.
SYMPTOM II. Solenoid always energized.*	
A) Defective solenoid driver transistor	Ground base of solenoid driver transistor (Ex: Q2). If solenoid remains energized, replace solenoid driver transistor. Retest module.
B) Defective diode (Shorted)	Measure voltage at base of solenoid driver transistor. If 0.3 VDC, replace diode, retest module. If .7 to 1.4 VDC, use jumper to connect TP7 pull-up resistor (1.2k Ω) to base of transistor driver (U1, U3 or U4 as appropriate).
C) Lack of continuity	If solenoid de-energizes for transistor drivers not connected to U2 determine reason for lack of continuity between 3.9k Ω pull up resistor and + 5 VDC. Repair, retest module.

*Solenoids associated with 1 of 16 decoder U2 are designed for impulse operation only and may become damaged if operated continuously.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, SOLENOID DRIVER CIRCUITS

CAUSE	PROCEDURE
SYMPTOM II. Solenoid always energized.* (Cont'd.)	
D) Defective integrated circuit U1, U3, U4	If solenoid remains energized, replace integrated circuit U1, U3 or U4 as appropriate. Retest module. If solenoid remains energized for transistor drivers associated with U2 replace integrated circuit U1, U3 or U4 as appropriate. Retest module. If solenoid de-energized, remove jumper. Remove input connector. Measure + 5 VDC at U2 pins 20-23 incl.
E) Lack of continuity	If voltage not present, determine reason for lack of continuity between 100k Ω pull-up resistor and + 5 VDC. Repair, retest module.
F) Defective Integrated circuit U2	If + 5 VDC is present at inputs, replace U2. Repair, retest module.
SYMPTOM III. U2 associated solenoids: 1/2, 1/4, 1/8 or one always energized. 1/2, 1/4, 1/8 or non energized.	
A) Defective Integrated circuit U2	Use AID1. Probe inputs at U2, pins 20-23 incl. If LED lights, replace U2. Retest module.
B) Lack of continuity	If LED does not light, use probe at J4, pins 3, 4, 5 and 6. If LED lights, find reason for lack of continuity to U4. Repair, retest module.
C) Defective Integrated circuit U2	If LED does not light, replace U2. Retest module.
SYMPTOM IV. All solenoids de-energized.	
A) Lack of continuity	Use Voltmeter to find reason for lack of continuity to + 5 VDC supply line. Repair, retest module.
SYMPTOM V. MPU does not flash LED on Power-up.	
Short on + 5 VDC line	Remove contact from connector J3, pin 25. If 5 VDC is present at TP1, remove C22. Test with ohmmeter.
A) Defective capacitor C22	If defective, discard. Replace C22, reinsert contact, connector J3. Retest module.
B) Defective Integrated circuit U2	If C22 is correct, replace integrated circuit U2.
C) Defective + 5 VDC Voltage Regulator	If + 5 VDC is not present, proceed to Voltage Regulator Diagnostic Table.

* Solenoids associated with 1 of 16 decoder U2 are designed for impulse operation only and may become damaged if operated continuously.

A3: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A3	AS-2518-16	Solenoid Driver/ Voltage Regulator Module, Complete
3-14	Resistors		Resistor, See Schematic for value.
15	RT1	E-00599-0014	Pot. (Linear) 25K
17	C25	E-00586-0014	Capacitor, 1 MFD, 20V
18	C26	E-00586-0059	Capacitor, 160 MFD, 350V
19	C24	E-00586-0063	Capacitor, 2 MFD @ 25V
20	C23	E-00586-0062	Capacitor, 11700 MFD, 20V
21	C1-C8, C11-C21	E-00586-0064	Capacitor, .002 MFD, 1kv
22	C22, C27, C28	E-00586-0065	Capacitor, .01 MFD, 500V
24	K1	E-00146-0791	Relay
25	Q1-Q19	E-00585-0034	Transistor, SE9302
26	Q22, Q23	E-00585-0041	Transistor, 2N3440
27	Q21	E-00585-0042	Transistor, 2N3584
28	Q20	E-00710	+5V Regulator, LAS1405 or 78H05KC or LM323K
30	CR1-CR21	E-00587-0015	Diode (IN4004)
31	VR1	E-00598-0010	Diode, Zener 140V, IN5275A
33	U1, U3, U4	E-00681	I.C. Transistor Array, CA3081
34	U2	E-00620-0039	I.C. Binary to 1/16 Decoder, 74L154
36		E-00592-0002	Relay Socket
37		M-1839	Relay Holder
39		E-00682	Heat Sink, TO18
40		E-00682-0001	Heat Sink, TO66
41		E-00682-0002	Heat Sink, TO3 Case
42		E-00715-0013	15 Pin Wafer Connector
43		E-00715-0016	12 Pin Wafer Connector
44		E-00715-0020	25 Pin Wafer Connector
45		E-00715-0021	9 Pin Wafer Connector
55		M-1837	Shield-Plexiglass

