Bally®

STANDARDIZED TEST PROCEDURES FOR BALLY'S HOME PINBALL GAMES

MANUFACTURED BY
BALLY MANUFACTURING CORPORATION • CONSUMER PRODUCTS DIVISION
10750 W. GRAND AVE. • FRANKLIN PK., ILL. 60131
(312) 451-1360
CABLE ADDRESS: MIDCO • TELEX NO. 72-1596

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CONTENTS

INTRODUCTION and ASSUMPTIONS

This manual has been developed to help the operator to trouble-shoot and fix Bally's new home model pinball games.

To facilitate the reader, this manual is divided into four parts. Part I, The Outside World, deals with the integrated circuits and discrete components used in the system. Part II, The Inside World, deals with the large scale integrated chips like the Central Processing Unit (CPU) and the Program Storage Unit (PSU). Part III, Other Possible Problems, encompasses the whole logic board. And Part IV, General Maintenance deals with the switch and other adjustments, lamp replacements of the entire game.

Assumptions

1. It is assumed in this manual that the logic board was once working well and has gone bad during use. That is, there are no shorts on the board.
2. It is assumed that the operator has a good power supply and all necessary parts available.
3. It is also assumed that the operator has access to a 15 MHz oscilloscope and all the necessary tools required for repairing the board.

THE DIAGNOSTIC TEST

The games have a special feature incorporated in them. This is the Diagnostic Test. It is strongly believed that this test could be effectively utilized to identify a good logic board and game, and help focus the problem area on an improperly functioning game.

The test is started by switching the "Diagnostic" switch on the logic board to "TEST" position. It will test the logic, the program, the drivers, the score display, the switches, the solenoids, and the lamps.

The diagnostic and sequence is as follows: (606-1000): (614-1000) (614-3000)

1. Logic and Program Test—When correct, it will display 600[illegible] on the score display. When wrong, the score display will show jibberish or be "OFF."

2. The Score Display and Drivers, the Switches and Drivers—It will go through a scanning sequence from 000000 to 999999.

   A. When a segment driver (lamp buffer) fails, the same segment in all digits will be permanently "OFF" or "ON."

   B. When a digit driver fails, that digit will be permanently "OFF" or "ON."

   C. When the score display fails, only one (or more) unrelated segments will be permanently "OFF."

   D. When a switch is "stuck," or a driver fails, it is shown in code on the score display when the test is finished. (See Table I for a cross reference of these codes.)

3. The solenoids and drivers are activated in the following sequence:

   A. Ball Return

   B. Left Slingshot

   C. Right Slingshot*

   D. Left Thumper-Bumper

   E. Right Thumper-Bumper

* On 0614-01000, the Right Slingshot is omitted.

614-2000:

(**NOTE:** 50k/100k Free Ball Switch must be in 100k position.)

1. Logic and Program Test: When the program is correct, it will display 600d on the score display at the beginning of the test. If the program is wrong, the score display will show jibberish or be off.
2. The score display and it's drivers, the switches and their drivers;
   A. The score display will go through a scanning sequence from 000000-999999.
   B. When a segment driver (lamp buffer) fails, the same segment in all digits will be either permanently "OFF" or "ON."
   C. When a digit driver fails that digit will be permanently "OFF" or "ON".
   D. When the score display itself fails, one or more unrelated segments will be permanently "OFF".
   E. With the 50K/100K switch in the 100K position 000000 will be shown on the score display. A "stuck" switch will not be indicated unless it was stuck prior to the test being started. (See Table 1 for a cross reference of "stuck" switch codes.)
   F. With the 50K/100K switch in the 100K position, the diagnostic test will continue until the test/play switch is moved into the play position.
   G. During the diagnostic test, the lights on the game will alternate in (2) groups as listed below:

      GROUP 1

      P-1, P-2, B-1, B-2, L-1, L-2, L-4, L-5, L-10, L-11, L-14, L-15, L-16, L-17, L-18*, L-22.

      GROUP 2

      P-3, P-4, B-3, B-4, B-5, L-3, L-6, L-7, L-8, L-9, L-12, L-13, L-18*, L-19, L-20, L-21 and game over.

* L-18 illuminated in both groups.

3. The solenoids and their respective drivers are activated in the following sequence:
   A. Ball Return
   B. Left Slingshot
   C. Right Slingshot
   D. Left Thumper Bumper
   E. Right Thumper Bumper

TABLE I

Cross-Reference for 'Stuck' Switches

READ OUT ON DISPLAY

LOCATION ON DISPLAY	1	2	4	8	3	5	6	7	9	⊏	⊐	⊔	⊏̲	Ŀ	6̸
1	S20	TILT	S11	S22	S20 TILT	S20 S11	TILT S11	S20 TILT S11	S20 S22	TILT S22	S20 TILT S22	S11 S22	S20 S11 S22	TILT S11 S22	S20 TILT S11 S22
10	S1	START	S6	S14 or S15	S1 START	S1 S6	START S6	S1 START S6	S1 S14 or S15	START S14 or S15	S1 START S14 or S15	S6 S14 or S15	S1 S6 S14 or S15	START S6 S14 or S15	S1 START S6 S14 or S15
100	S2	S7	S12	S21	S2 S7	S2 S12	S7 S12	S2 S7 S12	S2 S21	S7 S21	S2 S7 S21	S12 S21	S2 S12 S21	S7 S12 S21	S2 S7 S12 S21
1K	S3	S8	S10	S18	S3 S8	S3 S10	S8 S10	S3 S8 S10	S3 S18	S8 S18	S3 S8 S18	S10 S18	S3 S10 S18	S8 S10 S18	S3 S8 S10 S18
10K	S4	50K	S9	S16 or S17	X	S4 S9	X	X	S4 S16 or S17	X	X	S9 S16 or S17	S4 S9 S16 or S17	X	X
100K	S5	X	S13	S19	X	S5 S13	X	X	S5 S19	X	X	S13 S19	S5 S13 S19	X	X

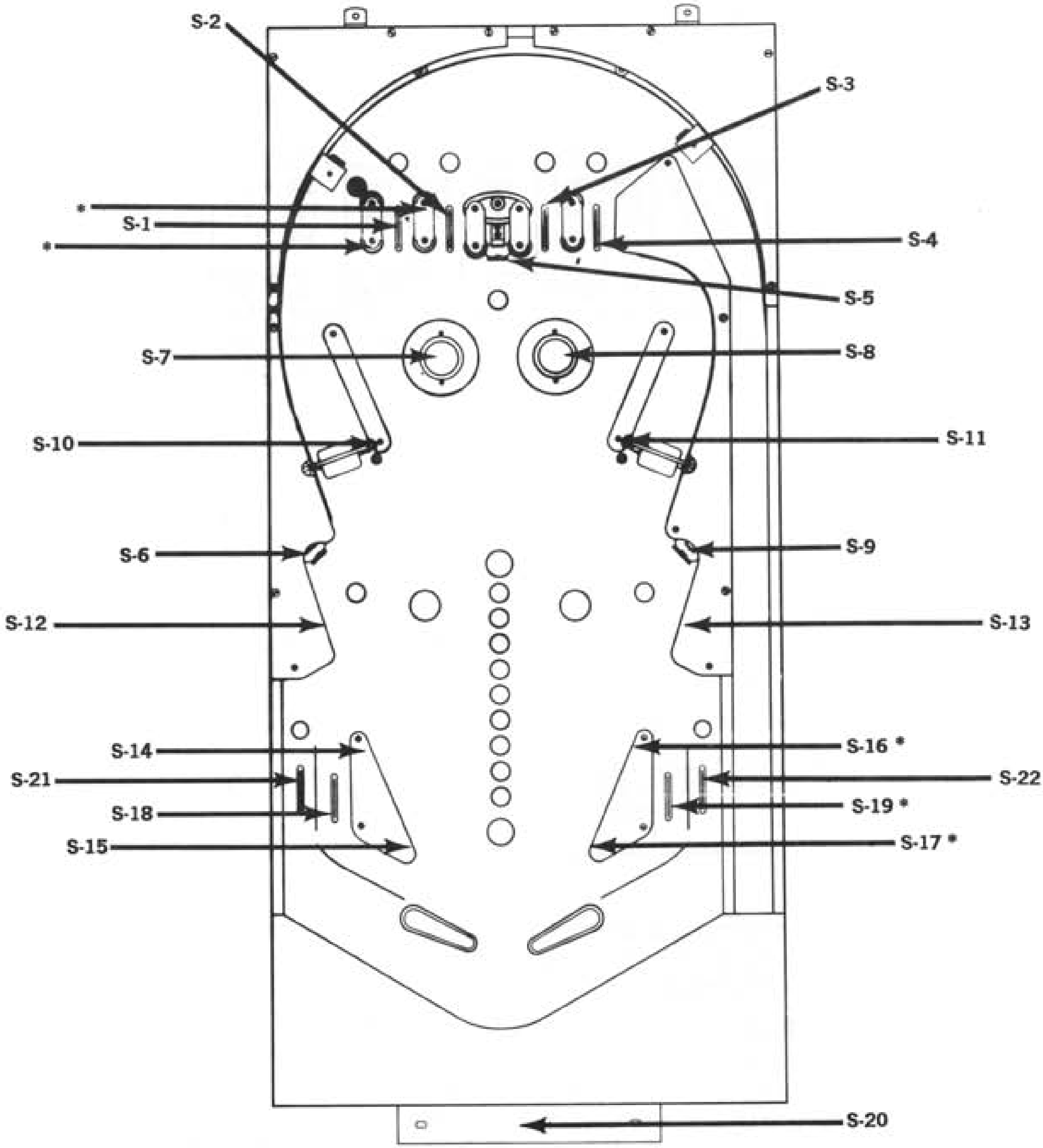
Any other number indicates that there is more than one 'stuck' switch. In this case, the displayed number is the sum of these switches. Examples:

DISPLAY	SWITCHES
0 0 0 0 1 1	S-20 and S-1
0 4 0 0 0 5	S-11 and S-20 and S-9
⊔ 0 0 0 0 1	S-20 and S-13 and S-19
0 0 ⊏ 0 ⊔ 0	S-6 and (S-14 or S-15) and S-8 and S-18

4. One light out during the test indicates bulb failure. Four or eight lights off indicates driver failure.

   For a further discussion on these failures and solutions, refer to the relevant section of this manual.

PLAYFIELD SWITCH LOCATIONS



(1) Rollover Switches (8)
S1, S2, S3, S4, S18, S19, S21, S22
(2) Sling Shot And Side Rubber Switches (6)
S12, S13, S14, S15, S16, S17
(3) Target Switches (3)
S5, S6, S9
(4) Thumper Bumper Switches (2)
S7, S8
(5) Ball Return Switch (1)
S20
(6) Spinner Target Switches (2)
S10, S11

* Not present in Model #614-1000.

PART I

THE OUTSIDE WORLD

The Score Display Section

The game score is displayed using an array of LEDs mounted in one package, the Litronix DL-6830. If the numerals on the display miss some segments, it could be either due to a bad display itself, or wrong information being fed into it.

The display can be viewed as a 7 x 6 matrix. The 7 corresponding to the 7 outputs of the BCD to Decimal decoders (IC 7448) and the 6 corresponding to the 6 display drivers (D1 through D6). If one or more of the numerals are completely blanked out, then the corresponding driver transistor (TIP 115) could be suspected and should be replaced if found defective. A typical display driver output is shown in Figure #1A. If one particular segment of the display is missing on all the numerals (e.g. Segment "a"), then that line should be followed backwards to isolate the problem.

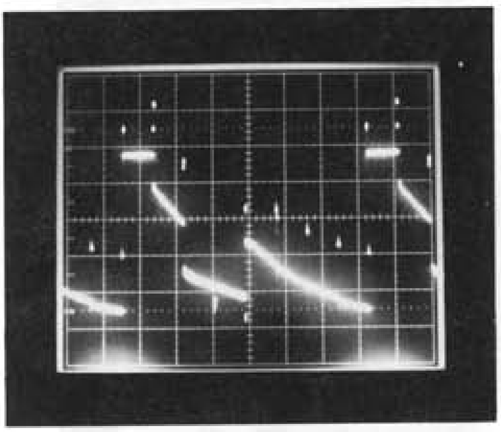
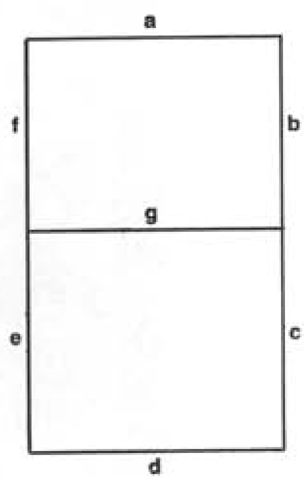


Figure #1A — Typical display driver output
Horz: 2ms/div.
Vert: 1v/div.



CAUTION: Do not try to ground the outputs of the lamp buffer (FSC 9667) to determine if the display is good or bad, as this could permanently damage the display.

The best way to check for a good display, if it cannot be determined by the Diagnostic Test, is to cut Pin 3 (lamp test) on the decoder (IC 7448) and ground it. This should light up all the segments of the display. If one or more segments blank out on some numerals while being lit on others, then the display is bad and should be replaced. If all the numerals miss the same segment, then that line should be followed backwards to isolate the problem. This could happen due to a bad lamp buffer (FSC 9667) or a broken 18 Ohm resistor. In some instances, the decoder (IC 7448) could also cause such problems, but it is usually not so.

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This display can be viewed also as a 7x6 matrix, the 7 corresponding to the 7 outputs of the CPU to the decimal decoder, ULN 2003B, and the 6 corresponding to the outputs of the Q drivers in the ULN 2073B's. Each of the ULN 2074B's drive 3 numerals each. If any of the numerals are missing, the output of the respective ULN 2074B should be checked. A typical output is shown in figure #1B. If one particular segment of the display is missing on all the numerals (e.g.; segment "A"), then that line should be followed backwards to isolate the problem. This could happen due to a bad ULN 2003B or one or more broken 47 Ohm resistors. In some instances the CPU could also cause such problems, but it is not usually so.

