Bally®

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ELECTRONIC PINBALL GAMES
REPAIR PROCEDURES

FO 560-3

F.O. 560-3 supercedes and replaces all previous publications above and includes repair procedures of all models of current and past Bally games.

The original MPU module, AS-2518-17, can be converted for use and games. With games the electronic sound capability, should this ever become necessary, the procedure is making this change is detailed in F.O. 597, which is part of kit #523. This kit is available through your local Bally Distributor.

The AID kit refers for service, the original and the new MPU module is kit #485-1. Figure A4-2 details the conversion of kit #485 to the kit #485-1 status. The change is simple, it allows testing of the A14 address line not used on the original MPU module AS-2518-17.

For service personnel wishing to obtain an AID kit, #485, is available through any Bally Distributor.

MASTER INDEX

PART I
MODULE REPLACEMENT INDEX

LIST OF FIGURES

AID, BALLY KIT #485-1, IS REQUIRED FOR USE WITH THIS PROCEDURE.

SEE PAGE 27 FOR CONVERSION OF AID KIT #485 TO AID KIT #485-1

FOR COMPONENT REPLACEMENT INDEX, SEE PAGE 21.

REFERENCES

1) F.O. 601, THEORY OF OPERATION, BALLY ELECTRONIC PINBALL GAMES.
2) M6800 MICROCOMPUTER SYSTEM DESIGN DATA MANUAL
MOTOROLA PRODUCTS, INC.
BOX 20912
PHOENIX, ARIZONA 85036

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 #485-1.

No special tools or equipment are required by the repair procedure. The AID kit, 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 electromechanical compoment repairs. Schematics are helpful, and are required as an aid to troubleshooting. A schematic for each module and a three sheet wiring diagram are included with each game.

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.

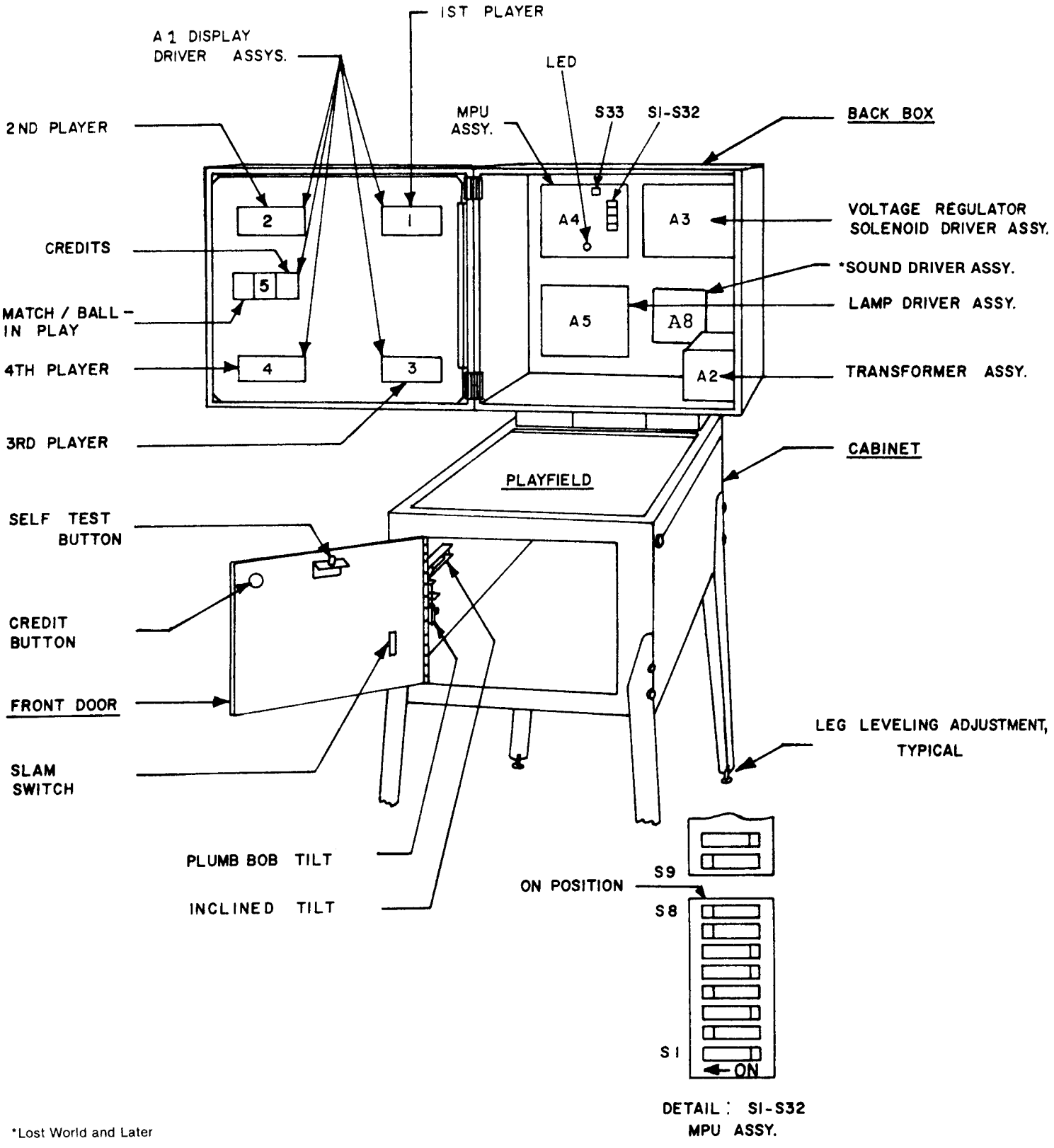
2) Pressing the self-test button again causes each digit on each display to cycle from 0 thru 9, all off, and repeat continuously. Improper operation consists of displays, digits or segments always on or always off. If improper, refer to Display Driver Diagnostic Table, Section VC, Page 12.

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 energize the sound module. A tune will be played repeatedly. Improper operation (lack of or distorted sound) is easily detected during this test. If improper, refer to Sound Module Diagnostic Table, page 21.

5) 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 twelve† 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.

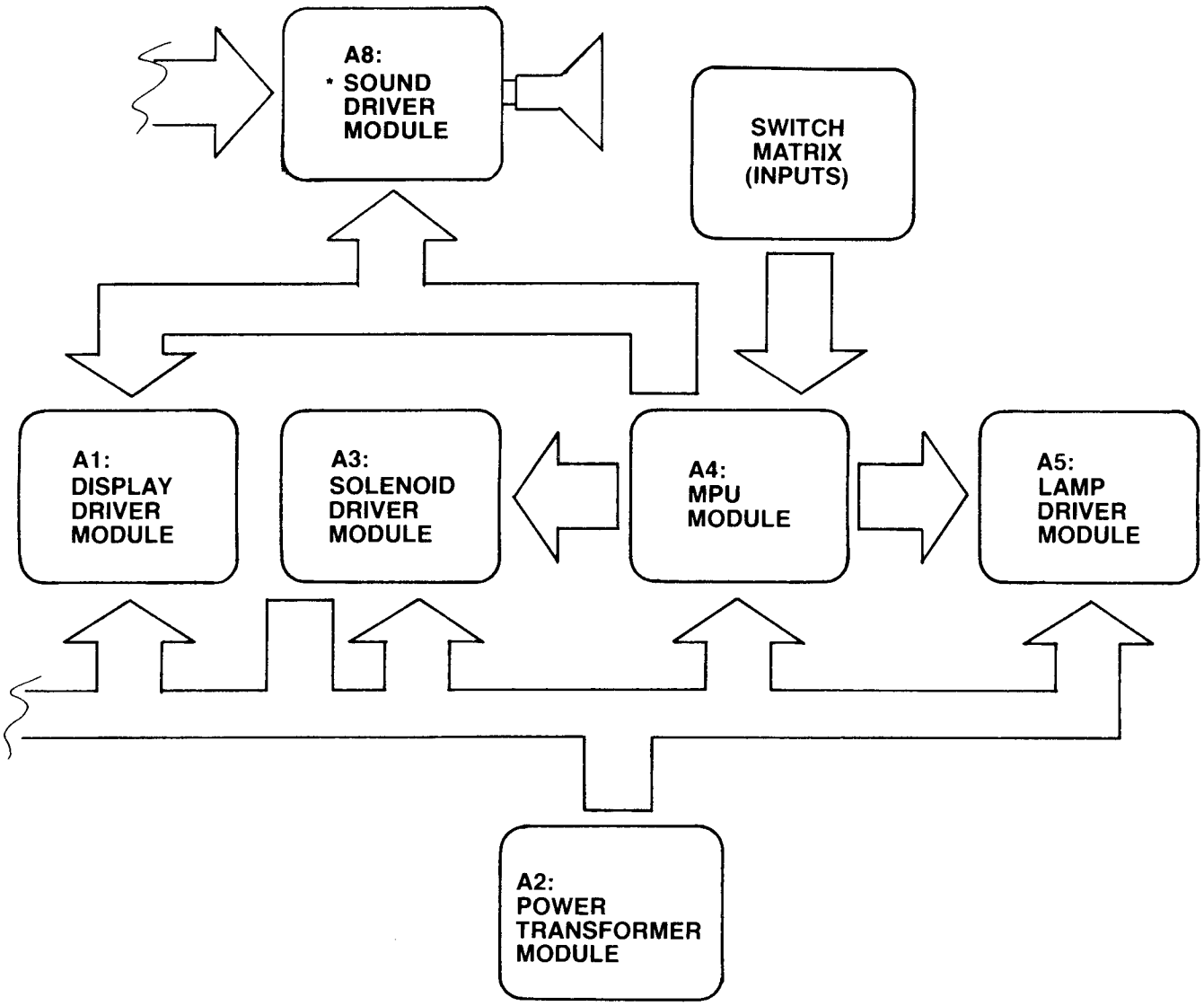
*See Figure I.
**Games (Lost World, #1119-E and Later) using Sound Modules AS-2518-32, only.
†Eleven times, Freedom, Game #1066-E, only.



*Lost World and Later

FIGURE I ELECTRONIC PINBALL MACHINE

BLOCK DIAGRAM—ELECTRONIC PINBALL GAME



*Lost World and Later.

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 $1/16$".

III. DESCRIPTION OF AID1 PROGRAM

At any time during steps 1, 2, 3 or 4 (or 5, Lost World or Later) of the Self-Diagnostic Test, a troubleshooting AID1 program can be initiated. Turn off the power. Plug in the AID1 module (J5, A4, MPU). Turn on the power. Press the self test button (See Figure I) inside the door. The AID1 program is entered 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 humming noise will be present.

AID1 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 AID1, 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 AID1 program through the Self-Test routine.

IMPORTANT: The only exit from AID1 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.

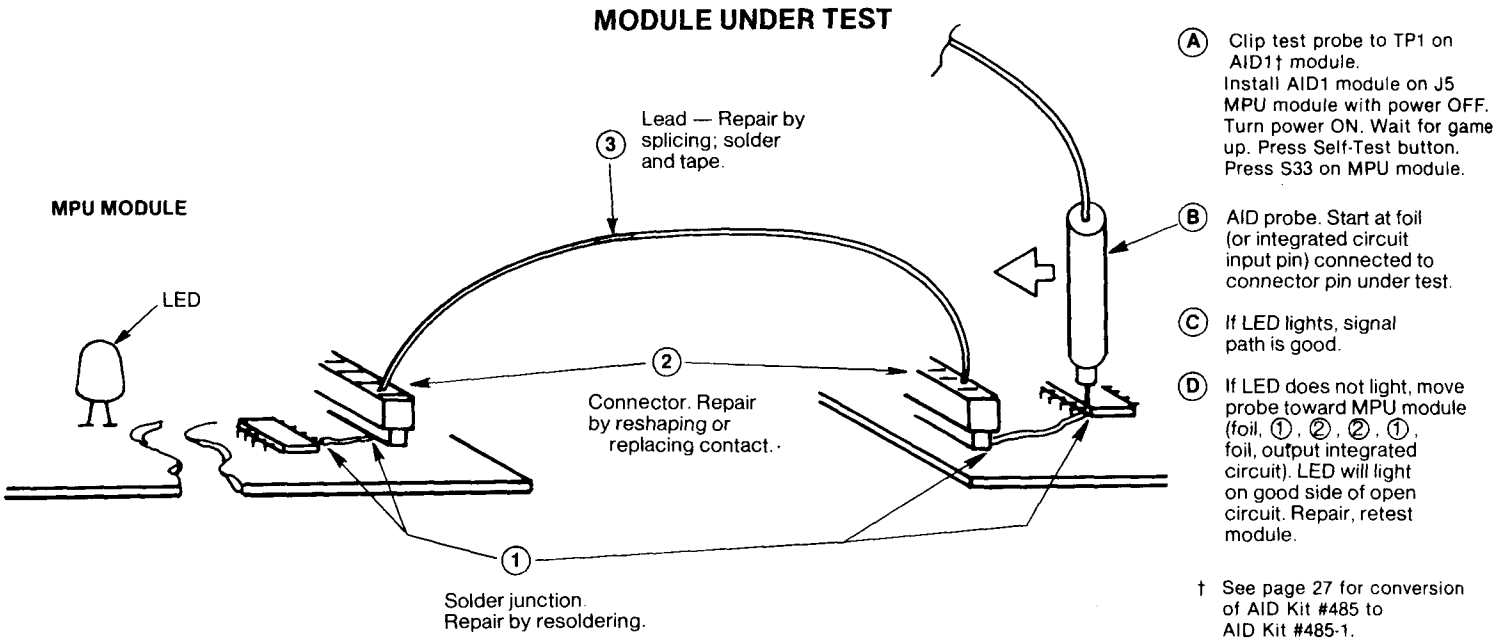
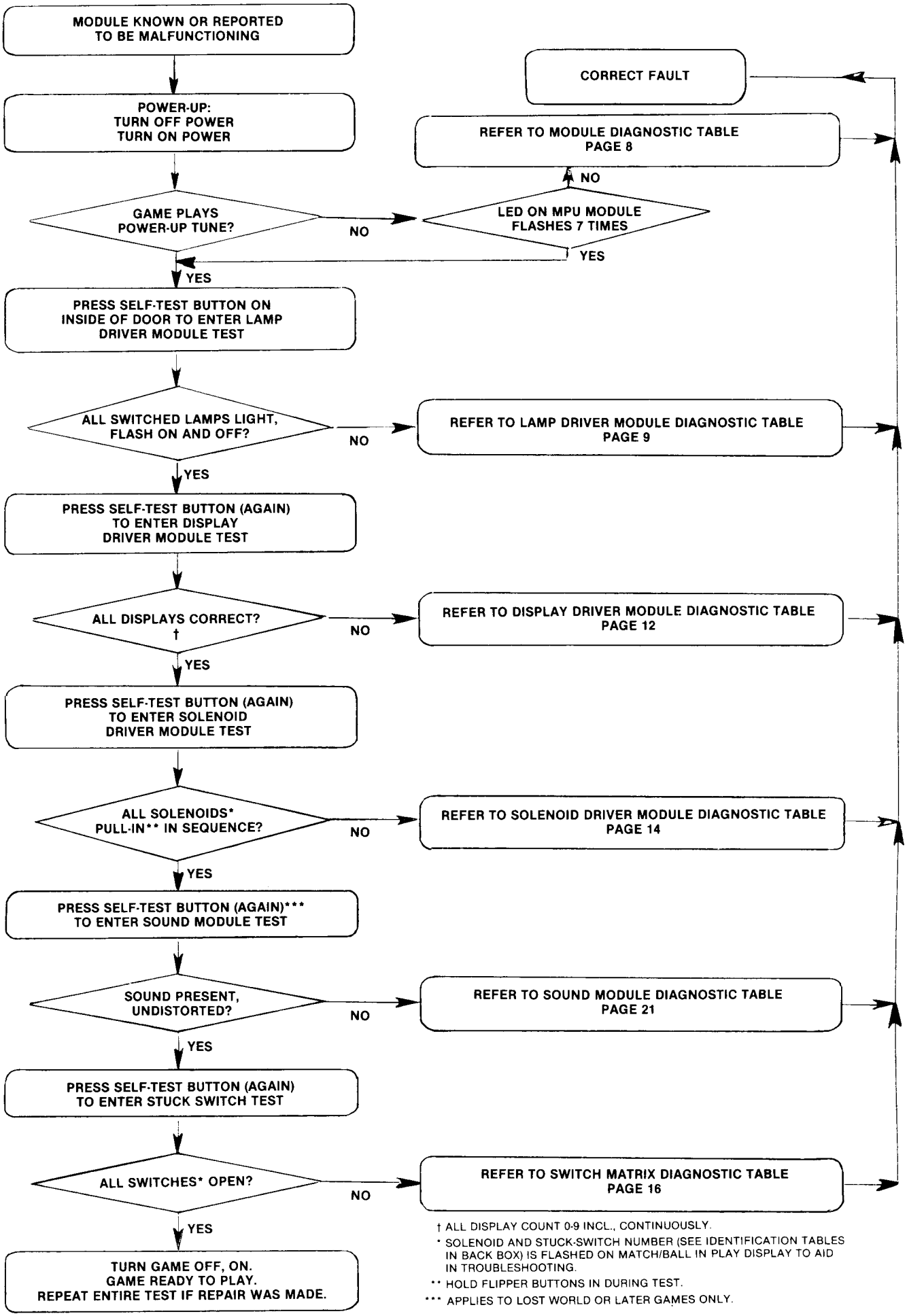


FIGURE IV USE OF THE AID1 PROGRAM IN FAULT LOCALIZATION



† 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.

*** APPLIES TO LOST WORLD OR LATER GAMES ONLY.

FIGURE III SELF DIAGNOSTIC TEST

IV. GENERAL

All Diagnostic procedures require that the game by 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, switches 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.

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 Self-Test procedure shown in Figure III and described in Section II.
2) When fault is discovered, go immediately to the appropriate Diagnostic Table. Do not go to next step in self test sequence! Read all of the symptoms in the Diagnostic Table before attempting to make a diagnosis. Follow the procedure associated with the symptom that best describes the fault.
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

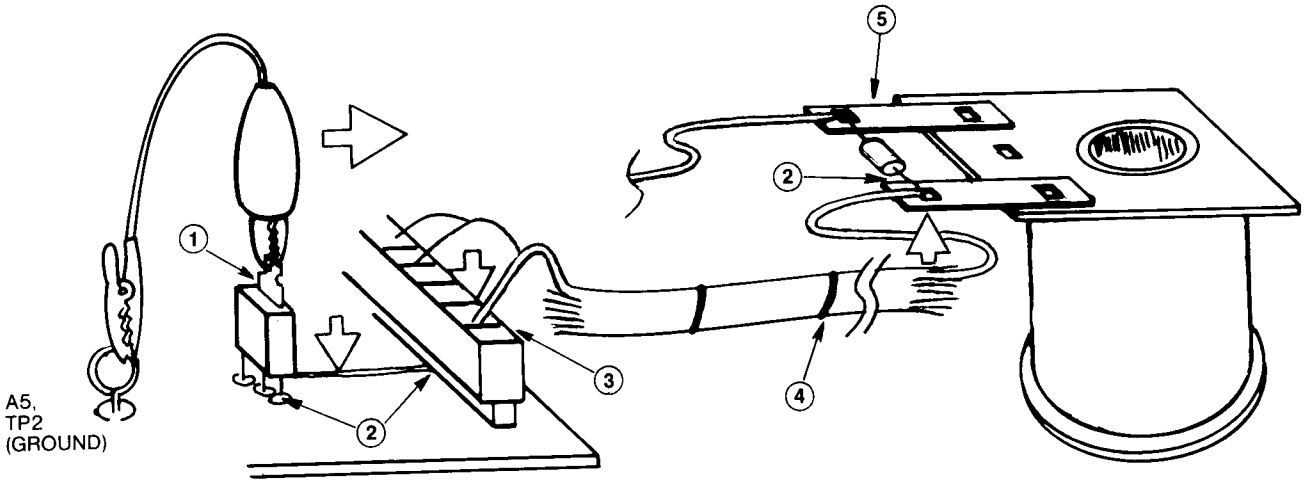
CAUSE	PROCEDURE
SYMPTOM I. LED on MPU fails to flash 7X on power-up	
A) +VCE Power Supply Incorrect	MEASURE: 5 ± .25 VDC at TP1 If incorrect, go to Voltage Regulator Diagnostic Table.
B) Power Suppy Incorrect	MEASURE: 11.9 ± 1.40 VDC at TP2 21.5 ± 2.7 VDC at TP3 If absent, check fuses on rectifier board. If incorrect, go to Power Transformer Diagnostic Table.

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.)	
C) Shorted Lead of Shorted Module Input	If correct, disconnect connector J1 at MPU module. Repeat Power-Up Test. If LED flashes 7X, use Self-Test to enter AID, go to Display Driver module and to Lamp Driver module Diagnostic Tables. If LED does not flash, replace J1 and disconnect J2 and J3. Repeat Power-Up Test. If LED flashes 7X, use Self-Test to ender AID. Replace J2 and J3. Go to switch Matrix Diagnostic Table.
D) Defective MPU	If LED still does not flash 7X, replace MPU module and repeat Self-Test.
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 or, games with Sound module, go to Sound Module 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) Burnt Out Bulb	Replace bulb(s). If fault is corrected, repeat Self-Test.
B) Lack of Continuity	If incorrect, use jumper from good lamp to the connected defective lamp, if light lites determine reason for lack of continuity between module SCR and light bulb or lamp socket and power source, repair, repeat Self-Test.
C) Broken Lead(s), etc.	If incorrect, follow procedure in Fig. V. Repair, repeat Self-Test.
D) Defective Module	If incorrect, replace Lamp Driver Module. If correct, repeat Self-Test.
SYMPTOM II. All Lamps Off	
A) Supply Voltage absent	Measure at lamp common: 5.4 ± .8 VDC. If absent, or out of limits, proceed to Transformer Module Diagnostic Table. Repair, repeat Self-Test. If correct, measure at TP1; Lamp Driver module: 5 ± .25 VDC. If absent, or out of limits, proceed to Voltage Regulator Diagnostic Table, repair. repeat Self-Test.
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	If LED does not light, replace MPU module. Repeat Self-Test. If LED lights, replace connector J1. Remove connector J4 on Lamp Driver module.
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 ± 5.4VDC; lamps, 5.4 ± .8VDC).

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 continously.	
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
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.
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.
SYMPTOM VIII. Erratic Operation	
Supply Voltage absent (+ 5 VDC)	Do II-A, for 5 volt supply leg only.
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 Selt-Test.

VC
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 edge connector. 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 edge connector. See Table II, Figure IV.
F) Defective Display Driver module	If LED lights at edge connector 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 edge connector, 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 edge connector. 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 edge connector. 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 edge connector. 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 edge connector. 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 Enable Lines at Display Driver module edge connector. 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 as Display Driver module edge connector. 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 BCD Data	D_0	25	19
	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
Six Player Game	J_1	20-24 incl.	15
	J_1	8	
	J_4	8	

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.

VD
DIAGNOSTIC TABLE: SOLENOID DRIVER MODULE A3
REPAIR LEVEL: MODULE REPLACEMENT

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.
D) Defective Solenoid Driver module	Remove connector J4. Use AID1. Probe J4, Pin 8. If LED lights, replace* Solenoid Driver module. Repeat Self-Test.
E) Lack of continuity	If LED does not light, use schematics and 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 solenoid(s) do not pull-in.	
A) Blown fuse on playfield (Eight Ball and Later)	If all Playfield Solenoids do not operate (except flippers). Replace fuse, Bally part #E-133-44 or Little Fuse #313-001 (3AG size), no substitutes. If correct, repeat Self-Test. If fuse blows, locate defective solenoid or associated diode. Replace. Repeat Self-Test.
B) 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.
C) 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. If still incorrect, replace sound module (Lost World and Later). Repeat Self-Test.
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) de-energize, repeat Self-Test.
D) Defective sound module†	If solenoids do not deenergize*, replace sound module. If solenoids deenergize, repeat Self-Test.
E) 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.
† Lost World or Later.