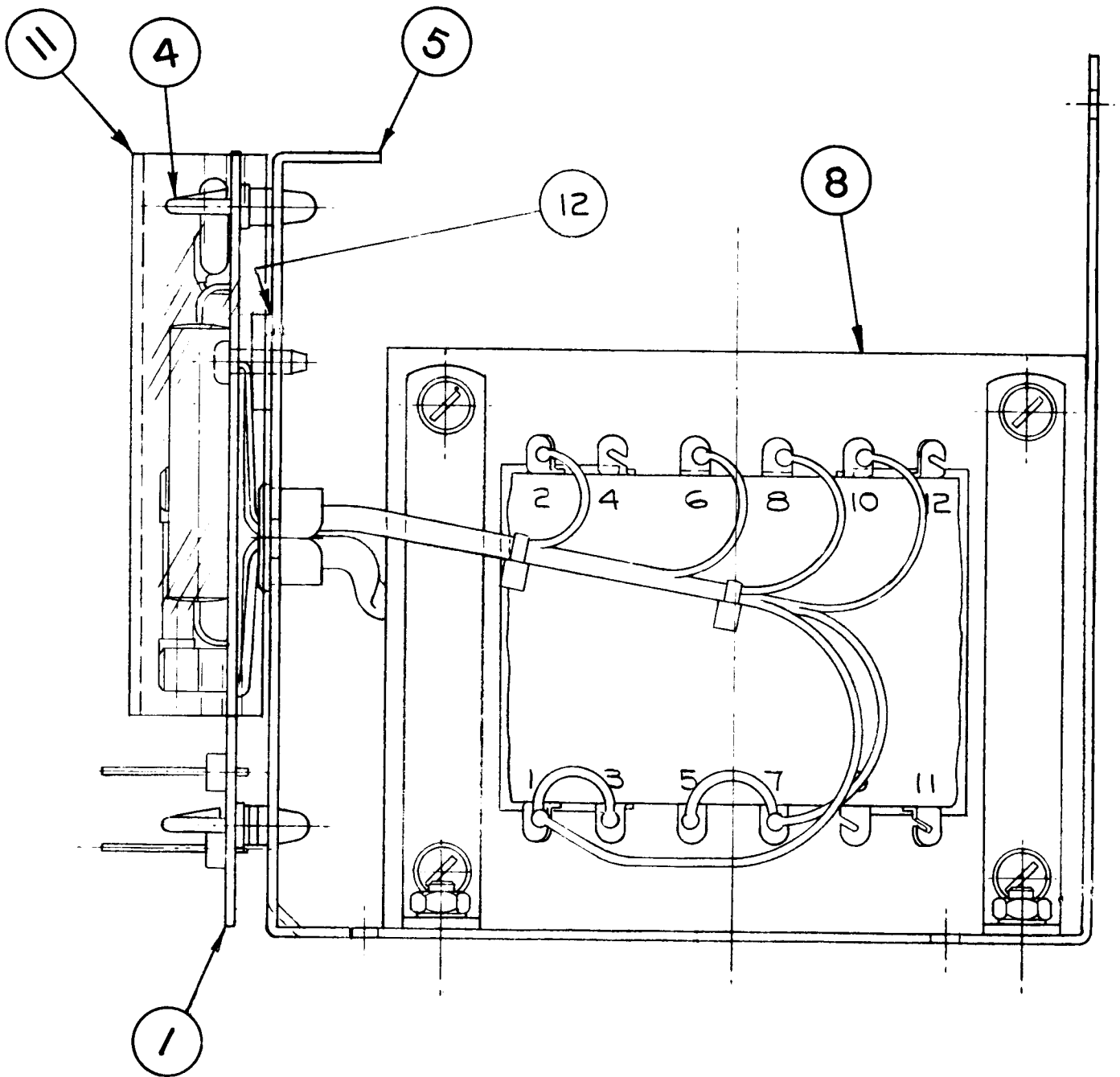
REF: Page 55, parts location.