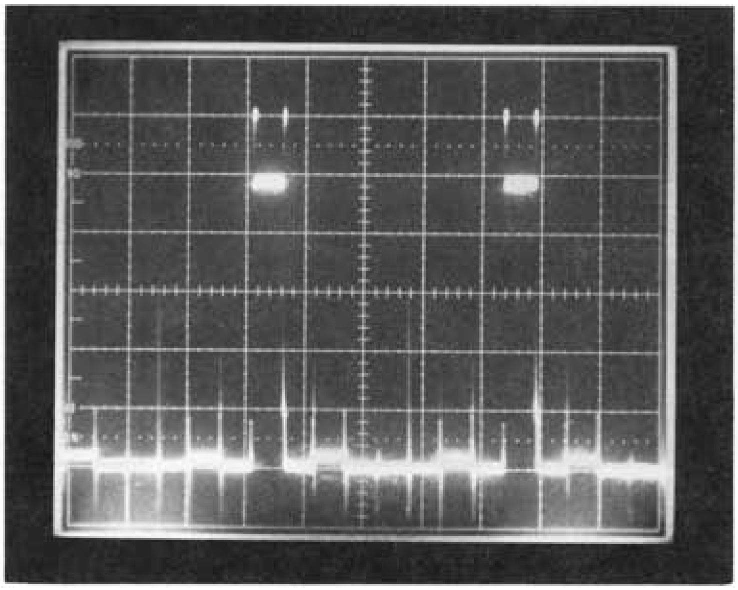


Figure #1B — Typical Q driver output
Horz: 2ms/div.
Vert: 1v/div.

The Matrix Section

All the lights (except the tilt light and the 5.25V AC lights) and all the switches located on the logic board and upper and lower playfields, can be included in this section.

The lights form an 8 x 4 Matrix comprised of 8 Multiplex (MX) lines and 4 Light (LT) lines. The switches can similarly be viewed as a 6 x 4 Matrix comprised of 6 Multiplex (MX) lines and 4 Switch (SW) lines. The MX lines are driven by the A drivers (TIP 115), the LT lines are driven by the B drivers (TIP 110), and the SW lines feed into the optical isolators (ILD 74).

614-2000: The MX lines are driven by the M drivers (TIP 125) and the LT lines are driven by the L drivers (TIP 110). The SW lines are fed into the CPU.

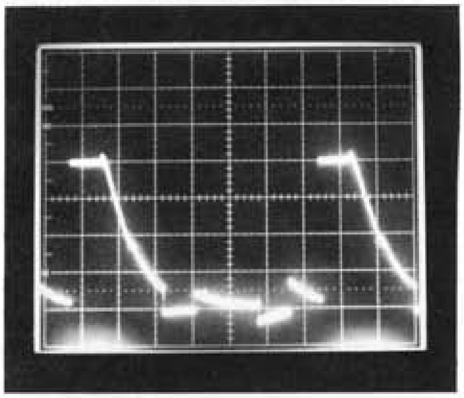


Figure #1C—
Typical "A + M" driver output
Horz: 2ms/div.
Vert: 5v/div.

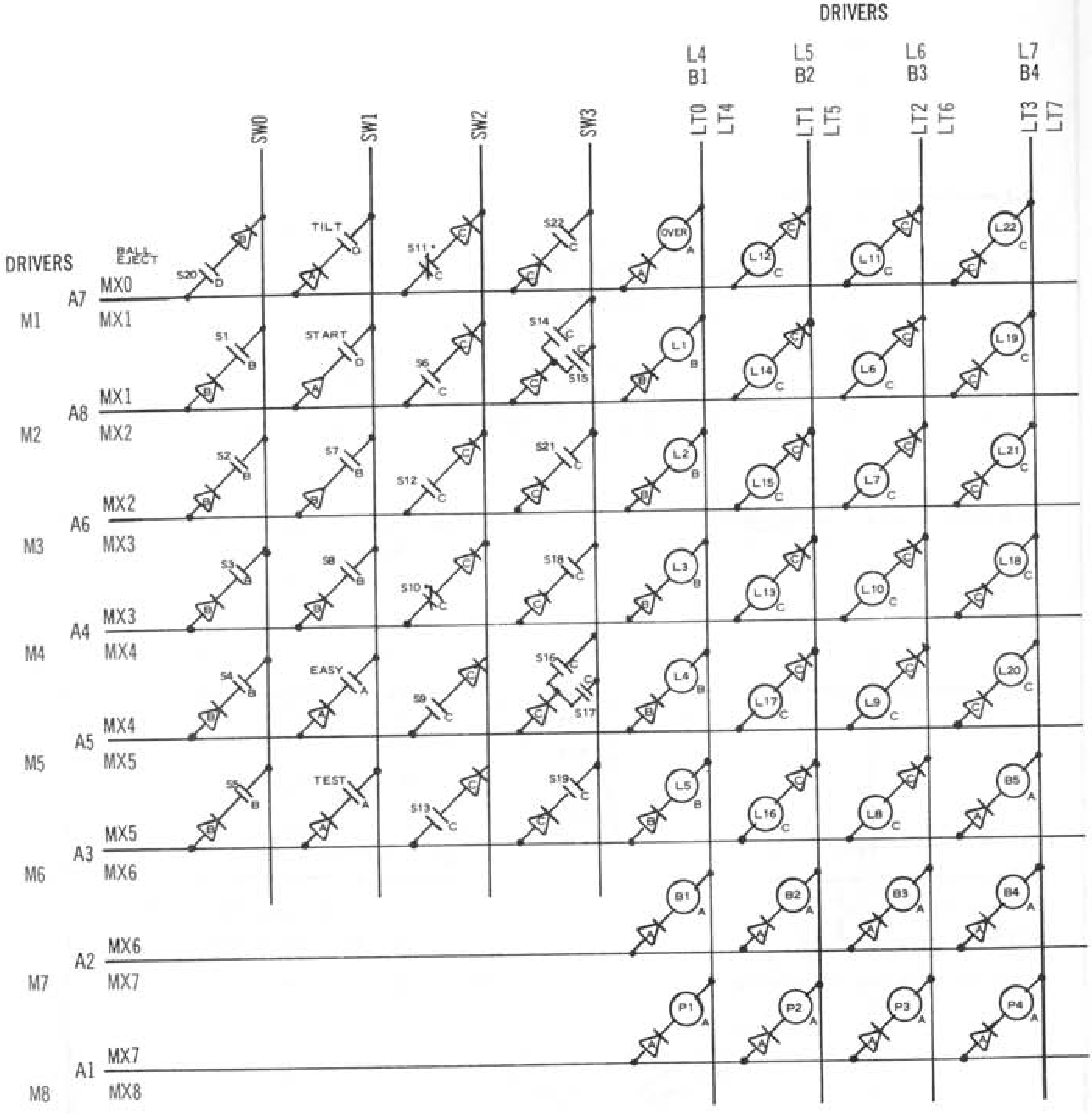
LIGHTS: As can be seen from Figure #2A, the A drivers control 4 lights each and the B drivers 8 each. Therefore, anytime there is a problem with the lights, the best procedure would be to note the light numbers of missing lights and look up the Matrix for the driver responsible. For example, if all 4 lights for the players (P1-P4) do not light up, then possibly the driver A1 could be bad. A typical A driver output is shown in Figure #1C. However, if light P1, light B1, and the Game Over Light on the logic board, together with lights L5, L4, L3, L2, and L1, do not light up, then possibly driver B1 is bad.

614-2000: As can be seen from figure #2A the M drivers control 4 lights each and the L drivers 8 lights each. Therefore, anytime there is a problem with the lights, the best procedure would be to note the light numbers of the missing lights and look up the numbers in the matrix to find the responsible driver. For example, if all 4 lights for the players (P1-P4) do not light up, then possibly the driver M8 could be bad. A typical M driver output is shown in figure #1C. However, if lights P1, B1, and the game over light on the logic board, together with lights L1, L2, L3, L4, and L5 do not light up, then possibly driver L4 is bad.

SWITCHES: If all the lights on the game and the logic board remain "ON" after the Diagnostic Test as required, then all the A and B drivers are most likely good. Any problem with the switches on the game would then be associated with the switch (SW) lines. The best bet in a situation of this kind would be to note all switch numbers that do not function properly and, referring to the Matrix, identify the SW line. Follow that line to the optical isolator (ILD 74) and check it out both at the input and output. This could be done with the scope probe on the output and by closing the switches on the corresponding SW line. When one of the switches is closed, there should be pulses on the output of the ILD 74. If this is not so, change the chip. If the pulses are present, make sure they reach the corresponding pin on the PSU #1 (pins 20, 23, 26, or 29). If the pulse is present at the input to the PSU and still the switch does not do its job, then change PSU #1.

614-2000: If all the lights on the game and logic boards flash during the diagnostic test as required, then all the M & L drivers are most likely good. Any problem with the switches on the game would then be associated with the switch (SW) lines. The best bet in a situation of this kind would be to note all the switch numbers that do not function properly and referring to the matrix, identify the SW line. Follow that line to the respective 240 Ohm resistor. Check carefully for a broken resistor or capacitor in this section. There should be a pulse on both sides of the resistor everytime one of the switches on that switch line is closed. If the pulses are present, make sure that they reach the CPU. If they reach the CPU check the outputs of the CPU at pins 9, 10, 11, 12, 13, and 14. If these are not present change the CPU.

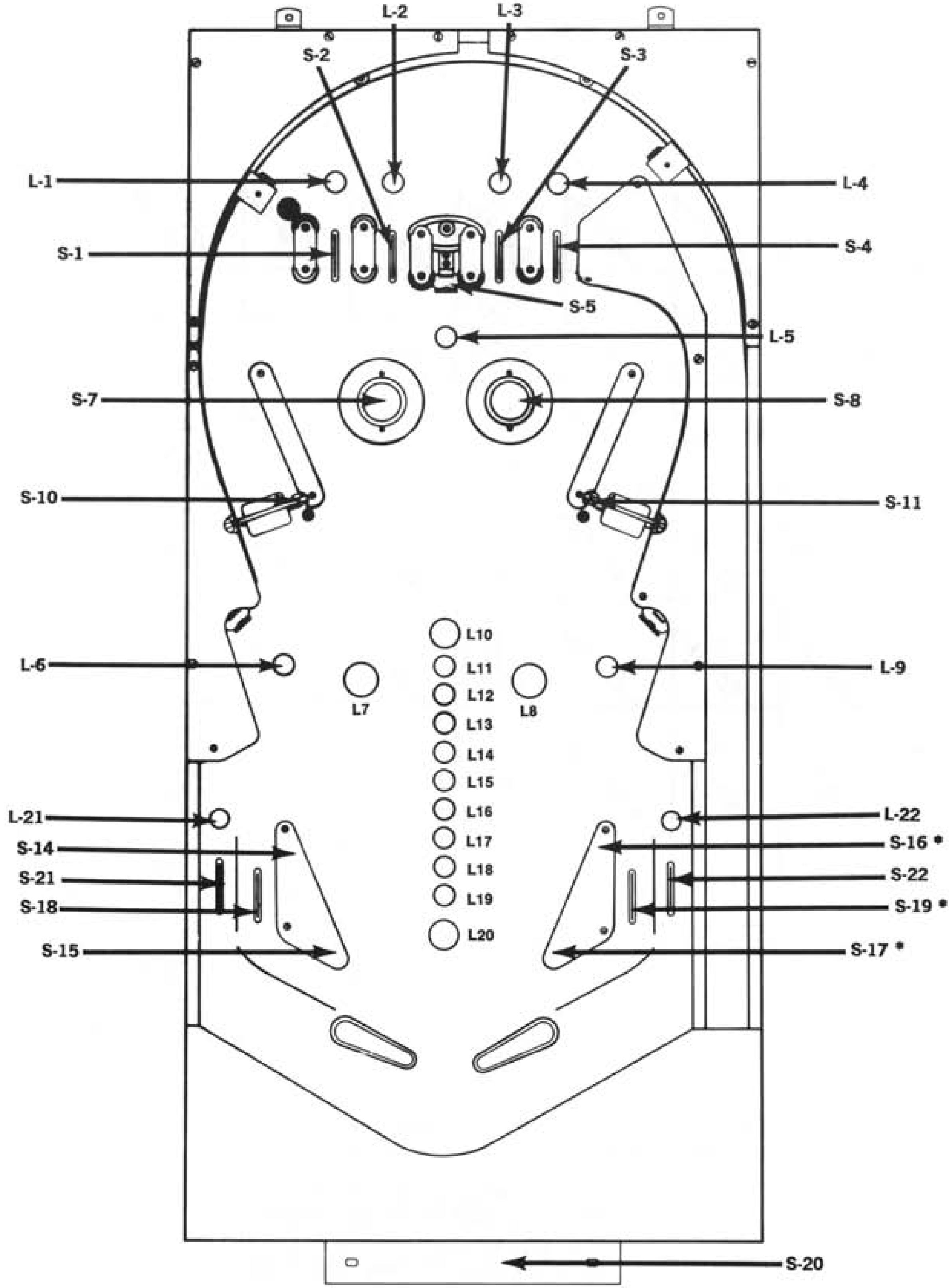
Figure #2A — The Matrix



NOTE: S-10 and S-11 are mechanically held activated; a ball will deactivate them.

A = Located on Logic PCB
B = Located on Upper Playfield PCB
C = Located on Lower Playfield PCB
D = Located in Playfield Cabinet

Figure #2B — Location of Switches and Lights



* Not present on Model #614-1000.

The Solenoid Section

This section can be easily checked by performing the Diagnostic Test. On performing this test, all five of the solenoids controlled by the logic board should be energized in the following order:

1. Ball Return
2. Left Slingshot
3. Right Slingshot *
4. Left Thumper-Bumper
5. Right Thumper-Bumper

When one or more of these solenoids do not energize, then the components that could be suspected would be the driver transistor (C1-C5)** or the solenoid itself. A good and easy way to eliminate the solenoid is to connect the leads of the suspected solenoid to a good one and test again. Using a scope, the transistor could be checked out by performing the test again. In most cases, replacing the TIP 145 transistor should set things right. However, if this does not solve the problem, check at the input to the transistor, before the 1K resistor, and see if it goes low or not when the Diagnostic Test is performed. If this does not occur, change the decoder IC 7445.