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 ± .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, J1, Sound 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, Sound 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.

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 voltage at TP2 is absent, replace fuse F1 on Voltage Regulator module A3 (1/4-A, Fast Blo), Bally Part #E-133-30 (not applicable to module AS-2518-16). 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	J4-16, 17	—	—	—
	J3-16	—	J4-3**	—	—
	J3-17	—	—	J1-20	—
+ 11.9VDC	J3-11	J4-12	—	—	—
	J3-12	—	—	—	J3-8
+ 43VDC	J3-5†	J4-15	—	—	J3-9, 12
+ 190VDC*	J3-8	—	—	J1-1	—
+ 230VDC	J3-6	—	—	—	J3-5
GND	J3-10	—	—	—	J3-17
	J3-3††	—	—	—	J3-18
	J3-18, 19	J4-18, 19	—	—	—
	J3-20	—	—	J1-13	—
	J3-21, 22	—	—	—	J3-15, 16
	—	—	J1-1, 2, 11, 12	—	J3-3, 4, 14

** VIA A8, J1-5
† VIA A8, J1-9
†† VIA A8, J1-6
} Lost World and Later.

VG
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	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. 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 (zero) at one test point, go to Symptom III. If incorrect (zero) at all test points, go to Symptom II. 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.)
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	If line voltage is absent at transformer, (across input leads), replace fuse *F6, 3 amps, slow blow.* 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.
B) Cable short	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.
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	Replace fuse: If fuse blows, replace Power Transformer module, repeat Self-Test. Exception: F4, + 43VDC circuit. Locate and replace defective solenoid. If solenoids are good, then replace Power Transformer module. If fuse does not blow, disconnect associated remote module connectors as applicable, see Table VIA.
A) Cable short	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.
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.

*Unplug line cord. Jumper J2-6 to connector pin 6, J2-7 to pin 7. Plug in line cord.

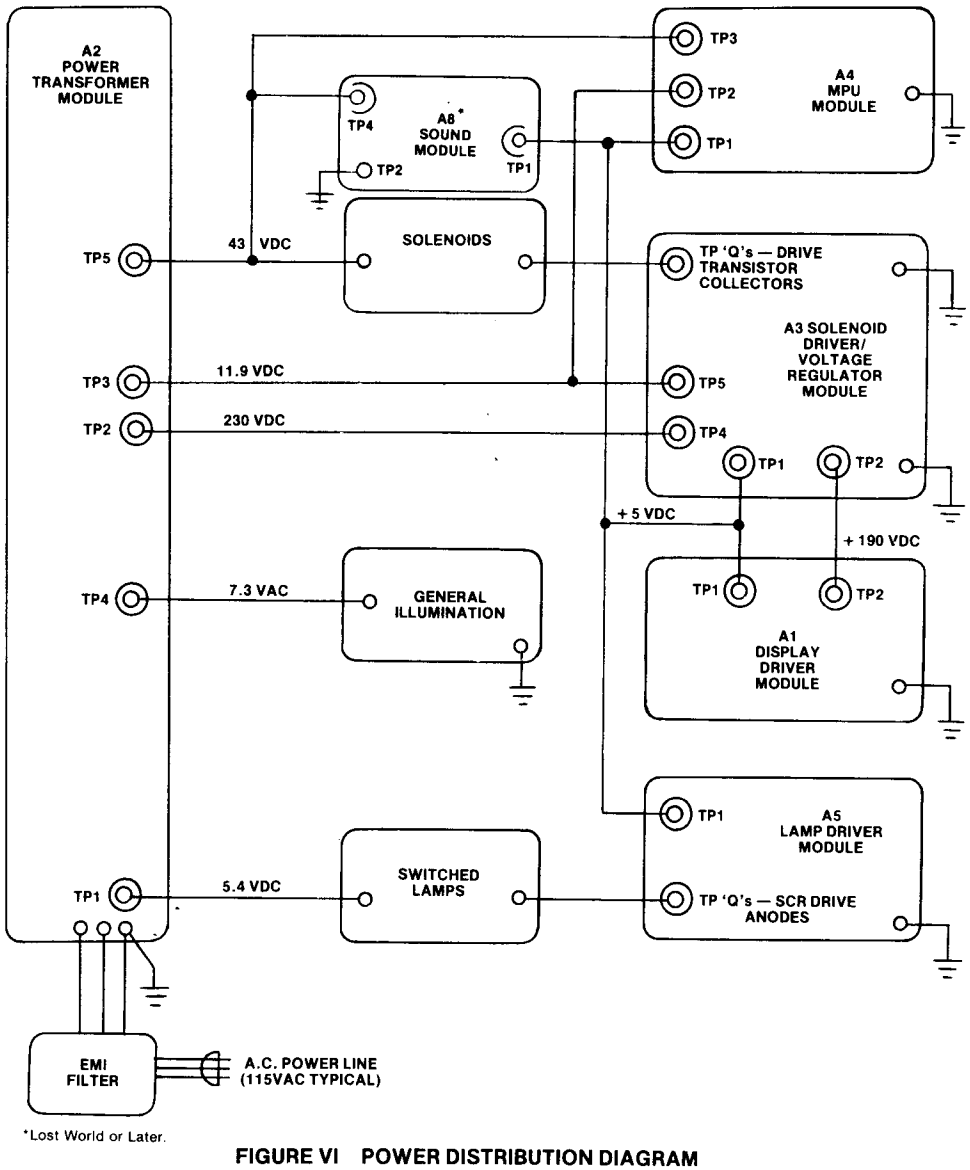
TABLE VI — POWER DISTRIBUTION CIRCUITRY*

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

*Refer to Figure VI and Schematics.
†VIA A8, J1-9, Sound module, Lost World and Later.

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



*Lost World or Later.

FIGURE VI POWER DISTRIBUTION DIAGRAM

VH
DIAGNOSTIC TABLE: SOUND MODULE A8 (LOST WORLD AND LATER)
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I: No Sound *(NOTE: For Computer Sound or Squawk & Talk, See Index Page 21)*	
A) Volume Control on Minimum	Place game in Sound Module Self-Test (Press Self-Test Switch on front door 4X). Adjust volume control on Sound Module for proper sound level.
B) Speaker Plug Disconnected	Connect plug. Do step A), above.
C) Supply Voltage Absent	Measure at TP1, +5 ± .25VDC. If absent, or out of limits, proceed to Voltage Regulator Diagnostic Table. Repair and repeat Self-Test. Measure at TP4, +43VDC ± 10%. If absent, proceed to Transformer Module Diagnostic Table, repair, repeat Self-Test. Measure at TP3, +12 ± 1.2VDC. If absent, or out of limits, replace Module.
D) Defective Sound Module	Use AID1. Probe input at Sound Module foil, adjacent to connector J1, pins 1, 2, 3, 4, 8 and 12. If LED lights, replace Sound Module.
E) Lack of Continuity	If LED does not light, use Schematics and see Figure IV to determine reason for lack of continuity or short on line. Repair, repeat Self-Test.

PART II
COMPONENT REPLACEMENT INDEX

LIST OF FIGURES

PARTS LIST

AID, BALLY KIT #485-1, IS REQUIRED FOR USE WITH THIS PROCEDURE.

SEE PAGE 27 FOR CONVERSION OF AID KIT #485 TO AID KIT #485-1.

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 (six, Lost World and Later) types of electronic modules used in the games is accomplished by using a known good game as a test-bed. (See Figures I & II, pages 4 and 5). 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 #485-1. 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 other 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 four types of modules. A flow chart for the complete test is given in Figure III, page 7. 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. The page numbers shown in the blocks are not applicable for use with this part (II) of this manual. See Figure 1, page 4 for location of Self-Test button on door.

C) The AID Kit, Bally Kit #485-1 extends the usefullness 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 humming noise 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".

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.

AID2A 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

INDEX
PROCEDURAL STEPS

FIGURES

TABLES

PARTS LIST

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 A_9-A_{12} 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 AID2A module, used to locate bus line faults on MPU address, data and read/write lines is included in the AID Kit, part #485-1, available from Bally, or may be made by the user. (Fig. A4-2)

The AID2A 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 touble 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.

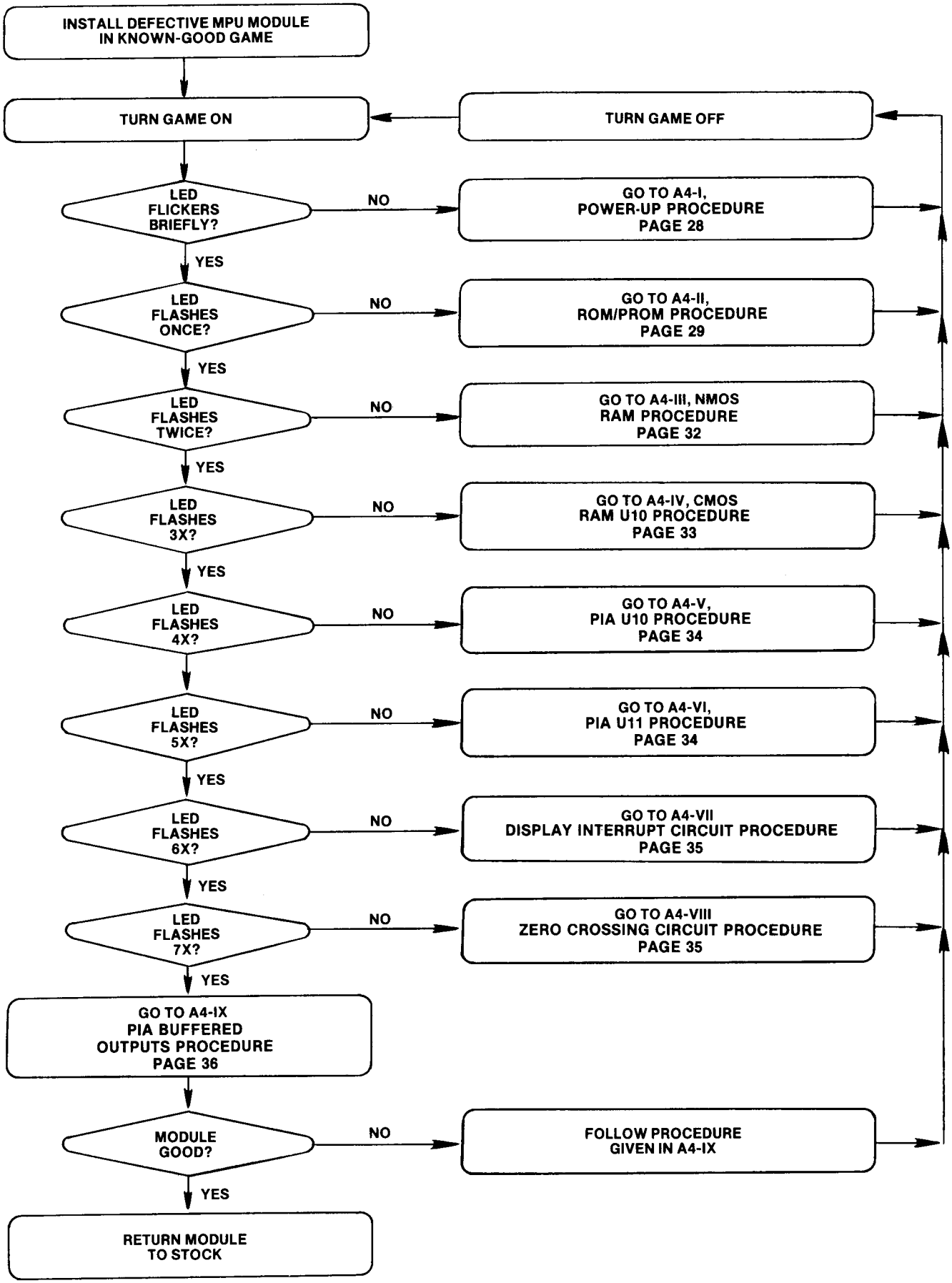


FIGURE A4-1 MPU MODULE TEST FLOW CHART

To Update AID2 Module to AID2A:

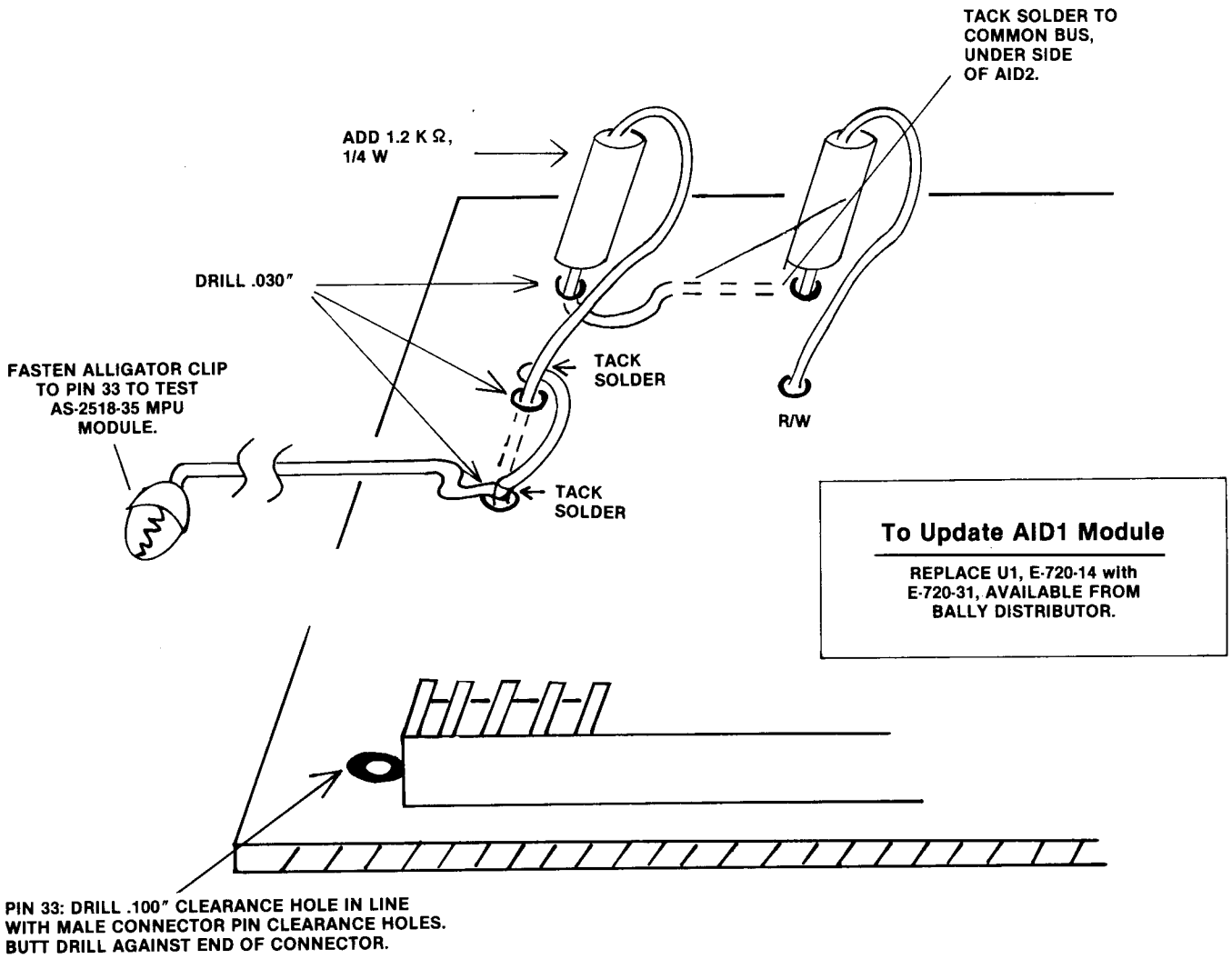


FIGURE A4-2: CONVERSION OF AID KIT #485 TO AID KIT #485-1

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 ± 1.4VDC. If correct, go to B). If absent, measure + 11.9 ± 1.4VDC at A3, TP5, Voltage Regulation/Solenoid Driver module.
Open on + 11.9VDC line	If present, locate and repair open between connector and TP2 on MPU module. Retest module.*
Short on + 11.9VDC 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 11.9VDC is present, measure at A4, TP1: + 5 ± .25VDC. If correct, go to C). If absent, measure 5 volts at A3, TP1, Voltage Regulation/Solenoid Driver module.
Open + 5VDC line	If present at A3, TP1, locate and repair open between connector and TP1 on MPU module. Retest module.*
Short on + 5VDC 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 (ϕ1 and ϕ2, 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	If $\overline{\text{Reset}}$ line is correct, measure at U9, pin 2: 4.95VDC ($\overline{\text{HALT}}$).
U9 defective	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-ϕ2 circuit	If VMA line is correct, use voltmeter and schematic to verify proper operation of VUA-ϕ2 circuit, U14D, U19B, U15C and D. If incorrect, locate and replace defective component in VUA-ϕ2 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 AID2A module on MPU connector J5.
2) Connect the resistor COMmon lead to GND loop on the AID2A module. Turn on Power.
3) Probe resistor loops A_0 thru A_{13}, D_0 thru D_7 and R/W on AID2A 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 AID2A, retest module.*
4) Address lines $A_{9, 10, 11,}$ and $_{12}$, the VUA-ϕ2' and the R/W line have logic gate inputs connected to them. $A_{9, 10, 11, 12}$, VUA-ϕ2' and R/W are associated with U17; $A_{9, 11, 12}$ and R/W with U18; A_9 and $_{12}$ with U19.
   If address lines $A_{9, 10, 11, 12}$ 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 AID2A, retest module.*
5) Connect resistor COMmon lead to the +5 V. loop on AID2A.
6) Probe resistor loops A_0 thru A_{13}, D_0 thru D_7 and R/W on AID2A with a voltmeter. All loops must read 4 volts or more. If correct, go to step 8. If a line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. If present, repair, remove AIDA, retest module.* If not present, go to 7.
7) Repeat step 4, above.
8) Connect the GND lead to D_7 on AID2A. Probe D_6-D_0, A_{14}-A_0, R/W incl. on AID2A with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted to D_7 by a solder splash. Repair, remove AID2A, retest module.*

NOTE: A_{12} could be shorted to VUA-ϕ2' if U17A were defective. If shorted, A_{12} reads 1.8 VDC. Replace U17. Remove test connector, retest module.*

9) Repeat step 8, GND lead connected to each of D_6-D_0, A_{14}-A_0, R/W, one at a time. If shorted adjacent leads are found, repair, remove AID2A 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 AID2A, 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 AID2A, retest module.*

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

TABLE A4-1 BUS-ASSOCIATED FAILURES

BUS LINE UNDER TEST	CPU- U9, PIN	ROM/PROM, PINS U1	U2	U3	U4	U5	U6	RAM 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 VOLATILE RAM U8, PIN	I/O PIA U10, PIN	I/O 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
$\overline{A_9}$-$\overline{A_{12}}$-VUA-ϕ2'	19	—	—
$\overline{\text{RESET}}$	17	—	—
VUA-ϕ2'	—	25	25
R/W	20	21	21
$\overline{A_{13}}$	—	—	—
$\overline{\text{HLT}}$	—	—	—
$\overline{\text{R/W}}$	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 AID2A be temporarily connected to the GND loop. Read 4 VDC or greater. Repair lack of continuity. Remove AID2A, 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 AID2A, 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 AID2A, 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	If LED flashes once on Power-Up, replace U9.
U9 defective	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 AID2A on MPU connector J5.
2) *Connect the resistor COMmon lead to GND loop on the AID2A module. Turn on power.*
3) Probe R/W resistor loop on AID2A 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 correct, go to 5.
   If the line reads greater than 1.2 volts check for a solder splash to an adjacent, high lead on the module. Repair, remove AID2A, 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 AID2A, retest module.*
5) *Connect resistor COMmon lead to the* +5 V. loop, AID2A.
6) Probe R/W resistor loop on AID2A with a voltmeter. The loop must read 4 volts or more If correct, go to 8. If the line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. Repair, remove AID2A, retest module.*
7) Repeat step 4, above. If good, go to step 8.
8) Connect the GND lead to R/W on AID2A. Probe D_7-D_0, A_{14}-A_0 incl., on AID2A 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 AID2A, 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 AID2A 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 AID2A, 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 AID2A module on MPU connector J5.
2) *Connect the resistor COMmon lead to GND loop on the AID2A module.* Turn on power.
3) Probe R/W resistor loop on AID2A 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 correct, go to 5. If the line reads greater than 1.2 volts, check for a solder splash to an adjacent, high lead on the module. Repair, remove AID2A, 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 AID2A, retest module.*
5) Connect resistor COMmon lead to the +5 V. loop on AID2A.
6) Probe R/W resistor loop on AID2A with a voltmeter. The loop must read 4 volts or more. If correct, go to 8. If the line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. Repair, remove AID2A, retest module.*
7) Repeat step 4, above. If good, go to step 8.
8) Connect the GND lead to R/W on AID2A. Probe D_7-D_0, A_{14}-A_0 incl. on AID2A with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted R/W by a solder splash. Repair, remove AID2A, 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 AID2A 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 AID2A, 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	Replace U10.
	U10 defective	If LED flashes 7X on Power-up, retest module.*
B)	U9 failure to execute	If LED flashes 3X on Power-up, replace U9.
	U9 defective	If LED flashes 7X on Power-up, retest module.*
C)	Fault on output line	If LED flashes 3X on Power-up, remove U10, use schematic and ohmmeter to check output lines at U10 socket, pins 2-9, for shorts to ground.
	Defective capacitor or shorted line	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 AID2A module on MPU connector J5.
2) Connect the resistor COMmon lead to the +5 V. loop on the AID2A 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 AID2A, 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 AID2A, retest the module.*

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	Replace U11.
	U11 defective	If LED flashes 7X on Power-up, retest module.*
B)	U9 failure to execute	If LED flashes 4X on Power-up, replace U9.
	U9 defective	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 AID2A module on MPU connector J5.
2) Connect the resistor COMmon lead to the +5 loop on the AID2A 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 AID2A, retest module.*
   B) Temporarily connect TP1, 1kΩ 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 AID2A, retest the module.*

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) ZERO CROSSING CIRCUIT
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 the following: U11, pin 38; U10, pin 37; U10, pin 38; U9, pin 4. Measure to ground to check for short.
	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 ± 2.7VDC. Repair, retest module.*

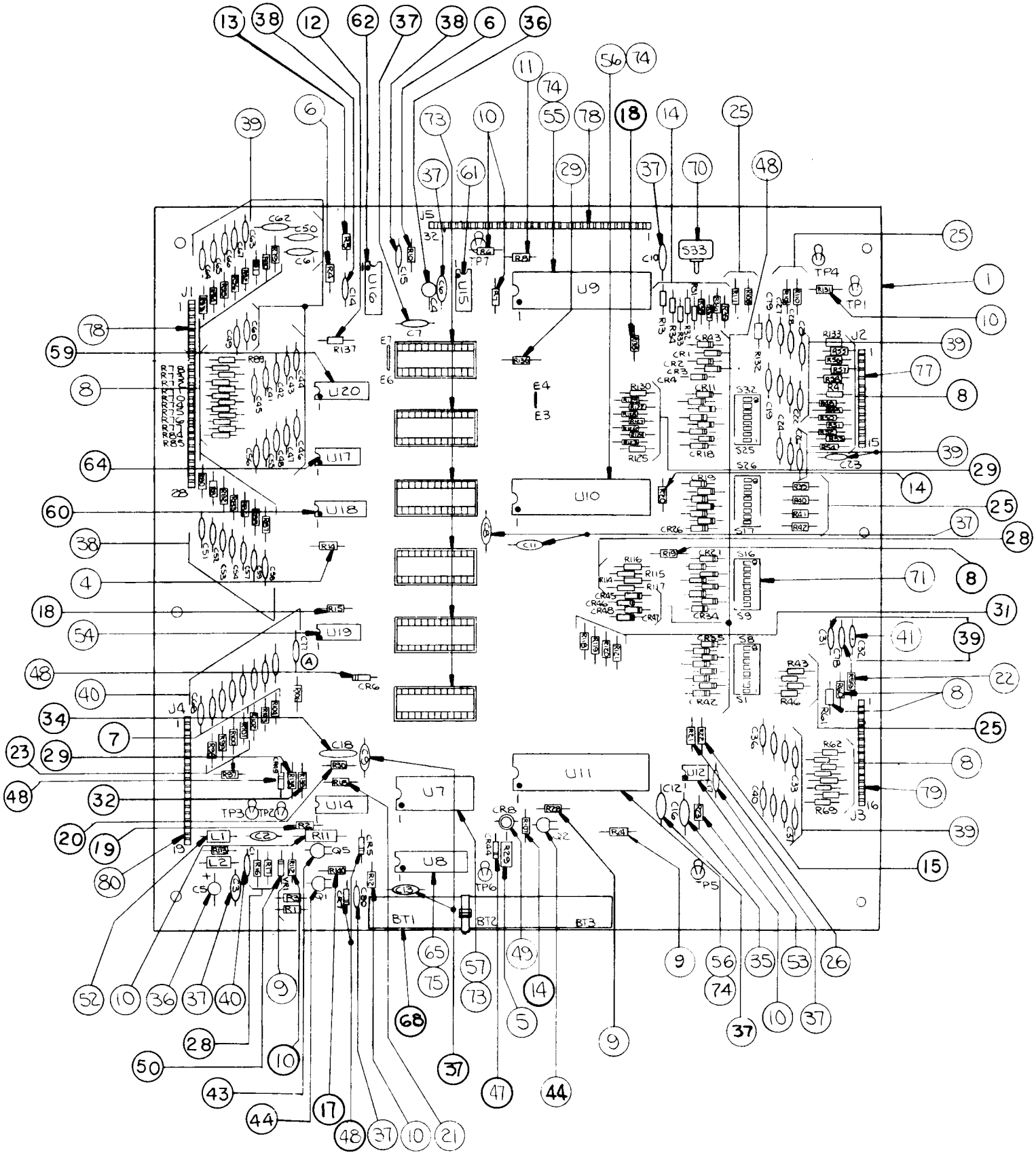
*If LED flashes 7X, do A4-IX.

