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ATARI®



Operation, Maintenance and Service Manual

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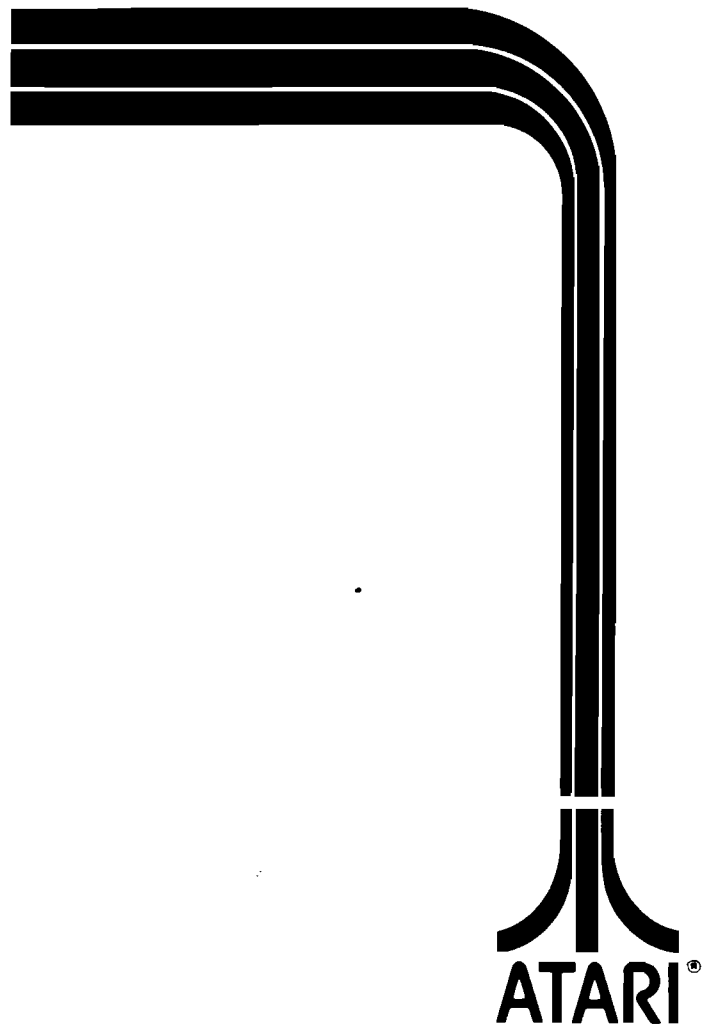
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# Time 2000™

## Operation, Maintenance and Service Manual

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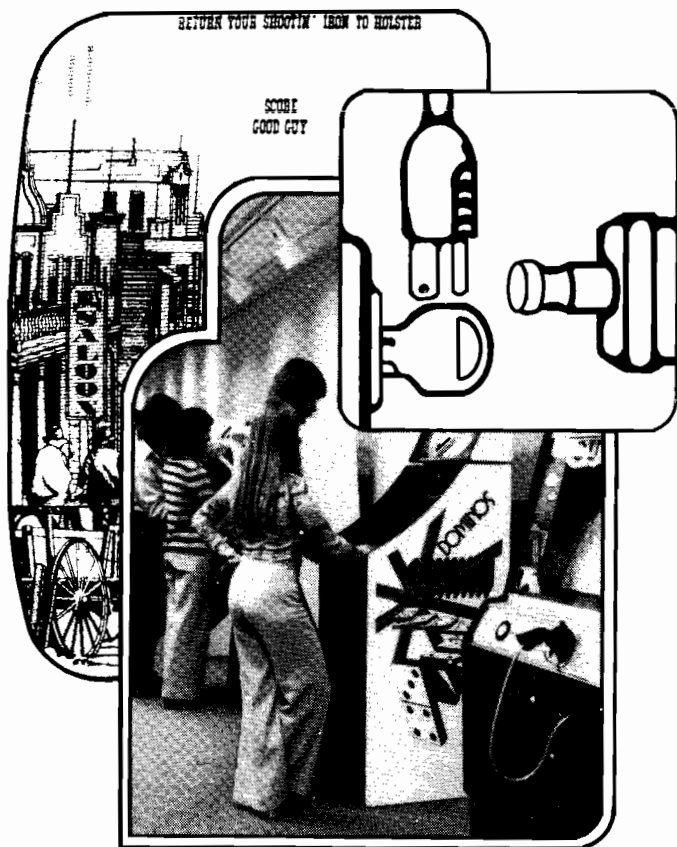
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## LOCATION SETUP

### NOTE

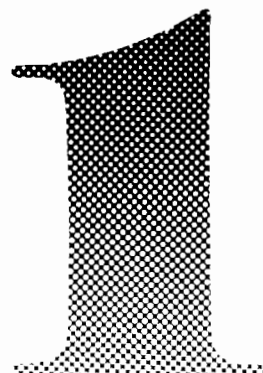
If reading through the manual does not lead to solving the specific maintenance problem, you can reach Atari's Customer Service Department by telephone (open Monday through Friday, 7:30 a.m. to 4:30 p.m. Pacific Time):

from *outside* California (800) 538-6892  
(toll-free)

from *inside* California (408) 984-1900

### A. INTRODUCTION

This Atari electronic pinball game for up to four players has the following features. An electronic display panel near the bottom left corner of the playfield shows player scores and player-up indications. Nearby two other electronic displays show ball number and game credits remaining. For a photograph of the playfield refer to Figure 1.



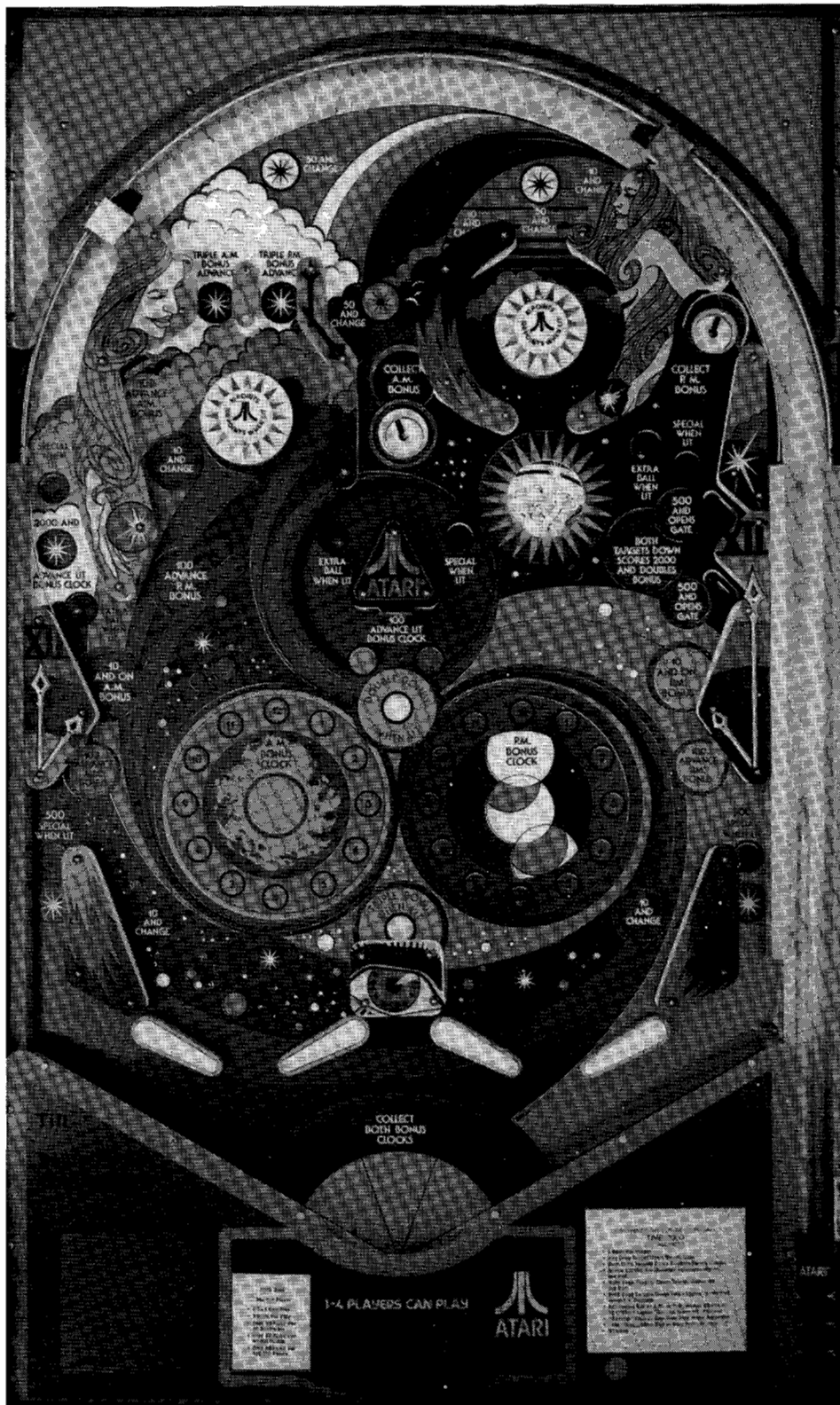


Figure 1 Top View of Playfield

During play two bonus clocks, formed on the playfield by green and yellow lamps, advance as players earn score points; they also indicate bonus points achievements. An Atari first is the *bonus retention feature which allows the player to collect the bonus without resetting it, and then allows him to continue to build up the bonus while the ball is still in play.* Table 2 lists the operator options. Whenever the game is not being played, its microcomputer causes various playfield lamps to blink on and off in sequence.

In addition to the sounds produced by solenoid-operated components (flippers, sling slots, pop bumpers, etc.), a speaker on the underside of the cabinet also produces a variety of tone sounds as the player earns score points. An optional tilt sound is also provided.

To quickly diagnose any component trouble, a self-test feature has been provided that shows operator options chosen and checks operation of all lamps, switches, solenoids and electronic displays.

## **B. INSTALLATION INSTRUCTIONS**

### **Unpacking**

Examine all parts of the cabinet, both interior and exterior, for shipping damage. As part of this you have to remove the lower arch panel, as follows.

Use a Phillips-head screwdriver to loosen and remove the screws that fasten the panel to the playfield. Then remove the panel and also remove the packing material from beneath it. Now examine the condition of the glass plate score panel and make sure that it is fully seated. (Figures 18 and 21 in Chapter 3 give details of the score panel mounting and show how its contacts have to be centered in connector J21.)

After this is done replace the panel, insert the screws and tighten them lightly. *Do not overtighten*, because that may cause the panel to warp.

Report any shipping damage immediately to the shipper and to Atari, Inc.

### **Assembly of Cabinet**

#### **NOTE**

For mechanical details of the cabinet and the back box, refer to Figure 2.

Step 1) Attach the four legs with the bolts supplied, using two per leg. The bolts screw into inserts permanently mounted inside the cabinet.

Step 2) Find the power cord coiled up inside the cabinet. Insert the plug through the slot cut in the pedestal portion of the cabinet, and then carefully withdraw the rest of the power cable. *CAUTION: Do not plug in the power cord yet.*

Step 3) Attach the back box. Use the key to unlock the small access plate on the rear side of the back box, and remove the plate. Then pull back on the locking slides. Remove the front glass. Place the box in position on the pedestal and attach it to the cabinet, using the bolts provided. Next mate the cable connector (designated P31) to the cabinet connector (J31).

Normally lamps will already be installed in the lamp sockets. Be sure flasher units are in each socket of a lamp that is to flash.

Now place the front glass down into its final position on the front of the box. Push the locking slides fully forward so that the glass is secured in place. Replace the access plate and lock it.

Step 4) Prior to shipment of the game from the factory, various quick-disconnect connectors and PCB edge connectors have been unplugged, and portions of the harness wiring have been temporarily tied down. Now remove these ties and mate all connectors. Refer to Figure 3 for locations of various connectors inside the cabinet. Please note that color-coded connectors mate with edge connectors of same color. Color dot on each edge connector is near pin 2.

#### **CAUTION**

Do not plug in the power cord yet.

### **To Open Game Cabinet:**

Step 1) Place Power On/Off Switch in its off position.