* Not present on Model #614-1000.
** S1-S5 Model #614-2000.

The Sound Section

The sound section of the logic board is simple and straightforward. As can be seen from the schematic, it is comprised of (1) PSU #1, (2) the transistor array (FPQ 3724), (3) the op-amp (μA 3401 or LM 3900), and the transistor (MPS 6531).

The frequency of the sound signal is varied internally in PSU #1 as required by the tone and is put out at pin 37 of PSU #1 as TONE. The strike is what makes the sound audible. In other words, when pin 2 of PSU #1 goes high, there will be a sound signal at pin 10 of the op-amp.

If the logic board looses its sound, the first place to check would be pins 37 and 2 of PSU #1. Turn the power switch "ON" and put the game in 1 player, first ball mode, by pushing the start switch once. There should be a square wave at pin 37, as shown in Figure #2C.

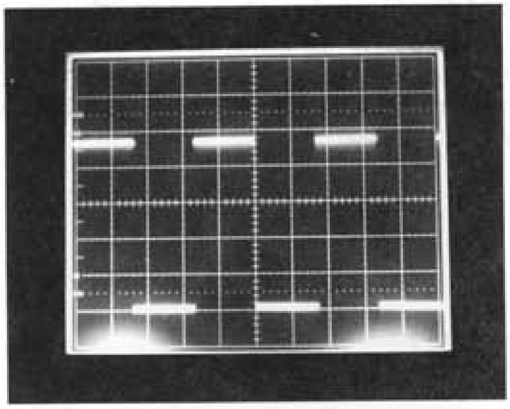


Figure #2C — Wave form of TONE in 1 player, first ball mode.
Horz: 2ms/div.
Vert: 1v/div.
Note: Frequency changes to last tone.

Now, everytime one of the switches on the playfield is closed, pin 2 of PSU #1 should go high momentarily. If this checks out, check pin 3 of the transistor array (FPQ 3724). It should be noted here that the 0.1 MF (Z5U) capacitor is very critical and should be replaced if suspected. Also, check if any of the resistors in this section are broken, in which case, replace them with the right values. If the sound signal appears at pin 10 of the op-amp each time one of the switches is closed, check out the transistor MPS 6531 and replace it if necessary.

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This sound section is comprised of (1) the CPU, (2) the op-amp (LM 3900) and (3) a portion of the ULN 2074B.

The frequency of the sound signal is varied internally in the CPU as required by the tone and is put out at pin 17 of the CPU as tone. When pin 16 of the CPU goes high there will be a sound signal at pin 10 of the op-amp LM 3900.

If the logic board loses its sound, the first place to check would be pins 16 and 17 of the CPU. Turn the power switch "on" and put the game in 1 player, first ball mode, by pushing the start switch once. There should be a square wave at pin 17, as shown in figure #2C. Now every time one of the switches on the playfield is closed, pin 16 of the CPU should go high momentarily. If this checks out, check pin 5 of the op-amp LM 3900. Check closely to see if any of the resistors are broken in this section and replace them with the right values. If the sound signal appears at pin 10 of the op-amp check out the ULN2074B, Q201, and replace it if necessary.

PART II
THE INSIDE WORLD

The Inside World naturally would comprise of the information processing of the Central Processing Unit (CPU) in conjunction with the instructions of the Program Storage Unit (PSU). It is anticipated that, other things in The Outside World remaining normal, The Inside World should function correctly. The famous Computer Science adage GIGO (Garbage In - Garbage Out) applies to this minicomputer as well. If the right input is funished to this computer, there is no reason why the right output should not be obtained. As such more emphasis is laid in this manual on The Outside World, as against The Inside World.

A quick and easy way to check if the CPU and PSUs are functioning properly would be to perform the Diagnostic Test. If the display shows the characters 600⊆ at the beginning of the test as it is supposed to, then it is confirmed that the CPU and PSUs are linked and functioning correctly.

If the display does not read 600⊆ at the beginning of the test, that is, if the score display shows jibberish or is "OFF," then the logic and program are incorrect.

If the display is "OFF" determine if the board is dead and if so, refer to Part III of this manual. If not, change PSU #1 before changing PSU #2. If this does not help, change the CPU. The possibility of damage to either the CPU or PSU is very remote unless the power supplied on 12V and 5V changed drastically. It should be noted here that PSU #1 and PSU #2 act as one unit. The only purpose of using PSU #2 is to provide more memory to the system. In other words, PSU #2 is used only as a ROM (Read Only Memory).

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If the display does not read 600d at the beginning of the test, then the logic and program are incorrect. If the display is "OFF" determine if the board is dead and if so, refer to Part III of this manual. The possibility of damage to the CPU is very remote unless the 5V supplied to it has changed drastically, or the CPU, due to its static nature, has been mishandled.

It is believed that an indepth study of the capabilities, or the operation, or the technology, of these components (CPU and PSU) is not mandatory for purposes of trouble-shooting or fixing these boards. What would be helpful for this purpose, however, would be a brief description of the relevant pin functions. This is, therefore, povided in the following pages. (Omit this section for 614-2000.)

Central Processing Unit*
3850

The 3850 is the Central Processing Unit of the F8 Micro-processor family. When connected to a 2 MHz crystal, the 3850 generates all necessary timing and control signals to make a functioning system. The 3850 is manufactured using N-Channel Isoplanar MOS Technology.

Some Relevant Pin Descriptions: (Refer to Figure #3A)

Ø and WRITE (Pins 1 and 2) are clock outputs which drive all other chips in the F8 family.

ROMCØ through ROMC4 (Pins 17, 18, 19, 20, and 21) are outputs which control the other chips in the F8 family.

DBØ through DB7 (Pins 15, 12, 9, 6, 35, 32, 29, and 26) are bidirectional data bus lines which link the 3850 with all other F8 chips in the system.

$\overline{\text{I/O ØØ}}$ through $\overline{\text{I/O 17}}$ are Input/Output ports through which the CPU communicates with The Outside World. Here $\overline{\text{I/O Ø1}}$ through $\overline{\text{I/O Ø7}}$, $\overline{\text{I/O 1Ø}}$ through $\overline{\text{I/O 13}}$, and $\overline{\text{I/O 17}}$, are only used.

RC (Pin 40) should be grounded when using the crystal mode for clock generation.

$\overline{\text{EXT RES}}$ (Pin 37) is used to externally reset the system. Here it is tied to a RC network (10K resistor, 0.22 MF capacitor) with an 80-100 m sec reset enable delay, and the system is automatically reset when the power is turned "ON."

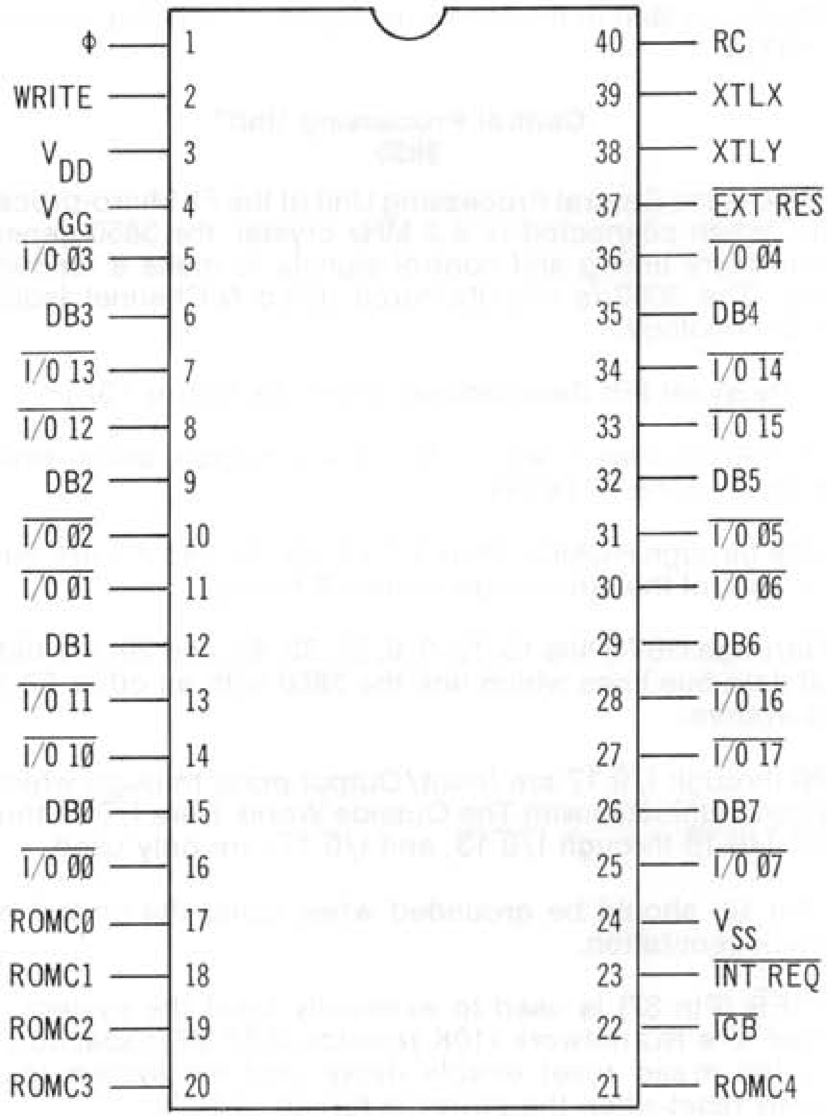
$\overline{\text{INT REQ}}$ (Pin 23) is used by the PSU #1 to signal the CPU that it has received an interrupt and is requesting that it be serviced. Once the PSU has acknowledged an interrupt, it will pull this $\overline{\text{INT REQ}}$ line low and hold it there until the CPU services it.

$\overline{\text{ICB}}$ (Pin 22) indicates whether or not the CPU is currently blocking (ignoring) the $\overline{\text{INT REQ}}$ line. If it is low, the CPU will respond to interrupt requests; if $\overline{\text{ICB}}$ is high, it will ignore them.

XTLX and XTLY (Pins 38 and 39) are used to generate the system clock.

*Source: Preliminary F8 Microprocessor Data Book, *Fairchild Semiconductors,* June 1975, Rev. A.

Figure #3A — Pin Configuration of 3850 CPU



PIN NAME	DESCRIPTION	TYPE
DBØ - DB7	Data Bus Lines	Bidirectional
Φ, WRITE	Clock Lines	Output
I/Ø ØØ - I/O Ø7	I/O Port Zero	Bidirectional
I/O 1Ø - I/O 17	I/O Port One	Bidirectional
RC	RC Network Pin	Input
ROMCØ - ROMC4	Control Lines	Output
EXT RES	External Reset	Input
INT REQ	Interrupt Request	Input
ICB	Interrupt Control Bit	Output
XTLX	Crystal Clock Line	Output
XTLY	External Clock Line	Input
V_{SS}, V_{DD}, V_{GG}	Power Lines	Input

Program Storage Unit*
3851

The 3851 Program Storage Unit (PSU) provides 1K bytes of ROM storage for a F8 microprocessor system. The PSU receives timing and control signals from the CPU (3850). An 8-bit wide bidirectional data bus transfers data words between the CPU and PSU. The PSU is manufactured using N-Channel Isoplanar MOS Technology.

Some Relevant Pin Descriptions: (Refer to Figure #3B)

Ø and WRITE (Pins 8 and 7) are clock inputs generated by the 3850 CPU.

ROMCØ through ROMC4 (Pins 17, 16, 15, 14, and 13) are control inputs from the 3850 CPU. These are decoded in the PSU to generate internal control signals for the PSU.

DBØ through DB7 (Pins 21, 22, 27, 28, 33, 34, 39, and 40) are bidirectional data bus lines which link the PSU with the CPU and other F8 chips (PSU #2) for the system. Data bytes pass into and out of the PSU on this data bus.

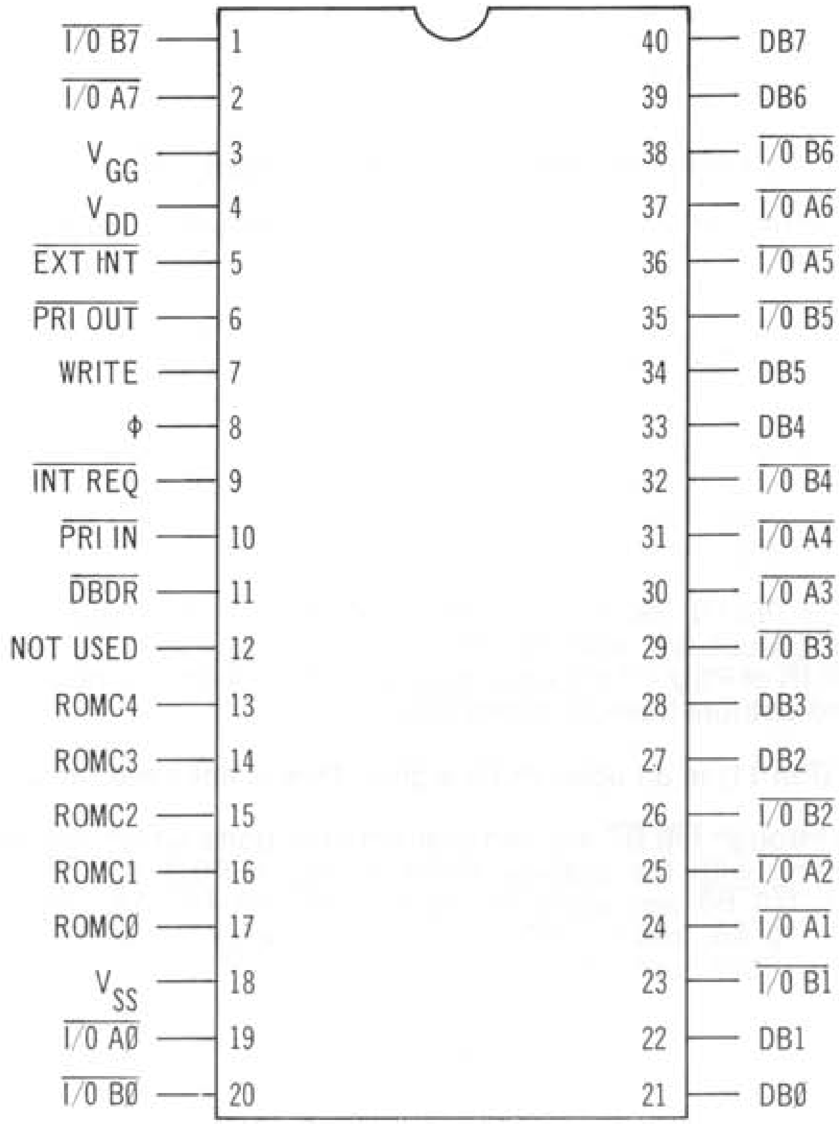
$\overline{\text{INT REQ}}$, $\overline{\text{PRI IN}}$, $\overline{\text{PRI OUT}}$, and $\overline{\text{EXT INT}}$ (Pins 9, 10, 6, and 5) are signals associated with the interrupt circuitry. Only $\overline{\text{INT REQ}}$ and $\overline{\text{PRI IN}}$ of PSU #1 are used here. All other inputs are tied high (5V) and outputs have no connections.