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.	
	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.
A) Fault in PIA U11 buffered output circuit	Remove connector A3J4, Solenoid Driver module. Probe A4J4, pins 1-8 and 10 incl.
	If correct, replace A3J4, go to B).
	If incorrect: If U11 was not replaced during previous testing, replace U11. Repeat test on J4.
U11 defective	If correct, proceed to B).
Open or shorted output line	If incorrect, determine reason for short or open on line. Repair, retest module.
B) Fault in PIA U10 switch Matrix buffered output circuit	Probe J2, pins 8-15 and J3, pins 9-16 incl. If correct, go to C). 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.
C) Fault on buffered display blanking line (CA2)	Probe J1, pin 10. If correct, go to D).
Open line	If incorrect, probe U19, pin 4. If correct, determine reason for lack of continuity. Repair and retest module.
U10 defective	If U19, pin 4 is incorrect, and U10 has not been previously changed, replace U10. Retest module.
	If correct, go to D).
U20, 14 or 19 defective	If incorrect, use voltmeter, voltages shown on schematic, to localize fault to U20, U14 or U19. Repair, retest module.
D) Fault on Display Latch Strobe buffered lines	Probe J1, pins 20-24. If correct, go to E). If incorrect: NOTE LINE.
	Probe U20 outputs, pins 2, 5, 7, 9 and 11, as appropriate.
Open line	If correct, determine reason for lack of continuity. Repair, retest module.
U10 and U11 defective	If incorrect, and U10 and U11 were not replaced in previous testing, remove U10 and U11. Replace and retest module.
U20 output defective	If incorrect, replace U20, retest module.
E) Open line, PIA non-buffered outputs	Probe J2, pins 1-5; J3, pins 2, 3; J1, pins 1-7, 12-19 and 25-28. If incorrect, determine reason for lack of continuity. Repair, retest module. If correct, return module to stock.

AS-2518-17 MPU MODULE

For AS-2518-35, See Page 39



A4: MPU MODULE
COMPONENT PARTS LIST

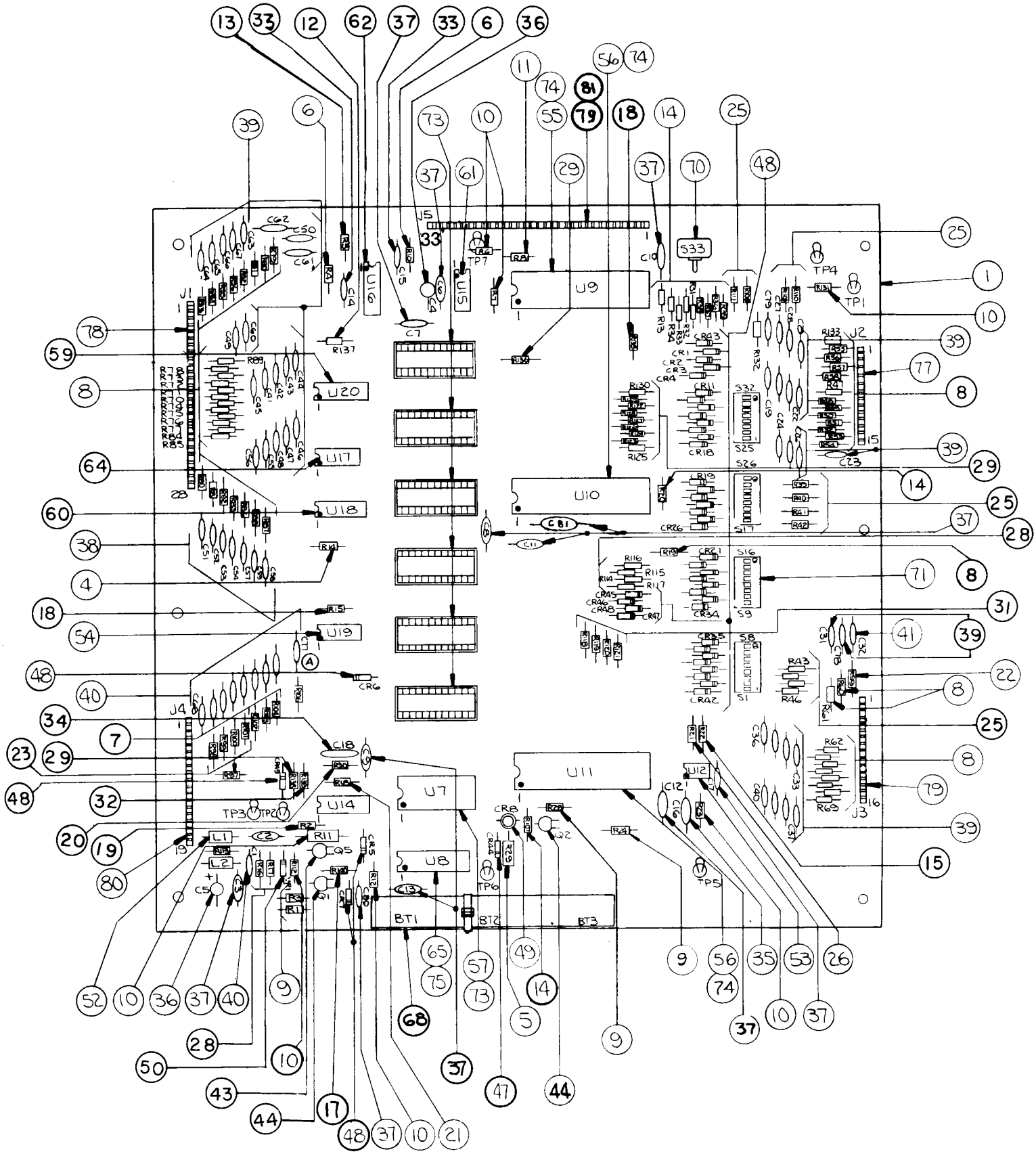
ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A4 (see note 1)	AS-2887-XXXX	**MPU Module Complete. See page 37.**
2	A4 (see note 2)	AS-2518-17	MPU Module less Program Memory, U1-6 incl.
3-32	See Schematic		Resistors, See schematic for value.
34	C18	**E-00586-0019**	**Capacitor, .05 MFD, 100V**
35	C16	**E-00586-0081**	**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-00586-0070**	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.

AS-2518-35 MPU MODULE

Used in Lost World and Later



A4: MPU MODULE
COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A4 (see note 1)	AS-2962-0	MPU Module Complete. Lost World
2	A4 (see note 2)	AS-2518-35	MPU Module less Program Memory, U1-6 incl.
3-32	See Schematic		Resistors, See schematic for value.
33	C14, C15	E-00586-0067	Capacitor, 470 PFD, 1kv
34	C18	E-00586-0088	Capacitor, .05 MFD, 16V
35	C16	E-00586-0081	Capacitor, .1 MFD, 100V
36	C4, C5	E-00586-0073	Capacitor, 4.5 MFD, 25V
37	C3, C6-C13, C17, C81	E-00586-0085	Capacitor, .01 MFD, 25V
38	C79, C41-C67	E-00586-0083	Capacitor, 470 PFD, 50V
39	C19-C31, C78, C33-C40	E-00586-0082	Capacitor, 390 PFD, 50V
40	C1, C2, C68-C77	E-00586-0084	Capacitor, 820 PFD, 50V
41	C32	E-00586-0077	Capacitor, 3000 PF, 1kv
43	Q5	E-00585-0023	Transistor PNP (MPS-3702)
44	Q1, Q2	E-00585-0031	Transisitor (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	Doide 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-00628-0003	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	J1	E-00715-0004	28 Pin Wafer Connector
79	J3, J5	E-00715-0017	16 Pin Wafer Connector
80	J4	E-00715-0018	19 Pin Wafer Connector
81	J5	E-00715-0024	17 Pin Wafer Connector

NOTE 1:
When ordering, fill in dash number. For example, AS-2962-0: LOST WORLD.

NOTE 2:
Order replacement memory chips U1-U6, 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 circujt 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.

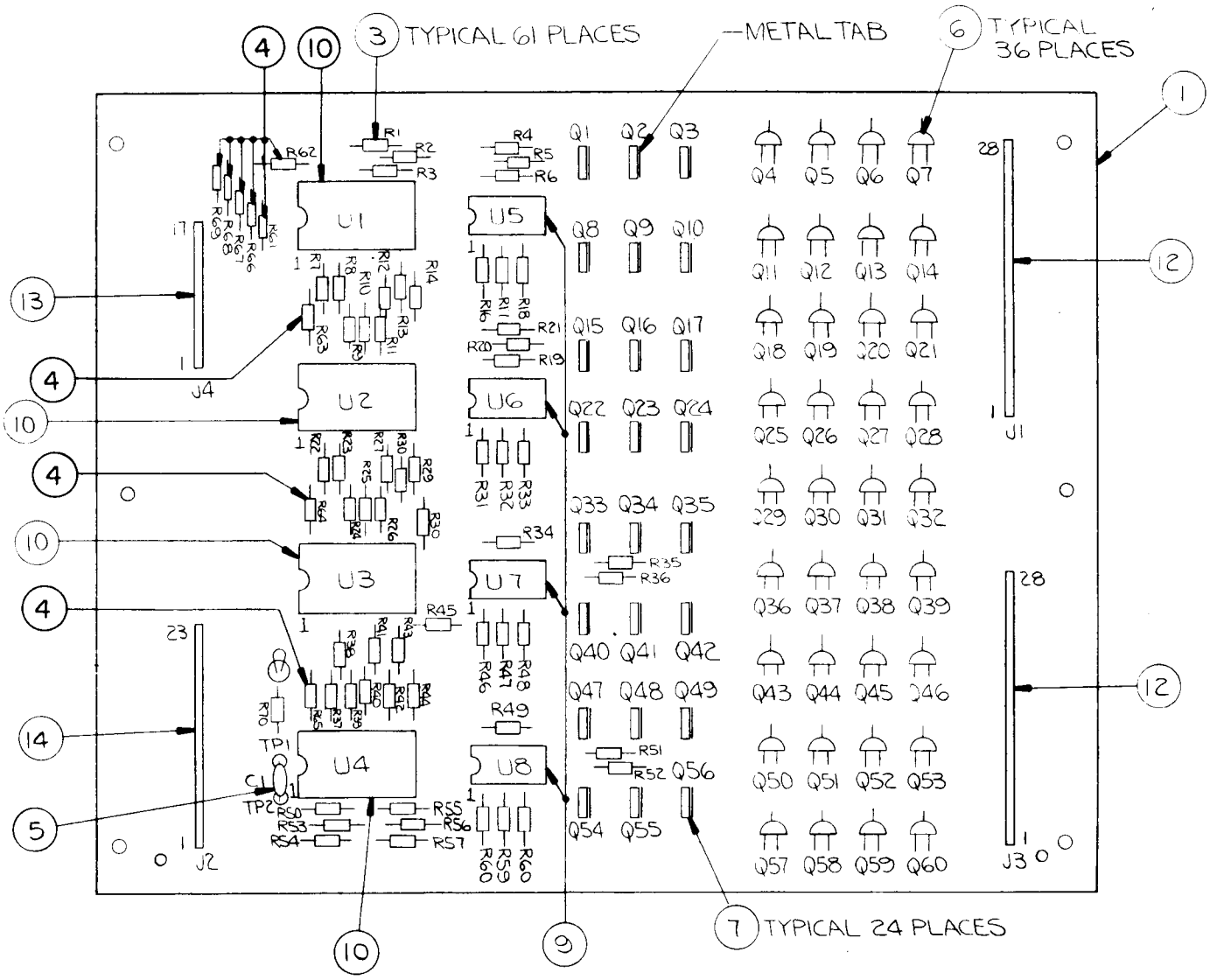
* Connecting a lamp-loaded SCR anode to TP6 causes the LED to flicker, alternating between bright and dim.

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.

CAUSE	PROCEDURE
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.
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.	
Short on + 5VDC line	Remove capacitor C1. Measure + 5VDC at TP1.
A) Defective capacitor C1	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.

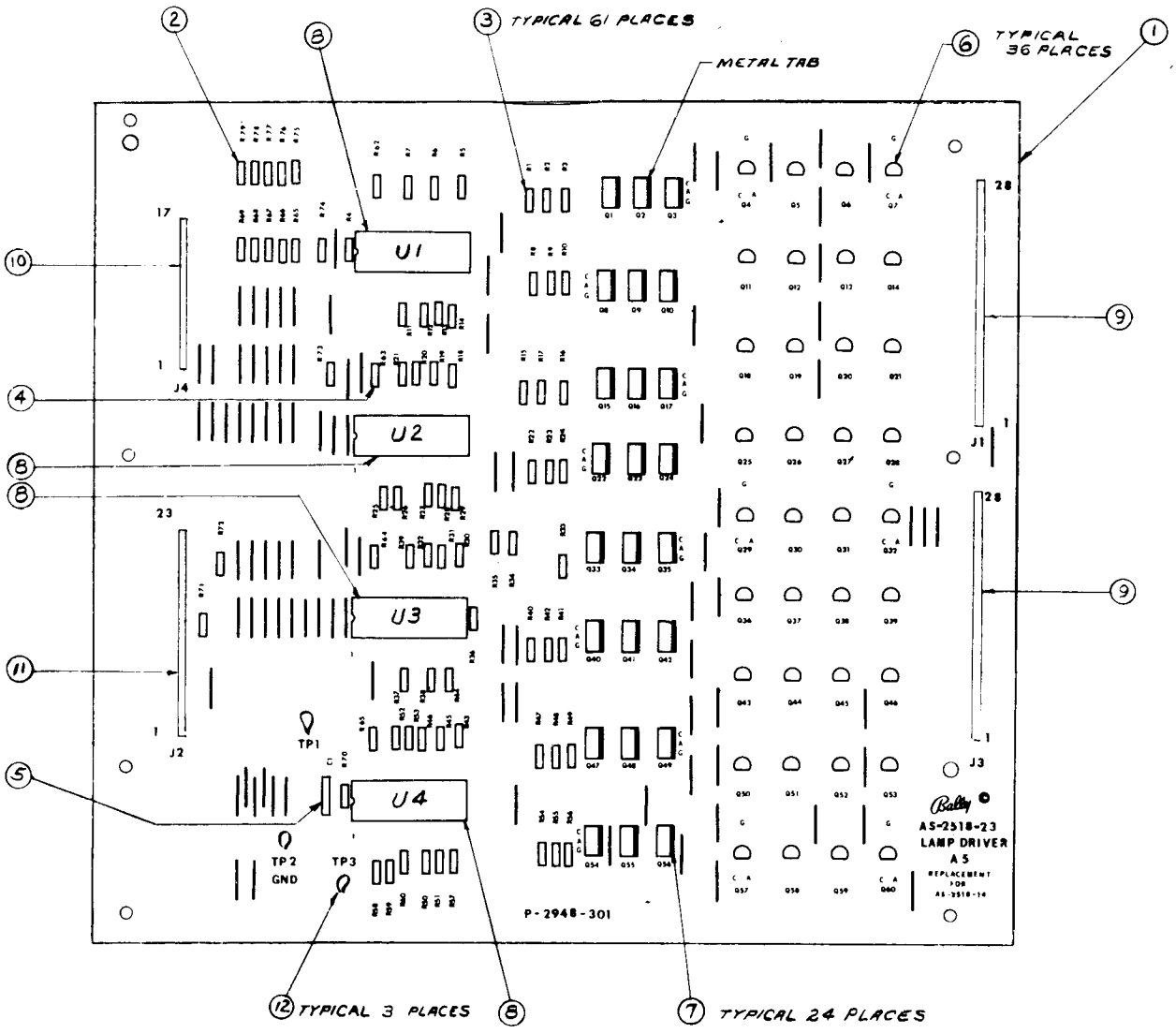
AS-2518-14 LAMP DRIVER MODULE



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%, ¼W
4	R61-R69	E-00105-0256	Resistor, 2.2M Ω, ¼W
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

AS-2518-23 LAMP DRIVER MODULE

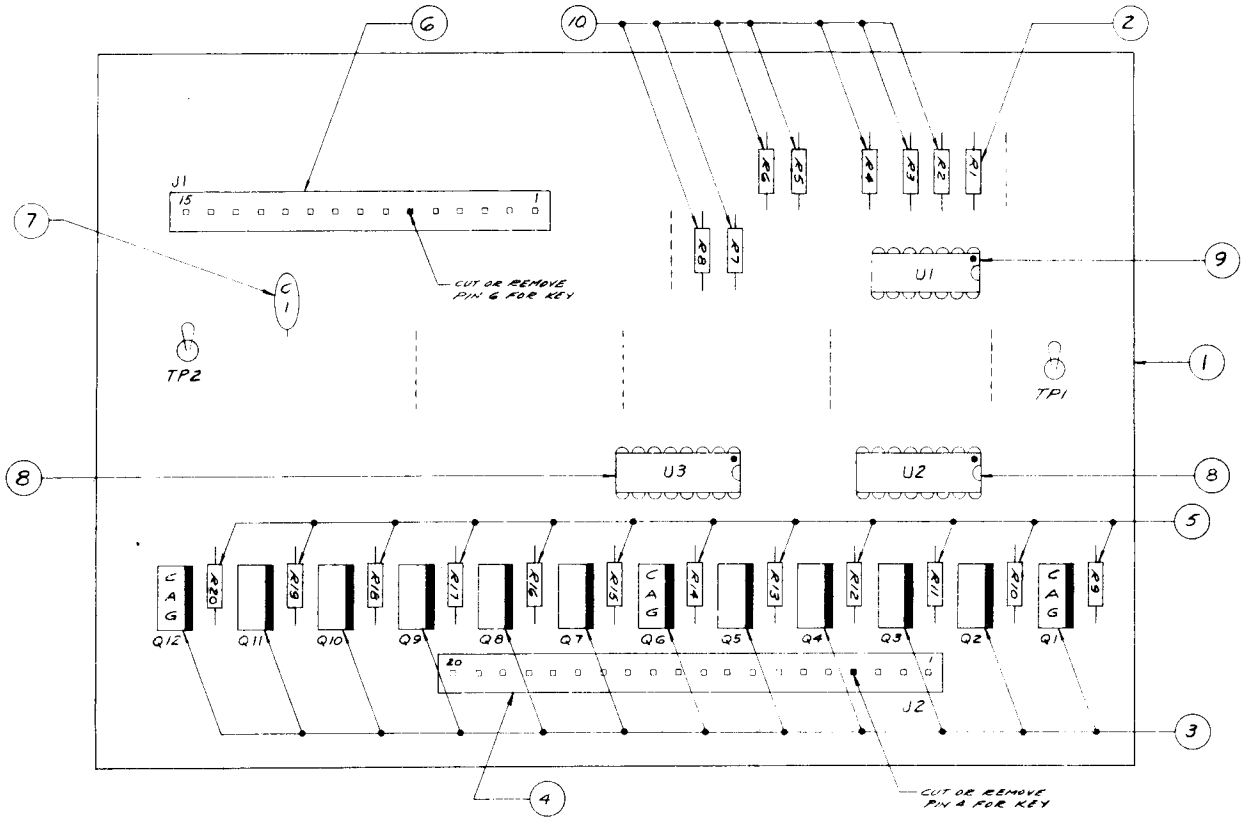


A5: LAMP DRIVER MODULE
COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A5	AS-2518-23	Lamp Driver Module, Complete
2	R71-R79	E-00105-242	Resistor, 20kΩ, 5%, ¼W
3	R1-R60, R70	E-00105-0237	Resistor, 2kΩ, 5%, ¼W
4	R61-R69	E-00105-0256	Resistor, 2.2MΩ, ¼W
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-Q60	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
8	U1-U4	E-00620-0037	I.C., Decoder, 14514B
9	J1, J3	E-00715-0004	28 Pin Wafer Connector
10	J4	E-00715-0013	17 Pin Wafer Connector
11	J2	E-00715-0014	23 Pin Wafer Connector
12	TP1, TP2, TP3	P-05399	Test Clip

NOTE: INTERCHANGEABLE WITH AS-2518-14.