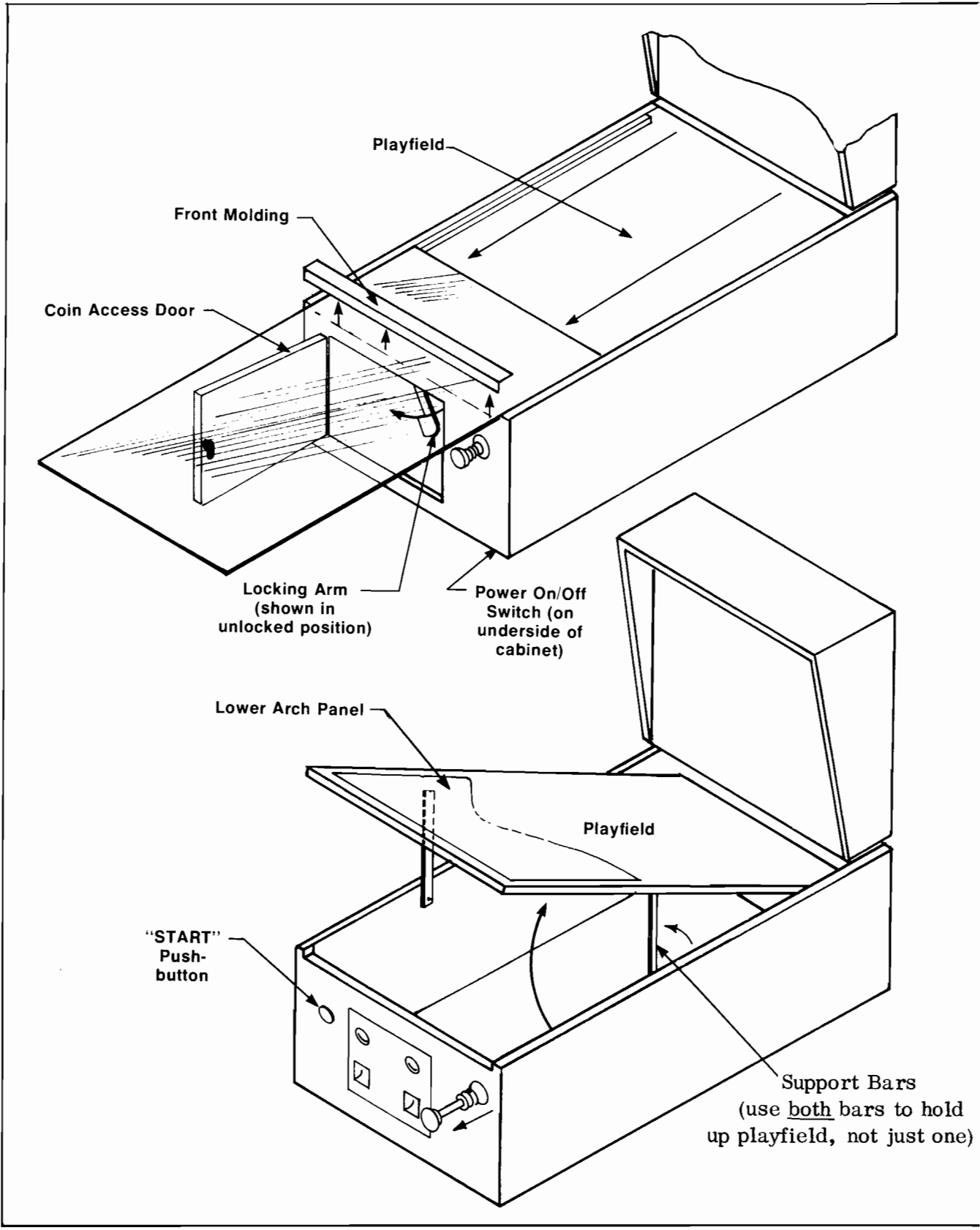
Step 2) Unlock and fully open the coin access door.

#### **NOTE**

The above steps will turn off AC power to the game; if any lamps remain lighted, immediately unplug the power cord. Then replace the Power On/Off Switch and replace or adjust the Interlock Safety Switch.

Step 3) Find the locking arm in the upper right corner of the coin door opening.

Step 4) Pull the locking arm all the way down into its unlocked position.



NOTE: For clarity lamps, lamp sockets and lamp wiring have been omitted.

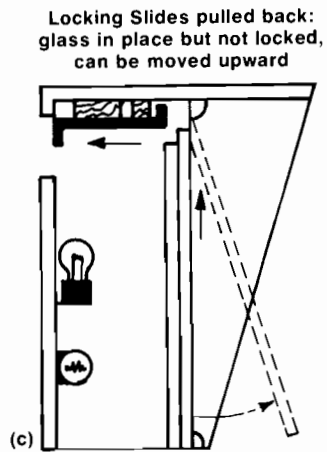
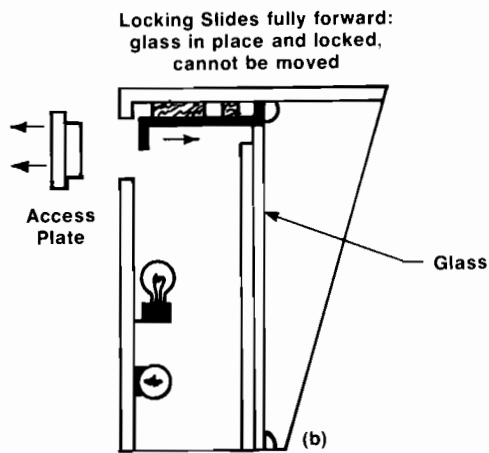
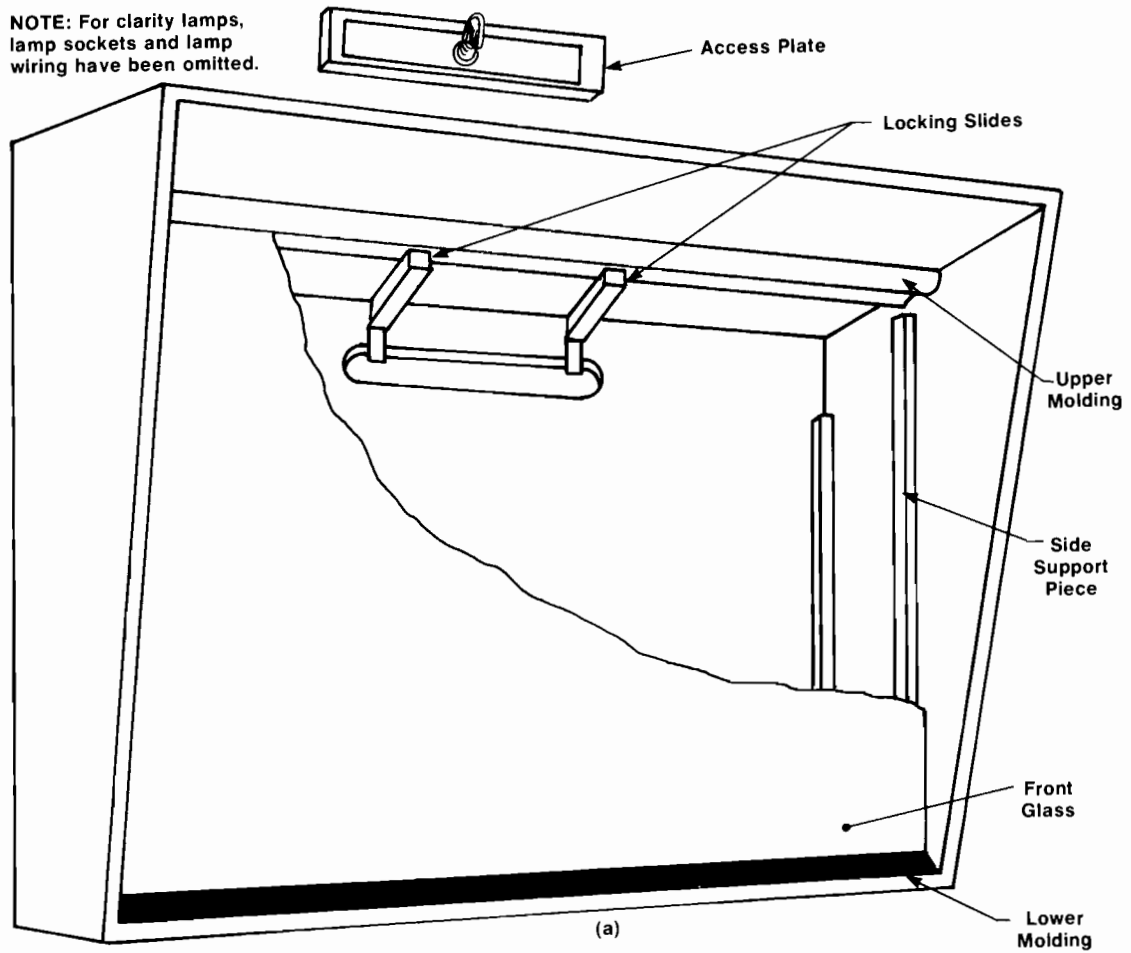


Figure 2 Illustrated Procedure for Opening and Closing Game Cabinet

Step 5) Lift up and completely remove the front molding piece.

Step 6) Slide the playfield cover glass all the way toward the front of the cabinet, and remove it from the cabinet.

Step 7) With one hand grasp the ball shooter and pull it back about two inches so that the tip of the shooter rod no longer protrudes past the edge of the playfield surface. While holding back the ball shooter handle, use the other hand to raise the end of the playfield board up past the ball shooter.

Step 8) While holding the playfield up with one hand, release the ball shooter handle and use that hand to remove the ball from the playfield. Next grasp the playfield support bar and raise the playfield up high enough so that the tip of the support bar can be placed in the recess cut on the bottom side of the playfield board, near the edge. Still holding the playfield, put the other support bar up into its recess. To ensure the playfield will stay in place, please use both support bars. If you need the room, the playfield may be raised completely and rested against the back box. However, before doing this, unplug the connectors from the Auxiliary PCB.

**WARNING**

Due to exposed voltages when the cabinet is open, only persons familiar with safety measures and repair procedures on electrical equipment should apply AC power and operate the game while the game cabinet is left open.

**To Close Game Cabinet:**

Step 9) Confirm that all game parts (such as the plastic sheet that is mounted over the Processor PCB) are in place, and that no foreign objects (such as tools, test equipment, soldering irons, etc.) are left lying inside the cabinet. Also confirm that all color-coded connectors are connected to the matching color coded edge connectors.

Step 10) Use one hand to lift up the playfield, and use the other hand to lower the support bars down into their folded (stowed) positions.

Step 11) Lower the playfield and with the other hand pull back on the ball shooter handle so that the playfield board can be lowered all the way

down into its normal play position. After this is done, release both the ball shooter handle and the playfield.

Step 12) Place the ball back onto the playfield and let it roll down into the outhole. (Do NOT put the ball in the shooter alley or leave it out on the playfield.)

Step 13) Replace the playfield cover glass by sliding it all the way back in its guides until it touches the rear end of the cabinet.

Step 14) Replace the front molding piece.

Step 15) Push the locking arm all the way back up into its fully locked position.

Step 16) Close and lock the coin access door. Make sure it is fully closed on all sides.

Step 17) Place the power on/off switch in its on position.

**To Open Back Box:**

Step 1) Unlock and remove the access plate on the top of the back side of the back box.

Step 2) Pull all the way back on the handles of the two locking slides (see sketches (a), (b) and (c)). Now the front glass will be free to be moved a short distance straight up.

Step 3) Raise the glass straight up (see phantom view sketches (b) and (c)).

Step 4) Pull the bottom edge of the front glass away from the lower molding, then lower the glass down far enough to clear the upper molding. Remove the glass completely.

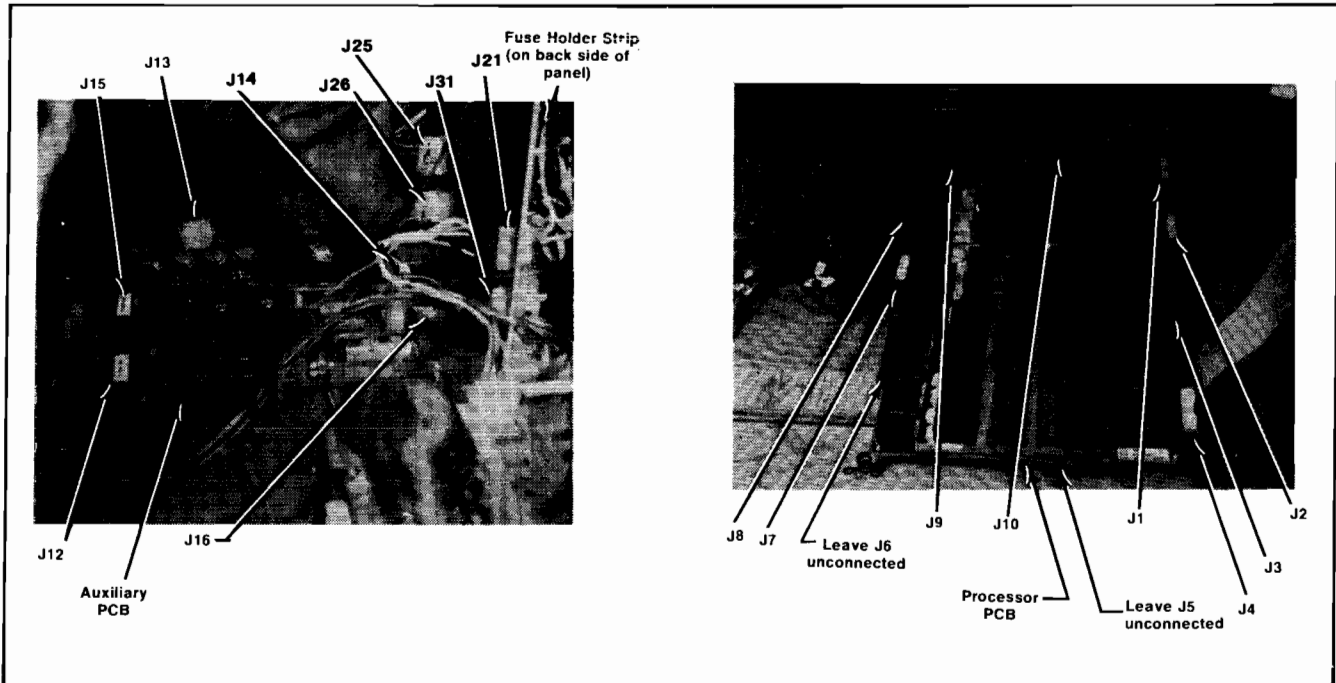
**To Close Back Box:**

Perform steps 1 through 4 in reverse order.