$\overline{\text{DBDR}}$ (Pin 11) is an open drain signal. This is not used here.

$\overline{\text{I/0 AØ}}$ through $\overline{\text{I/0 B7}}$ are two bidirectional ports which link the F8 system with the outside world. Here, on PSU #1, $\overline{\text{I/0 BØ}}$ through $\overline{\text{I/0 B3}}$ are used as input ports and $\overline{\text{I/0 AØ}}$, $\overline{\text{I/0 A1}}$, $\overline{\text{I/0 A2}}$, $\overline{\text{I/0 A6}}$, and $\overline{\text{I/0 A7}}$, are used as output ports. The I/0 ports on PSU #2 are not used.

*Source: Preliminary F8 Microprocessor. Data Book, *Fairchild Semiconductor*, June 1975, Rev. A.

Figure #3B — Pin Configuration of 3850 PSU



PIN NAME	DESCRIPTION	TYPE
$\overline{\text{I/Ø AØ}}$ - $\overline{\text{I/0 A7}}$	I/0 Port A	Bidirectional
$\overline{\text{I/0 BØ}}$ - $\overline{\text{I/0 B7}}$	I/0 Port B	Bidirectional
DBØ - DB7	Data Bus	Input
ROMCØ - ROMC4	Control Lines	Input
Φ, WRITE	Clock Lines	Input
$\overline{\text{EXT INT}}$	External Interrupt	Input
$\overline{\text{PRI IN}}$	Priority In	Input
$\overline{\text{PRI OUT}}$	Priority Out	Output
$\overline{\text{INT REQ}}$	Interrupt Request	Output
$\overline{\text{DBDR}}$	Data Bus Drive	Output
V_{SS}, V_{DD}, $_{GG}$	Power Supply Lines	Input

PART III

Other Possible Problems

Dead Board

When none of the lights except the 5.25V AC lights light up on turning the power "ON," and the Diagnostic Test cannot be performed, or the game cannot be started, the board is referred to as DEAD. Although this is not expected to happen, when it does happen, it could be due to various reasons. Some of the more common ones, along with the methodology to identify and rectify them, are listed below.

1. Check the power supply out. If another one is handy, replace the power supply.
2. Check all the voltages (22V, 18V, 12V,* +5V and VLED=5 to 6V) on the logic board. If any of these voltages is missing and it is found that the power supply is not responsible for it, check for possible shorts and/or bad capacitors causing it, and regain the lost voltage first.

3A. If all the voltages seem good and the board remains dead, check the clock section (Pins 39, 38 of the CPU). These waveforms are shown in Figure #4A and Figure #4B.

3B. For model #614-2000 Pins 1 and 2 of the CPU are used instead of 38 & 39. Refer to figures 4C & 4D for these waveforms.

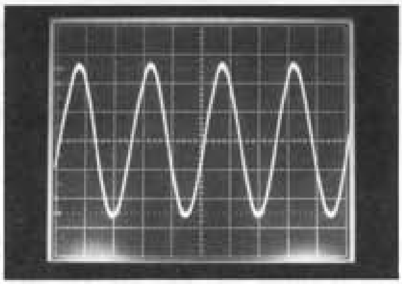


Figure #4A — Clock at Pin 38
Horz: 0.2μs/div.
Vert: 1v/div.

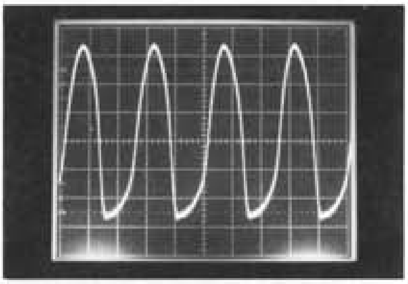


Figure #4B — Clock at Pin 39
Horz: 0.2μ/div.
Vert: 1v/div.

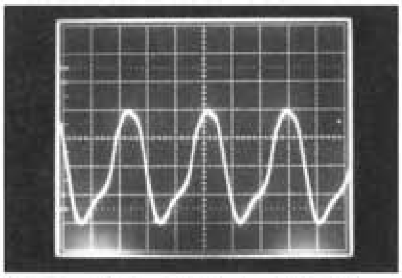


Figure #4C — Clock at Pin 1
Horz: 1μs/div.
Vert: 1v/div.

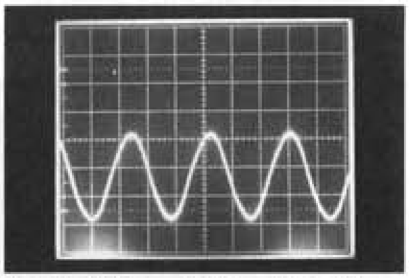


Figure #4D — Clock at Pin 2
Horz: 1μs/div.
Vert: 1v/div.

4. If the wave forms, as shown in Figures #4A through #4D are not present, refer to page 24 and check the fail-safe circuit.

* 12V not present on 614-2000.

(Omit #s 5 through 8 for 614-2000.)

5. If pins 38 and 39 look good, check the timing pulses on pins 1 and 2 of the CPU. These are shown in Figure #5A and Figure #5B. If this is missing, check for +5V and +12V on the CPU at pins 3 and 4, respectively. If pins 1 and 2 do not have the right pulses, change the CPU.

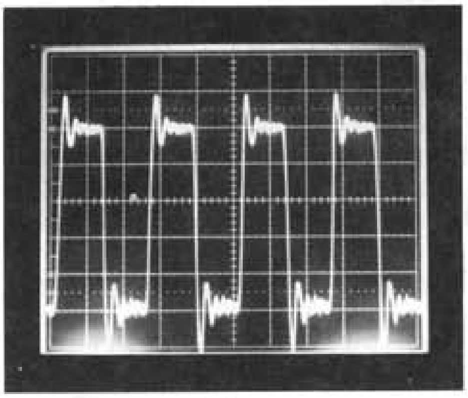


Figure #5A —
Timing pulse at Pin 1 of CPU
Horz: 0.2μs/div.
Vert: 1v/div.

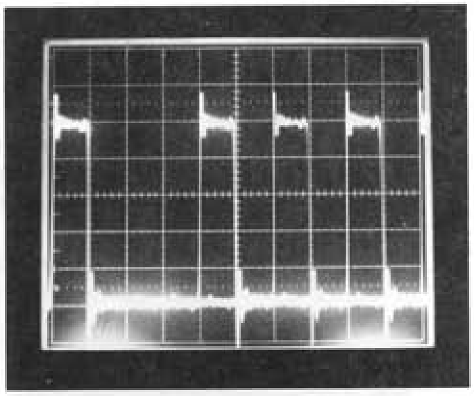


Figure #5B —
Timing pulse at Pin 2 of CPU
Horz: 0.5μs/div.
Vert: 1v/div.

6. Now, check the control signals on pins 17, 18, 19, 20, and 21 of the CPU. Make sure these reach pins 13, 14, 15, 16, and 17 of PSU #1 and PSU #2. A typical waveform of the control pulse is shown in Figure #6. If these check good, and in most cases they should, then proceed to step 7. If any of them does not seem right, proceed to next step.

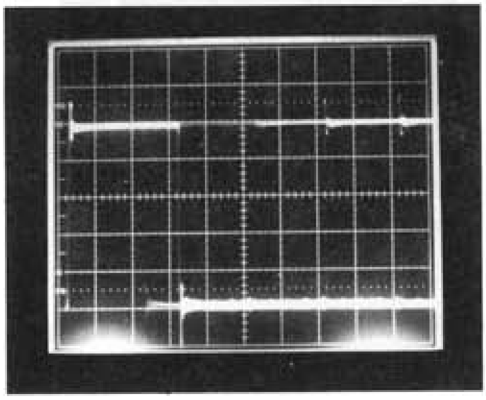


Figure #6 —
Control signal at Pin 17 of CPU
Horz: 1μs/div.
Vert: 1v/div..

7. Check the data bus lines pins 6, 9, 12, 15, 26, 29, 32, and 35 of CPU. Make sure they get to PSU #1 and PSU #2. There should be fast switching pulses on these pins. A typical data bus line is shown in Figure #7. Also make sure these are not short together. This could be done by holding the scope probe on one and momentarily grounding the others.

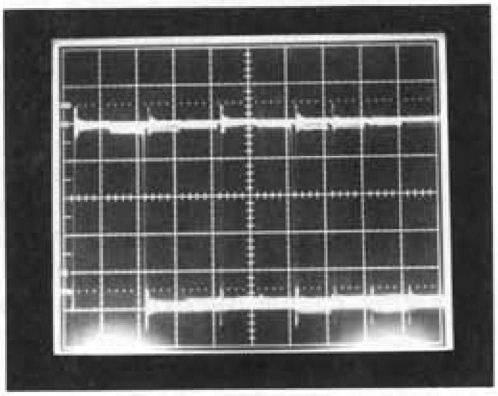


Figure #7 — Data bus line.
Pin 6 of CPU.
Horz. 1μs/div.
Vert: 1v/div.

8. Check pins 11, 10, and 5 of the CPU. There should be square wave outputs on them. If pin 11 has a pulse (as shown in Figure #8), then CPU and PSU are functioning normally. Proceed to step 8. If it is just a high, then there is something wrong on the data bus or the control lines or PSU #1 may be bad. Refer back to step 6 and change PSU #1 before changing the CPU.

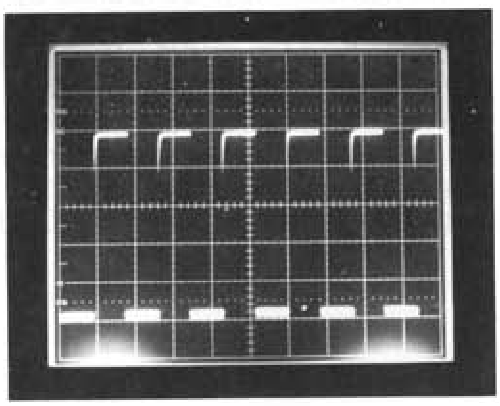


Figure #8 — Pin 11 of CPU.
Horz: 2ms/div.
Vert: 1v/div.

THE FAIL SAFE CIRCUIT: This circuit is designed to prevent multiplexing if the CPU or PSU do not strobe properly. This protects the display and light bulbs from getting damaged. In other words, if pin 11 of CPU is high, pin 4 of the op-amp (μA 3401) would be high, which results in preventing the decoders (IC 7445s) from decoding. If there is a pulse on pin 11 of the CPU (as shown in Figure #8) and pin 4 of the op-amp remains high, then check the fail-safe circuit thoroughly. Check the external strapping on connector D, pins 1 and 2. Check for broken resistors or diodes in that section. If they seem good, replace the 0.01 MF capacitors and IN 4004 diodes before changing the op-amp itself.

614-2000: If Pin 9 of CPU is high, Pin 4 of the op-amp (LM 3900) would be high, which results in preventing the decoders (IC 7445) from decoding. If there is a pulse on Pin 9 of the CPU (as shown in Figure #8 and Pin 4 of the op-amp remains high, then check the fail-safe circuit thoroughly. Check the external strapping on connector D, Pins 8 & 9. Check closely for broken resistors or diodes in that section. If they seem good, replace the 0.01MF capacitors and the IN 4004 diodes before changing the op-amp itself.

THE TILT LIGHT: This is the only light other than the 5.25V AC lights which is not in the Matrix but is controlled by the logic board. If the tilt light does not light when the tilt switch is closed, check the bulb and socket first. Then check pins 24 and 25 of PSU #1 and see if they go high when the tilt switch is closed with the game in Play mode. If this checks out, check the output of the decoder (IC 7445) at pin 9 and see if it goes low or not. If it does, the decoder is good so change the transistor array (FPQ 3724). If not, change the decoder.

614-2000: The tilt light is the only light, other than the 5.25 VAC light that is not in the matrix, but is controlled by the logic. If the tilt light does not light when the tilt switch is closed check the bulb and socket first. If the bulb appears to be good, check Pin 6 of the CPU and see if it goes high when the tilt switch is closed with the game in the play mode. If this checks out check driver L3's output. If the tilt light remains on all the time check driver L3 for a short. If it appears to be good check Pins 6 of the CPU and if it is high without the tilt switch being closed change the CPU.

PART IV
GENERAL MAINTENANCE

Switch Adjustment

1. ROLLOVER SWITCHES
   (1) The ball must actuate the switch when rolling thru the rollover area from both directions. The switch actuator can be formed up slightly to get actuation. See figure #9. **CAUTION:** When adjusting actuator be sure it is centered in the slot and does not rest above the playfield surface.
   (2) The ball must not hang up (stop) on the actuator.
   (3) The switch actuator must always return to the up position after actuation.