AS-2518-43 AUXILIARY LAMP DRIVER



A9: AUXILIARY LAMP DRIVER
COMPONENT PARTS LIST

ITEM	QTY.	REFERENCE DESIGNATION	BALLY PART NO.	DESCRIPTION
1	1		P-2948-355	P.C. Board (M-645-461)
2	1	R1	E-105-173	Resistor 2.2 Meg. Ω
3	12	Q1 Thru Q12	E-585-29	SCR MCR 106-1
4	2	J2	E-715-34	10 Pin Wafer Pin Connector
5	12	R9 Thru R20	E-105-237	Resistor 2K Ω
6	1	J1	E-715-39	15 Pin Wafer Pin Connector
7	1	C1	E-00586-0065	Capacitor .01 MFD
8	2	U3, U2	E-620-84	MC14555B Binary 1 to 4
9	1	U1	E-620-85	MC14013B Dual D Flip Flop
10	7	R2 Thru R8	E-105-242	Resistor 20K Ω

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 AID 1 Probe junction of base resistor (old style display AS-2518-15-R2, 4, 6, 8, 10 or 12, if appropriate; new style display AS-2518-21-R43, 44, 45, 46, 47 or 48, if 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.

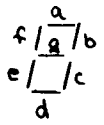
SYMPTOM VI. Display Count is improper.

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.
	B) Defective Integrated Circuit U1	If LED lights, replace U1. Retest module.
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 ± .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	6	5	5
6	6	8	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	8	9	9

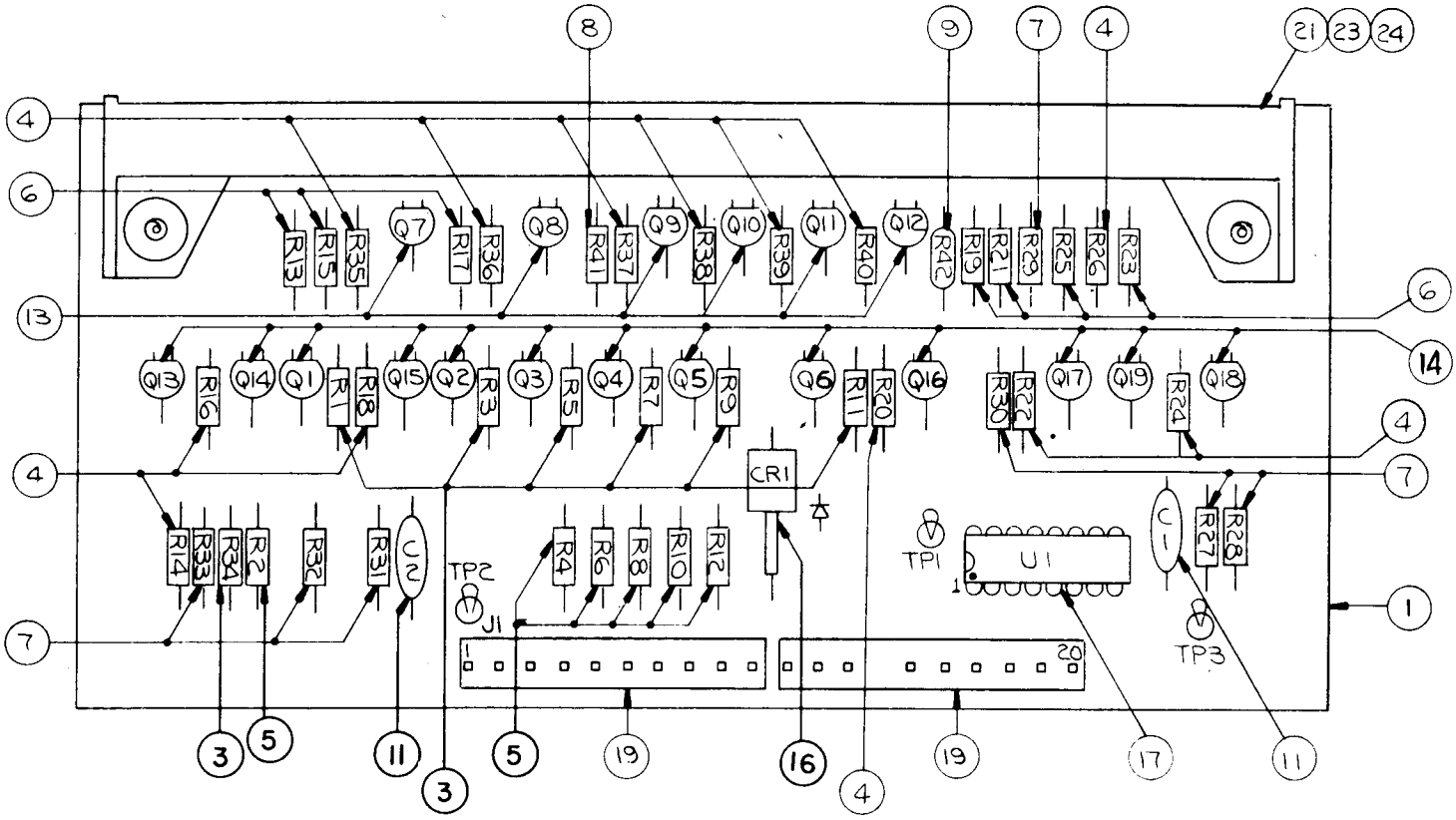
TABLE "B" — SEGMENT ALWAYS OFF

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	5	6	6
7	7	7	7	7	7	7	7
8	8	6	8	8	9	8	0
9	9	5	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.

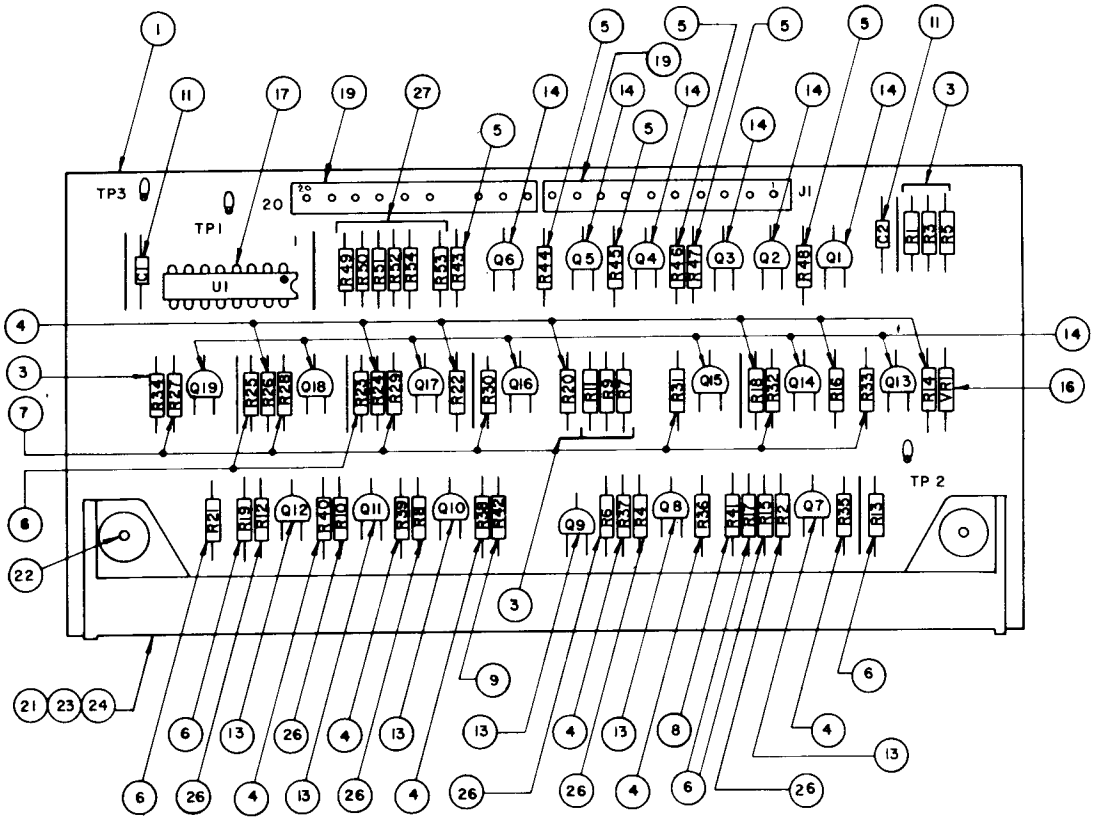
AS-2518-15 DISPLAY DRIVER MODULE



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, ¼W
4	R14, R16, R18, R20, R22, R24, R26, R35-R40	E-00105-0227	Resistor, 300K, ¼W
5	R2, R4, R6, R8, R10, R12	E-00105-0228	Resistor, 9.1K, ¼W
6	R13, R15, R17, R19, R21, R23, R25	E-00105-0229	Resistor, 1.5K, ¼W
7	R27-R33	E-00105-0230	Resistor, 1K, ¼W
8	R41	E-00105-0231	Resistor, 39K, ¼W
9	R42	E-00105-0271	Resistor, 240K, ¼W
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-00715-0034	10 Pin Wafer Connector
21	DS1	E-00680	Digital Display Panel
23		P-02399	Display Mounting (Top)
24		P-02399-0001	Display Mounting (Bottom)

AS-2518-21 DISPLAY DRIVER MODULE



A1: DISPLAY DRIVER MODULE
COMPONENT PARTS LIST

ITEM	QTY.	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	1		P-2948-296	P.C. Board, M-645-392
3	7	R1, R3, R5, R7, R9, R11, R34	E-105-226	Resistor, 100K Ω
4	13	R14, R16, R18, R20, R22, R24, R26, R35, R36, R37, R38, R39, R40	E-105-227	Resistor, 300K Ω
5	6	R43, R44, R45, R46, R47, R48	E-105-228	Resistor, 9.1K Ω
6	7	R13, R15, R17, R19, R21, R23, R25	E-105-229	Resistor, 1.5K Ω
7	7	R27, R28, R29, R30, R31, R32, R33	E-105-230	Resistor, 1K Ω
8	1	R41	E-105-231	Resistor, 39K Ω
9	1	R42	E-105-271	Resistor, 240K Ω
10				
11	2	C1, C2	E-586-65	Capacitor, .01 MFD
13	6	Q7, Q8, Q9, Q10, Q11, Q12	E-585-32	Transistor (2N5401)
14	13	Q1, Q2, Q3, Q4, Q5, Q6, Q13, Q14, Q15, Q16, Q17, Q18, Q19	E-585-33	Transistor (MPS-A42)
16	1	VR1	E-598-7	Zener Diode, 110V
17	1	U1	E-620-38	I.C. Decoder
18				
19	2	J1	E-715-34	10 Pin Wafer Pin Connector
21	1	DS1	E-680	Digital Display Panel
22	2		M-1836	Hi-Lo Screw, W/H
23	1		P-2399	Display Mounting (Top)
24	1		P-2399-1	Display Mounting (Bottom)
26	6	R2, R4, R6, R8, R10, R12	E-105-287	Resistor, 2.2K Ω
27	6	R49, R50, R51, R52, R53, R54	E-105-242	Resistor, 20K Ω
28	As Req'd			Wire Jumper

NOTE: INTERCHANGEABLE WITH AS-2518-15

SOLENOID DRIVER/VOLTAGE REGULATOR MODULE A3

INDEX

PROCEDURAL STEPS

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 ± .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 ± .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 ± .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 ± .25 VDC).	
A) Defective capacitor C23	Disconnect one lead of capacitor C23, 11,700Mf. Dischage 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 Ω) 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 Ω).
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. If fuse did not blow, unsolder one lead of diode CR21. Measure CR21 diode with an ohmmeter, both directions.
G) Defective diode CR21, transistors Q21, Q22, Q23	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 Ω) 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 Ω). Retest module.
C) Defective transistor Q23	If C28 is good, replace transistor Q23 and R7 (22k Ω). 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.
SYMPTOM V. V_{OUT} (TP2) = 190 VDC; V_{OUT}, J3, Pin 8 = 0 VDC: AS-2518-22 only.	
Blown Fuse	Replace fuse F1 (Bally Part #E-133-30, 1/4-A Fast Blo).

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) 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 array (U1, U3 or U4, as appropriate). If solenoid does not pull-in, measure voltage (DC) at collector-diode junction while grounding the base of the transistor array. 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.

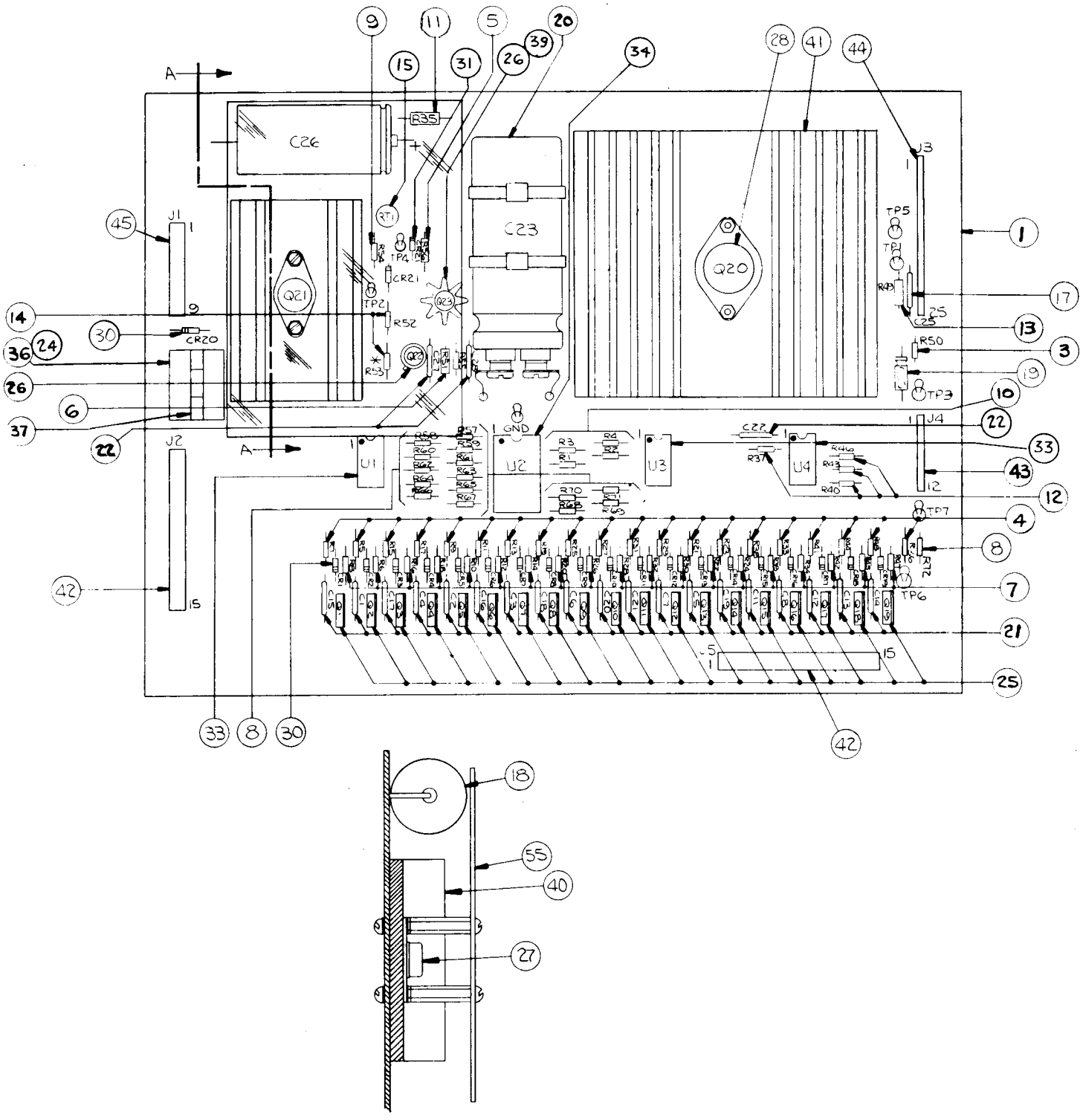
*Solenoids associated with 1 of 16 decoder U2 are designed for impulse operation only and may become damaged if operated continuously.

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.

AS-2518-16 SOLENOID DRIVER/VOLTAGE REGULATOR MODULE

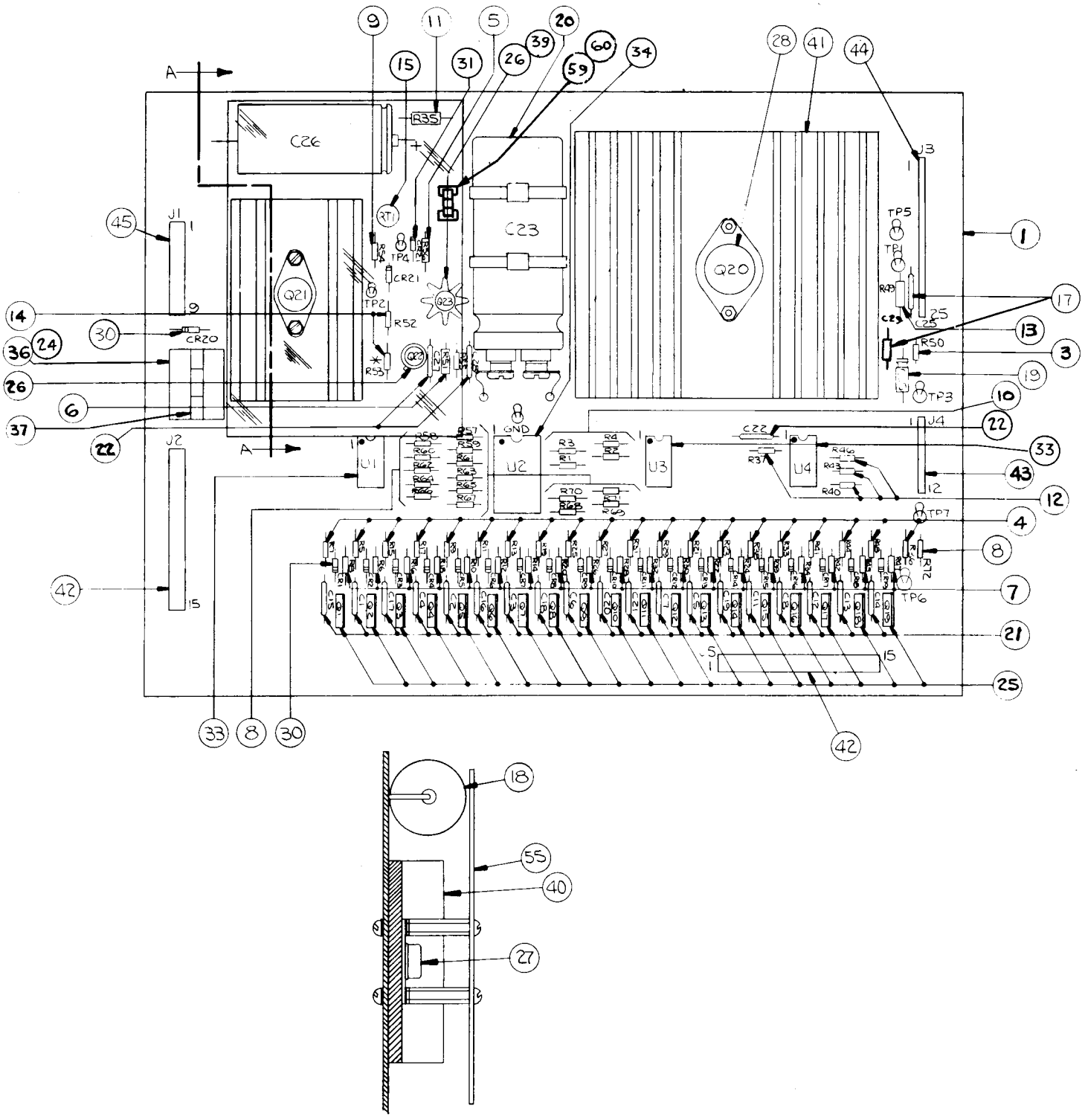


A3: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE
COMPONENT PARTS LIST

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-00715-0039	15 Pin Wafer Connector
43		E-00715-0016	12 Pin Wafer Connector
44		E-00715-0020	25 Pin Wafer Connector
45		E-00715-0033	9 Pin Wafer Connector
55		M-1837	Shield-Plexiglass

REF: Page 56, parts location.

AS-2518-22 SOLENOID DRIVER/VOLTAGE REGULATOR MODULE



NOTE: INTERCHANGEABLE WITH AS-2518-16

A3: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE
COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A3	AS-2518-22	Solenoid Driver/ Voltage Regulator Module, Complete
3-14	Resistors		Resistor, See Schematic for value.
15	RT1	E-00599-0014	Pot. (Linear) 25K
17	C25, 29	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-00146-0795	Relay, Printed Circuit
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, TO5
40		E-00682-0001	Heat Sink, TO66
41		E-00682-0002	Heat Sink, TO3 Case
42		E-00715-0039	15 Pin Wafer Connector
43		E-00715-0016	12 Pin Wafer Connector
44		E-00715-0020	25 Pin Wafer Connector
45		E-00715-0033	9 Pin Wafer Connector
55		M-1837	Shield-Plexiglass
59		E-00148-0021	Fuse Clips
60	F1	E-00133-0030	Fuse 8 AG-1/4 Amp.

*USED WITH ITEM 24, E-00146-0791, PLUG IN RELAY ONLY

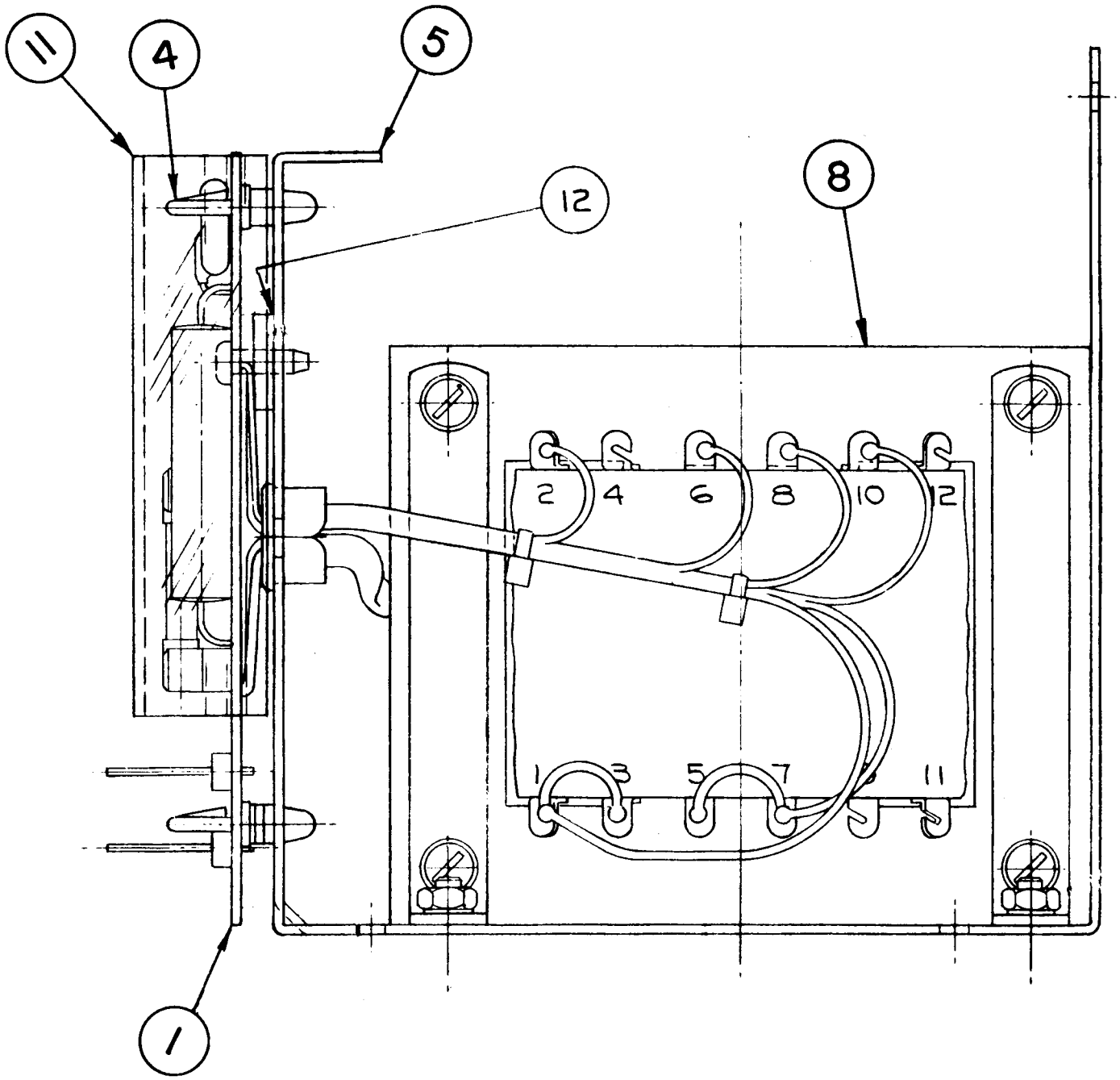
REF: Page 58, Parts Location.