**Setup Adjustments and Checks**

After assembling the cabinet, put the game on location and do the following.

Step 1) Adjust the leveling screws built in at the floor ends of the legs. Use a carpenter-type bubble level to insure that the cabinet will be truly level, both side to side and front to back. *Do not place the level on the playfield surface.* Instead put it in the two places shown in Figure 4.



**Figure 3 Locations of Certain Connectors Inside the Cabinet**

Step 2) After the game cabinet has been properly leveled, the tilt pendulum should be hanging in the center of the metal ring that surrounds it. Sensitivity can be adjusted by loosening the thumb screw on the pendulum bob and then sliding it up or down on the pendulum shaft.

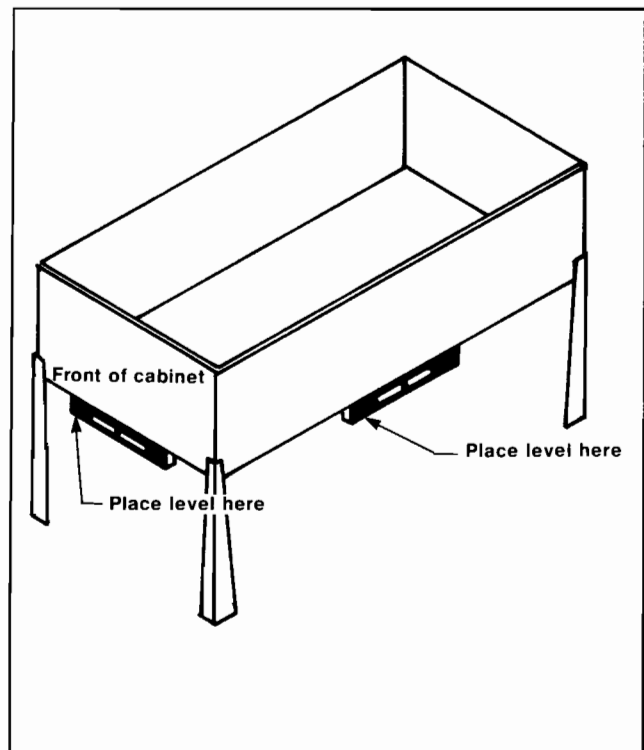
Lowering the bob reduces clearance between the bob and the ring, and thus makes the switch more sensitive (meaning that it is easier to tilt the game). After adjusting, tighten the thumb screw.

Step 3) Verify that all fuses are in place and fully seated.

Step 4) Verify that all connectors are correctly and fully mated, and that those to the printed circuit boards are color code matched and fully seated.

Step 5) Make sure that no loose foreign objects are present (especially metal objects which could cause electrical short circuits), and that no harness wires have become disconnected, pulled loose or broken. Check *all* major assemblies.

Step 6) Close up the cabinet, close and lock the coin access door.



**Figure 4 Leveling of Cabinet at Game Site**

**Table 1 Game Specifications**

<b>GENERAL</b>	
Cabinet Dimensions:	Width 74 cm (29 inches), Depth 131 cm (51½ inches); for other dimensions refer to Figure 5.
Playfield Glass Dimension:	Tempered Glass Width: 70 cm (27¾ in.); Depth: 114 cm (45 in.); Thickness 0.64 cm (¼ in.)
Coin Mechanisms: Cash Box:	Two identical mechanisms (connected in parallel) Removable; located behind locked access door to coin mechanism assembly.
Power Cord:	Approximately 10 ft. long, extending from rear of cabinet and having grounded three-prong plug for conventional wall outlets.
Power On/Off and Power Interrupt Switch:	Atari has installed two series-wired on/off switches into the game. The Power On/Off Switch is for energy conservation. Located on the bottom right front corner of the cabinet, it is convenient for shutting the game off during slow business or closing hours. The second switch is the Power Interrupt Switch. This switch is installed inside the coin door. Its purpose is to remove power from the game when the coin door is open. This prevents the hazard of accidental shock when you stick your hand through the coin door.
Back Box Lighting:	Five incandescent lamps inside Back Box, each 7.5 watts; two lamps lighted constantly, and other three with plug-in flasher units that cause them to blink on and off.
Coin Mechanism Lighting:	One GE #47 incandescent lamp mounted inside cabinet.
Convenience Outlet:	Mounted inside cabinet; accepts 2- or 3-prong plug from test equipment or soldering iron during troubleshooting or repair of game.
Number of Players:	Any number of persons from 1 to 4 can play.
Flippers:	Total of four flippers, controlled in pairs. Left flipper pushbutton controls extreme left and right center flippers; right flipper pushbutton controls extreme right and center left flippers.
Self-Test Feature:	For troubleshooting purposes game can be put into a Test mode of operation during which any of four types of diagnostic tests can be performed.
Power Requirement:	Game is shipped to you for the operation on the standard power source of your location. If solenoids of game operate sluggishly, contact Atari Customer Service for information to modify the input voltage requirements.
Fusing:	Main set of three fuses located inside cabinet near the front, for Line Power, Back Box and Service Outlet. Another set of six fuses on the Power Supply Assembly inside the cabinet connected in secondary windings of power transformer.
<b>ENVIRONMENTAL</b>	
Operating and Storage Temperature Range:	From 0° Celsius (32° Fahrenheit) to 49° Celsius (120° Fahrenheit), ambient temperature.
Relative Humidity:	Maximum of 95% without condensation.



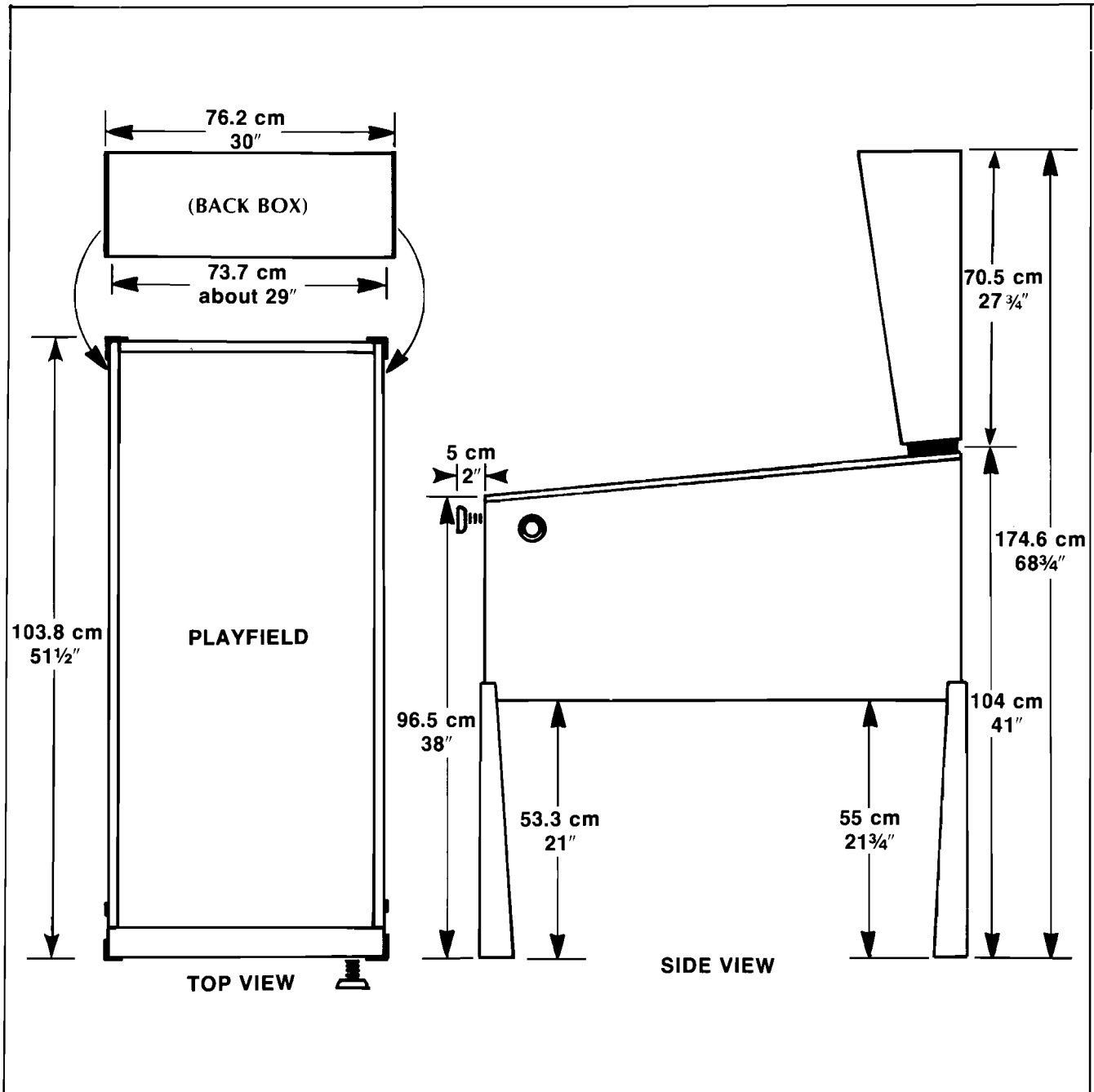


Figure 5 Cabinet Dimensions

### Application of AC Power

Make sure that the coin access door is fully closed, and then plug the power cord into an AC outlet providing the AC power listed in Table 1. The wall outlet must accept a three-prong plug and the receptacle must be connected to a good earth ground.

If the Power On/Off Switch is in its *ON* position, the back box lamps will light up as soon as the power cord has been plugged in. If this switch is in its *OFF* position, place it *ON* so that the lamps come on.

If there is no response at all from the game, unplug the power cord *immediately* and refer to the instructions in Section B of Chapter 3 for fuse replacement.

**CAUTION**

No troubleshooting steps should be attempted inside the cabinet by anyone not familiar with safety measures and repair procedures on electrical equipment.

### C. ADJUSTING OPERATOR OPTIONS

#### Check on Operation of Interlock Switch

The interlock switch is a safety switch mounted inside the cabinet alongside the coin access door. Its purpose is to prevent accidental electrical shock to a person who reaches inside the cabinet through the coin door openings. At the factory this switch is mechanically adjusted so that it will automatically transfer to its *off* position (switch contacts open) whenever the door is opened. When the interlock switch is in its *off* position, the AC power leading to the game's power supply is interrupted. When the door is closed, the interrupt switch is adjusted to be in the *on* position (switch contacts closed) and AC power is allowed to reach the game's power supply, meaning that the game can operate.

After application of AC power, unlock and slowly open the door. The correct response is that by the time the edge of the door has moved about 2 to 3 inches away from the cabinet all lamps should be unlighted, verifying that the interlock switch has automatically transferred to *off*. While opening the door do not insert fingers inside the cabinet and do not allow foreign objects to fall inside. If the lamps continue to be lighted up even after the door has been opened, immediately close and lock it and unplug the power cord from the wall outlet. Then replace and/or adjust the interlock switch.

Do not go on to the remaining paragraphs in this section until the operation of the interlock switch has been checked and found to be correct.

#### Changing the Settings on DIP Switches at F2 and F4

Operator options are selected by manually setting the positions on various miniature switches mounted on the Processor PCB inside the game cabinet. Table 2 describes options, switch settings and effects of options on game play.

After deciding which options are wanted, perform the following steps.