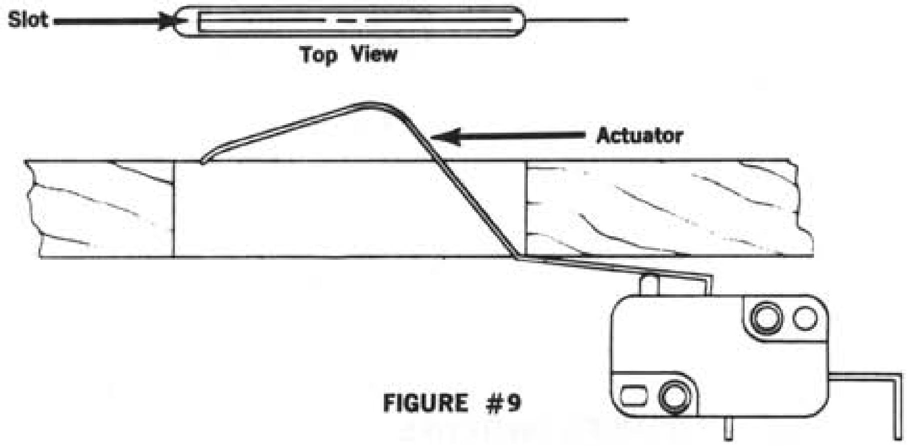


FIGURE #9

2. SLING SHOT AND SIDE RUBBER SWITCHES
   (1) The rubber bumper must be evenly stretched around all posts.
   (2) The switch actuator blade must be adjusted to make the switch actuate (klicking sound) when it moves 1/16 inch from the rubber bumper. If the switch is adjusted too close the Sling Shot will chatter. See figure #10.

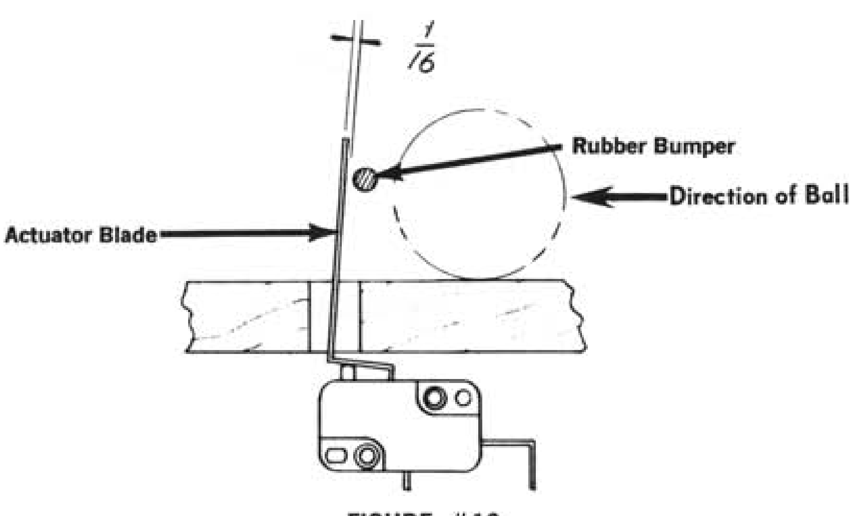


FIGURE #10

3. TARGET SWITCHES
   (1) The switch must actuate and reset (klick-klick) freely in playfield slot.
   (2) The rear stop bracket must be adjusted (by bending) to be 5/32 inch from actuation point of the switch. See figure 11.

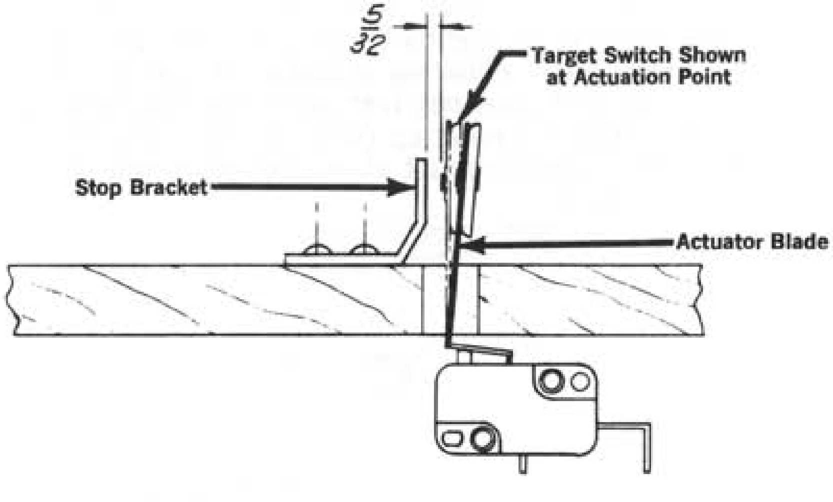


FIGURE #11

4. THUMPER BUMPER SWITCHES
   (1) The thumper bumper spoon must be centered about the thumper bumper actuating point in all directions. See figure 12.
   (2) When the thumper bumper wafer is depressed (at any point on the periphery) the switch must actuate. Adjust (by bending) the switch actuator arm to meet this requirement.

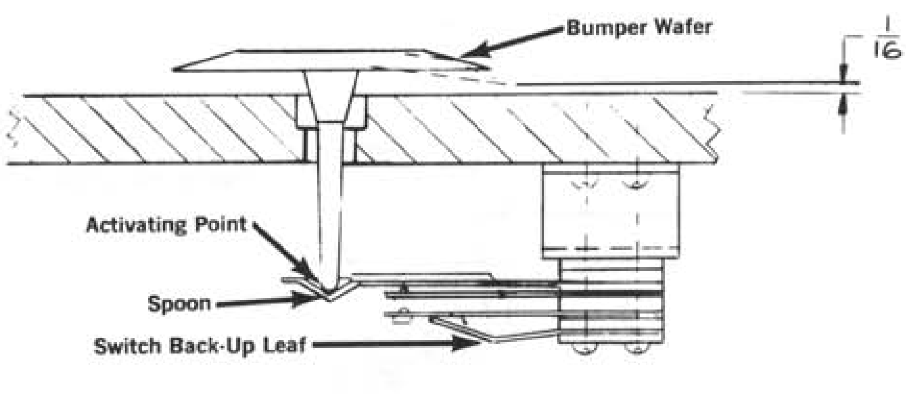


FIGURE #12

5. BALL RETURN SWITCH

To adjust ball return switch, adjust switch actuator to actuate when ball stops in position shown in figure #13 . If switch actuates before ball returns to position shown, ball ejection will start prematurely and cause ball to hang up.

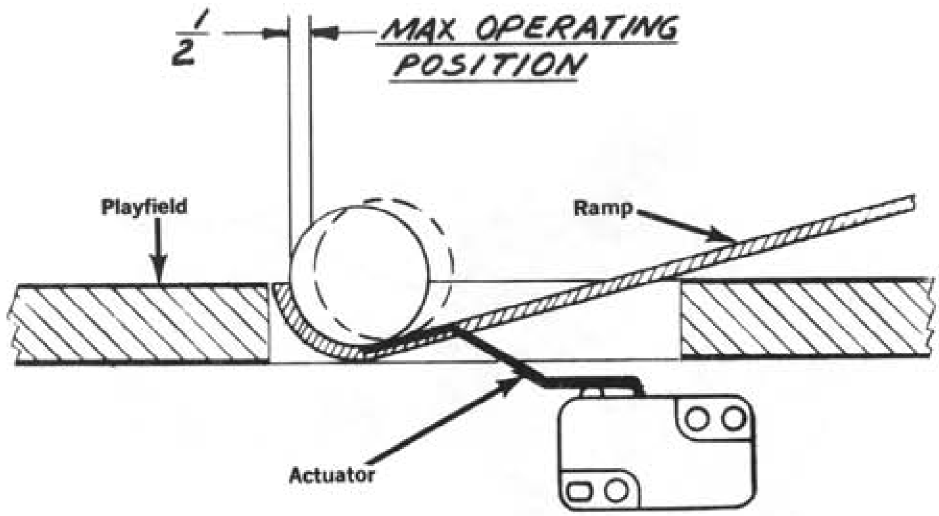


FIGURE #13

6. SPINNER TARGET SWITCHES

Adjust the switch actuation arm (by bending) until the switch actuates (klick) in the lower ⅓ of spinner travel. See Figure #14.

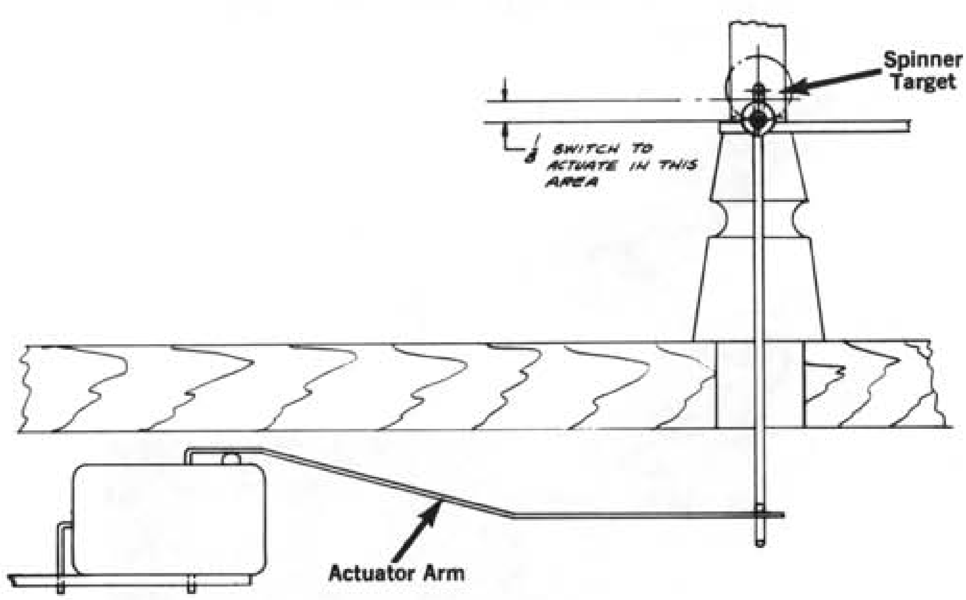


FIGURE #14

7. TO CLEAN PLAYFIELD:
   (1) Remove playfield glass as shown in figure #15 and #16.
   (2) Wipe playfield surface with a soft rag or slightly dampened towel.

8. TO SERVICE BOTTOM OF PLAYFIELD:
   (1) Remove three screws in cabinet front and lift off trim moulding. See figure #15.

FIGURE #15

   (2) Carefully slide out playfield glass as shown in figure #16.
   (3) Remove two screws in bracket holding down playfield as shown in figure #16.

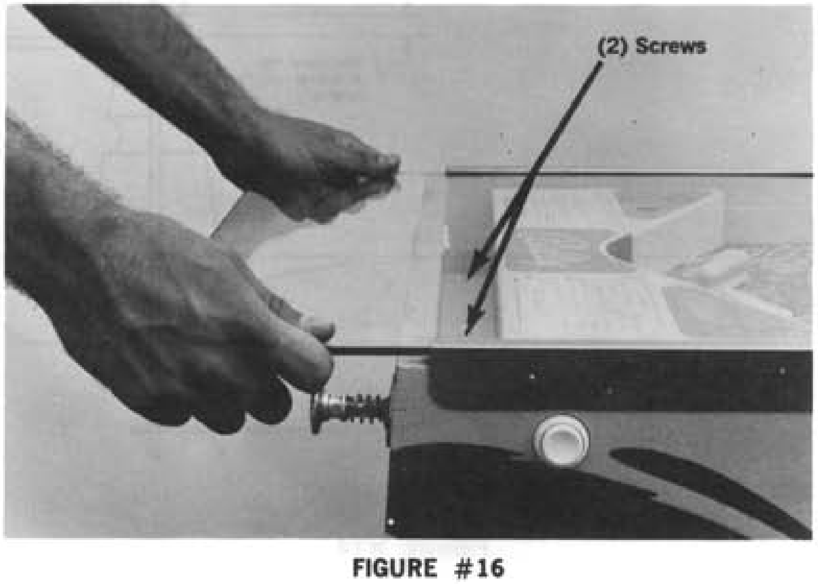


FIGURE #16

(4) Raise playfield from front and place against cabinet back box with playfield resting in provided notches in playfield support rails. See figure #17. The playfield bottom, (lamps, switches and solenoids) flipper switches, tilt assembly and power supply are now easily accessable.

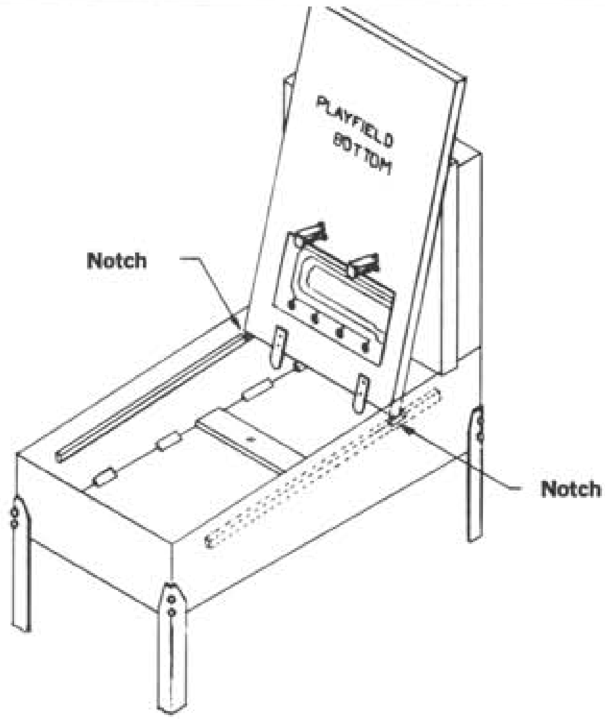


FIGURE #17

9. The pendulum tilt, which is located in the left front section of the cabinet, may be adjusted as desired. To make tilt more sensitive, loosen thumb screw in tilt bob and raise bob closer to bob ring, retighten thumb screw. See figure #18.