POWER TRANSFORMER MODULE A2 PROCEDURAL STEPS

POWER TRANSFORMER MODULE A2 PROCEDURAL STEPS

DIAGNOSTIC TABLE: POWER TRANSFORMER MODULE, A2
REPAIR LEVEL: COMPONENT REPLACEMENT

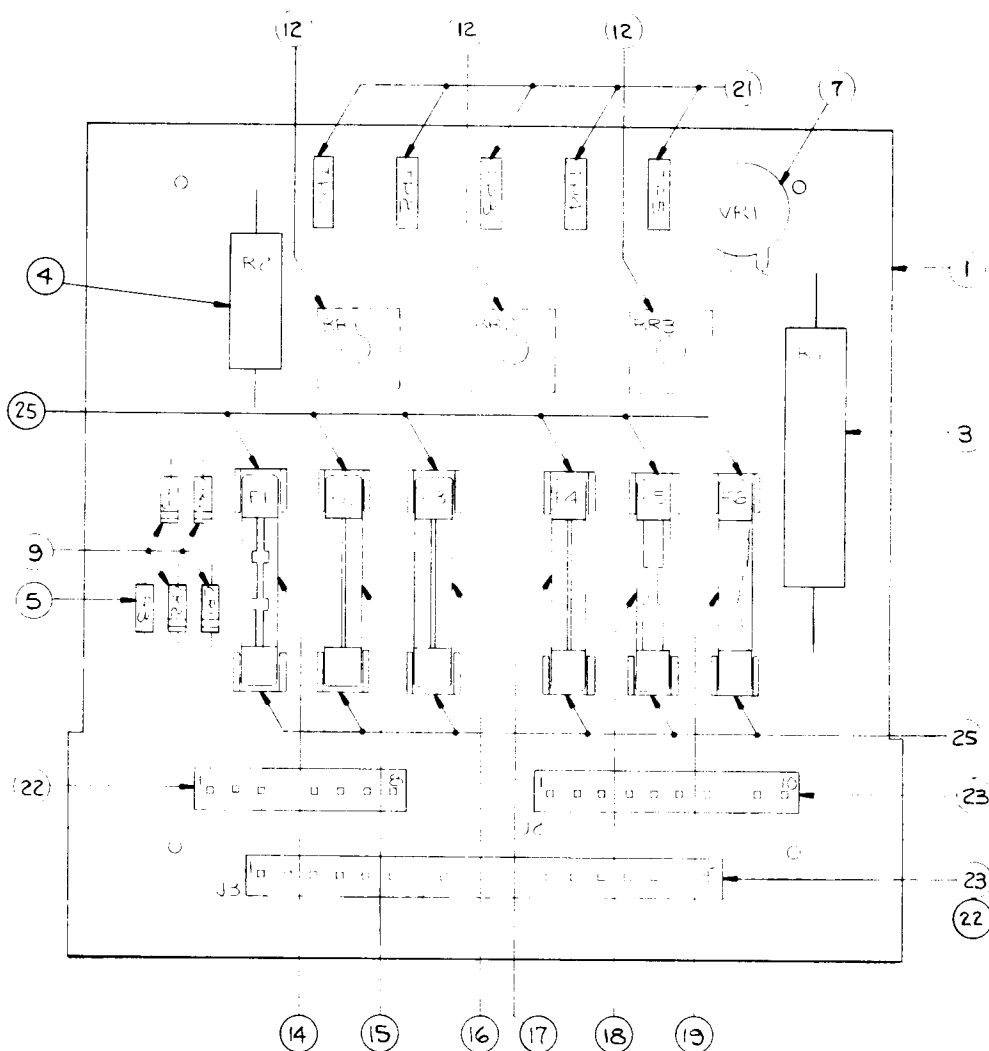
CAUSE	PROCEDURE
SYMPTOM I. Output voltage(s) out of limits.	
	Measure at: TP1 5.4 ± .8 VDC TP2 230 ± 27.4 VDC TP4 7.3 ± .9 VAC TP5 43 ± 5.4 VDC TP3 11.9 ± 1.4VDC
A) Improper line voltage	Measure at: J2-6 to 7, line voltage ± 10%. If line voltage exceeds the ± 10% limit, a variac can be used to adjust the input line voltage during the module test.
B) AC input jumpering not compatible with line voltage	If voltage(s) at test points are still out of limits, examine AC input jumpers. Determine if connections are proper for line voltage at test site. (see card in back box). Rearrange if necessary.
C) Defective bridge rectifier	If voltage at test point is low and out of limits, change bridge rectifier, retest module. If still out of limits, change transformer. Retest module.
D) Lack of continuity	If voltage at test point is high and out of limits, determine reason for lack of continuity to output connector. Repair, retest module.
E) Defective transformer	If voltage at TP4 is out of limits, change power transformer. Retest module. If module always blows input fuse F6 momentarily short across fuse holder. (about 3 seconds.)
SYMPTOM II. Module blows fuse.	
A) Defective bridge rectifier	If fuse F1, 2, 3 or 4 blows, change associated bridge rectifier, retest module.
B) Defective Power Transformer	If no fuses blow, replace power transformer. Retest module.