- Step 1) Place the Power On/Off Switch to the *off* position.
- Step 2) Unlock and open the cabinet, propping up the playfield with the built-in support bars.
- Step 3) Remove the four screws that hold the plastic sheet in place over the Processor PCB, and remove the sheet.
- Step 4) Locate the switches on the board, as shown in Figure 6.
- Step 5) Change the switch settings to select the desired options.
- Step 6) Replace the plastic sheet over the PCB, and reinstall the screws that hold it in place.
- Step 7) Make sure that no foreign objects have fallen or been left inside the cabinet. Then lower the playfield.
- Step 8) If any of the options selected affect the instructions or other information shown on the Instruction Card, replace with a new card.
- Step 9) Close and lock the cabinet by performing steps 9 through 17 given in Figure 2.

**Table 2 Switch Settings for Operator Options**

Name of Option	Switch	Toggle Settings	Effect on Game
Operating Mode	Location F2	1 off	Play Mode and Attract Mode
Self Test Mode	Location F2	1 on	Test mode only
Coin/Credit Mode for left coin chute	Location F2	2 off, 3 off, 4 off	1 coin, 1 credit
	Location F2	2 on, 3 off, 4 off	1 coin, 2 credits

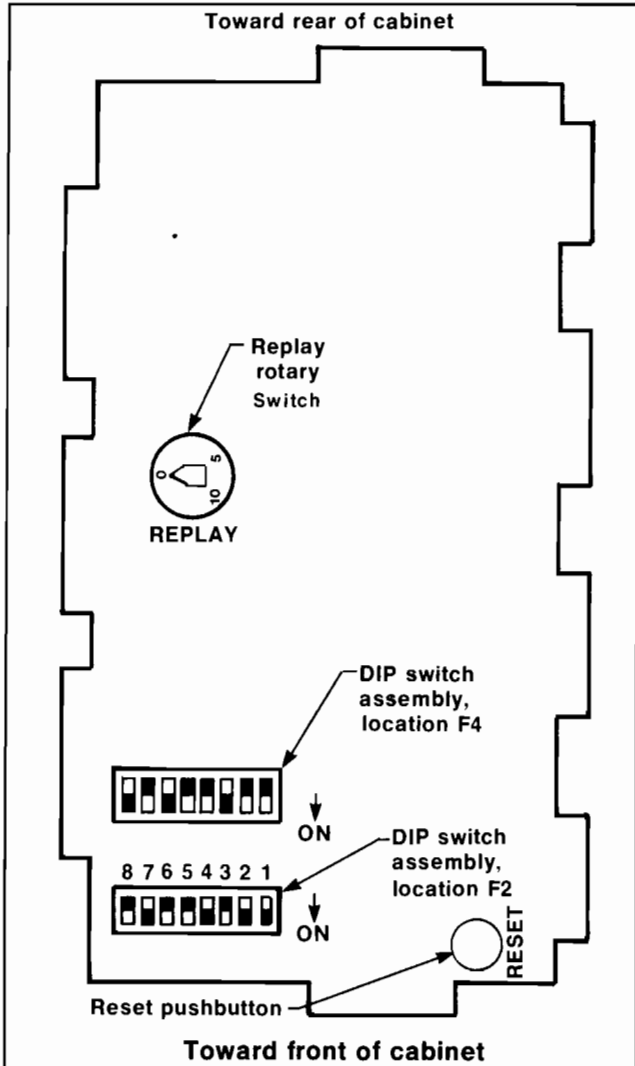
**Table 2 Switch Settings for Operator Options**

	Location F2	2 off, 3 on, 4 off	1 coin, 3 credits
	Location F2	2 on, 3 on, 4 off	1 coin, 4 credits
	Location F2	2 off, 3 off, 4 on	1 coin, 5 credits
	Location F2	2 on, 3 off, 4 on	1 coin, 6 credits
	Location F2	2 off, 3 on, 4 on	2 coins, 1 credit
	Location F2	2 on, 3 on, 4 on	2 coins, 3 credits
Coin/Credit Mode for right coin chute	Location F4	4 off, 5 off, 6 off	1 coin, 1 credit
	Location F4	4 on, 5 off, 6 off	1 coin, 2 credits
	Location F4	4 off, 5 on, 6 off	1 coin, 3 credits
	Location F4	4 on, 5 on, 6 off	1 coin, 4 credits
	Location F4	4 off, 5 off, 6 on	1 coin, 5 credits
	Location F4	4 on, 5 off, 6 on	1 coin, 6 credits
	Location F4	4 off, 5 on, 6 on	2 coins, 1 credit
	Location F4	4 on, 5 on, 6 on	2 coins, 3 credits
Balls per game	Location F4	1 on	3 balls
	Location F4	1 off	5 balls
Maximum Game Credits	Location F2	5 off, 6 off	8 games
	Location F2	5 on, 6 off	12 games
	Location F2	5 off, 6 on	15 games
	Location F2	5 on, 6 on	20 games
Exceeding Replay Score (for replay setting see selection of Replay Score Setting)	Location F2	7 off, 8 off	No replay, No extra ball
	Location F2	7 on, 8 off	Extra ball
	Location F2	7 off, 8 on	Replay
	Location F2	7 on, 8 on	Replay
Selection on "Special"	Location F4	7 off, 8 off	Extra ball
	Location F4	7 on, 8 off	Replay
	Location F4	7 off, 8 on	10,000 extra points
	Location F4	7 on, 8 on	10,000 extra points
Match	Location F4	2 off	Match off
	Location F4	2 on	Match on
Slam/Tilt Warning Sound	Location F4	3 off	Sound off
	Location F4	3 on	Sound on
Replay Score Setting	"REPLAY"		For exceeding a score of:
	rotary	position 0	40,000 60,000 80,000
	switch	1	50,000 70,000 90,000
		2	60,000 90,000 120,000
		3	70,000 100,000 130,000
		4	80,000 120,000 160,000
		5	90,000 130,000 170,000
		6	100,000 150,000 200,000
		7	110,000 160,000 210,000
	8	120,000 180,000 240,000	

**Table 2 Switch Settings for Operator Options**

9	130,000	190,000	250,000
10	140,000	210,000	280,000
11	150,000	220,000	290,000
12	160,000	240,000	320,000
13	170,000	250,000	330,000
14	180,000	270,000	360,000
15	190,000	280,000	370,000
	Number of free balls or games granted:		
	1	2	3

NOTE: The microcomputer will sense switch settings each time after game power is turned on. Persons servicing the game and having power on while the playfield is propped up should depress the "RESET" pushbutton on the PCB after making any switch setting changes.

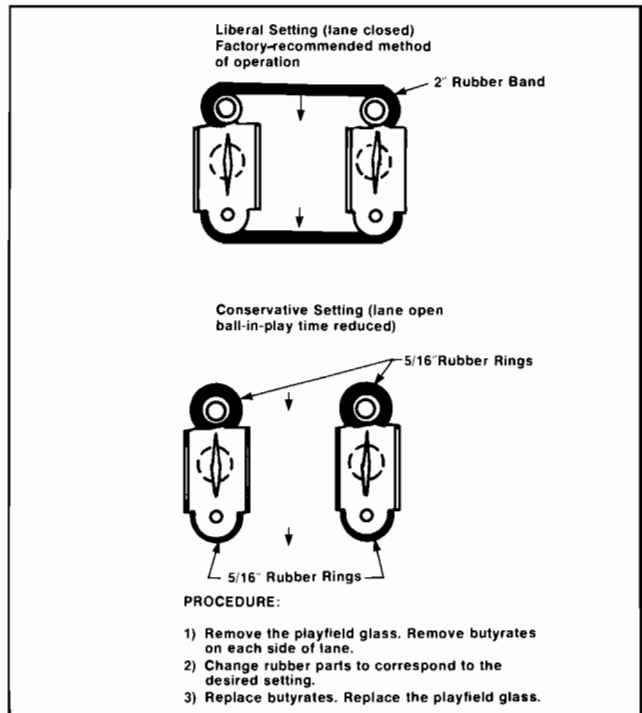


**Figure 6 Locations of Operator Option Switches on Processor PCB**

### Percentaging of Ball-in-Play Time

A simple mechanical adjustment on the playfield's center drain lane provides the operator with two choices for percentaging of ball-in-play time. Figure 7 shows how to make this adjustment.

In the liberal setting the lane is closed, and the ball reaches the outhole through either side drain lane. In the conservative setting the center lane is open, providing a third path to the outhole and thus reducing ball-in-play time by about 10 to 20 percent.



**Figure 7 Operator Adjustments on Center Drain Lane**

## D. PERFORMING SELF-TEST

### Putting the Game into Test Mode

On the DIP switch assembly at location F2, placing switch 1 to "ON" puts the game into test mode. Four tests are available, performed only in sequential order starting with Test 1.

### Test 1—Display of Options and Lamp Test

On the score display panel the scores corresponding to the setting of the "REPLAY" rotary switch will appear as shown in Figure 8, the Ball display will show the selection made in the Number of Balls option, and the Credit display will show the selection made in the Maximum Game Credits option. Also all playfield lamps will light up and remain lighted for as long as the game is kept in the test mode. (The lamps in the back box are unaffected by the test mode.)

#### CAUTION

When replacing lamps use #47 bulbs only; other bulb types can cause damage to the lamp driver circuits.

To change to Test 2 depress and release the "START" pushbutton.

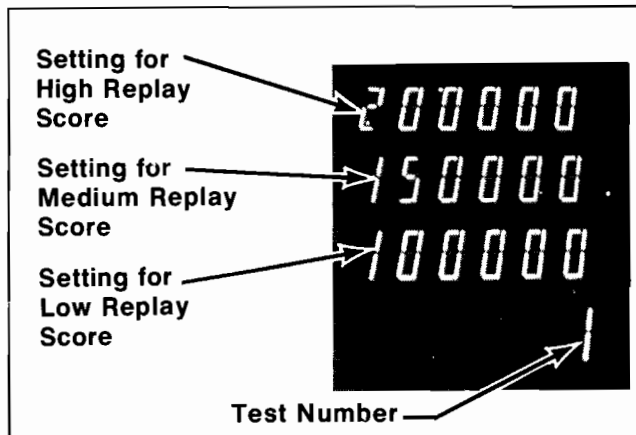


Figure 8 Typical Pattern During Options Display and Lamp Test Portion of Test Mode

### Test 2—Switch Test

First, make sure ball is not in outhole!

If all playfield switches are *off* (open), then the speaker will not produce any tones. But if the speaker produces a descending-tone sound every second it means that one or more switches are stuck in the *on* position. The number showing in the Credit Display will identify the switch (or set of parallel-connected switches). Table 3 lists the numbers that correspond to the game's switches. If more than one switch is stuck, then each number will be displayed for one second.

Table 3 Numbers Displayed During Switch Test

Number Shown in CREDIT Display	Switch Stuck in <i>On</i> or Closed Position
01	Left coin-mechanism switch
02	Right coin-mechanism switch
03	START-button switch on front of game
04	Coin door slam switch
17	Cabinet tilt switch (mounted on floor of cabinet)
18	Pendulum tilt switch and eight anti-cheater magnetic switches
19	Left flipper pushbutton
20	Right flipper pushbutton
21	Left pop bumper
22	Right pop bumper
23	Center hole kicker
24	Right hole kicker
33	Left slingshot
34	Right slingshot
35	All 10 AND CHANGE standup switches
36	10 AND ON A.M. BONUS standup switch (on left side)
37	10 AND ON P.M. BONUS standup switch (on right side)
38	Outhole kicker
39	100 ADVANCE A.M. BONUS (target switch)
40	Upper drop target
41	Lower drop target
42	Both 100 ADVANCE P.M. targets
43	Center target
44	2000 AND ADVANCE LIT CLOCK (magnetic switch)
45	TRIPLE A.M. BONUS ADVANCE (magnetic)
46	TRIPLE P.M. BONUS ADVANCE (magnetic)
47	Three 50 AND CHANGE switches (magnetic)
59	Left side drain
60	Right side drain (gate lane)

To change to Test 3 depress and hold down the START button. At first the game will test the start switch, but after a few seconds the game will change over to Test 3 and a beep tone will be heard. Release the START button after this happens.

**Test 3—Solenoid Test**

This test allows you to operate each solenoid, one at a time. Table 4 lists a number for each solenoid. The number of the solenoid under test shows in the Credit display, and that solenoid operates each time you press the *left* flipper pushbutton. To advance to the next solenoid on the list, depress the *right* flipper pushbutton.

To change to Test 4 depress and release the START button.