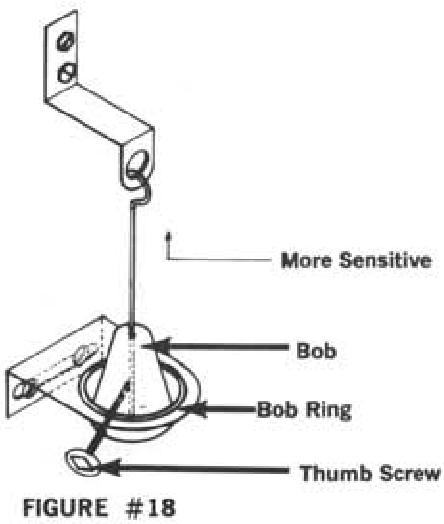


FIGURE #18

10. TO CHANGE ANY BUMPER RUBBER

(1) Remove acorn nuts holding plastic cap. See figure #19.
(2) Remove plastic cap.
(3) Remove worn bumper rubber.
(4) Stretch new bumper rubber around bumper rubber posts. Tension on bumper rubber must be evenly distributed about all bumper posts.
(5) Replace plastic cap and acorn nuts. Do not overtighten acorn nuts. Allow plastic cap to move slightly on top of bumper posts.

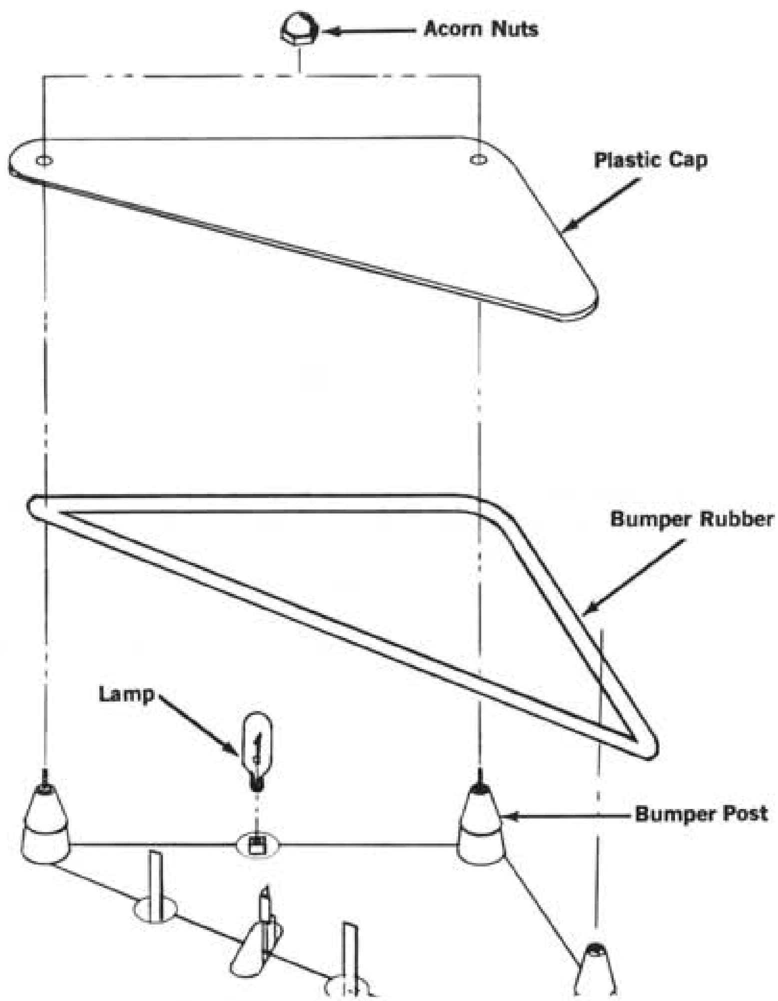


FIGURE #19

Lamp Replacement

11. TO REPLACE ANY LAMP MOUNTED ABOVE PLAYFIELD SURFACE
    (1) Remove acorn nuts from plastic cap covering burned out lamp. See figure #19.
    (2) Remove plastic cap.
    (3) Pull burned out lamp straight out of receptacle and insert new one.
    (4) Replace plastic cap and acorn nuts. Do not overtighten acorn nuts. Allow plastic cap to move freely on top of bumper posts.

12. TO REPLACE ANY LAMP MOUNTED ON CIRCUIT BOARD
    (1) Twist lamp receptacle counterclockwise and remove from board. See figure #20.
    (2) Pull burned out lamp straight out of receptacle and insert new one.
    (3) Twist receptacle back into board. (Clockwise)

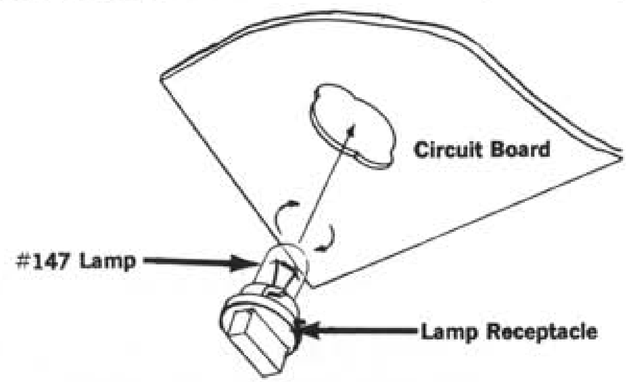


FIGURE #20

13. TO REPLACE THUMPER BUMPER LAMPS:
    (1) Remove two screws in thumper bumper cap.
    (2) Remove thumper bumper cap.
    (3) Twist out burned out lamp (see figure #21) and replace with new #455 lamp.
    (4) Replace thumper bumper cap and screws.

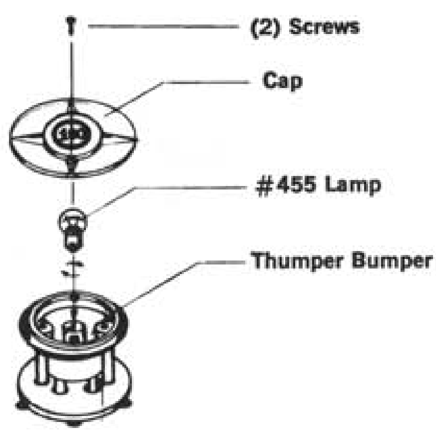


FIGURE #21

14. TO REPLACE DISPLAY INSERT LAMPS:
   (1) Remove three screws in insert moulding and remove moulding (see figure #22).
   (2) Remove insert display glass.
   (3) Replace burned out lamp with new #147 lamp.
   (4) Replace display glass, moulding and three screws.

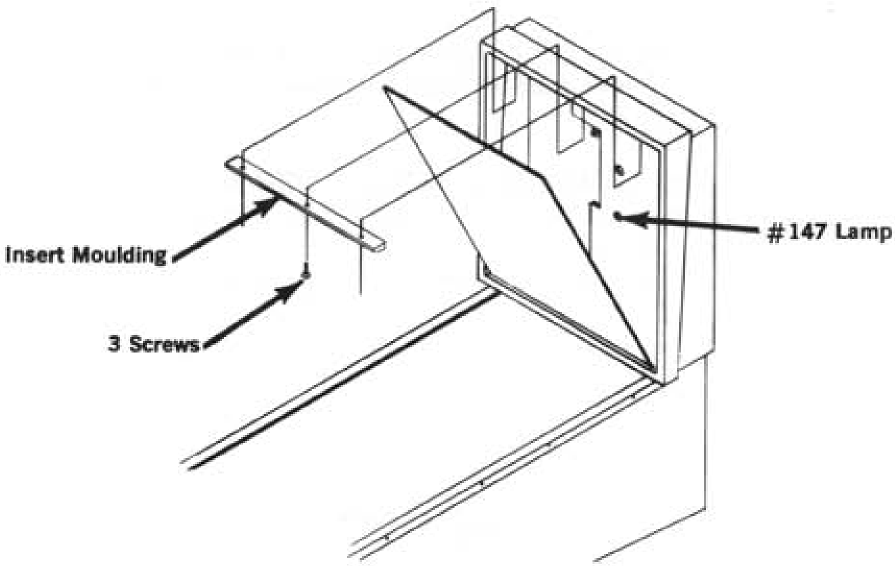


FIGURE #22

15. SOLENOID WIRING: (2 Thumper Bumpers, 2 Slingshots, 2 Flippers, 1 Ball Return)
   If for any reason the wiring of any solenoid is removed, it must be replaced in the following manner. The white wire must be connected (by push on) to the terminal identified with a white marking. (see figure #23)
   CAUTION: Failure to connect solenoids as instructed will result in serious damage to electronic components on logic board.

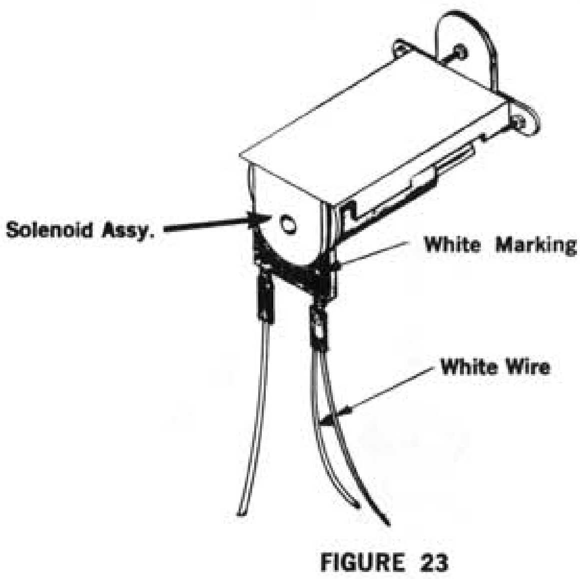


FIGURE 23

16. TO REPLACE OR CHECK 8 AMP. FUSE:(Not present on 614-2000.)
    (1) Remove playfield glass (figure #15 and #16) and raise playfield. See figure #17.
    (2) The transformer assembly is located in the right rear corner of the bottom cabinet. Remove fuse from this assembly by twisting fuse cap. See figure #24.
    (3) Replace with new 8 amp. fuse.

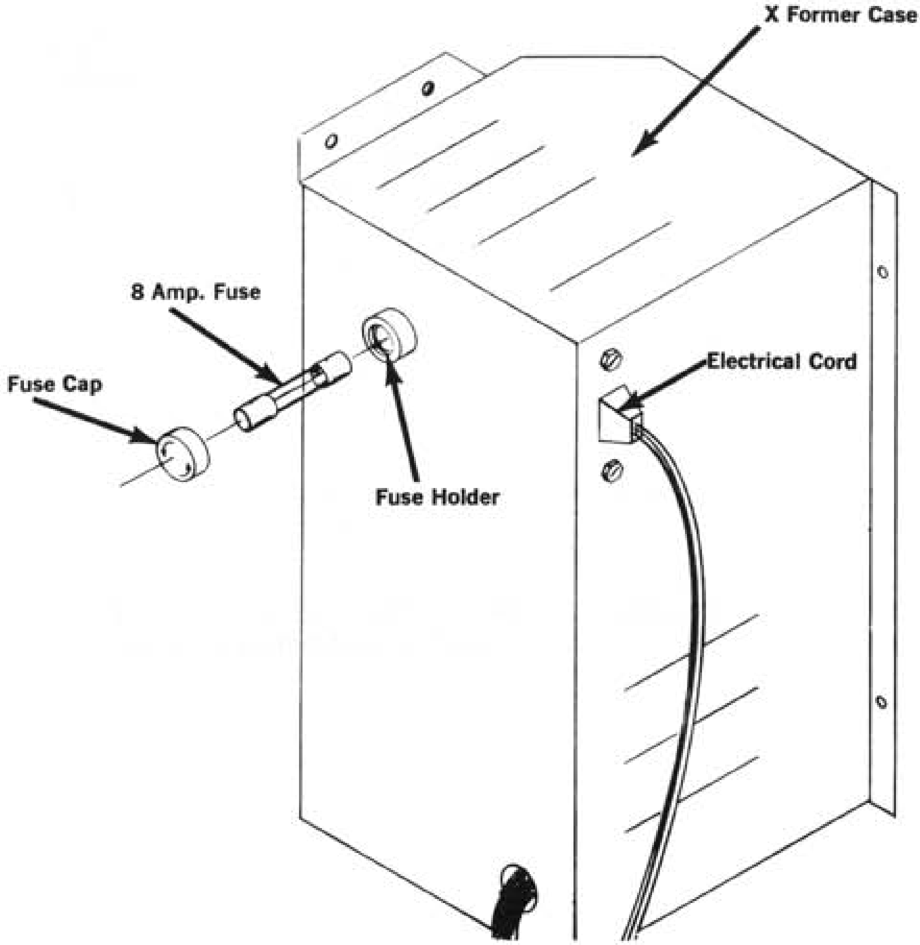


FIGURE #24

17. TRANSFORMER (614-2000):

Aside from the difference in the logic circuitry and physical appearance, the 614-2000 has one other distinct feature which is not present in our other home pinballs. This feature is the addition of five circuit breakers (2 - 3.9 amp and 3 - 2.5 amp) to the transformer.

These circuit breakers have been added to prevent solenoid and transformer burn-up. An explanation of the responsibilities of each circuit breaker is as follows:

3.9 amp Playfield Illumination:	9 display lights on periphery of playfield and both thumper bumper lamps.
3.9 amp Score & Scorebox Illumination:	6 display lights behind scorebox glass.
2.5 amp Right & Ball Return Solenoids:	All solenoid assemblies located on the right side of the playing surface, including the ball return solenoid.
2.5 amp Left Solenoids:	All solenoid assemblies located on the right side of the playing surface.
2.5 amp Feature Lights:	All lights connected with all switches and bonus scoring.

TROUBLE SHOOTING

BEFORE PERFORMING ANY MAINTENANCE OR SERVICE ON YOUR GAME, ITS ELECTRICAL CORD MUST BE DISCONNECTED FROM THE OUTLET AND REMAIN DISCONNECTED UNTIL THE SERVICE HAS BEEN COMPLETED.

IF ALL GENERAL MAINTENANCE AND TROUBLE SHOOTING PROCEDURES HAVE BEEN FOLLOWED AND GAME STILL MALFUNCTIONS, CALL YOUR DEALER FOR SERVICE.