**A2: POWER TRANSFORMER MODULE
COMPONENT PARTS LIST**

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
0	A2	AS-2877	Power Transformer Module, Complete
1		AS-2518-18	Rectifier Board Assembly
4		M-1829a	Circuit Board Support
5		A-3840b	Mounting Plate & Stud Assembly
8		E-00122-0125c	Transformer 120/240V, 50/60 Hz
11		P-2692b	P.C.B Cover
12		M-1834	Heat Sink Compound

AS-2518-18 RECTIFIER BOARD ASSEMBLY

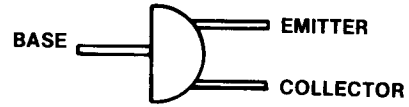


RECTIFIER BOARD ASSEMBLY (Part of) A2: POWER TRANSFORMER MODULE COMPONENT PARTS LIST

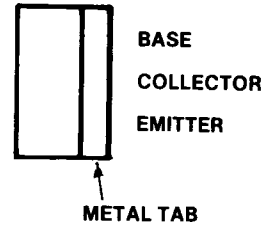
ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	P/O A2	AS-2518-18	Rectifier Board Assembly, Complete
3	R1	E-00104-0092	Resistor, 10%, 600 Ohm, 10W
4	R2	E-00104-0091	Resistor, 25 Ohm, 5W
5	R3	E-00105-0226	Resistor, 5%, 100K Ohm, 1/4W
7	VR1	E-00623	Varistor
9	CR1, CR2, CR3, CR4	E-00587-0006	Diode (IN4004)
12	BR1, BR2, BR3	E-00602-0003	Bridge Rectifier (VJ248 VARO)
14	F1	E-00133-0010	Fuse, 10A, 32V, 3AG
15	F2	E-00133-0028	Fuse, 3/4A, 250V, 3AG, S.B.
16	F3	E-00133-0004	Fuse, 4A, 32V, 3AG
17	F4	E-00133-0005	Fuse, 5A, 32V, 3AG
18	F5	E-00133-0027	Fuse, 20A, 32V, 3AG
19	F6	E-00133-0024	Fuse, 3A, 3AG, S.B.
21		E-00684	Test Point
22	J1, J2	E-00715-0010	8 Pin Wafer Connector
23	J3	E-00715-0011	10 Pin Wafer Connector
25		E-00148-0021	Fuse Clips

TRANSISTOR LEAD CONNECTIONS

MPU { 2N3904 (NPN)
 MODULE { 2N4403 (PNP)
 DISPLAY { 2N5401 (PNP)
 DRIVER { MPS-A42 (NPN)



SOLENOID { SE9302 (NPN)
 DRIVER {



SILICON-CONTROLLED RECTIFIER LEAD CONNECTIONS LAMP DRIVER MODULE

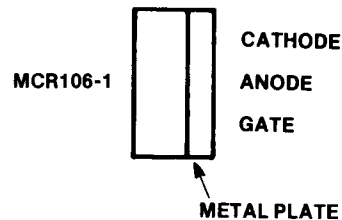
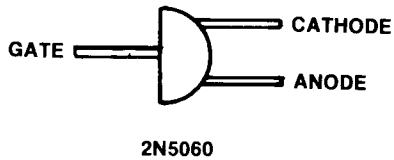


FIGURE IV SEMICONDUCTOR LEAD CONNECTIONS

MODULE REPAIR SPARE PARTS KITS

The following is a list of module repair parts kits recommended for doing component replacement to each of the five module types. Each of the kits can be ordered from your Bally Distributor.

KIT # PARTS KIT FOR REPAIR OF MODULE:

- 490 Power Transformer Module, A2
- 492 Solenoid Driver/Voltage Regulator Module, A3
- 493 Display Driver Module, A1
- 494 Lamp Driver Module, A5
- 503 MPU Module, A4 (Does not include Memory Chips U1-U6)