POWER TRANSFORMER MODULE A2 PROCEDURAL STEPS

POWER TRANSFORMER MODULE A2
PROCEDURAL STEPS

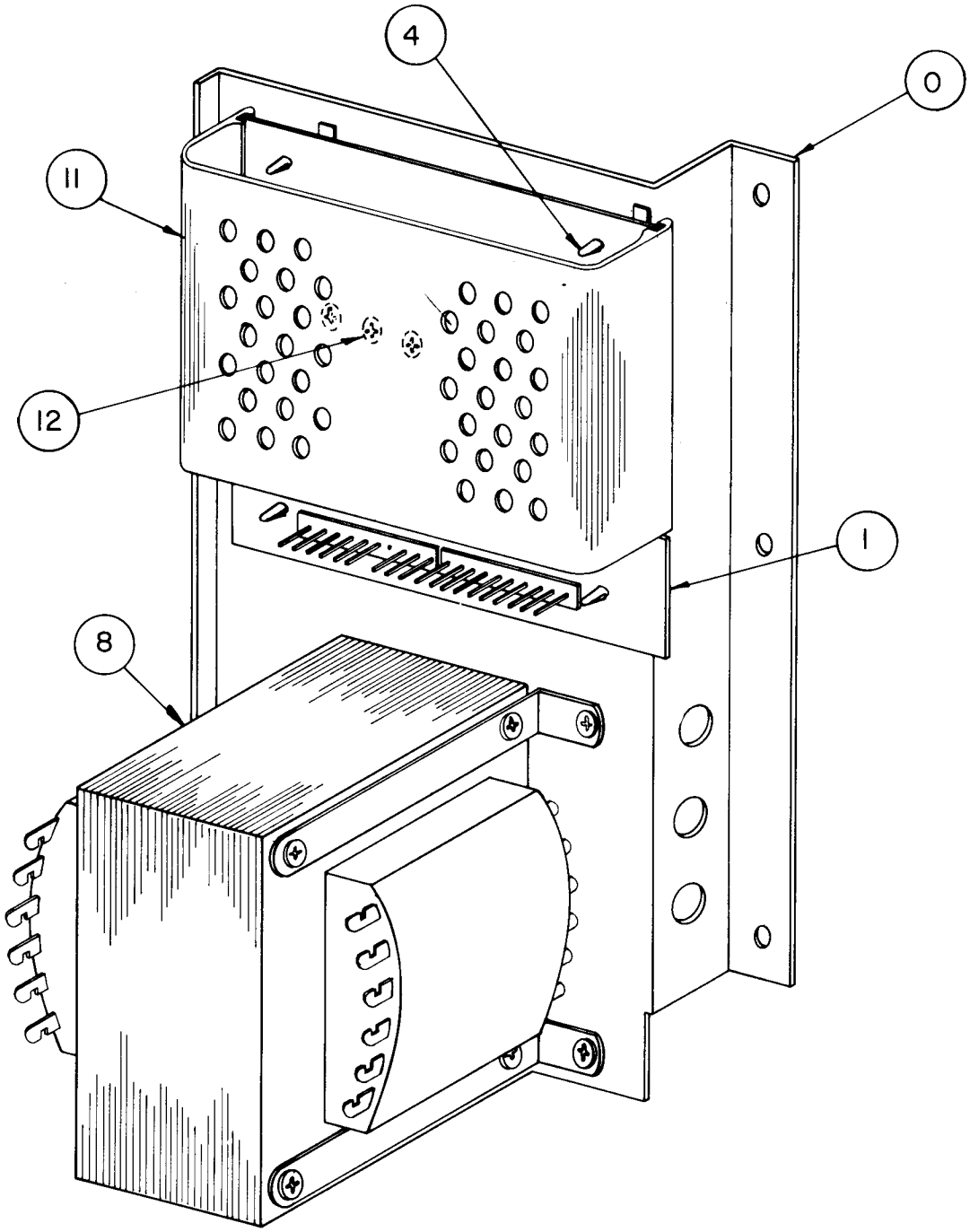
DIAGNOSTIC TABLE: POWER TRANSFORMER MODULE, A2
REPAIR LEVEL: COMPONENT REPLACEMENT

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
	Measure at: J2-6 to 7, line voltage ± 10%.
A) Improper line voltage	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.
SYMPTOM II. Module blows fuse.	
	If module always blows input fuse F6, momentarily short across fuse holder (about 3 seconds).
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



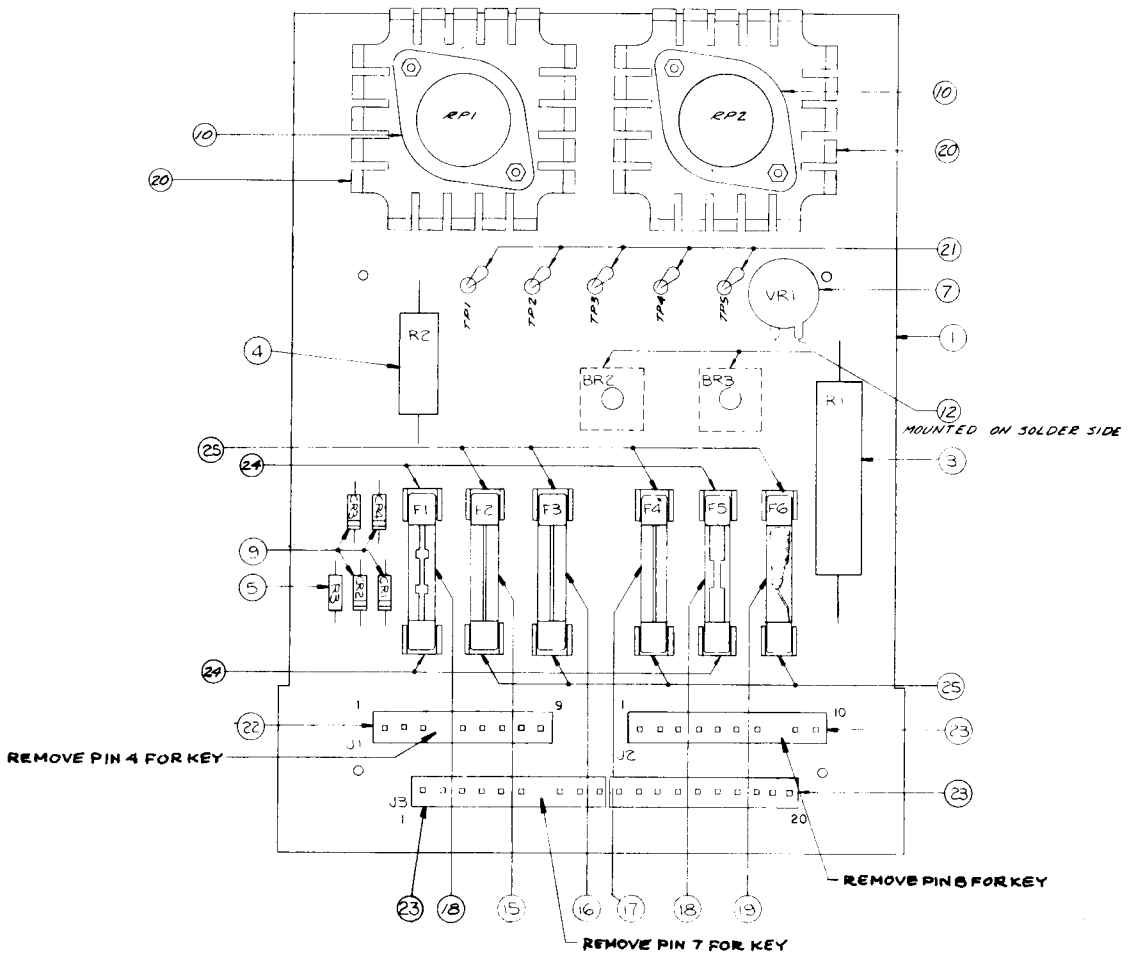
A2: POWER TRANSFORMER MODULE

COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
0	A2	AS-2877-1	Power Transformer Module, Complete
1		AS-2518-18	Rectifier Board Assembly
4		M-1829-2a	Circuit Board Support (4 Req'd.)
8		E-00122-0125c	Transformer 120/240V, 50/60 Hz
11		P-2692b	P.C.B Cover
12		M-1834	Heat Sink Compound

NOTE: RECOMMENDED REPLACEMENT FOR AS-2877

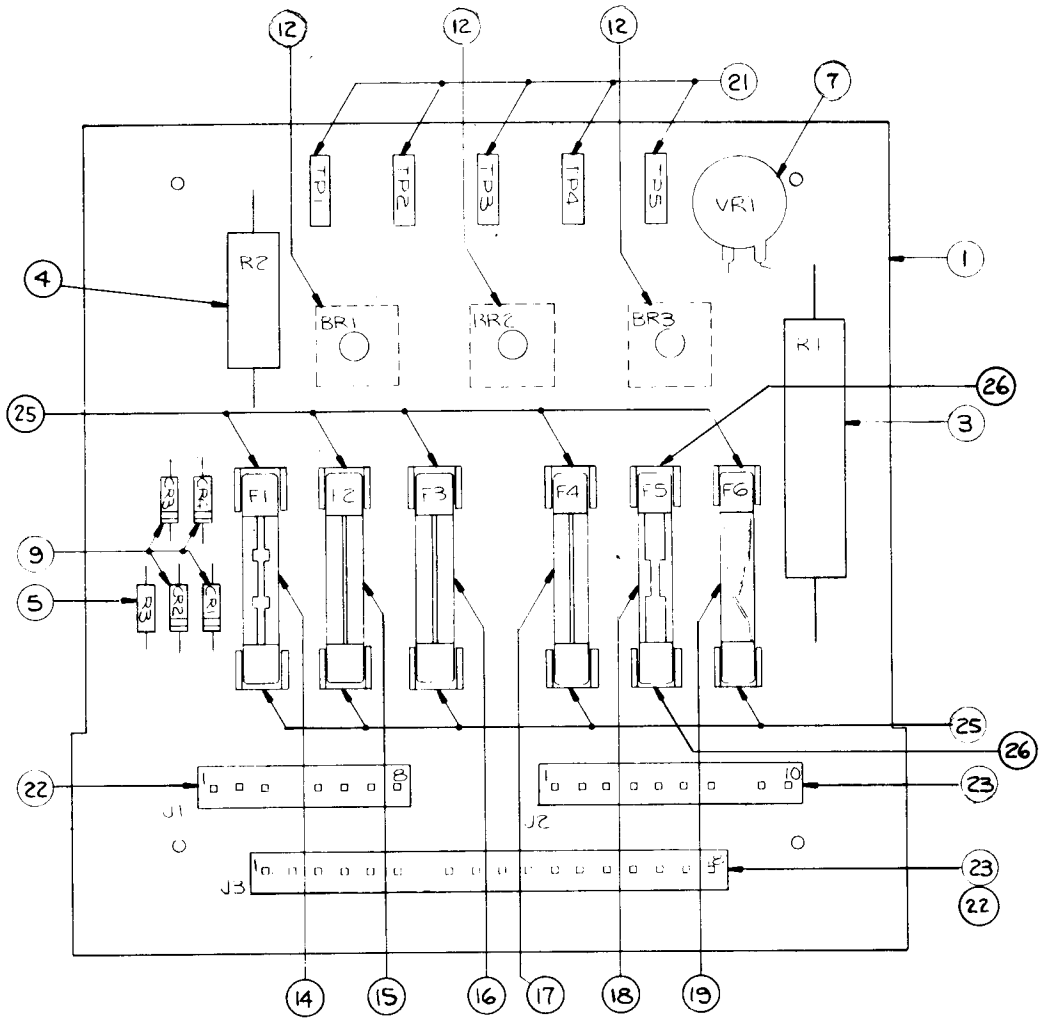
AS-2518-49 RECTIFIER BOARD ASSEMBLY



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

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	P/O A2	AS-2518-49	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, ¼W
7	VR1	E-00623	Varistor
9	CR1, CR2, CR3, CR4	E-00587-0006	Diode (IN4004)
10	RP1, RP2	E-00602-0004	Rectifier Package (R712E, VARO)
12	BR2, BR3	E-00602-0003	Bridge Rectifier (VJ248 VARO)
15	F2	E-00133-0028	Fuse, ¾A, 250V, 3AG, S.B.
16	F3	E-00133-0004	Fuse, 4A, 32V, 3AG
17	F4	E-00133-0005	Fuse, 5A, 32V, 3AG
18	F1, F5	E-00133-0027	Fuse, 20A, 32V, 3AG
19	F6	E-00133-0024	Fuse, 3A, 125V, 3AG, S.B.
20	FOR RP1, RP2	E-00682-0011	Heatsink, 6053B
21	TP 1, 2, 3, 4, 5	P-05399	Test Point
22	J1	E-00715-0033	9 Pin Wafer Connector
23	J2, J3	E-00715-0034	10 Pin Wafer Connector
24	F1, F5	E-00148-0022	Fuse Clips
25	F 2, 3, 4, 6	E-00148-0021	Fuse Clips

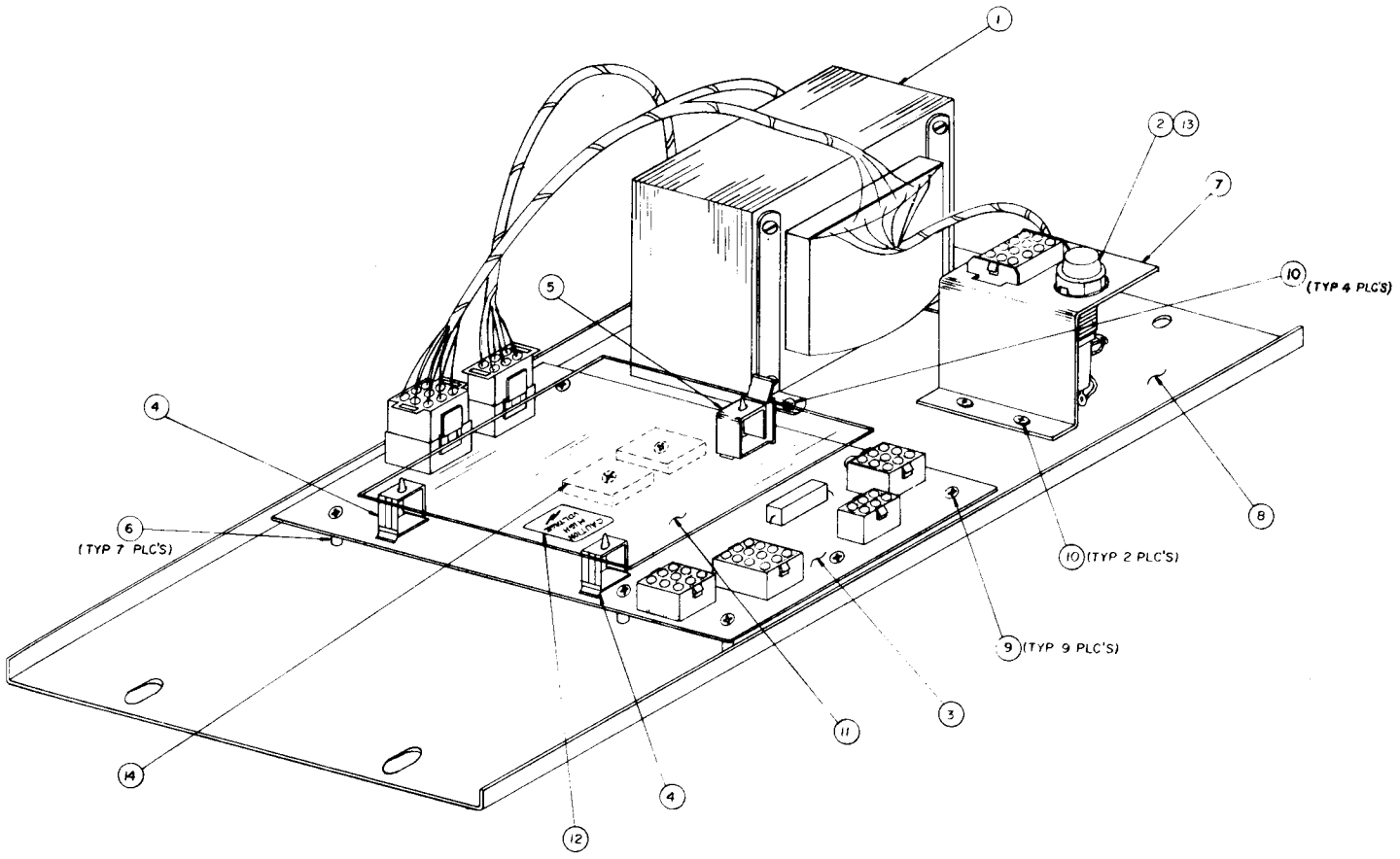
AS-2518-18 RECTIFIER BOARD ASSEMBLY



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, ¼W
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, J3	E-00715-0032	8 Pin Wafer Connector
23	J2, J3	E-00715-0034	10 Pin Wafer Connector
25		E-00148-0021	Fuse Clips
26		E-00148-0022	Fuse Clips

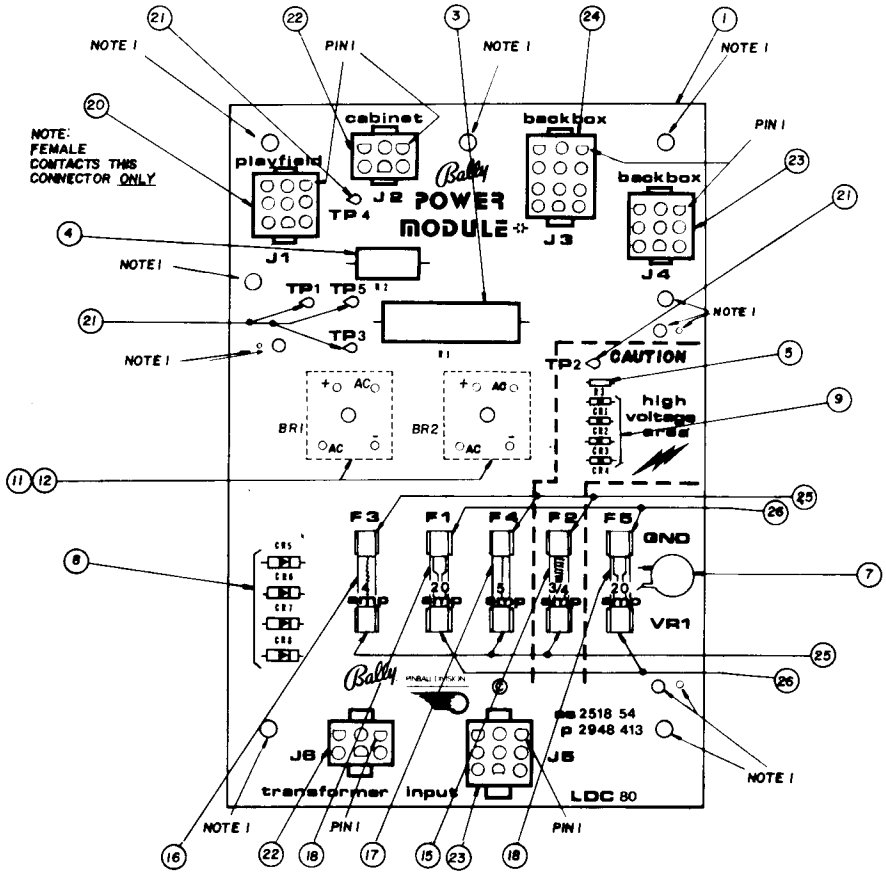
A2: POWER TRANSFORMER MODULE



COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
0	A2	AS-2877-6	Power Transformer Module, Complete
1		AS-3071-2	Transformer
2		E-148-25	Fuse Holder
3	A2	AS-2518-54	Power Module Assy.
4		M-1829-4	Hinged Support
5		M-1829-3	Edge Holder
6		M-1829-5	Spacer
7		P-6442-244b	Fuse & Connect Brkt.
8		P-6442-246	Chassis
9		RLPP-832-1812	Screw
10		RLPP-1032-1806	Screw
11		P-2692-2	Shield
12		M-469-936a	High Voltage Sticker
13		E-133-24	3A S.B. Fuse
14		M-1834	H. S. Compound

AS-2518-54 RECTIFIER BOARD ASSEMBLY



(Part of) A2: POWER TRANSFORMER MODULE

COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
0	A2	AS-2877-6	Power Transformer Module, Complete
1	P/O A2	AS-2518-54	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, ¼W
7	VR1	E-00623	Varistor
8	CR5, CR6, CR7, CR8	E-00587-0022	3A Diode
9	CR1, CR2, CR3, CR4	E-00587-0015	Diode (IN4004)
10			
11	Used with BR1-2	P-1973-480	Spacer
12	BR1, BR2	E-00602-0006	Bridge Rectifier
15	F2	E-00133-0028	Fuse, ¾A, 250V, 3AG
16	F3	E-00133-0004	Fuse, 4A, 32V, 3AG
17	F4	E-00133-0005	Fuse 5A, 32V, 3AG
18	F1, F5	E-00133-0027	Fuse, 20A, 32V, 3AG
19			
20	J1	E-806-9	9 CKT Socket Header
21	TP1, 2, 3, 4, 5	P-05399	Test Clip
22	J2, J6	E-805-6	6 CKT Pin Header
23	J4, J5	E-805-9	9 CKT Pin Header
24	J3	E-805-12	12 CKT Pin Header
25	F2, 3, 4	E-00148-0021	Fuse Clips
26	F1, 5	E-00148-0022	Fuse Clips (Low Resistance)

SOUND DRIVER MODULE A8 PROCEDURAL STEPS

Functionally, the Sound module is divided into six circuit areas, as follows:

1. Power Supply (Q1 and associated components).
2. Tone Data Processor (U2, P/O U1 and U3).
3. Programmable Frequency Generator (U13, U1C, U4, U5 and U11).
4. Tone Trigger Generator (U7, and associated circuitry).
5. Voltage Controlled Alternator (U8).
6. Audio Amplifier (U9 and U10).

The following outlines a simplified test sequence to aid in quick localization of a fault to one of these circuit areas. Once the area of the fault has been determined, use must be made of the referenced sections for a more detailed analysis.