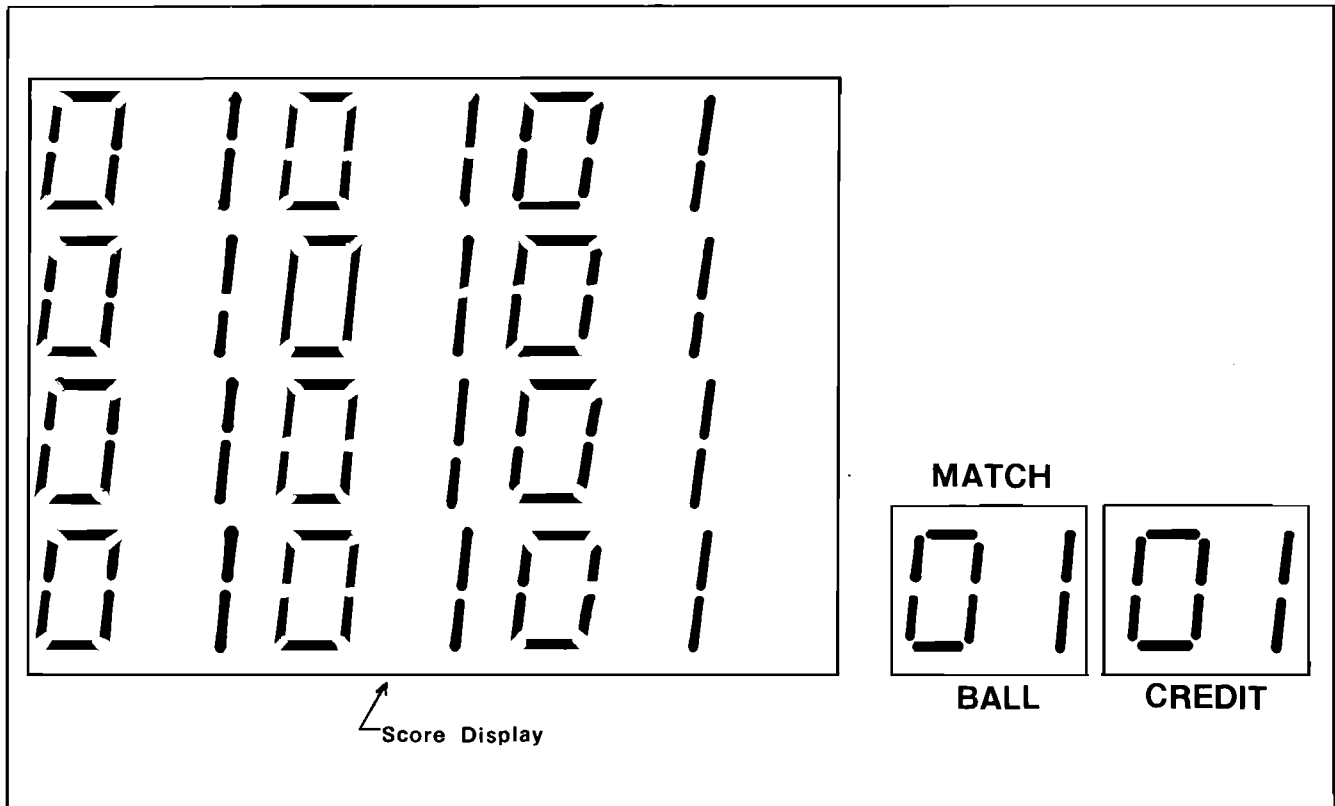
**Test 4—Display Test**

This test automatically exercises the displays through all numbers. At the beginning of the test the pattern 01 appears in all displays, as shown in Figure 9. After a few seconds the pattern changes to 12, then subsequently to 23, 34, 45, 56, 78, 89 and 90. While this is happening the “player up” indications on the Score Display will also be lighting up, one at a time.

**Table 4 Numbers Displayed During Solenoid Test**

Number Shown in CREDIT Display	Solenoid Being Tested
01	Gate (on right side of playfield)
02	Right pop bumper
03	Left pop bumper
04	Right hole kicker
05	Center hole kicker
06	Right outside flipper
07	Right center flipper
08	Left center flipper
09	Left outside flipper
10	Right slingshot
11	Left slingshot
12	Outhole kicker
13	Upper drop target
14	Lower drop target

To change back to Test 1, depress and release the START button.



**Figure 9 Typical Pattern During Display Test Portion of Test Mode**



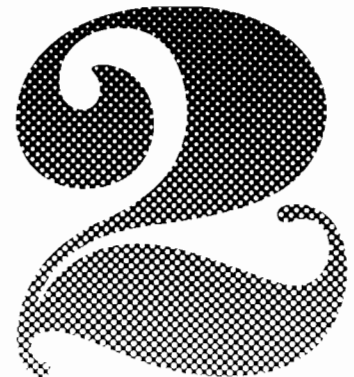
## GAME PLAY

### A. OPERATING MODES

The game has three modes: attract, play and test. In normal use it alternates between attract and play, and is put into test for maintenance and troubleshooting purposes only. Refer to Chapter 1, Section D for a description of Test Mode.

After AC power is turned on the game starts out in the attract mode. After a player deposits the coins required for a play sequence and depresses the START pushbutton, the game changes over to the play mode. Whenever AC power to the game is turned off, the lock-out coil on the coin door is de-energized and the game will not accept coins.

The lamps inside the Back Box continue to operate during all three modes.



## **B. ATTRACT MODE**

During Attract the flipper controls are disabled, the ball is left lying in the outhole, and the speaker does not produce any sounds. Also on the playfield certain lamps will be blinking on and off. Specifically, the lamps in the clocks light up one at a time (in a counter-clockwise direction on the A.M. Clock, and clockwise on the P.M. Clock), the SPECIAL lamps light one at a time, the EXTRA BALL lamps light one at a time, the DOUBLE BONUS and TRIPLE BONUS lamps light alternately, and the pop bumpers also light alternately.

Two separate cases have to be described—after initial application of AC power and after completion of a play sequence in the play mode.

After application of power all 8's will be showing in the Credit, Match and Score Panel Displays. The "player up" indications on the Score Display will light up one at a time in numerical sequence. Furthermore, if at the moment that power was applied the ball had been lying in any kicker hole on the playfield, the microcomputer will sense this condition and energize the kicker solenoid so that the ball is ejected and can roll down into the Outhole.

The game changes over to Attract after the last player's last ball has fallen into the outhole, and after the match feature is completed (provided that the game is structured to allow the match feature). In this case final player scores from the just-completed play sequence remain on the Score Panel, the Credit Display indicates the number of game credits remaining, and the match number remains showing in the Match Display.

To insure a long, trouble-free operating life for the Score Display panel, the microcomputer automatically blanks out all numbers in this display after the first two minutes of the attract mode have elapsed. This display is never turned off during the play mode, however.

## **C. PLAY MODE**

If the Credit Display is showing any number other than 00, a player needs only to depress the START pushbutton in order to change the game over from the attract to play mode.

The Credit Display showing 00 means that no credit is remaining and that the player must deposit money into the game. After the coin mechanisms have accepted the number of coins needed for one

play, the game responds as follows: The Score Panel goes blank, the Credit Display will change to show the number of game credits given for the coins deposited, and the speaker momentarily produces a tone.

After a player has depressed the START button, the game responds as follows:

- 1) The uppermost row in the Score Panel will show all zeros, and the words *1ST UP* to the right of the zeros will start to blink on and off.
- 2) The number in the Credit Display decreases by 1.
- 3) The Match Display will now become the Ball Display and will indicate *01*, meaning that the ball #1 is in play.
- 4) The ball is ejected from the outhole and rolls over to the ball shooter.
- 5) The playfield lamps will stop blinking, and 1000 and BALL IN PLAY lamps will be constantly lighted. All other score-related lamps remain unlighted.
- 6) The flipper controls are enabled.
- 7) On the player panel just above the ball shooter the lamp behind the numeral *1* (surrounded by yellow) will light, indicating that so far one player is playing.

Up to this point and even up until the ball hits the first score point object, additional players may be added to the game. They do this by depositing money (if necessary), and by then depressing the START pushbutton. Each time the game responds by adding another row of zeros in the Score Panel, decreasing the Credit Display by 1, and lighting another lamp just above the ball shooter.

If a ball rolls all the way down to the outhole without achieving any score whatsoever, the outhole kicker will then eject the ball so that the player can shoot again. But if a ball achieves any score it is counted as one of the play balls.

As soon as the first score points are earned, the lock-out coil on the coin door is de-energized and the coin mechanisms will not accept any coins until after the play sequence ends. The game's speaker also produces sounds when score points are earned, as follows:



- 1) For each 1000 points a low-pitch, long-duration tone
- 2) For each remaining 100 points a medium-pitch, medium-duration tone
- 3) For each remaining 10 points a high-pitch, short-duration tone.

### Scoring and Cumulative Effects

Score points awarded for hitting various playfield objects, falling into dropholes, and rolling over certain spots on the playfield are printed in playfield graphics shown in Figure 1. The microcomputer adds these points immediately to the player's accumulated score.

At the beginning of the play mode the "1" lamps in both clocks are lit. Also the yellow A.M. lamp and the right pop bumper lamps are lit, but each subsequent scoring event causes the A.M and P.M. lamps and the pop bumper lamps to light up alternately.

Players "advance" the clocks (cause additional clock lamps to light up) in any of three ways:

- 1) By rolling over the sensor in the upper left ball lane
- 2) By hitting a rebound target
- 3) By rolling through either the TRIPLE A.M. BONUS ADVANCE or the TRIPLE P.M. BONUS ADVANCE lanes near the top left of the playfield.

Besides the points awarded immediately, these player accomplishments can also have a cumulative effect on the number of points awarded while that ball is in play. For example, if the ball rolls into the center drophole while the "3" lamp in the A.M. clock is lit, the player immediately receives three times as many bonus points as he or she would have received had only the "1" lamp been lit.

Other examples of cumulative effects include double bonus points (given if the DOUBLE BONUS WHEN LIT lamp is turned on), triple bonus points (given if the TRIPLE BONUS WHEN LIT lamp is lit), extra ball and the "special" feature.

### Bonus, Double Bonus and Triple Bonus

The player can collect the A.M. clock bonus by rolling the ball into the center drop hole, and collect the P.M. clock bonus by rolling into the right drophole. The player also collects both clock bonuses when the ball rolls through a drain lane.

The player lights up the DOUBLE BONUS WHEN LIT lamp by knocking down both drop targets with the same ball. Both targets then pop back up. However, at the start of the player's last ball the DOUBLE BONUS WHEN LIT is automatically turned on so that knocking down *both* targets with this ball causes the TRIPLE BONUS lamp to light.

### Extra Balls

If the player manages, with the same ball, to knock down both drop targets *twice*, then the three EXTRA BALL lamps will light up sequentially, one at a time. If the player subsequently rolls the ball into the left ball lane or a drophole *while that EXTRA BALL lamp is lit*, then the player is given an extra ball.

In addition to the foregoing, it is also possible for players to earn extra balls if the operator options for exceeding replay score and the "special" selection are set to allow this.

### "Special" Feature

The player lights the lower two 500 SPECIAL WHEN LIT lamps by advancing either clock all the way to 12, after which these two lamps remain lit. Also the upper three SPECIAL WHEN LIT lamps will light up sequentially, one at a time. The player can now collect the "special" either by rolling the ball through either side drain lane, or else by rolling the ball into the upper left lane or a drophole *while that "SPECIAL" lamp is lit*. A player may collect one special for each of the two clocks with one ball. When the special is collected, the SPECIAL WHEN LIT lamps go dark.

### Tilt Condition

The game is provided with a pendulum tilt switch, a slam tilt switch on the coin door, another slam-type switch on the floor of the cabinet, and eight anti-cheater magnetic switches distributed in various positions beneath the playfield. If the microcomputer senses any closure of the above switches, it will put the game into a "tilt" condition and light the *TILT* lamp.

If the slam/tilt warning sound owner option has been selected, a sound is produced when the game is tilted.

### Match Score Option

If this option is selected, after the last player's last ball has reached the outhole the Ball Display changes into a Match Display (the lamp behind the word BALL will be unlighted, and the lamp behind the word

MATCH will light). Then numerals in the display will momentarily "spin" at random; after that ceases, the number left showing will be the match number.