1. ALL LITES "OFF" — NOTHING WORKS.
   (1) Make sure the electrical cord is firmly inserted in wall outlet.
   (2) Depress "on-off" switch.
   (3) Reset circuit breaker.
   (4) Check 8 amp. fuse.
   (5) Check power supply connections.
2. DISPLAY INSERT LITES "ON" — PLAYFIELD LITES "OFF".
   (1) Remove rear cabinet panel.
   (2) See that connectors on logic board are firmly in place.
   (3) Remove playfield glass (figure # 15 and #16) and raise playfield. See figure #17. See that connectors on upper and lower playfield boards are firmly in place.
3. PLAYFIELD LITES "ON" — DISPLAY INSERT LITES "OFF".
   (1) Remove rear cabinet panel.
   (2) See that connectors on logic board and display insert are firmly in place.
4. GAME WILL NOT START:
   (1) Remove playfield glass (figure #15 and #16) and raise playfield. See figure #17.
   (2) Make sure "push-on" connectors are firmly attached to start switch terminals.
   (3) Actuate switch via start button and listen for klicking sound.
   (4) If start button stroke is too short to actuate switch, the switch blade may be bent slightly to get actuation.
5. BALL WILL NOT EJECT TO SHOOTER:
   (1) Remove playfield glass (figures #15 and #16) and raise playfield. See figure #17.
   (2) Make sure "push-on" connectors are firmly attached to solenoid terminals and ball return switch terminals.
   (3) Check switch adjustment. See figure #13.
6. SWITCH WILL NOT SCORE OR OPERATE SOLENOID:
   (1) Remove playfield glass. See figures #15 and #16.
   (2) Operate switch manually and listen for actuation. (Klicking sound).
   (3) Adjust switch as indicated in figures # 9 to #14.
7. SOLENOID DOES NOT OPERATE:
   (1) Remove playfield glass (figures # 15 and #16) and raise playfield. See figure #17.
   (2) Make sure "push-on" connectors are firmly attached to solenoid terminals.
   (3) Check adjustment of solenoid operating switch. (Klick). If no (klick) is heard adjust as indicated in figures # 9 to #14.
8. FLIPPER SOLENOID WILL NOT OPERATE OR OPERATES WEAKLY:
   (1) Remove playfield glass (figures # 15 and #16) and raise playfield. See figure #17.
   (2) Make sure "push-on" connectors are firmly attached to flipper solenoid terminals.
   (3) Make sure that flipper button switch is making solid contact. Switch may be adjusted by bending switch blade slightly.
   (4) Clean flipper button switch with piece of fine emery cloth to insure continuity.
   (5) When Flipper operates weakly, switch on coil assembly may be adjusted (by bending) so solid contact is made (between switch contact) when Flipper is at rest. These contacts must be open when solenoid plunger is at the end of its stroke. This condition may be simulated by moving Flipper on to a "up" position manually.

DRIVERS "A"

	2200 OHM	1000 OHM	TIP-115	IN 4001
A-1	R212	R213	Q212	----
A-2	R214	R215	Q214	----
A-3	R216	R217	Q216	D216
A-4	R218	R219	Q218	D218
A-5	R220	R221	Q220	D220
A-6	R222	R223	Q222	D222
A-7	R224	R225	Q224	D224
A-8	R226	R227	Q226	D226

DRIVERS "B"

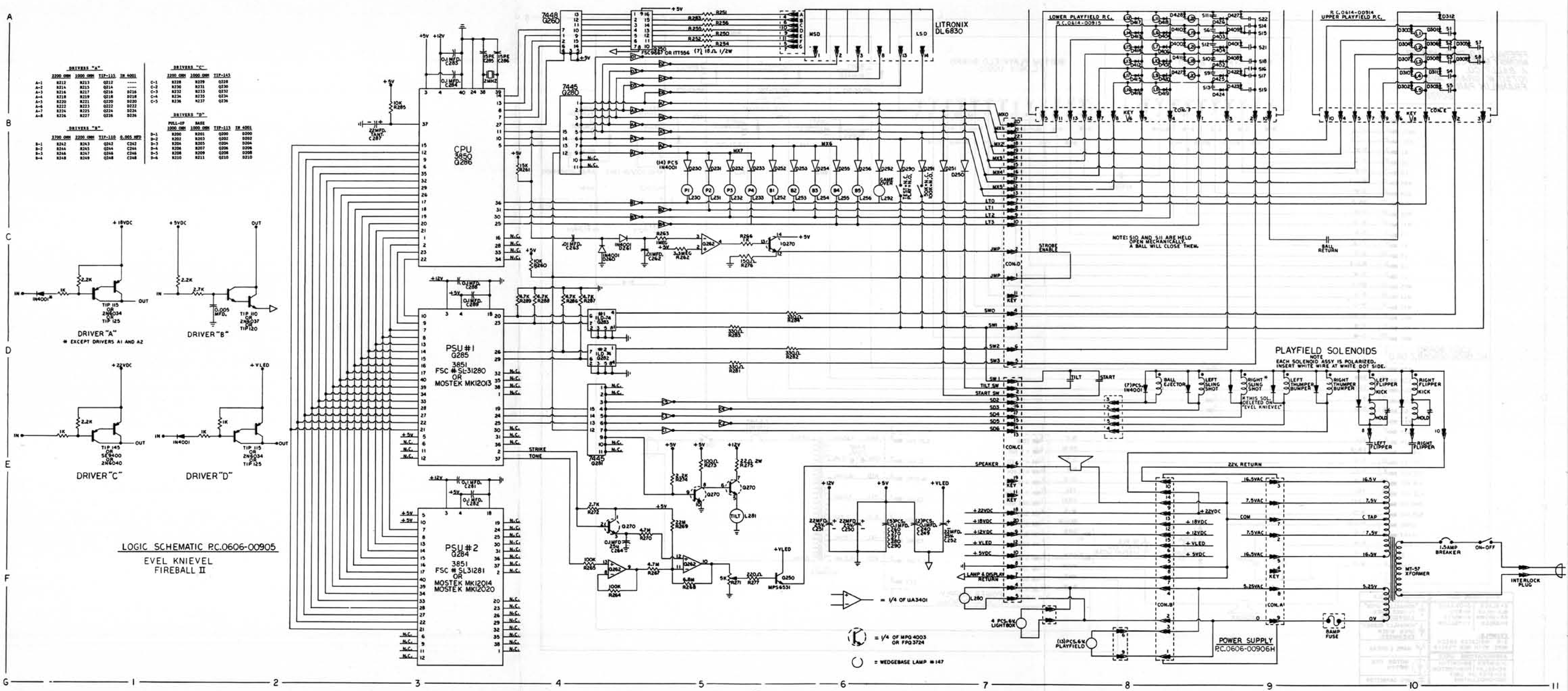
	2700 OHM	2200 OHM	TIP-110	0.005 MFD
B-1	R242	R243	Q242	C242
B-2	R244	R245	Q244	C244
B-3	R246	R247	Q246	C246
B-4	R248	R249	Q248	C248

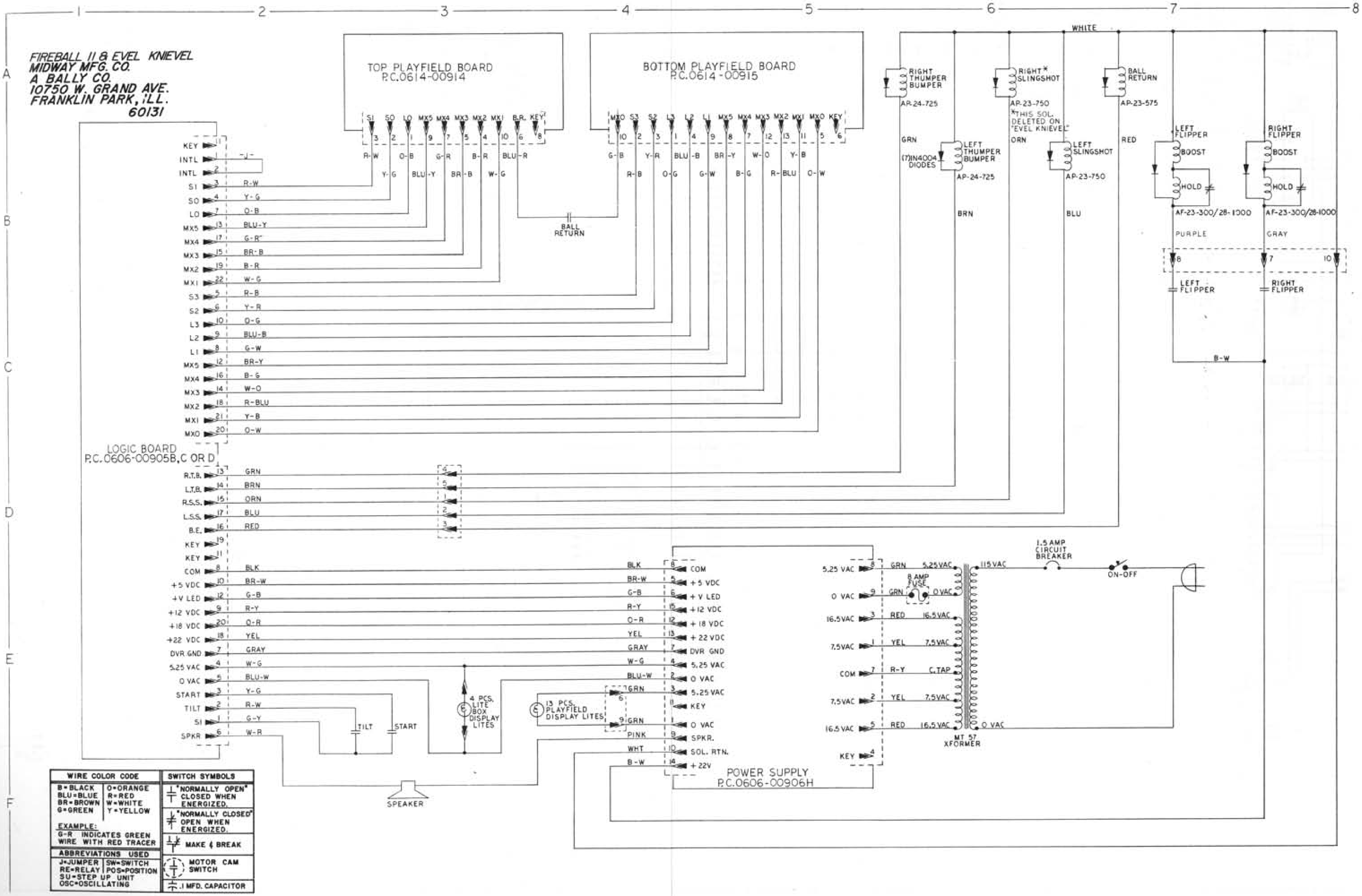
DRIVERS "C"

	2200 OHM	1000 OHM	TIP-145
C-1	R228	R229	Q228
C-2	R230	R231	Q230
C-3	R232	R233	Q232
C-4	R234	R235	Q234
C-5	R236	R237	Q236

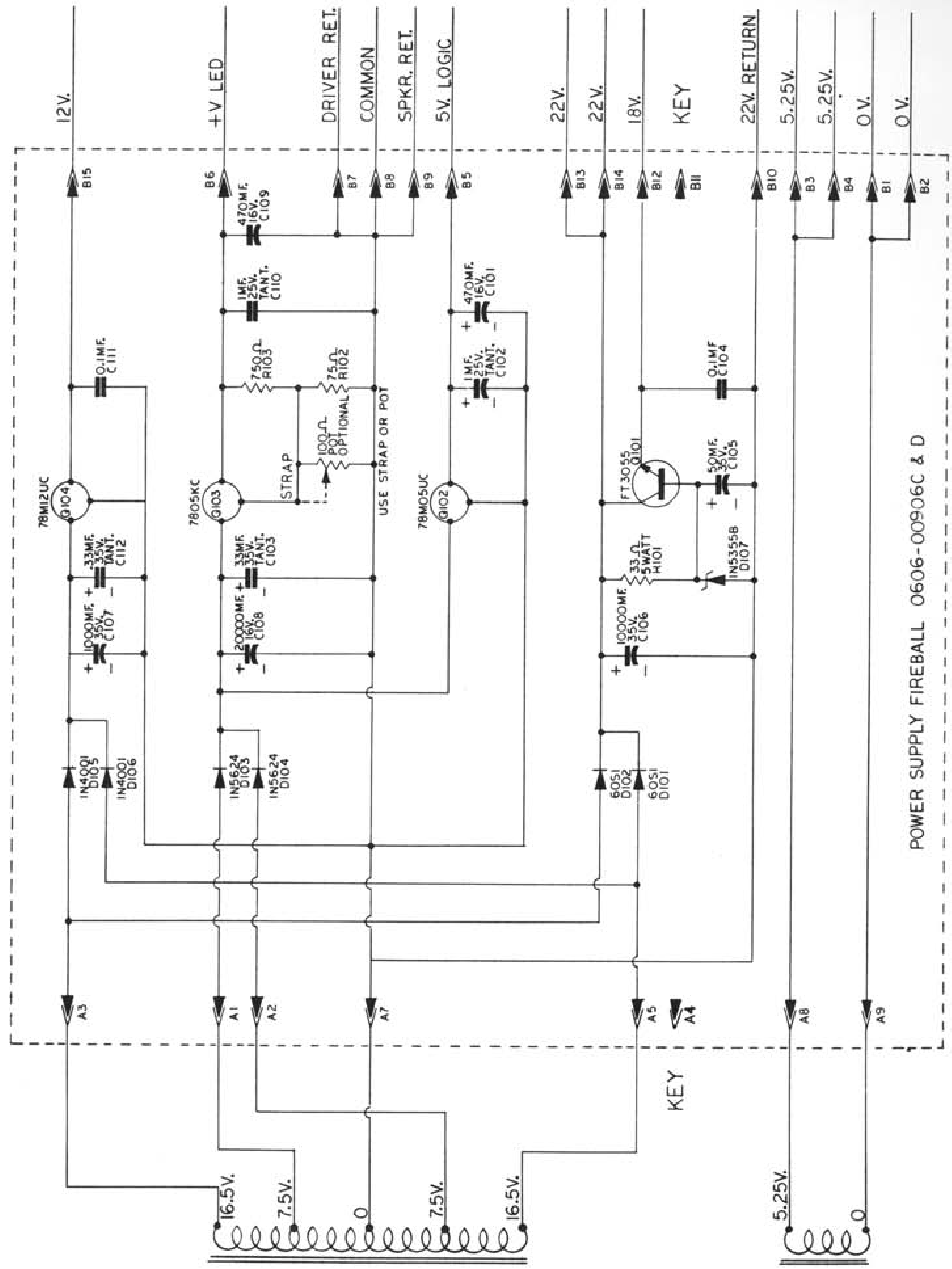
DRIVERS "D"