Unless stated otherwise, all measurements are made with respect to TP2, the ground line of the Sound module.

1. POWER SUPPLY CHECK

Measure +5 ± 0.25 VDC at TP1 and +12.5 ± 1.3 VDC at TP3. If incorrect, go to Section I.

2. FREQUENCY GENERATOR CHECK

Measure +0.8 VDC at junction of R3 and R5. If incorrect, go to Section II.

3. AUDIO AMPLIFIER CHECK

Measure +2 VDC (approx.) at U9, pin 2. Observe that a ticking sound is produced each time U9, pin 2 is touched with meter test lead. If incorrect, go to Section III.

4. TONE TRIGGER GENERATOR CHECK

With the game in play mode, activate any playfield switch that will result in momentary solenoid (slingshot, etc.) activity. On the Sound module, connect a jumper from TP1 (+5V) to U2, pin 5 (the junction of R24 and R28, see shematic). No sound should be heard, unless a playfield switch is activated.

If sound is heard with the jumper installed, refer to Sections V and II (in that order).

Activate a playfield switch. If sound is heard with jumper in place, but not without it, go to Section IV.

5. VOLTAGE CONTROLLED ATTENUATOR CHECK

Temporarily place a short between pins 1 and 2 of U8 on the Sound module and activate a playfield switch.

If sound is heard with the short installed, but not without it, refer to Section III.

If sound is not heard with the short in place, refer to Sections V and II (in that order).

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: COMPONENT REPLACEMENT
SECTION I: POWER SUPPLY ASSOCIATED FAILURES

CAUSE	PROCEDURE
SYMPTOM I: No Sound or distorted sound. TP1 (+5V) Voltage incorrect.	
A) Open +5 VDC line	Measure +5 ± .25 VDC at TP1. If absent at A3-TP1, use standard troubleshooting techniques to locate and repair short on +5 volt distribution circuit on Sound module. and TP1 on Sound module.
B) Short on +5 VDC line	If absent at A3-TP1, use standard troubleshooting techniques to locate and repair short on +5 volt distribution circuit on Sound module.
SYMPTOM II: No Sound or distorted sound. TP3 (12.5 ± 1.3 VDC) voltage low or absent.	
A) Open +43 VDC line	Measure +43 ± 5.4 VDC at TP4. If correct, proceed with C). If absent, measure +43 volts at A2-TP5, Power Transformer module. If present at A2-TP5, locate and repair open between connector and TP4 on Sound module.
B) Short on +43 VDC line	If absent at A2-TP5, use standard troubleshooting techniques to locate and repair short in +43 volt circuit on Sound module.
C17 Shorted	In particular, check for shorted capacitor C17 on the Sound module.
C) Short on +12 volt line	With power off, connect positive lead of ohmmeter to TP3, negative to ground and measure resistance. The resistance should be in excess of 1k Ω (3k Ω typically). If low or shorted, use standard troubleshooting techniques to locate and repair the short on +12 volt distribution circuit. NOTE: Short or low impedance circuit on +12 volt line may result in damaged Q1 and CR4. It is therefore advisable to replace Q1 and CR4 after the short has been repaired.
D Defective +12V Regulator	Measure +67 ± 7 VDC at positive terminal of C17.
CR3 Open	If absent, replace CR3.
CR3 Shorted C17 Open	If equal to TP4 voltage, check CR3 for short and/or C17 for open and replace as necessary.
	Measure voltage at collector of Q1. With no sound output (volume control all the way CCW) the collector of Q1 should be within a few volts of the voltage at positive terminal of C17. If the collector voltage is low or absent, check the following and replace defective components as necessary.
R36 Open	a) Open or high resistance R36.
Q1 Shorted	b) Q1 collector to base short causing overload through CR4.
Overloaded +12V line	c) Excessive current drain on +12V line.
Q1 Open	If voltage at collector of Q1 is normal and the voltage at base of Q1 is +13 ± 1.3 volts, replace Q1.
R22 Open	If voltage at base of Q1 is low or absent, check for open R22 and replace if defective.
CR4 Shorted C18 Shorted	If R22 is not defective, check for shorted CR4 or C18. If either is found defective, replace along with Q1.
CR4 out of tolerance	If voltage at base of Q1 is out of tolerance, replace CR4.
SYMPTOM III: No Sound or distorted sound. TP3 (+12.5 ± 1.3 VDC) voltage abnormally high.	
Q1 Shorted CR4 Open R22 Shorted	Check for shorted Q1, open CR4, and/or shorted R22. If either is found defective, replace along with Q1 and CR4. NOTE: Voltages higher than +16V on the +12V line may result in damage to IC's U7, U8, U9 and U10.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: COMPONENT REPLACEMENT
SECTION II: FREQUENCY GENERATION ASSOCIATED FAILURES

CAUSE	PROCEDURE
SYMPTOM I: No Sound. (Clock Signal failure).	
A) Clock generator U1B, U1C defective	Measure +2.5 VDC on U1B, pin 4. If correct, go to IIIB. If incorrect, replace U1.
B) Clock generator component defective	If still incorrect after U1 replacement, check for defective clock generator components.
C) U4 defective	The fault may also be due to defective clock input line on U4. Replace as necessary.
SYMPTOM II: No Sound or incorrect tone sequence. (Frequency division failure)	
	Momentarily connect a jumper lead from TP1 (+5V) to U2, pin 5. This will clock in 'null' address data and cause all data lines to U4 and U5 to go low (0 to +0.5 VDC), except DP1 on U4, pin 5 which will be high (+3.5 to +5 VDC). If 'null' address condition is not attained, refer to Section V.
A) U4 and/or U5 defective U11 clock input line defective	Measure +2.5 VDC at U11, pin 1. (Additional testing may be performed with the game operating in chime mode. In this case the signal at U11, pin 1 changes from 'null' condition square wave to a series of narrow pulses, and the voltage at U11, pin 1 is approximately +0.1 VDC). If correct, proceed with next step. If incorrect, replace U4, U5 and/or U11.
B) U11 defective	Measure +2 VDC at pins 9 and 11 of U11. If incorrect, replace U11.
C) Waveshaping circuit defective	Referring to the schematic, trace the signal from U11, pins 9 and 11 to U8, pin 2. Replace defective circuit components as necessary.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: COMPONENT REPLACEMENT
SECTION III: AMPLIFICATION ASSOCIATED FAILURES

CAUSE	PROCEDURE
SYMPTOM I: Activating a chime associated switch produces no sound, unless pins 1 and 2 of U8 on Sound modules are shorted.	
A) Sustain Adjust RT2 set incorrectly	With the short removed, check if the fault is not caused by improperly set sustain adjust (RT2). Readjust RT2 if necessary.
B) Tone trigger on envelope generator defective	If still incorrect, check for defective tone trigger and envelope generator function, as described under SYMPTOM IIA, Section IV.
C) U8 defective	If the trigger and envelope functions are normal, replace U8.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: COMPONENT REPLACEMENT (Cont'd)
SECTION III: AMPLIFICATION ASSOCIATED FAILURES (Cont'd)

CAUSE	PROCEDURE
SYMPTOM II: No Sound or distorted sound. Frequency generator, tone trigger and envelope generator function normally.	
A) Volume control (RT3) set incorrectly	Check if the fault is not caused by volume control set all the way CCW, or too far CW. Readjust RT3, if necessary. If still incorrect, use a jumper lead in series with a 0.05 mfd. capacitor to feed the signal from the junction of R5, R14, R15 and U8, pin 2 to U10, pin 2. Activate a sound associated switch.
B) Defective loudspeaker	If sound is absent, or distorted, check and replace the loudspeaker, if defective.
C) Defective U10	If loudspeaker is not defective, replace U10. Also check U10 associated components and replace if defective.
D) Defective U9 or volume control RT3	If sound is heard in Step B), but not without the jumper, replace U9. Also check volume control (RT3) and replace if defective.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: COMPONENT REPLACEMENT
SECTION IV: TONE TRIGGER AND ENVELOPE GENERATING CIRCUIT ASSOCIATED FAILURES

CAUSE	PROCEDURE
SYMPTOM I: With U2, pin 5 jumpered to +5V (see test), sound function appears normal, except for short sustain duration. Sound sequences cannot be obtained without the jumper.	
	On the Sound module, connect a voltmeter to measure voltage at J1, pin 8. Connect a jumper from TP1 (+5V) to the junction of R24, R28 and U2, pin 5. With the game in a state to accept a player and the ball in the outhole, press the player-up button. Observe that the voltage at J1, pin 8 is at a high level (approx. +4 VDC) when the player-up sound is heard, and then goes to a low level (approx. 0 VDC) as the outhole solenoid energizes.
A) Solenoid Bank Select line fault	If voltage at J1, pin 8 of the Sound module is incorrect, investigate wiring on Sound module for a short to +43 VDC or ground line. Repair and retest.
B) Defective U7 or associated components	On the Sound module, remove the jumper from TP1 to U2, pin 5 and connect the voltmeter to measure trigger voltage at U7, pin 3. Observe that the trigger voltage changes from a low level (approx. 0 VDC) when no sound is played, to a positive value (single chime note will produce approx. 0.25 VDC peak reading, noise sequences may produce 6 VDC peaks), when a sound associated switch is activated. (Sound may not be heard at this point, however, the voltage should change as indicated.) If trigger voltage is absent, replace U7 or associated components (Q2, etc.) as necessary. Retest.
C) U2 clock input line defective	Proceed as in step B) above, except connect the voltmeter to measure voltage at U2, pin 5. Observe that the voltage at U2, pin 5 changes from a low level (0 VDC) to approx. one-third the maximum value observed in step B), when the same sound associated switch is activated. If incorrect, check for open signal path from U7, pin 3 to U2, pin 5, including voltage divider R24 and R28. Repair if defective. Else, replace U2. Retest.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: COMPONENT REPLACEMENT
SECTION IV: TONE TRIGGER AND ENVELOPE GENERATING CIRCUIT ASSOCIATED FAILURES (Cont'd)

CAUSE	PROCEDURE
SYMPTOM II: Chime sound is absent or decays abnormally. Sustain adjust (RT2) does not function normally.	
	Place the game in chime mode. Connect a voltmeter to measure voltage at the junction of CR1 and CR2 on the Sound module.
A) Defective envelope circuit components	Observe that the voltage is at a low level (0 VDC) and mometarily increases to approx. +2.5 VDC when a single chime associated switch is activated. (Multiple chimes or noise sequences will cause higher peak readings.) If incorrect, refer to the schematic and check envelope circuit components CR1 through R11. Repair and retest. Refer also to step B) of SYMPTOM I.
B) Defective sustain adjust circuitry or defective U8	Connect voltmeter to measure voltage at U8, pin 3. Observe that with no sound associated switches activated, the voltage changes smoothly from 0 VDC with RT2 CCW to approx. +0.5 VDC with RT2 CW.
Defective RT2	If DC level at U8, pin 3 cannot be adjusted or changes abruptly when RT2 is rotated, change RT2. Retest.
U8, pin 3 input defective	If voltage at U8, pin 3 is incorrect, refer to the schematic and check sustain circuitry from R11 to U8, pin 3, and R14 for defective components, solder splashes or otherwise abnormal conditions. Repair as required, else, replace U8. Retest.
U8 defective	If voltage at U8, pin 3 is correct, disconnect voltmeter from U8, pin 3. (All jumpers should also be disconnected.) Set volume control (RT3) approx. 1/4 turn CW and activate a chime associated switch. Set Sustain Adjust (RT8) CW.
	If sound is heard, but sustain cannot be set for normal decay, replace U8. Retest.
	If sound is not heard with RT2 all the way CW, refer to Section III.

SECTION V
TONE DATA BUS ASSOCIATED FAILURE PROCEDURE

PART I: TROUBLESHOOTING WITH AID1.

1) Turn off power. Install AID1 module on MPU connector J5. Clip AID1 test probe to TP1 of AID1. On the Sound module connect a jumper from TP1 (+5V) to the junction of R24, R28 and U2, pin 5.

2) Turn power ON and after game powers up, (power-up tune may not be heard with defective Sound module) initiate Self Diagnostic Test by pressing Self-Test switch button inside the cabinet door.

3) Enter AID1 program by pressing S33 on the MPU module.

4) Using AID1 test probe, examine the data lines at the points listed in Table I. Normal operation is indicated if the LED on the MPU module lights and any humming noise disappears each time a data line is probed. In this manner, the signal can be traced from its origin on the MPU module to the Sound Module Tone Memory U3.

   If signal is not present at any of the test points of Table I, refer to the schematic and wiring diagrams to determine the defective components involved. Repair and retest.

TABLE A8-I TONE DATA BUS ASSOCIATED FAILURES

LINE UNDER TEST	MPU MODULE	SOUND MODULE
(Sol.) Address A	J4 - 4	J1- 1 U2- 4 U1- 2 U3-10
(Sol.) Address B	J4 - 3	J1- 2 U2- 7 U1-10 U3-11
(Sol.) Address C	J4 - 2	J1- 3 U2-13 U1-12 U3-12
(Sol.) Address D	J4 - 1	J1- 4 U2-14 U1-15 U3-13
Address E	J1 - 7	J1-12
Sol. Bank Select	J4 - 10	J1- 8

5) Remove jumper from TP1 to U2, pin 5 and measure 0 VDC (approx.) on U2, pin 5. If incorrect, refer to the schematic, determine the cause, and repair, replacing U2 if necessary. Retest.

PART II: TROUBLESHOOTING WITHOUT THE USE OF AID

If AID1 module is not available or if the AID1 tests do not locate the problem, the operation of the Sound module Address Data Latch (U2) and Tone Memory (U3) can be checked with the use of jumper leads and a voltmeter. The jumper leads are needed to simulate and clock-in desired address signals, while the voltmeter is used to observe if correct logic signal levels are present.

1) Place the game in normal operating mode (not in Self-Diagnostic Test). Do not operate any playfield switches.

2) Check that address input signals at Sound module connector J1, pins 1, 2, 3 and 4 are all high (approx. 4 volts).

   Investigate associated wiring on Sound module for shorted address lines. Repair and retest.

3) Clock-in and latch the address signal (address lines all high). This is accomplished by momentarily connecting a jumper on the Sound module from TP1 (+ 5V) to the junction of R24, R28 and U2, pin 5. Latching occurs on the high to low transition of the clock signal (simulated by the jumper).

   With the jumper removed, measure 0 VDC (approx.) on U2, pin 5. If incorrect, refer to the schematic, determine the cause and repair, replacing U2 if necessary. Retest.

   If U2 output data at pins 3, 9, 12 and 15 are not the inverse of the latched address data, replace U2. If fault persits, replace U1.

   If U2 outputs are correct, but U3 inputs at pins 10, 11, 12 and 13 are not, replace U3 and/or U1.

   If U3 inputs are correct, but its outputs at pins 1, 2, 3, 4, 5, 6, 7 and 9 are not, replace U3. If problem persists, check for line loading by U4 and/or U5, replacing same if necessary.

4) Proceed as above to clock-in and latch other address data combinations listed in Table A8-II. Examine, if correct logic levels are present. Replace defective components as required.

   To simulate low address signals on lines A, B, C and D, connect jumpers from Sound module TP2 (+ 5V GND) to those U2 data inputs (pins 4, 7, 13, 14) for which the low address is required. With the "Address Jumpers" in place, clock-in and latch the data by momentarily connecting a jumper from TP1 (+ 5V) to U2, pin 5. Remove this jumper first, and then all address jumpers.

   Address E signal is not latched in the Sound module, but is held by the MPU at either a high or a low level, depending on the last sound sequence. On the Sound module, the original is inverted by Q3 and then applied to U3, pin 14. Table A8-II references this signal as seen at U3, pin 14. To change the signal from high to low, connect a jumper from TP2 (+ 5V GND) to U3, pin 14. To change from low to high, connect a jumper from TP2 to base of Q3. (Leave this jumper connected when the state of the address E signal must be altered.)

TABLE A8 - II TONE MEMORY PROGRAM

ADDRESS INPUTS					DATA OUTPUTS AT U3 PINS							
E	D	C	B	A	1	2	3	4	5	6	7	9
L	L	L	L	L	H	H	H	H	H	H	H	L
L	L	L	L	H	H	H	H	H	L	L	L	L
L	L	L	H	L	H	H	H	L	L	L	H	L
L	L	L	H	H	H	H	L	H	L	H	H	L
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H	H	H	H	L	L	L	H	H	L	L	L	L
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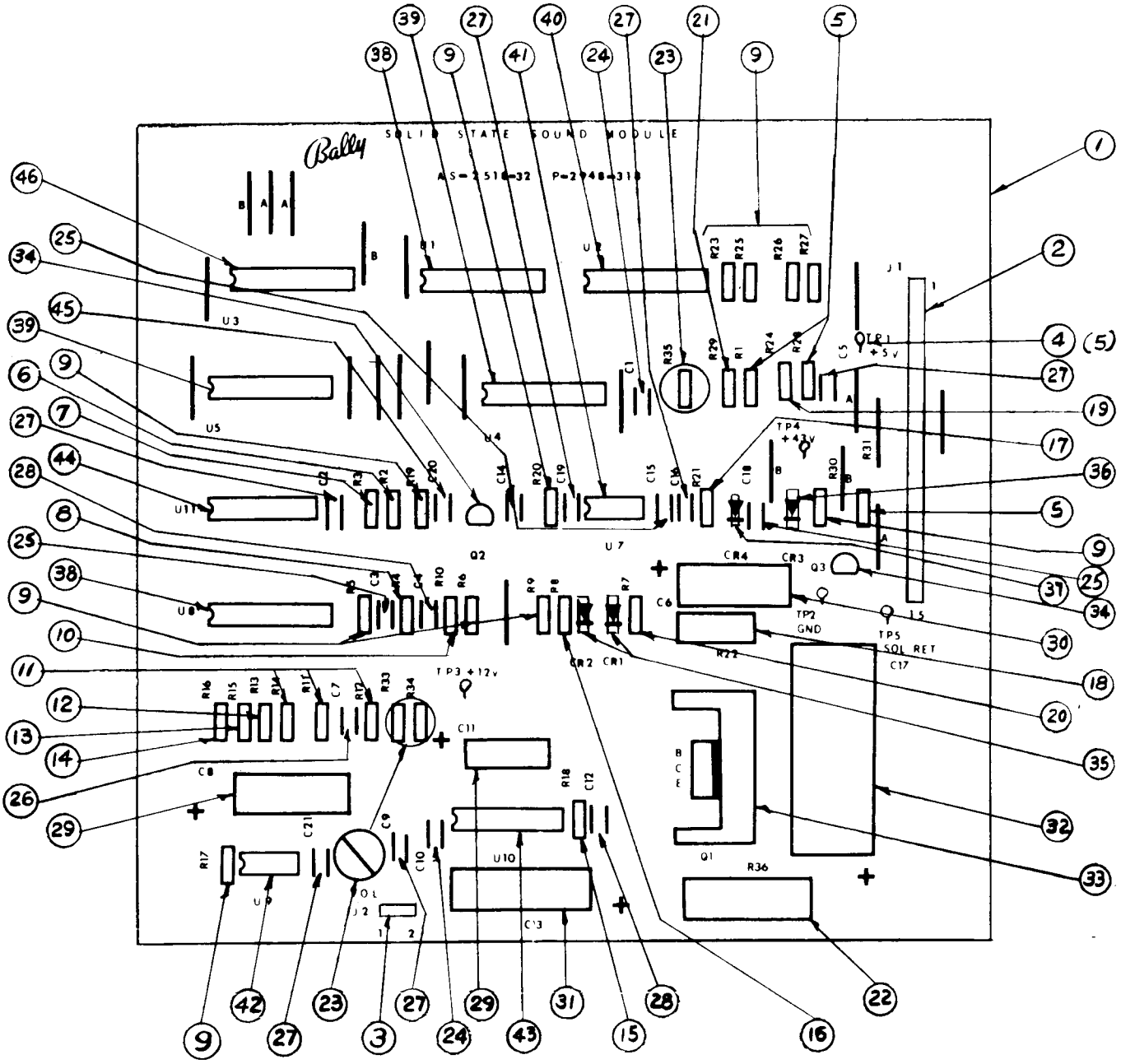
AS-2518-32 SOUND MODULE



A8: SOUND MODULE
COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A8 (see note 1)	AS-2888-1	PWB Module Complete—
2	J1	E-00715-0039	15 Pin Connector
3	J2	E-00715-0026	2 Pin Connector
4	TP1-TP5	P-05399	Test Clip
5	R1, R28, R31	E-00105-0239	Resistor ¼W 5% 4.7K
6	R2	E-00105-0281	Resistor ¼W 5% 15K
7	R3	E-00105-0282	Resistor ¼W 5% 33K
8	R4	E-00105-0257	Resistor ¼W 5% 3.9K
9	R5, R6, R9, R17, R19, R20; R23, R25, R26, R27, R30	E-00105-0185	Resistor ¼W 5% 10K
10	R10	E-00105-0248	Resistor ¼W 5% 150K
11	R11, R12, R14	E-00105-0285	Resistor ¼W 5% 1M
12	R13	E-00105-0284	Resistor ¼W 5% 470K
13	R15	E-00105-0279	Resistor ¼W 5% 360
14	R16	E-00105-0280	Resistor ¼W 5% 470
15	R18	E-00105-0278	Resistor ¼W 5% 2.7
16	R8	E-00105-0287	Resistor ¼W 5% 2.2K
17	R21	E-00105-0246	Resistor ¼W 5% 110K
18	R22	E-00105-0286	Resistor 1W 4.7K
19	R24	E-00105-0223	Resistor ¼W 5% 82K
20	R7	E-00105-0289	Resistor ¼W 5% 1.1K
21	R29	E-00105-0230	Resistor ¼W 5% 1K
22	R36	E-00104-0096	Resistor 5W, 10% 75Ω
23		E-00599-0015	Resist. Var. 91B, 10K
24	C1, C10	E-00586-0068	Cap., Disc. 100PF 1000V
25	C3, C14, C15, C18	E-00586-0065	Cap., Disc. .01MFD 500V
26	C7	E-00586-0087	Cap., Disc. .02MFD 500V
27	C19, C2, C5, C9, C16, C21	E-00586-0088	Cap., Disc. .05MFD 16V
28	C4, C12	E-00586-0089	Cap., Disc. .1MFD 25V
29	C8, C11	E-00586-0090	Cap., Elect. 1MFD 25V
30	C6	E-00586-0063	Cap., Elect. 2MFD 25V
31	C13	E-00586-0091	Cap., Elect. 100MFD 25V
32	C17	E-00586-0092	Cap., Elect. 100MFD 100V
33	Q1 (TIP 29)	E-00585-0043	Transistor NPN
34	Q2, Q3 (2N 3904)	E-00585-0031	Transistor NPN
35	CR1, CR2 (1N 4148)	E-00587-0014	Diode
36	CR3 (1N 4004)	E-00587-0015	Diode
37	CR4 (1N 5243)	E-00598-0011	Diode, Zener
38	U1, U8 (MC 14049B)	E-00620-0033	Hex Inverter (I.C.)
39	U4, U5 (MC 14526B)	E-00620-0044	Programmable 4 Bit Counter
40	U2 (MC 14042B)	E-00620-0045	Quad. Latch
41	U7 (555)	E-00620-0004	Timer I.C.
42	U9 (LM 741)	E-00620-0047	Operational Amp.
43	U10 (LM 380N)	E-00620-0048	Audio Amplifier
44	U11 (86 L93)	E-00620-0046	4 Bit Binary
45	C20	E-00586-0064	Cap., Disc. .002
46	A8 (see note 2)	AS-2518-32	PWB Module Less Program Memory U3

NOTE 1:
When ordering specify name of game.