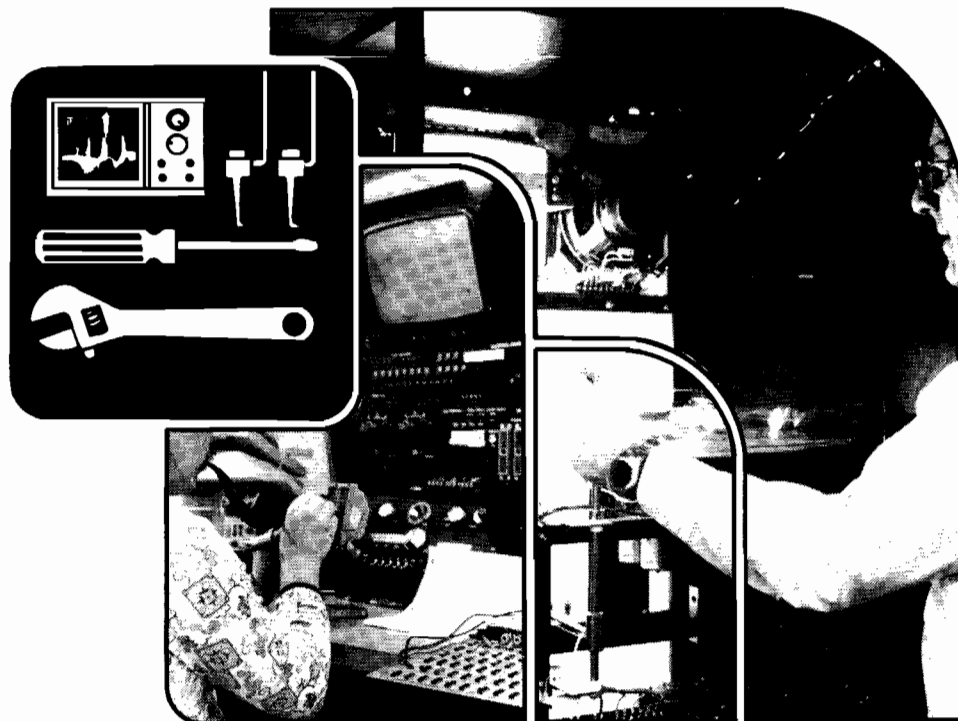
The microcomputer then compares the match number with the two least significant digits in each player's score. One game credit will be awarded for each match-up. Therefore a maximum of four matches are possible after a four-player game has ended.

#### **Maximum Game Credits Option**

This option places an upper limit on the number of game credits that can be accumulated at any one time. Game credits can be obtained in any of three

ways: by depositing money into the game, by earning replays (provided that the game is structured to allow replays), and by the match option (provided that this option is selected). As soon as the number shown in the Credit Display reaches the maximum selected by the operator, the lockout coil in the coin mechanism is de-energized (meaning that the coin mechanism will not accept any coins) and players will not be awarded any more replay credits.

After the START pushbutton has subsequently been depressed one or more times, the number in the Credit Display will be reduced below the maximum and additional credits can be obtained, but only up to an amount equal to the selected maximum.



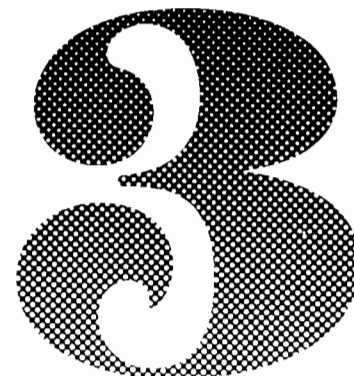
## MAINTENANCE AND ADJUSTMENTS

Due to its solid-state electronic circuitry, this Atari game should require very little maintenance and only occasional adjustment. Information given in this chapter and elsewhere in the manual is intended to cover most servicing situations that may be encountered at the game site. The procedures given are in sufficient detail to be understood by a person with moderate technical ability.

### A. CLEANING

#### Exterior Cabinet Parts

The exterior parts of the game cabinet and glass may be cleaned with any non-abrasive household cleaner. If desired, special coin machine cleaners which leave no residue can be obtained from distributors.



**Playfield**

The surface of the playfield has a finish chosen for its long-wearing property. Check the surface periodically to make sure that it is both clean and free of foreign material. Also, periodically check the ball to make sure that it also is smooth and clean. Immediately replace any ball that is chipped, burred, corroded, or pitted. A defective ball will cause damage to the playfield surface in a very short time.

Much of the player appeal in pinball games depends on smooth ball travel over the entire playfield. To keep the playfield and ball from wearing out prematurely, Atari recommends using only a non-abrasive cleaner.

Do *not* use such products as "Formula409" or "Windex," kitchen cleansers, soapy cleaning pads or steel wool, waxes or polishes, or great amounts of water. These products may easily scour and damage the silk-screened artwork, and/or cause buildup of gummy residue.

**B. FUSE REPLACEMENT**

To gain access to the two sets of fuses inside the game cabinet perform steps 1 through 8 of the procedure given in Figure 2.

**WARNING**

As an additional safety measure when replacing fuses, always unplug the power cord before opening the cabinet.

The first fuses to check are those on the fuse holder strip mounted on the right cabinet sidewall near the ball shooter. Table 5 describes the three fuses on this strip.


**CAUTION**

When changing fuses make sure that the replacement fuses have the ratings specified by Atari, and that the fuse is being placed in the *correct* fuse holder.

**Table 5 Fuses Located Near Ball Shooter**

Position on Strip	Designation	Circuit Protected	Rating
Uppermost fuse	F8	Line Power	10 amps, 125 volts
Middle fuse	F9	Service Outlet	5 amps, 125 volts
Bottom fuse	F7	Back Box	2 amps, 125 volts

**Table 6 Fuses Located on Power Supply Assembly**

Position on Strip	Designation	Circuit Protected	Rating
Uppermost fuse  Bottom fuse	F1	Audio	2 amps, 125 volts
	F2	Displays	0.5 amps, 125 volts
	F3	Displays	0.5 amps, 125 volts
	F4	Lamps	15 amps, 250 volts
	F5	Logic	7 amps, 32 volts
	F6	Solenoids	15 amps, 250 volts

The next fuses to check are those on the fuse holder strip mounted on the power supply assembly at the rear of the cabinet. Figure 3 shows the exact location, and Table 6 describes the six fuses on this strip.

After all fuses have been replaced or else checked OK, close and lock the cabinet by performing steps 9 through 17 of the procedure given in Figure 2. Then plug the power cord back into the AC outlet.

### C. COIN MECHANISM

#### Components on Coin Door

Figure 10 shows the back side of the coin door assembly where the game's two coin mechanisms are mounted. Included is the lock-out coil assembly; the lock-out wires are connected to this assembly but are hidden behind the coin mechs. During the attract mode the microcomputer energizes the lock-out coil, causing the lock-out wires to retract far enough to allow genuine coins to reach the coin box. But during play mode (and also when AC power to the game has been turned off) the lock-out coil is de-energized, causing the lock-out wires to move out far enough to divert coins over to the return chute.

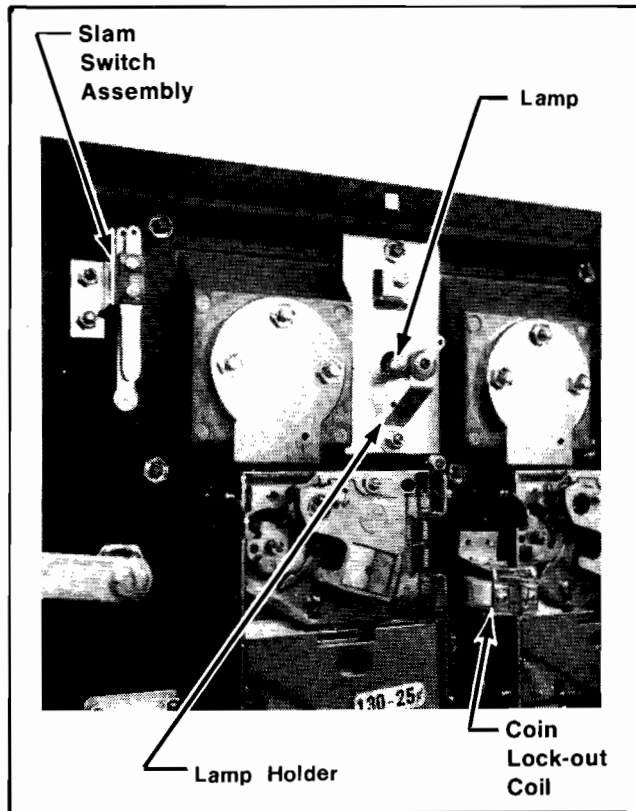


Figure 10 Coin Door Assembly

Directly below each coin mechanism is a secondary coin chute and a coin switch with a trip wire extending out to the front edge of the chute. When the trip wire is positioned correctly, a coin passing down the secondary chute and into the coin box will momentarily push the trip wire down and cause the switch contacts to close.

Also shown in the photograph is a slam switch assembly. It has been included to defeat any players who might try to obtain free game plays by violently pounding on the coin door to momentarily close the contacts on a coin switch. The slam switch contacts connect to the microcomputer system, which will ignore coin switch signals whenever the slam switch contacts are closed.

#### Access to Coin Mechanisms

To remove jammed coins, and for maintenance cleaning, each magnet gate assembly can be hinged open without removing it from the door, as shown in Figure 11. Or, if necessary, each coin mechanism can be entirely removed from the door merely by pushing down on a release lever and simultaneously tilting the mechanism back, then lifting it up and out. This is shown in Figure 12.

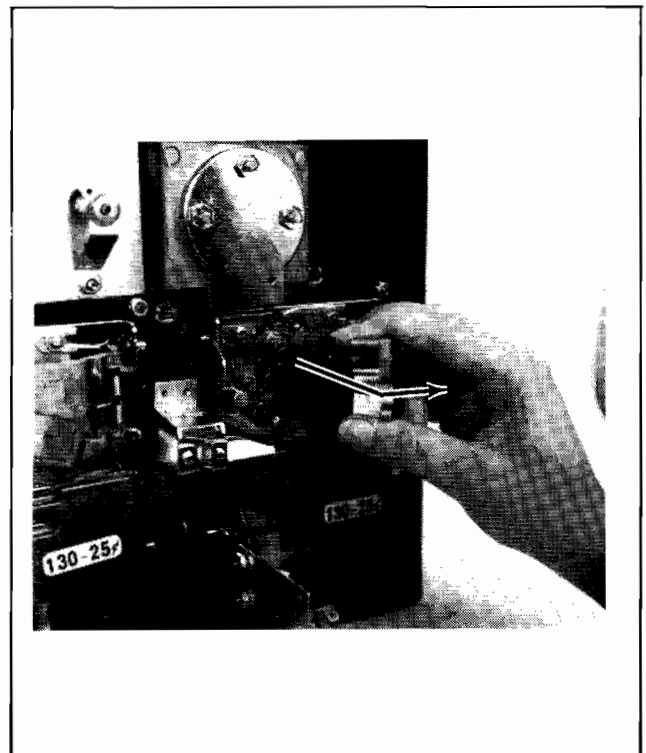
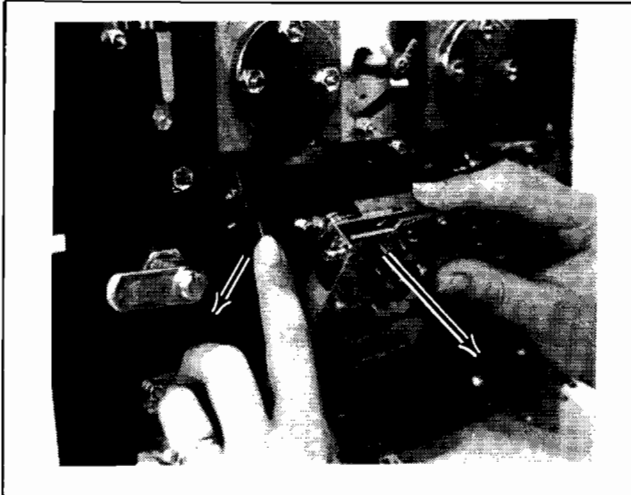


Figure 11 Hinging Open the Magnet Gate Assembly



**Figure 12 Removal of Coin Mechanism**

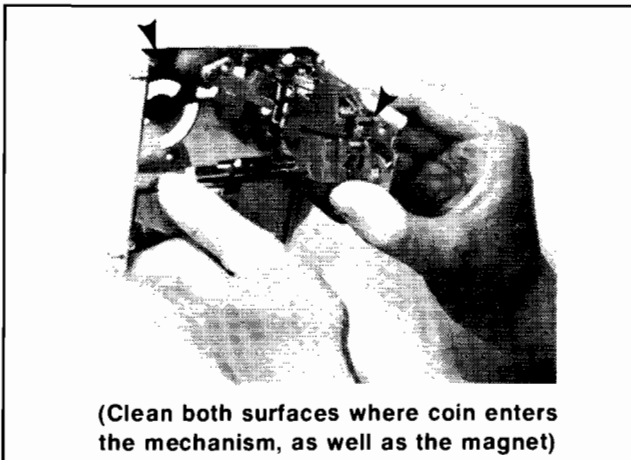
### Cleaning of Coin Paths

#### CAUTION

The use of an abrasive (such as steel wool or a wire brush) or a lubrication on a coin mechanism will result in a rapid buildup of residue.

By talking to many operators, we have found that the best method of cleaning a coin mechanism is by using hot or boiling water and a mild detergent. A toothbrush may be used for those stubborn buildups of residue. After cleaning, flush thoroughly with hot or boiling water, then blow out all water with compressed air.