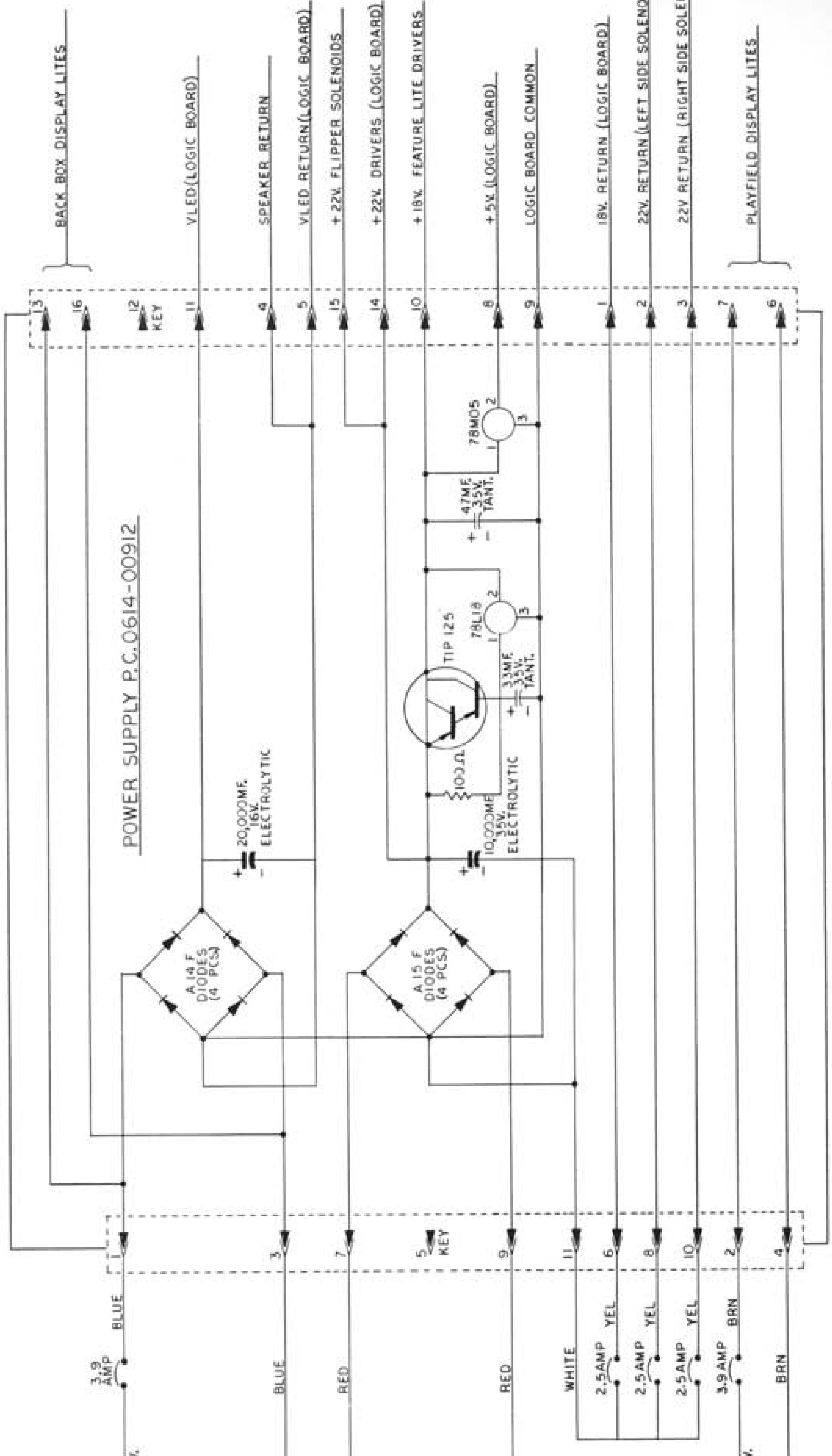
	PULL-UP 1000 OHM	BASE 1000 OHM	TIP-115	IN 4001
D-1	R200	R201	Q200	D200
D-2	R202	R203	Q202	D202
D-3	R204	R205	Q204	D204
D-4	R206	R207	Q206	D206
D-5	R208	R209	Q208	D208
D-6	R210	R211	Q210	D210





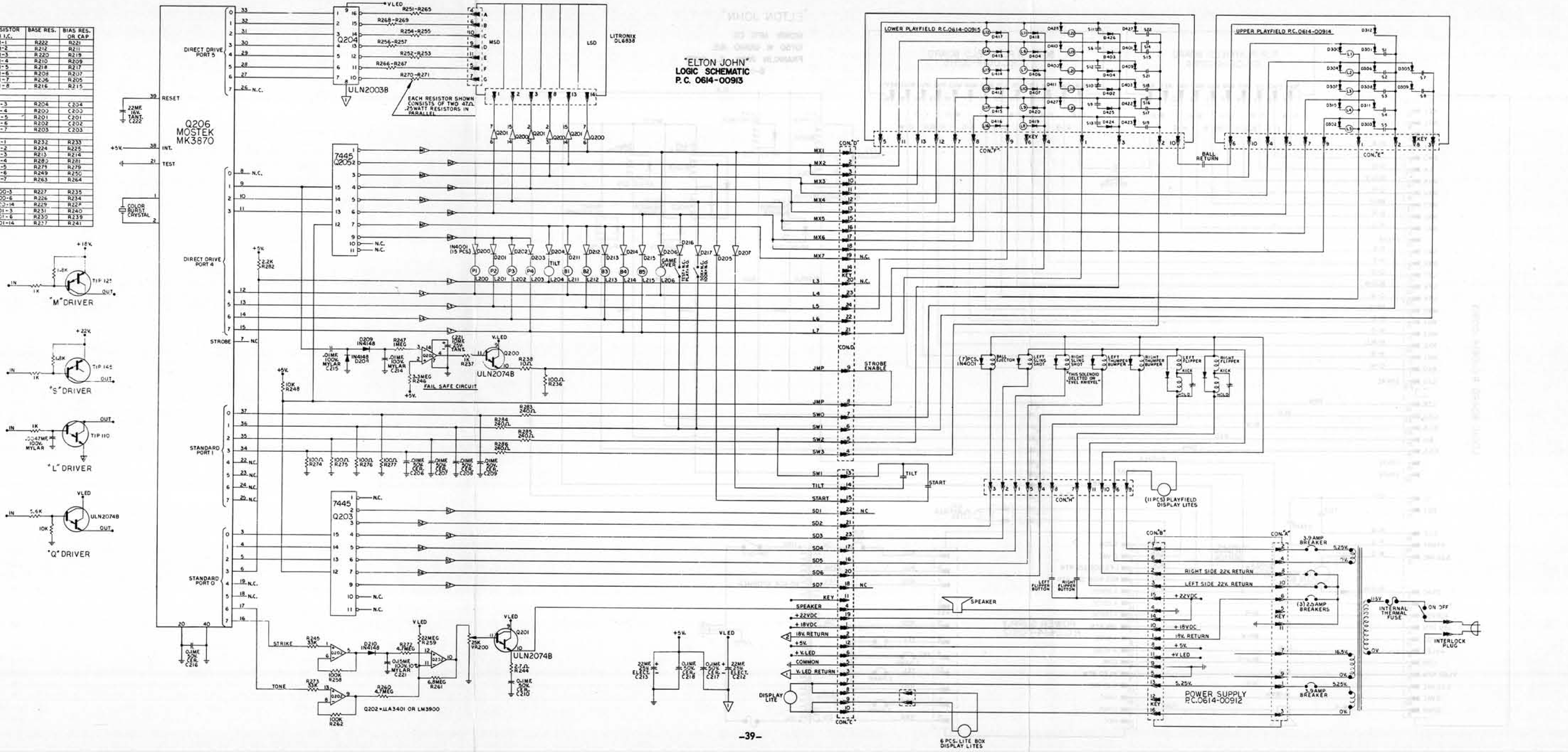
FIREBALL II & EVEL KNIEVEL
MIDWAY MFG. CO.
A BALLY CO.
10750 W. GRAND AVE.
FRANKLIN PARK, ILL.
60131
TOP PLAYFIELD BOARD
P.C.0614-00914
BOTTOM PLAYFIELD BOARD
P.C.0614-00915
BALL RETURN
LOGIC BOARD
P.C.0606-00905B,C OR D
RIGHT THUMPER BUMPER
AP-24-725
RIGHT* SLINGSHOT
AP-23-750
*THIS SOL. DELETED ON "EVEL KNIEVEL"
BALL RETURN
AP-23-575
LEFT THUMPER BUMPER
AP-24-725
(7)1N4004 DIODES
LEFT SLINGSHOT
AP-23-750
LEFT FLIPPER
BOOST
HOLD
AF-23-300/28-1000
RIGHT FLIPPER
WHITE
GRN
ORN
RED
BRN
BLU
PURPLE
GRAY
B-W
1.5 AMP CIRCUIT BREAKER
ON-OFF
115 VAC
8 AMP FUSE
MT 57 XFORMER
POWER SUPPLY
P.C.0606-00906H
4 PCS. LITE BOX DISPLAY LITES
13 PCS. PLAYFIELD DISPLAY LITES
TILT
START
SPEAKER
KEY
INTL
S1
S0
L0
MX5
MX4
MX3
MX2
MX1
S3
S2
L3
L2
L1
MX0
R.T.B.
L.T.B.
R.S.S.
L.S.S.
B.E.
COM
+5 VDC
+V LED
+12 VDC
+18 VDC
+22 VDC
DVR GND
5.25 VAC
0 VAC
SPKR
SPKR.
SOL. RTN.
+22V
16.5VAC
7.5VAC
C.TAP
WIRE COLOR CODE
B=BLACK
BLU=BLUE
BR=BROWN
G=GREEN
O=ORANGE
R=RED
W=WHITE
Y=YELLOW
EXAMPLE:
G-R INDICATES GREEN WIRE WITH RED TRACER
ABBREVIATIONS USED
J=JUMPER
SW=SWITCH
RE=RELAY
POS=POSITION
SU=STEP UP UNIT
OSC=OSCILLATING
SWITCH SYMBOLS
"NORMALLY OPEN" CLOSED WHEN ENERGIZED.
"NORMALLY CLOSED" OPEN WHEN ENERGIZED.
MAKE & BREAK
MOTOR CAM SWITCH
.1 MFD. CAPACITOR


POWER SUPPLY FIREBALL 0606-00906C & D
12V.
+V LED
DRIVER RET.
COMMON
SPKR. RET.
5V. LOGIC
22V.
22V.
18V.
KEY
22V. RETURN
5.25V.
5.25V.
0 V.
0 V.
B15
B6
B7
B8
B9
B5
B13
B14
B12
B11
B10
B3
B4
B1
B2
470MF. 16V. C109
1MF. 25V. TANT. C110
470MF. 16V. C101
0.1MF. C111
750Ω R103
75Ω R102
1MF. 25V. TANT. C102
0.1MF C104
100Ω POT OPTIONAL
STRAP
USE STRAP OR POT
78M12UC
Q104
7805KC
Q103
78M05UC
Q102
FT3055 Q101
50MF. 35V. C105
.33MF. 35V. TANT. C112
33MF. 35V. TANT. C103
33Ω 5WATT H101
1N5355B D107
1000MF. 35V. C107
20000MF. 16V. C108
10000MF. 35V. C106
1N4001 D105
1N4001 D106
1N5624 D103
1N5624 D104
6051 D102
6051 D101
A3
A1
A2
A7
A5
A4
A8
A9
KEY
16.5V.
7.5V.
0
7.5V.
16.5V.
5.25V.
0


POWER SUPPLY P.C. 0614-00912
BACK BOX DISPLAY LITES
VLED (LOGIC BOARD)
SPEAKER RETURN
VLED RETURN (LOGIC BOARD)
+22V. FLIPPER SOLENOIDS
+22V. DRIVERS (LOGIC BOARD)
+18V. FEATURE LITE DRIVERS
+5V. (LOGIC BOARD)
LOGIC BOARD COMMON
18V. RETURN (LOGIC BOARD)
22V. RETURN (LEFT SIDE SOLENOIDS)
22V RETURN (RIGHT SIDE SOLENOIDS)
PLAYFIELD DISPLAY LITES
KEY
78M05
47MF. 35V. TANT.
TIP 125
78L18
33MF. 35V. TANT.
100Ω
10,000MF. 35V. ELECTROLYTIC
20,000MF. 16V. ELECTROLYTIC
A14 F DIODES (4 PCS.)
A15 F DIODES (4 PCS.)
KEY
BLUE
3.9 AMP
5.25V.
BLUE
0V.
RED
18V.
RED
0V.
WHITE
2.5AMP
YEL
2.5AMP
YEL
2.5AMP
YEL
3.9 AMP
BRN
5.25V.
BRN
0V.

TRANSISTOR OR I.C.	BASE RES.	BIAS RES. OR CAP
M-1	R222	R221
M-2	R212	R211
M-3	R220	R219
M-4	R210	R209
M-5	R218	R217
M-6	R208	R207
M-7	R206	R205
M-8	R216	R215
L-3	R204	C204
L-4	R200	C200
L-5	R201	C201
L-6	R202	C202
L-7	R203	C203
S-1	R232	R233
S-2	R224	R225
S-3	R213	R214
S-4	R280	R281
S-5	R279	R279
S-6	R249	R250
S-7	R263	R264
Q200-3	R227	R235
Q200-6	R226	R234
Q200-14	R229	R22P
C231-3	R231	R240
Q201-6	R230	R239
Q201-14	R227	R241

"ELTON JOHN" LOGIC SCHEMATIC P.C. 0614-00913



"ELTON JOHN"

MIDWAY MFG. CO.
10750 W. GRAND AVE.
FRANKLIN PARK, IL. 60131
8-1-77