NOTE 2:
Order replacement memory chip U3 specifying name of game and part no. stamped on chip.

GENERAL

To select a sound, the Sound module decodes the address signals received from the MPU module via the five address lines A, B, C, D and E (J1, pins 1, 2, 3, 4, and 12). The address is read and the sound is started only if a sound interrupt is also received from the MPU. This interrupt is caused by the low to high transition of the solenoid bank select signal (J1, pin 8).

The troubleshooting procedure, outlined herein, assumes that the MPU module is functional and that the above signals are generated. In general, since four of the address lines (A, B, C and D) and the solenoid bank select are shared with the Solenoid Driver module A3, faulty operation of these signals may also result in solenoid drive problems. In this case, the Sound module should be disconnected and if the fault persists, reference should be made to the MPU and/or Solenoid Driver Troubleshooting Procedures. If the fault clears with the Sound module disconnected, the cause of the address or solenoid bank select signal degeneration should be determined and corrected at the Sound module. If that signal continuity exists between MPU and Sound module connectors. For a more complete test, AID may be used. Also, SW1 test switch on the Sound module may be used to start a test sound independent of MPU signals. This feature permits an overall check of the Sound module operation and may be used to simulate playfield switch activity. (NOTE: Early sound program versions *do not* provide this capability.)

TEST AND MEASUREMENT TECHNIQUES

Unless otherwise specified, all voltage measurements indicated on the schematic or called for in the troubleshooting procedure are made with reference to the ground test point TP3. Use of a Simpson 250 VOM, or equivalent, is assumed.

1. AC and AUDIO VOLTAGE MEASUREMENTS.

AC and audio voltage measurements require the addition of a 0.1ufd (25WVDC min.) capacitor in series with the test lead connected to the signal (+) terminal of the voltmeter. This is necessary to block any DC voltage which may be present. Failure to observe this technique will result in misleading AC readings when using Simpson 250 VOM. (Other voltmeter models may have a built-in DC blocking capacitor or provide a special terminal for measuring AC signals in presence of DC. Reference should be made to manufacturer's recommendations, if use of a voltmeter other than Simpson 250 is necessary.)

2. SOUND-IN-PROGRESS.

Some measurements indicated on the schematic, or called for in the test procedure, are to be made with or without sound in progress. When sound is heard, the term is self-explanatory. When, due to a malfunction, sound is not heard, "with sound" or "sound-in-progress" measurements should be performed under test conditions where a sound would normally be heard. (In practice there are several ways to achieve this. The game may be brought up to play and a play field switch, that should produce a sound, activated just before the measurement is to be taken. If the sound options switch is set such that no background sound is produced, both the "with" and "without" sound measurements can be readily obtained in this way. Another way is to put the game in sound self-test mode, in which case the sound interrupt triggering a test sound will occur automatically.) Similarly, measurements with no sound should be made under test conditions where no sound (including background) would normally be produced.

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-I
REPAIR LEVEL: POWER SUPPLY RELATED FAILURES

CAUSE	PROCEDURE
SYMPTOM IA: No Sound or Distorted Sound. TP2 (+5VDC) Voltage Incorrect.	
A) Open +5V Line	Measure +5 ± .25VDC at TP2. If absent, measure +5VDC at A3-TP1 of Solenoid Driver/Voltage Regulator module. If present at A3-TP1, locate and repair open between connector and TP2 on the Sound module.
B) Defective +5V Regulator Circuit	If incorrect at A3-TP1, refer to Solenoid Driver/Voltage Regulator Troubleshooting Procedures.
SYMPTOM IB: No Sound or Distorted Sound. TP1 (+11.9 ± 2.4VDC) Voltage Incorrect.	
A) Open +12V Line or Open CR1	Measure +11.9 ± 2.5VDC at TP1. If absent, measure +11.9VDC at A3-TP5 of Solenoid Driver/Voltage Regulator module. If present at A3-TP5, locate and repair open between connector and TP1 on the sound module. Check also for open CR1. If incorrect at A3-TP5, refer to Solenoid Driver/Voltage Regulator Troubleshooting Procedures.
SYMPTOM IC: Distorted Sound. TP1 (0.1VAC Max.) voltage excessively high.	
A) Open C15 or Shorted CR1	Measure 0 to 0.1 VAC at TP1. If excessively high, measure 0 to 0.5VAC at J1-10. If correct at J1-10, check for open C15 or shorted CR1 and replace if defective. Check also for open +5 unreg. return line to J1-15.
B) Open C6	If problem persists, check for open C6. Replace if defective.
C) Defective A3-C23	If AC ripple at J1-10 is excessively high, check for faulty A3-C23 filter capacitor on Solenoid Driver/Voltage Regulator module. Replace if defective.

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-II
REPAIR LEVEL: AUDIO CIRCUITRY RELATED FAILURES

CAUSE	PROCEDURE
SYMPTOM IIA: No Sound or Intermittent Sound.	
A) Defective Loudspeaker	With volume control set to maximum (RT1 all the way CW) measure 0VDC, 2 to 6VAC audio signal (with sound in progress) at J2-2. If audio is correct, check for continuity of loudspeaker connections from J2-1 and J2-2. Repair if defective, else replace loudspeaker. If audio is absent, check for shorted loudspeaker. Replace if defective.
B) Shorted or leaky C8	If voltage at J2-2 is not 0VDC, replace C8. (NOTE: With loudspeaker open or disconnected, the DC voltage will float to about +1.5VDC.)
C) Open C8	If audio is not present at J2-2, measure 2 to 6 VAC audio signal at U9-4. If correct, replace C8.

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-II
REPAIR LEVEL: AUDIO CIRCUITRY RELATED FAILURES

CAUSE	PROCEDURE
SYMPTOM IIA: No Sound or Intermittent Sound	
D) Defective U9, C5 or C7	With no sound in progress, measure +6 ± 1VDC at U9-4. If correct, check for shorted or leaky C5 or C7. If not found defective, replace U9. If (with sound in progress) audio is not present at U9-4, measure .2 ± 1VAC audio signal at U9-1. If present, replace U9.
E) Defective RT1, C5, or R6	If audio is not present at U9-1, measure 1.5 ± .5VAC at U8-4 with sound in progress. If correct, check for open RT1, C5 or R6. Replace as necessary.
F) Defective U8 and associated components	If audio is not present at U8-4, measure .35 ± 1VAC at TP6 with sound in progress. If audio is present at TP6, replace U8. Also check for defective associated components and replace as necessary. If audio is not present at TP6, refer to A8-III.
SYMPTOM IIB: Sound is present, but has muffled quality due to excessive high frequency attenuation.	
A) Shorted Q1	Check for shorted Q1 and replace if necessary.

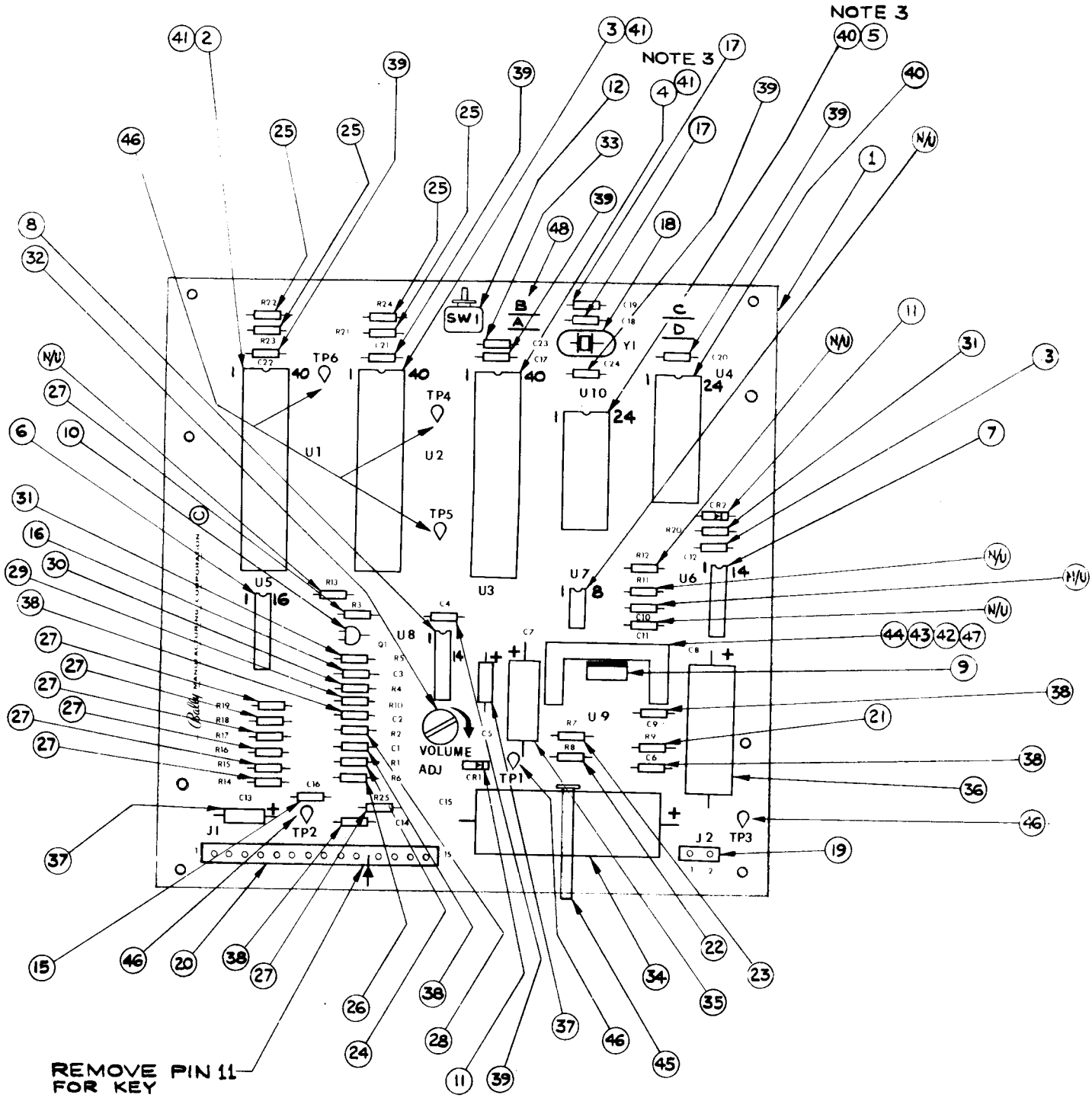
DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-III
REPAIR LEVEL: MICROPROCESSOR AND MEMORY RELATED FAILURES

CAUSE	PROCEDURE
SYMPTOM IIIA: No Sound or Abnormal Pitch	
A) Defective Y1, C18, C19, U3 or U1	Measure +2.5 ± .2VDC at TP5. If incorrect, replace U3, U1, Y1, C18 or C19 as necessary.
SYMPTOM IIIB: No Sound.	
A) Defective U6	Measure 0VDC at U6-3. Momentarily turn off game power and then turn it on again. Note that the meter kicks positive at the time the game is turned on. If incorrect, replace U6 or associated reset circuit components (C12, R20, CR2).
B) Defective U1 or U2	Measure +2.5 ± 1VDC at TP4 when sound is in progress; 0VDC with no sound. If correct, measure audio signal at TP6 (See A8II-F). If incorrect at TP6, refer to section A8II. If audio is not present at TP6, but TP4 measurements are correct, replace U1. If problem is not correctred replace U2.
C) Defective U4, U10, U3 or U6	If TP4 voltage is not 0 with no sound, momentarily turn off the game power and then turn it on again. If TP4 voltage does not go to 0 after about 8 seconds from power-on, replace U4 or U10. If the problem is not corrected or repeats, check for address/data bus shorts or opens and repair as necessary.

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-III
REPAIR LEVEL: MICROPROCESSOR AND MEMORY RELATED FAILURES

CAUSE	PROCEDURE
SYMPTOM IIIB: No Sound.	
	If none found, replace U3. Check also for defective U6 and replace if necessary.
D) Interrupt line fault	If voltage at TP4 measures 0VDC with sound in progress, measure $+3.5 \pm 0.5$VDC at U2-40 (with game in sound self-test mode). If incorrect, measure $+4 \pm 0.5$VDC at A4J4-10 of MPU module. If correct at MPU connector, repair interrupt line to J1-8 of the sound module. If incorrect at A4J4-10, check for possible short to ground. If none found, refer to MPU troubleshooting procedure.
E) Defective U2 or U3	If interrupt line checks OK, replace U2 and/or U3.

AS-2518-51 SOUND MODULE



A8: SOUND MODULE
COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART NO.	DESCRIPTION
1	A8 (see note 1)	E-3022-1	PWB Module Complete
2	U1	E-620-124	Sound Chip AY-3-8910
3	U2	E-620-29	PIA, 6820/21
4	U3	E-620-125 (E620-128)	CPU, 6808 (6802 Note 3)
5	U10	E-620-30	Ram, 6810 (Note 3)
6	U5	E-620-33	Hex Inverter 4049B
7	U6	E-620-5	Quad 2 Input 4011B
8	U8	E-620-126	Amp, LM3900
9	U9	E-620-127	Power Amp, TDA 2002
10	Q1	E-585-31	Transistor, 2N3904
11	CR1, 2	E-587-6	Diode, 1N4004
12	SW1	E-658-1	Switch
13	C12	E-586-118	Cap. .2MF ±20% Y5P, 16 V.
15	C16	E-586-83	Cap. 470 PF 50 V.
16	C3	E-586-120	Cap. 68 PF, ±20% 1K
17	C18, 19	E-586-121	Cap. 27 PF, ±20% 1K
18	Y1	E-744-5	Crystal, 3.579545 MHZ
19	J2	E-736-2	Connector, Wafer, 2 Pin KK156
20	J1	E-736-15	Connector, Wafer, 15 Pin KK156
21	R9	E-105-196	Resistor, 1 Ohm, ¼ W., 5%
22	R8	E-105-211	Resistor, 2.2 Ohm, ¼ W., 5%
23	R7	E-105-303	Resistor, 220 Ohm, ¼ W., 5%
24	R1	E-105-230	Resistor, 1 K, ¼ W., 5%
25	R21, 22, 23, 24	E-105-238	Resistor, 3.3K. Ohm, ¼ W., 5%
26	R6	E-105-239	Resistor, 4.7K., ¼ W., 5%
27	R3, 14, 15, 16, 17, 18, 19, 25	E-105-185	Resistor, 10K., ¼ W., 5%
28	R2	E-105-245	Resistor, 30K., ¼ W., 5%
29	R10	E-105-252	Resistor, 180K., ¼ W., 5%
30	R4	E-105-225	Resistor, 200K., ¼ W., 5%
31	R5, 20	E-105-285	Resistor, 1M, ¼ W., 5%
32	RT1	E-599-16	Potentiometer 1K
33	C23	E-586-122	Cap. .001 ±20% 2SF
34	C15	E-586-123	Cap. 4700 MF @ 25 V.
35	C7	E-586-124	Cap. 470 MF @ 6.3 V
36	C8	E-586-125	Cap. 220 MF @ 25 V.
37	C5, 13	E-586-90	Cap. 1 MF @ 50 V.
38	C9, 1, 14, 6, 2	E-586-89	Cap. .1 MF
39	C4, 22, 17, 21, 20, 24	E-586-85	Cap. .01 MF
40	XU10, XU4	E-712	Socket, 24 Pin
41	XU1, XU2, XU3	E-712-1	Socket, 40 Pin
42	Used with 43	LSPR-00632-1106	Bolt, 6 x 32 x ⅜
43	Used with 42	N-00632-2112	Nut, 6 x 32
44	H.S for U9	E-682-8	Heat Sink, 6030BTT
45	Used with C15	E-647-5	Ty Rap
46	TP1, 2, 3, 4, 5, 6	P-5399	Test Point
47	Use with 44, 9	M-1834	Thermal Grease
48	Jumper, B		22 AWG Wire, Solid Tinned
		W-1211c	Schematic

NOTE 1: When ordering specify name of game.

NOTE 2: Order replacement memory chip U4 specifying name of game and part no. stamped on chip.

NOTE 3: When using item 4, 6808 you must use item 5, 6810 and the "B" jumper. When item, 6802 is available delete item 5 and use "A" jumper.

SOUND/SPEECH MODULE AS-2518-61

THEORY OF OPERATION

I. SQUAWK & TALK (S & T) SELF-TEST

The S & T module has, as part of integrated circuit U5, a program designed to test the module each time power is turned on. No action is required on the operator's part to initiate the test. The program causes the μP chip to test itself (U1), the scratch pad memory (U6), each of the I/O chips (PIA's, U7 and U11), the sound generator chip (U12), and the speech generator chip (U8). If the μP chip finds all circuits in proper operating order it initializes the S & T module and makes it ready for sound effects. If the μP finds a fault during the course of Self-Test, it stops at that point in the test and does not allow game play.

The accuracy of the S & T Self-Test is about 90%. The S & T module catches all faults except D/A converters, voltage controlled amplifiers, power amplifier, speech PHROM and input interface problems.

The interesting idea behind the S & T Self-Test is that not only does it prevent sound generation when faults are detected, but like the MPU module it helps to localize these faults. The LED on the S & T module flashes once for each successfully completed test. Simply counting the number of flashes of the LED after power-up localizes the fault to the offending circuit of the module.

A) 1ST FLICKER

On Power-Up, the μP chip (U1) requires that +5±.25VDC be applied before the reset line is allowed to swing from Ø to +4.8VDC. If these conditions are met, and if the μP chip is good, the LED on the module flickers briefly. (approx. 300msecs.)

The reset circuit on the S & T module works with the +5VDC regulator VR1 to prevent the reset line from going high until the +5V supply has had time to stabilize after power on. At power on, C1 slowly charges via R1. The voltage across C1 is monitored by U15. When it reaches +1.7VDC, U15 takes the reset line high. U15 is a "Schmitt Trigger" device with a built-in hysteresis to prevent slowly changing inputs from causing multiple outputs. Diode CR1 across R1 provides a quick discharge path for C1 in the event that the +5V momentarily disappears.

If the LED stays on, the probable causes are: Faulty U5, faulty U15, leaky C1, open R1, leaky CR1, or faulty U17.

B) 1st FLASH

The μP chip (U1) next goes out to the NMOS RAM (U6). It attempts to write then read back all 256 patterns (00000000 to 11111111) in each of the 128 scratch pad RAM locations. If at any point in this test the μP fails to correctly read back a pattern that it has written, U6 is deemed defective and the μP will not allow sounds to be made. If the μ completes the 256 X 128 = 32,768 tests successfully, it flashes the LED.

If the LED fails to flash the probable causes are: Faulty U6, faulty U15, or faulty U17.

C) 2nd FLASH

The μP chip (U1) now tests the first PIA chip, U7. Each of the two PIA chips, U7 and U11 are identical and interchangeable. The test for both is identical.

To determine if each of the two PIA chips are good, the μP chip does the following:

III. POWER SUPPLIES

The S & T requires two supplies for normal operation. A +12.0VDC @ 3A unregulated voltage is required for the LED, VR1, and U18 the audio power amplifier. The regulated +5VDC for all components is derived (via VR1) from this voltage. A full wave rectified 6.3 V voltage is required for VR2. The regulated −5VDC for the speech generator chip is derived from this voltage. CR7, CR8, C37 and C38 form a voltage doubler on the input of VR2. This insured sufficient negative voltage on VR2's input to meet the −7.5V requirement even at low line voltage.

IV. AUDIO CONTROL

The Squawk & Talk audio portion is made up of three sections: A speech channel, a sound channel, and a power amplifier. Speech and sound signals are individually filtered and amplified, then combined at the power amplifier for audible output. Each channel has provisions for volume control by the μP, or by a local/remote potentiometer. The volume control mode is selected by jumpers on the board.

A) SPEECH CHANNEL

The Squawk & Talk generates speech via a LSI integrated circuit U8. Commands and speech data are passed to this chip thru the PIA U7. The speech chip uses the information it receives to control an electronic vocal tract that produces a speech signal across R14. This signal contains unwanted high frequency components that are removed in a low pass filter that follows. One-fourth of U13, C19, C20, C21, R11, R15, R16, R27 and R81 form a second order low pass filter which attenuates signals above 5kHZ at the rate of 12 db/octave. This filtered speech signal is mixed with an optional off-card audio signal and is presented to the speech voltage controlled amplifier (VCA). The output of the speech VCA is fed into the power amplifier.

B) SOUND CHANNEL

Sound effects may be generated by two different sources on the Squawk & Talk module. One method uses an LSI programmable sound generator chip, U12 that is controlled via PIA U11. Commands are passed to this device which cause it to produce tones and noise by dividing down its input clock. A wide variety of sounds can be made with minimal processor interaction, however all of the waveforms produced are square wave based. The other method of sound generation employs a bus-compatible digital to analog converter, U10, driven by the μP. The μP actually constructs waveforms by controlling the DAC. This technique is used for generating sinusoidal type sound effects.

The output of the PSG, U12, is developed across R36. The harsh square waves are softened by a low pass filter before being mixed with the output of the DAC. One-fourth of U13, C31, C32, C35, R33, R37, R38, R50, R51, R52 and Q2 form second order low pass filter which attenuates signals above 3.5kHZ at the rate of 12db/octave. Transistor Q2, when switched on, via PIA U11, decreases the filter's cutoff point to about 200HZ. This feature is used for very low frequency sounds. After the output of the DAC is attenuated or amplified by the sound voltage controlled amplifier (VCA) it is mixed with the speech and then power amplified.

1) It tests each of the two full byte port initialization registers in a manner similar to that of U6.

2) It tests each of the two full byte I/O registers, PA$\emptyset$-PA7, PB$\emptyset$-PB7, in a similar manner to U6.

3) It then tests the CA2 and CB2 ports. The ports are initialized as outputs. The port is then written into to see if it can store a '1' and then a '0'. When both ports are found good, the µP flashes the LED.

D) 3rd FLASH

The µP chip (U1) performs the same tests for U11 as it did for U7. It then flashes the LED.

E) 4th FLASH

The µP chip (U1) performs a test similar to the test for U6 on the sound generator chip, U12. U12 is controlled through PIA, U11. If the sound chip passes all tests then the µP flashes the LED.

F) 5th FLASH

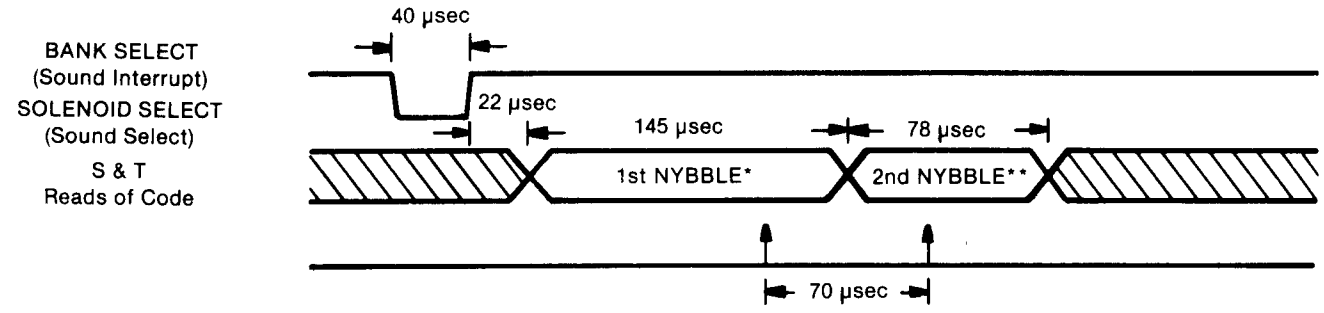
The speech generator chip (U8) requires an initialization sequence on power-up. Since the speech chip is a 'slow' device, there is an acknowledgement signal from the speech chip to the µP (via PIA U7). Every time a write to the speech chip is performed, the speech chip responds with an acknowledgement. The µP attempts to send 9 bytes of initialization data to the speech chip, one at a time, waiting for the acknowledgement for each byte. If it is successful in doing this, the speech chip is deemed functional and the µP flashes the LED.