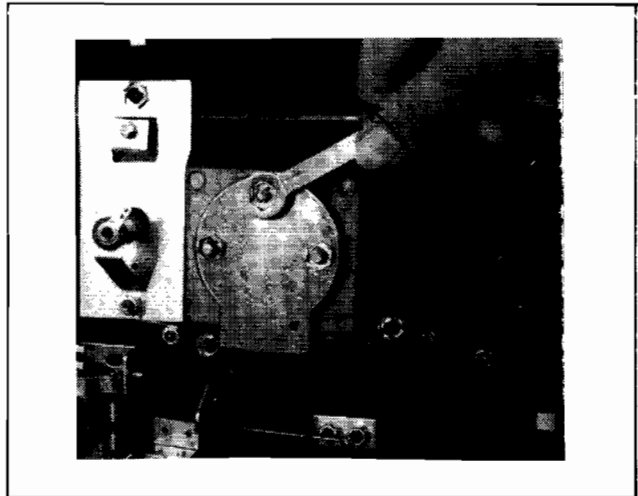
Figure 13 shows the surfaces to clean inside the



**Figure 13 Surfaces to Clean Inside the Coin Mechanism**

coin mechanism. These include the inside surface of the mainplate, and the corresponding surface of the gate assembly. There may also be metal particles clinging to the magnet itself. To remove these you can guide the point of a screwdriver or similar tool along the edge of the magnet.

If coins are not traveling as far as the coin mechanisms, you will need to clean the channel beneath the coin slot. To gain access to this channel, use a  $\frac{3}{8}$ -inch wrench and remove all three nuts that secure the cover plate (refer to Figure 14). Removing the plate will provide access to the entire channel.



**Figure 14 Removal of Plate Covering Rear of Coin Slot**

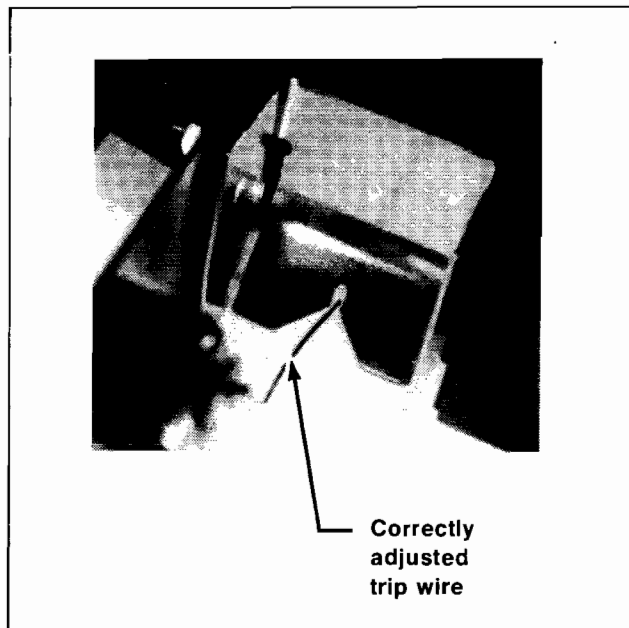
Also clean the inside surfaces of the secondary coin chutes, but when doing this be careful not to damage or bend the trip wires on the coin switches.

### Adjustment of Coin Switch Trip Wire

In order for a coin switch to operate reliably when a coin travels down the secondary coin chute, the rest position of its trip wire should be as shown in Figure 15. *Use extreme care when handling or touching these wires.*

### Mechanical Adjustments on Coin Mechanism

Coin mechanisms are adjusted prior to shipment from the factory and normally will retain these adjustments for many months. If, due to wear or other causes, it becomes necessary to make new adjustments, remove the coin mechanism from the coin door. Then take it to a clean well-lighted area where it can be placed in a vertical position on a level surface (such as a bench top). Besides a screwdriver, you will



**Figure 15** Detail View of Coin Switch and Trip Wire

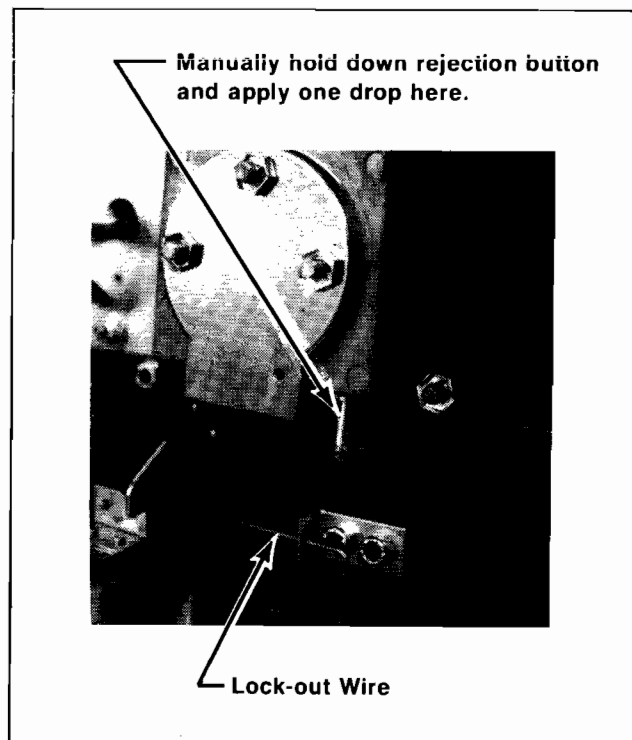
need a set of several coins, including both new and old, worn ones. Figure 16 shows an exploded view of the mechanism and gives procedures for adjusting the kicker, separator, and the magnet gate. These adjustments should only be done by someone who has experience in servicing coin mechanisms and who understands their operation.

#### **Lubrication**

Do not apply lubrication to the coin mechanisms. The only points that may need lubrication (and only rarely) are the shafts of the scavenger buttons (coin rejection buttons) where they pass through the coin door. Apply only one drop of light machine oil, and be positive that no oil drops down onto a coin mechanism. Figure 17 shows this lubrication point.

#### **General Troubleshooting Hints**

The first action is to look for jammed coins. After these have been removed, examine the coin path for presence of foreign material or loose objects (such as chewing gum, small metallic objects, paper wads, etc.). In cases where game usage is heavy, it may be necessary to clean the entire coin path periodically, in order to prevent build-up of contaminants that can hinder the movement of coins through the mechanisms. Also confirm that the trip wire on each coin switch is intact, and is properly adjusted. If troubles still persist, check the conditions and positions of the lock-out wires, and the mechanical adjustments on the coin mechanisms, before suspecting the electronics. If a coin mechanism rejects genuine



**Figure 17** Close-up View of Lubrication Point

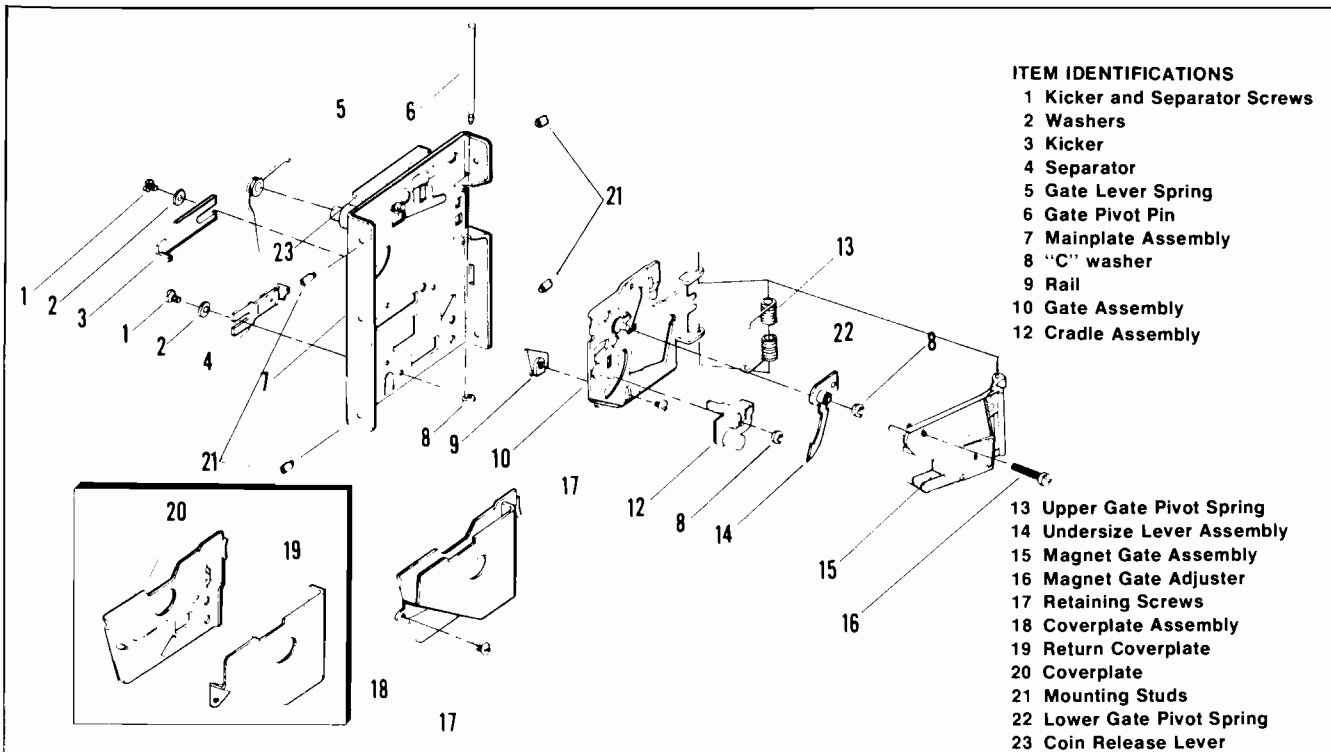
coins, try to readjust it. If this is not successful, then replace it with a working mechanism.

Correct operation of the slam switch can be verified by putting the game into the test mode and performing the switch test (refer to Chapter 1, Section D). Correct operation of the other switches and of the lock-out coil can also be checked by the switch test, or else merely by manually operating them and watching game responses as it changes from the attract mode to ready-to-play and play modes, and then back to attract mode again.

## **D. GAME CONTROLS AND PLAYFIELD COMPONENTS**

Opening the cabinet and raising the playfield will give access to the playfield components and the game controls—START pushbutton switch, flipper switches, pendulum tilt and cabinet tilt switches, Power On/Off Switch, speaker, and the ball shooter.

The game's microcomputer system improves game reliability and significantly reduces maintenance requirements because it replaces conventional electromechanical devices such as step-up rotary switches and motorized trip relay banks. Another game feature is that adjustment-free sealed-contact



**Kicker and separator**

1. Set the acceptor with the back of the unit facing you in the test position.
2. Loosen the kicker and separator screws (1) and move the kicker (3) and the separator (4) as far to the right as they will go. Lightly tighten the screws.
3. Insert several test coins (both old and new) and note that some are returned by striking the separator.
4. Loosen the separator screw and move the separator a slight amount to the left. Lightly retighten the screw.
5. Insert the test coins again and, if some are still returned, repeat Step 4 until all the coins are accepted.
6. Loosen the kicker screw and move the kicker as far to the left as it will go. Lightly retighten the screw.
7. Insert the test coins and note that some are returned.
8. Loosen the kicker screw and move the kicker a slight amount to the right. Lightly retighten the screw.
9. Insert the test coins again and, if some are still returned, repeat Step 8 until all the coins are accepted.
10. Be sure that both screws are tight after the adjustments have been made.

**Magnet gate**

1. Set the acceptor with the front of the unit facing you in the test position.
2. Turn the magnet gate adjusting screw (16) out or counterclockwise until none of the coins will fit through.
3. With a coin resting in the acceptor entrance, turn the adjuster in or clockwise until the coin barely passes through the magnet gate.
4. Test this adjustment using several other coins (both old and new) and, if any fail to pass through the magnet gate, repeat Step 3 until all the coins are accepted.
5. Fix the magnet gate adjusting screw in this position with a drop of glue.

**Additional Cleaning**

- 1) Remove the transfer cradle (12) and the undersize lever (14).
- 2) Use a pipe cleaner or similar effective cleaning tool to clean the bushings and pivot pins.
- 3) Replace the transfer cradle and the undersize lever.
- 4) To be certain the coin mechanism is completely free of any residue, place the mechanism in a solution of boiling water and mild detergent for several minutes. Carefully remove it and let it air-dry completely before reinstalling in the door.

Figure 16 Adjustments on Coin Mechanism



switches replace all open-contact blade-type switches. Also, sealed magnet sensor switches replace all rollover button and rollover wire activated switches; problems of dirt interfering with switch operation are avoided.

### **Isolating Defective Components**

Put the game into the test mode and use the switch test and solenoid test to isolate defective components. The PCB schematics, and the interconnect and wiring diagram shown in Figure 13, show the component designations and arrangements of the connectors in the wiring harness.

### **Solenoid Fuse Links**

Plugged onto connector J8 on the Processor PCB is a special miniature PCB assembly that provides individual "fuse links" for each solenoid line. This assembly is identified by the Atari part number A008928; each fuse link consists of a short length of #36 gauge, solid copper, bare wire. The wire will melt, thereby opening the circuit, as soon as a very high current (caused by a shorted solenoid) starts to flow. These fuse links have been added to prevent the driver transistor from overheating and damaging the surface of the PCB if current flow starts to exceed the maximum fused value.