G) SQUAWK & TALK INITIALIZATION

The µP (U1) now initializes the two PIA's (U7 and U11) and waits for an interrupt.

II. NORMAL OPERATION

The S & T accepts address signals from the MPU to select one of the sound or speech signals stored in its memory. It then plays the request by controlling the sound generator chip (U12) or D/A converter (U10) for sounds, or the speech generator chip (U8) for speech. The S & T is notified of a sound/speech request by an interrupt from the MPU. This interrupt is generated by toggling the solenoid bank select signal on the MPU which is the sound interrupt input to the S & T. The code number of the sound/speech required is passed as two half-bytes (nybbles) over the MPU solenoid select lines which are the sound select inputs to the S & T. The current timing for this process is shown below.



*Least significant 4-bits
**Most significant 4-bits

Invalid code numbers are ignored by the S & T.

C) SPEECH & SOUND VCA CIRCUITS

By employing a voltage controlled amplifier in each channel, the Squawk & Talk provides a large degree of gain control flexibility. Each VCA either attenuates or amplifies its signal according to the control voltage it is supplied with. Provisions have been made for this control voltage to be supplied from three sources for each channel. Potentiometers R69 and R70 provide a conventional, local volume control. If a remote volume capability is desired, removing R69, R70 and connecting two 1K pots in a similar fashion via J2 allows dual channel control with a three wire link without using shielded cable. Finally, by re-jumpering the S & T either VCA's control voltage may be supplied by the computer.

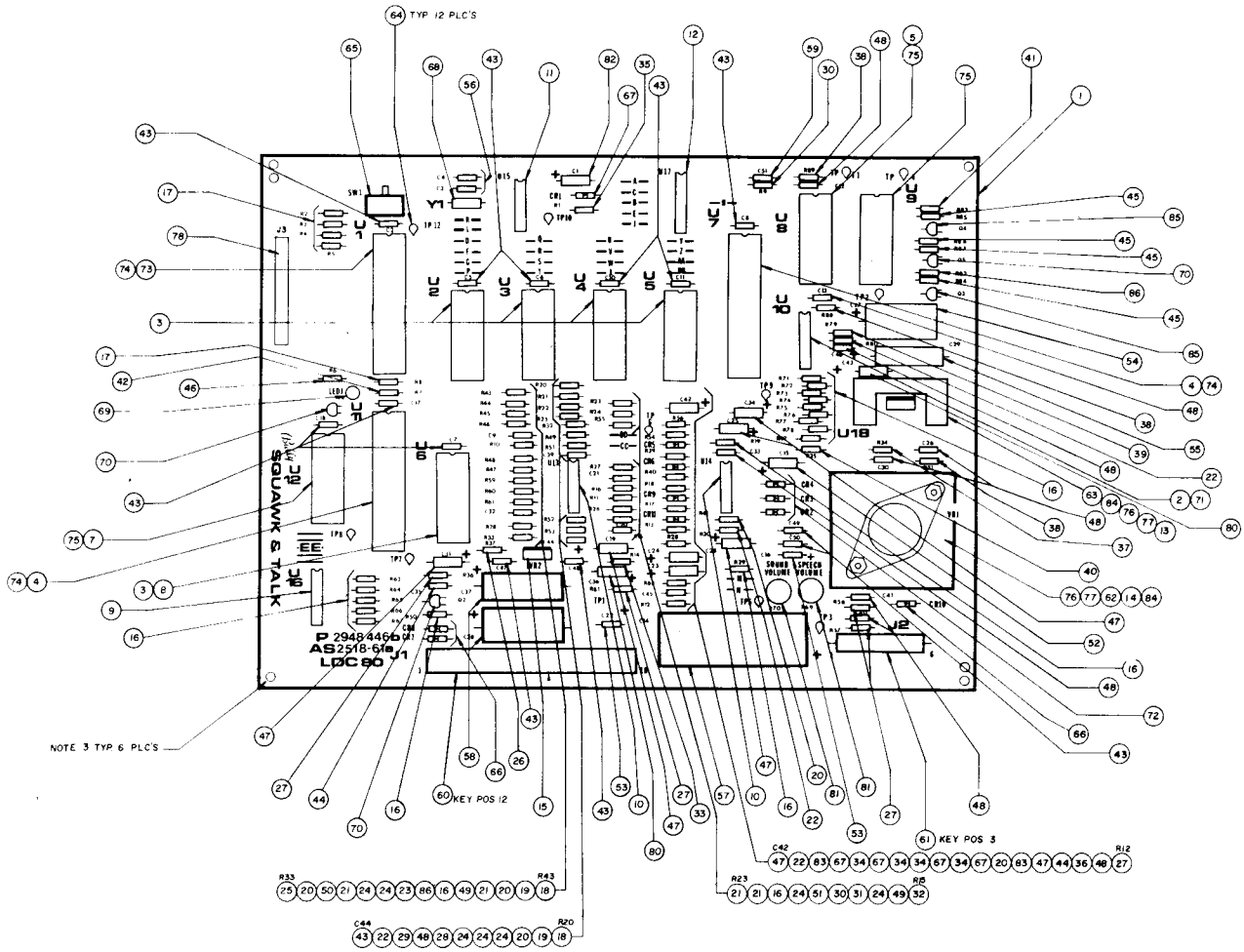
Two accounting meters maintained in the MPU and accessible through the accounting/self-test functions are sent to the S & T every power-up. The μP on the S & T uses this information to initialize a 4-bit DAC for each channel which provides that channel's VCA control voltage. Thus the volume may be remotely controlled without running any wires.

The speech channel VCA consists of one-fourth of U14, C28, R13, R17, R18, R19, R28, R29, R30, CR9 and CR11. The sound channel VCA consists of one-fourth of U14, C42, R39, R40, R41, R54, R56, CR5 and CR6. Varying the cathode voltage on CR5 or CR11 changes the diode's small signal resistance. This resistance works with the input resistors R28 or R54 as a voltage divider to vary the amount of signal input to the op-amp for a control voltage range of 2.2 ⟷ 4.3VDC, the VCA's gain varies from −36 ⟷ +4db.

D) POWER AMPLIFIER

Device U18 is an 8 watt I.C. power amplifier. It accepts audio signals from the speech and sound channels and amplifies them to an audible level suitable for an arcade. Network C29, R31 and R34 form a feedback circuit that sets the gain of the amplifier to 40db. C27 couples the signal to the speaker while blocking the D.C. component, and C30 and R35 from a high frequency shunt to prevent the amplifier from oscillating.

SQUAWK & TALK MODULE
AS 2518-61A



ITEM	QTY.	REFERENCE DESIGNATION	DESCRIPTION	BALLY PART #
1	1	PWB	M-645-577b	P-2948-446b
2	1	U10	AD 558 DAC	E-620-171
3	5	Used with U2 thru U6	24 Pin I.C. Socket	E-712
4	2	U7, U11	6821 P.I.A.	E-620-29
5	1	U8	Tms 5200 Speech	E-620-167
7	1	U12	AY3-8912 Sound	E-620-166
8	1	U6	6810 RAM (SEE NOTE 1)	E-620-30
9	1	U16	4049 Hex Inverter	E-620-33
10	2	U13, U14	LM 3900	E-620-126
11	1	U15	74LS14 Schmidt Inverter	E-620-169
12	1	U17	74LS155	E-620-168
13	1	U18	TDA 2002 Power Amp	E-620-127
14	1	VR1	LM323, 5V Regulator	E-710
15	1	VR2	7905, -5V Regulator	E-620-165
16	19	R10, 19, 29, 42, 50, 63-67, 71-78, 55	Resistor, ¼W, 10K	E-105-185
17	5	R2-5,8	Resistor, ¼W, 5%, 3.3K	E-105-238
18	2	R20, 43	Resistor, ¼W, 5%, 820K	E-105-343
19	2	R21, 44	Resistor, ¼W, 5%, 390K	E-105-310
20	5	R13, 22, 38, 41, 45	Resistor, ¼W, 200K	E-105-225
21	4	R23, 24, 46, 61	Resistor, ¼W, 5% 100K	E-105-226
22	4	R30, 53, 56, 80	Resistor, ¼W, 5% 2K	E-105-237
23	1	R47	Resistor, ¼W, 5%, 2.7K	E-105-151
24	7	R25, 26, 27, 32, 49, 59, 60	Resistor, ¼W, 5% 1m	E-105-285
25	1	R33	Resistor, ¼W, 5%, 91K	E-105-313

SQUAWK & TALK MODULE
AS 2518-61A

COMPONENTS PARTS LIST

ITEM	QTY.	REFERENCE DESIGNATION	DESCRIPTION	BALLY PART #
26	1	R37	Resistor, ¼W, 5%,30K	E-105-245
27	5	R12, 36, 57, 58, 81	Resistor, ¼W, 5%, 1K	E-105-230
28	1	R51	Resistor, ¼W, 5%, 750K	E-105-344
29	1	R52	Resistor, ¼W, 5%, 9.1K	E-105-228
30	2	R9, 16	Resistor, ¼W, 5%, 130K	E-105-203
31	1	R11	Resistor, ¼W, 5%, 150K	E-105-248
32	1	R15	Resistor, ¼W, 5%, 220K	E-105-161
33	1	R14	Resistor, ¼W, 5%, 1.8K	E-105-346
34	4	R17, 18, 39, 40	Resistor, ¼W, 5%, 910K	E-105-347
35	1	R1	Resistor, ¼W, 5%, 27K	E-105-243
36	1	R68	Resistor, ¼W, 5%, 510 Ω	E-105-311
37	1	R34	Resistor, ¼W, 5%, 2.2 Ω	E-105-211
38	3	R31, 88, 89	Resistor, ¼W, 5%, 220 Ω	E-105-303
39	1	R79	Resistor, ¼W, 5%, 7.5K	E-105-345
40	1	R35	Resistor, ¼W, 5%, 1 Ω	E-105-196
41	1	R83	Resistor, ¼W, 5%, 11K	E-105-360
42	1	R7	Resistor, ¼W, 5%, 8.2K	E-105-223
43	14	C2, 5-8, 10, 11, 17, 18, 44, 47-50	Capacitor, Ceramic, .01μF, 25V	E-586-85
44	2	C23, 35	Capacitor, Ceramic, .47μF, 16V	E-586-130
45	4	R84-87	Resistor, ¼W, 5%, 2.2K	E-105-287
46	1	R6	Resistor, ¼W, 470Ω	E-105-342
47	7	C19, 24, 25, 28, 31, 34, 42	Capacitor, Electrolytic, 1μF, 25V	E-586-90
48	10	C12, 13, 26, 30, 33, 39, 40, 41, 45, 46	Capacitor, Ceramic, .1μF, 25V	E-586-89
49	2	C9, 20	Capacitor, Ceramic, 470pF, 50V	E-586-83
50	1	C32	Capacitor, Ceramic, 68pF	E-586-120
51	1	C21	Capacitor, Ceramic, 100pF	E-586-68
52	1	C15	Capacitor, Electrolytic, 10μF, 16V	E-586-135
53	2	C16, 22	Capacitor, Tantalum, 4.7μF, 25V	E-586-73
54	1	C27	Capacitor, Electrolytic, 1000μF, 16V	E-586-136
55	1	C29	Capacitor, Electrolytic, 470μF, 6V	E-586-124
56	2	C3, 4	Capacitor, Ceramic, 27pF	E-586-121
57	1	C14	Capacitor, Electrolytic, 4700μF, 25V	E-586-123
58	2	C37, 38	Capacitor, Electrolytic, 330μF, 50V	E-586-147
59	1	C51	Capacitor, Monolythic, 10pF	E-586-150
60	1	J1	18 Pin Wafer Connector (156)	E-736-18
61	1	J2	6 Pin Wafer Connector (156)	E-736-6
62	1	Used with VR1	Heatsink, 6053B	E-682-11
63	1	Used with U18	Heatsink, 6030B	E-682-8
64	12		Test Points	P-5399
65	1	SW. 1	P.C.B. Switch	E-658-1
66	3	CR7, 8, 10	Diode (IN4004)	E-587-15
67	5	CR1, 5, 6, 9, 11	Diode (IN4148)	E-587-14
68	1	Y1	Crystal, 3.579	E-744-5
69	1	LED1	LED	E-679
70	3	Q1-2, 5	Transistor, 2N3904	E-585-31
71	1	Used with U10	Socket I.C. 16 Pin	E-712-16
72	3	CR2-4	Diode, VR332	E-587-22
73	1	U1	6808 or 6802 (SEE NOTE 1) Microprocessor	E-620-125 or 128
74	3	Used with U1, 7, 11	Socket, I.C. 40 Pin	E-712-1
75	3	Used with U8, 9, 12	Socket, I.C. 28 Pin	E-712-28
76	3	Used with U18, VR1	Screw	LSPR-00632-1106
77	3	Used with U18, VR1	Nut	N-00632-2112
78	2	J3	Header, 20 Pin	E-766-20
80	2	C36, 43	Capacitor, 2μF, 16V	E-586-63
81	2	R69, 70	Pot. 1K	E-599-16
82	1	C1	Capacitor, Electrolytic, 47μF	E-586-148
83	2	R28, 54	Resistor, 82K	E-105-341
84	AR	Used with U18, VR1	Thermal Compound	M-1834
85	2	Q3, 4	Transistor, 2N4403	E-585-23
86	2	R82, 48	Resistor, ¼W, 5%, 2.4K	E-105-312
			JUMPERS—SEE NOTES	

THEORY OF OPERATION
FOR
"SAY IT AGAIN" (AS-2518-81) MODULE

The "SAY IT AGAIN" echo module performs the function of simulating a large reverberant environment in which the sounds are repeatedly reflected from one side to another, resulting in distinct audible echos. This is accomplished by the use of an analog delay line, which delays the audio signal by an amount which is proportional to a clocking signal frequency. Part of the delayed signal is fed back and mixed with the incoming signal to obtain multiple echos. The amount of the signal fed back, and therefore the number of echo repeats, is controlled by the setting of R29 (Regeneration Control). With this control set in the OFF position (fully counterclockwise), none of the delayed signal is fed back, so the original signal and one repeat is heard. As the regeneration is increased, more and more repeats will be heard until at maximum, about 10 or more repeats, can be heard depending on the strength of the incoming signal.

The "SAY IT AGAIN" module itself is comprised of 4 basic blocks which are (1) an input filter, (2) the analog delay line, (3) the output filter, and (4) the clock. First, the input filter is required to remove signal frequency components which would cause distortion in the unit. The device operates on a sampled data principle, necessitating the removal of frequencies which are greater than one-half the sampling (clock) frequency. This is accomplished by the use of a 4th order Butterworth active filter. After filtering, the input signal is applied to the analog delay line which is a 4096 stage bucket brigade analog shift register. At each clock transistion, a sample of the audio signal is transferred from one state (or bucket) to the next. At the end, the samples are smoothed to form the original signal again, except that is delayed by an amount which depends on the clock frequency. The output filter performs the smoothing function and filters out the clock frequency, and it is identical to the input filter. The clock is a CMOS oscillator with additional logic circuitry to obtain a two-phase signal which does not overlap while in the high state.

Other parts of the "SAY IT AGAIN" module include a bias control network which is required because the analog delay line must have a certain DC voltage upon which the audio signal rides in order to function properly. The unit-to-unit variation is such that it must be trimmed for each particular unit (See "SAY IT AGAIN" SET UP PROCEDURE). If this control is out of adjustment, the delayed sound will be distorted, and if it is badly misadjusted there will be no sound through the delay line at all, so it is recommended that once properly adjusted, the bias control be left alone.

Also contained in the "SAY IT AGAIN" unit is a power-up squelch which simply shuts off the delayed signal when power is first applied until the clock oscillator has time to stabilize. There is also an ON/OFF input so that the unit can be turned ON or shut OFF by means of an external signal.

SET UP PROCEDURE
FOR
"SAY IT AGAIN" (AS-2518-81) MODULE

Two adjustments are required to establish proper operating conditions for the echo unit. First is the Bias Adjustment which is required to minimize distortion and maximize the signal to noise ratio. The second is the Regeneration Adjustment which sets the number of times the echo will repeat.

To make the Bias Adjustment begin by turning the Speaker Volume Control OFF (fully counterclockwise) or disconnect the leads to the speaker. This is necessary because a loud tone is used for the Bias Set Up and this tone will be very annoying to listen to. Second, turn the Regeneration Control (R29) OFF (fully counterclockwise), to prevent the regenerated signal from affecting the Bias set up. Then connect a jumper wire between TP1 and TP2 and another jumper wire between TP3 and TP4. Using a voltmeter, with the common lead at TP1 (ground), measure the A.C. voltage at TP5. Adjust the Bias Control (R15) until this reading is maximum. It should be about .5VAC, but this will vary from unit to unit. The important thing is to obtain a maximum reading.

To make the regeneration adjustment, disconnect the jumpers and the voltmeter and turn the speaker volume control to a listenable level, or reconnect the speaker leads. Press the Squawk and Talk Test Switch and adjust the Regeneration Control (R29) until the desired number of echo repeats is heard. Usually this would be about 5 to 10 repeats, but it is a subjective matter and should be adjusted to where it sounds best.

TROUBLESHOOTING FOR "SAY IT AGAIN" (AS-2518-81) MODULE WHEN OSCILLOSCOPE IS AVAILABLE

To troubleshoot the "SAY IT AGAIN" module, begin by identifying the symptom and following the Field Troubleshooting Procedures outlined for that symptom. If the symptom is "Sound but no echo", follow the set up procedure for the Bias Adjustment (R15) since misadjustment is the most likely cause. If, after following the set up procedure, it is found that no setting of the Bias resistor (R15) produces a reading at TP5, then most likely an I.C. is at fault. In order to determine which I.C. is at fault, an oscilloscope is required.

Start by turning the Speaker Volume Control down (fully counterclockwise) or disconnect the speaker leads, then turn the Regeneration Control (R29) down (fully counterclockwise). Then connect a jumper wire between TP1 and TP2 and another jumper wire between TP3 and TP4 as in the "SAY IT AGAIN" SET UP PROCEDURE. This will send a test signal through the board. Verify this by observing with the oscilloscope (TP1 is ground), a filtered square wave approximately 200 to 250 Hz at about 1 V peak to peak at TP6. If this is not present, the fault is U1 or an associated component, which can be determined by tracing back from TP6 to U1, Pin 9, then U1, Pin 5 to U1, Pin 4 with the oscilloscope to see where and if the test signal appears. If the signal is not present, conclude that U1 is bad. If it does appear at one of these points, then the faulty stage has been isolated, and measurements can be taken to determine the component which is at fault.

If the test signal is present at TP6, then check for the test signal at TP5. Adjust the Bias Control (R15) until the test signal appears at TP5. Then adjust R15 until the signal at TP5 is maximum and most closely resembles the appearance of the signal at TP6, then check for the same signal at TP13 (plus about 4V to 8VDC offset). If the test signal appears at TP13, but not at TP5, then check for 10V to 12VDC at TP11. If this voltage is at TP11, conclude U4 is bad. If not, check U4, Pin 12 for 0-2 VDC. If higher, either J1-3 is shorted to ground or Q3 is bad. If TP11 is not at 10 to 12VDC and U4, Pin 12 is at 0 to 2 VDC, check for 0 to 2 VDC at U4, Pin 6. If present, conclude U4 is bad. If higher, check for 10 to 12VDC at U4, Pin 5. If present, U4 is bad. If lower, C30, D2, R53 or R55 is bad.

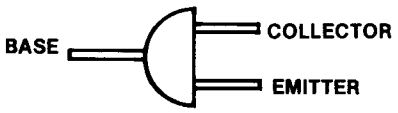
If no setting of the Bias Control (R15) produces a signal at TP13, check for a square wave clock about 9 to 10Khz, at 10 to 12V peak to peak at TP7 and TP8. If clock signal is present at TP7 and TP8, conclude U2, Q1 or Q2 is bad. Most likely U2. If clock is not present, check for same clock signal at TP9. If not at TP9, U5 is probably at fault. If clock is at TP9, look for it at TP10. If not at TP10, conclude U7 is bad. If clock signal is at TP10, conclude U6 is bad.

FIELD TROUBLESHOOTING PROCEDURE
FOR
"SAY IT AGAIN" (AS-2518-81) MODULE

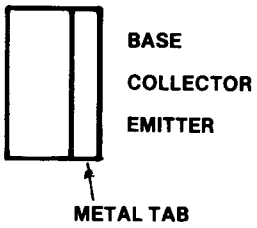
SYMPTOM	PROBABLE CAUSE	ACTION
SYMPTOM IIA: LED flickers briefly on Power-up. (Cont'd.)		
I. No Sound of any kind.	1. Cables, Connectors.	Check wiring.
	2. Power supply bad.	With common lead at TP1 (GND) measure +12VDC at TP12.
	3. U3 bad.	With common lead at TP1 (GND) measure +4 to +8VDC at TP13.
	4. Squawk & Talk bad.	Refer to Squawk & Talk troubleshooting procedures.
II. Sound but no echo.	1. Bias (R15) misadjusted.	Refer to "SAY IT AGAIN" SET UP PROCEDURES.
	2. I.C. bad (U1, U2, U4-U7).	Replace module or refer to SAY IT AGAIN" Oscilloscope Troubleshooting Procedures.
III. Too few echo repeats.	1. Regeneration (R29) misadjusted.	Refer to "SAY IT AGAIN" SET UP PROCEDURES.
IV. Too many echo repeats.	1. Regeneration (R29) misadjusted.	Refer to "SAY IT AGAIN" SET UP PROCEDURES.
	2. Bias (R15) misadjusted.	Refer to "SAY IT AGAIN" SET UP PROCEDURES.
V. Echo badly distorted.	1. Bias (R15) misadjusted.	Refer to "SAY IT AGAIN" SET UP PROCEDURES.

TRANSISTOR LEAD CONNECTIONS

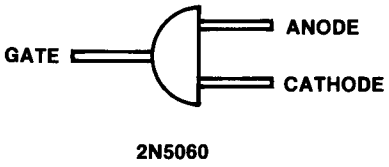
MPU MODULE { 2N3904 (NPN) / 2N4403 (PNP)
DISPLAY DRIVER { 2N5401 (PNP) / MPS-A42 (NPN)



SOLENOID DRIVER { SE9302 (NPN)



SILICON-CONTROLLED RECTIFIER LEAD CONNECTIONS
LAMP DRIVER MODULE



2N5060

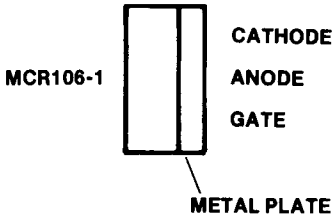


FIGURE IV SEMICONDUCTOR LEAD CONNECTIONS

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
503	MPU Module, A4 (Does not include Memory Chips U1-U6)
518	Sound PCB (Does not include Memory Chips)