Whenever a fuse link is found to be open, perform the following two checks before replacing the link. After making sure that AC power to the game is shut off, first use an ohmmeter to measure the solenoid's DC resistance. Flipper solenoids, the heaviest usage components, should have a DC resistance of approximately 7.7 ohms. The gate solenoids, the next heaviest usage components, should have a DC resistance of approximately 7.7 ohms. The gate solenoids, the next heaviest usage components, should read approximately 200 ohms. Secondly, use the ohmmeter to check the collector-emitter junction of the 2N6044 driver transistor. Replace the defective solenoid and/or drive transistor before replacing the fuse link and applying power to the game.

### **Troubleshooting of Playfield Switches Connected in Parallel**

As described in Chapter 1, Section D, you can use the switch test both for automatically detecting switches with stuck contacts and for manually identifying switches with stuck contacts and for manually identifying switches whose contacts are not closing properly. But in instances where contacts from two or more switches are connected in parallel, additional troubleshooting steps will be needed in order to verify whether or not a given switch is defective.

For example, switch test #42 simultaneously checks both 100 ADVANCE P.M. Bonus target switches. To confirm whether just one or else both switches are defective, one at a time you must temporarily unsolder the wire to the normally open contact of each switch, while leaving the other switch still connected. Then perform the switch test separately for each switch connected alone.

Wiring connections to the playfield switches are shown along the right side of the Interconnect and Wiring Diagram, second sheet, Figure 31. Note the eight switches S29 through S36 wired in parallel; these are rebound switches mounted behind rubber strap rings in various places on the playfield. Players are awarded 10 points each time the ball forces any switch to close.

Also note that the pendulum tilt switch, S10, is connected in parallel with S11 through S18, which are magnetic sensor switches mounted in various places beneath the playfield. During play if the microcomputer senses this switch closure, caused either by the pendulum switch or by any of the other eight switches, it will respond by putting the game in the "tilt" condition. The mounting position of these twelve is somewhat lower beneath the playfield surface than is that of the game's other magnetic sensor switches. Because of this lower position, during play the ball cannot cause any of these twelve switches to close. But if players try to cheat the game by sliding a very strong magnet along the surface of the glass above the playfield, one of these switches will be forced closed and the microcomputer will put the game in "tilt" to defeat the player.

## **E. GAS-DISCHARGE DISPLAYS**

The displays are designed to be maintenance-free, so they normally require attention only if incorrect operation is observed. Use the following procedures to isolate and correct problems with the displays.

### **Preliminary Operational Checks**

Make sure that the coin door is closed and locked. Then plug in the power cord and place the Power On/Off Switch in its *on* position. Immediately after AC power is applied, the Score Display should be showing all 8s and the *PLAYER UP* indications (1ST UP, 2ND UP, etc.) light one at a time, in numerical sequence. All 8s should be showing in the Credit Display and the Match/Ball Display.

The displays are all operating properly if every display segment lights up at least once. But if one or

more segments remain dark, perform the following procedures to determine whether the problem is in the displays or elsewhere in the game's circuitry.

### Removal of Lower Arch Panel

To gain access to the displays open up the game cabinet and remove the lower arch panel, as follows:

- 1) Perform Steps 1 through 6 of the procedure given in Figure 2 for opening the cabinet.
- 2) Use a Phillips-head screwdriver to remove the screws that fasten the Lower Arch Panel to the playfield.
- 3) Remove the Lower Arch Panel. The displays will now be exposed as shown in Figure 18.

### Check on +90 Volts and -90 Volts Power Supply Voltages

#### WARNING

Whenever AC power is applied to the game, voltage potential differences as large as 180 volts are present at the bare terminals of the score panel's edge connector J21, and at various other points on both printed circuit boards.

- 1) Defeat the Interlock Safety Switch by pulling all the way out on the switch's spring-loaded plug.
- 2) Place the Power On/Off Switch in the *on* position.
- 3) Connect a voltmeter across the following capacitors shown in Figure 18, and check for the readings listed below:

*On Match/Credit Display PCB* place meter's ground lead on "plus" side of C2; other lead placed on "plus" side of C1 gives +90 volts reading, and on "minus" side of C2 gives -90 volts reading.

*On Score Panel PCB* also place ground lead on "plus" side of C2; other lead on "plus" side of C1 gives +90 volts reading, and on "minus" side of C2 gives -90 volts reading.

- 4) If one or more readings are low (or at zero volts), then check each PCB separately as follows. Disconnect J19 and then re-measure the voltages on the Score Display PCB. If the voltages are OK, then some portion of the circuitry on the Match/Credit Display PCB is pulling down the supply voltages. If the voltages are still incorrect, reconnect J19, dis-

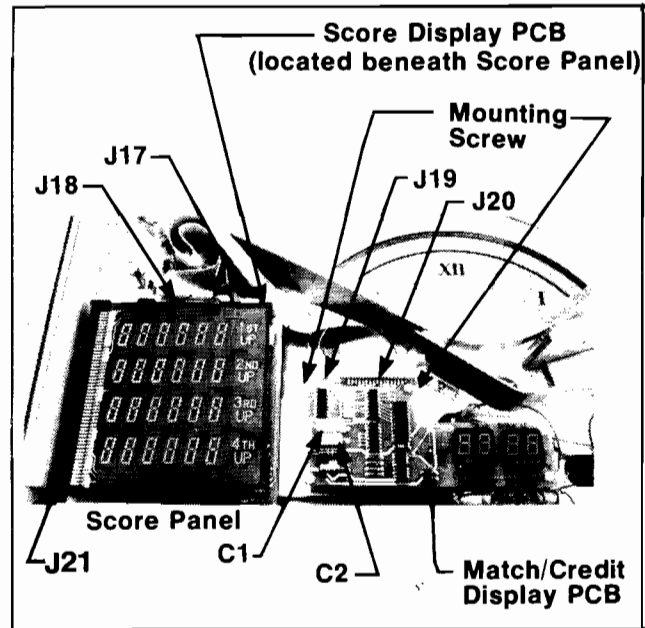


Figure 18 Top View of Score and Match/Credit Display Assembly

connect J17, and re-measure the voltages on the Match/Credit Display PCB. If voltages are OK, then some portion of the circuitry on the Score Display PCB is pulling down the supply voltages.

If the voltages remained incorrect while each board was checked separately, leave J17 and J19 both disconnected then check the +90 volt and -90 volt outputs on the Auxiliary PCB (where the high voltage power supply circuitry is located). These 90-volt supply voltages must both be present on each display PCB before the displays can light up.

If all voltage readings on the display PCBs are within 5% of the correct values, then go on to the next portion of the procedure.

### Score Panel Removal and Visual Checks

After the +90 volt and -90 volt supply voltages have been verified, the next troubleshooting step on the score panel will be to remove it from connector J21.

- 1) Turn off AC power to the game, preferably by pulling out the power plug from the wall outlet.
- 2) Remove the metal clips holding the score panel onto the bracket arms of J21 (refer to Figure 19).
- 3) Using your right hand, grasp the right edge of the score panel. Carefully lift it up approximately ¼

inch, and then pull it straight out and remove it completely.

- 4) Examine the positions of the terminal pins on J21. Tips of the pins should be aligned in the same plane, as shown in Figure 19's detail view. If not bent out of alignment, all pins can then make contact with the score panel's terminal strips when the panel is plugged in.
- 5) Next examine the condition of the terminal strips on the score panel. If the surfaces of the strips are corroded, use a pencil eraser to clean them off. Be careful, however, not to rub the eraser against any of the tiny metal ribbons touching certain strips up

near the glass "seal" (refer to Figure 20). These ribbons must be perfectly centered over the correct pins, not halfway off.

### Replacement of Score Panel

After the visual checks have been made on the J21 terminal pins and on the score panel, the original score panel can be put back, or else a new score panel can be substituted in its place. Carefully observe the following procedure when replacing the score panel.

- 1) Using both hands, grasp the right-hand edge of the panel and carefully slide it fully into connector J21, perfectly aligned. Then lower the edge down until the entire panel rests in the bracket arms.

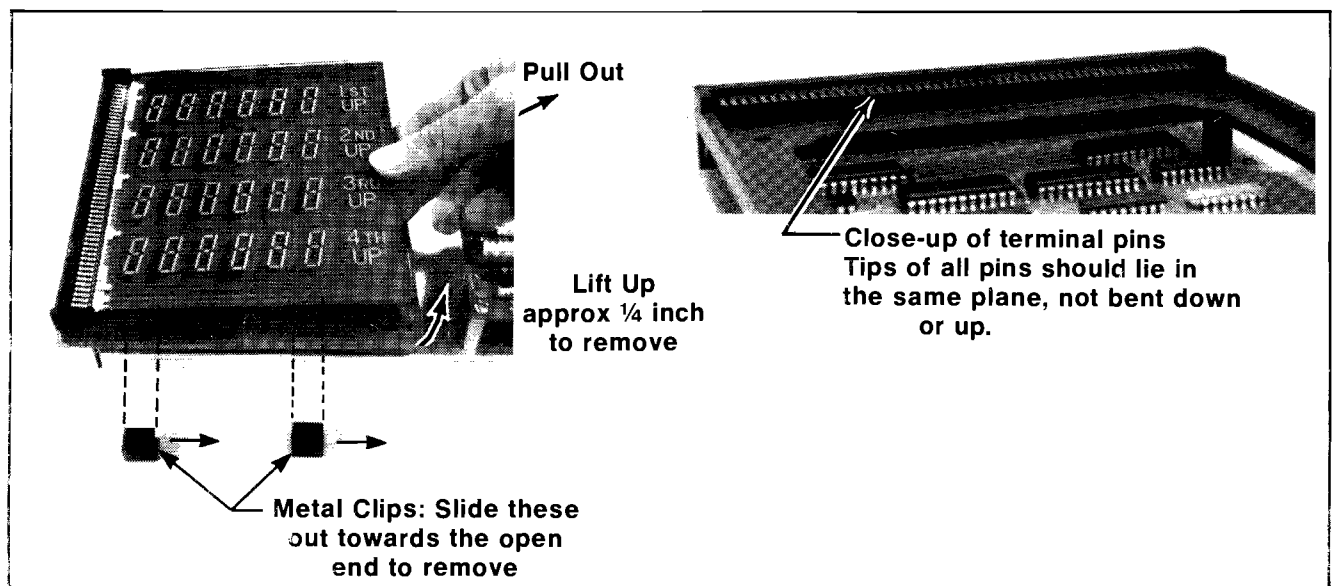


Figure 19 Removal of Score Panel

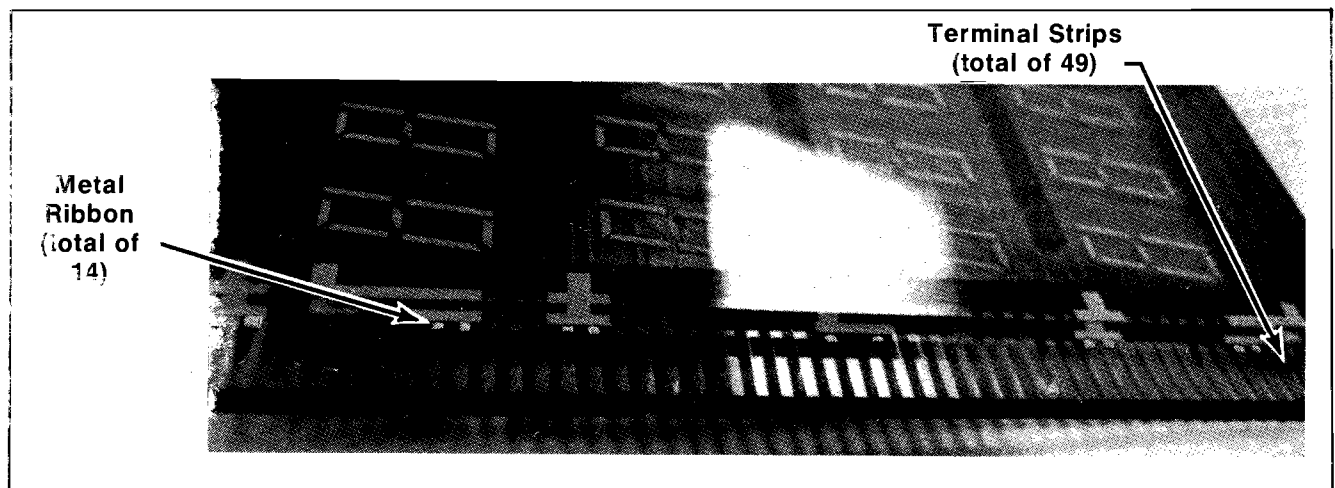
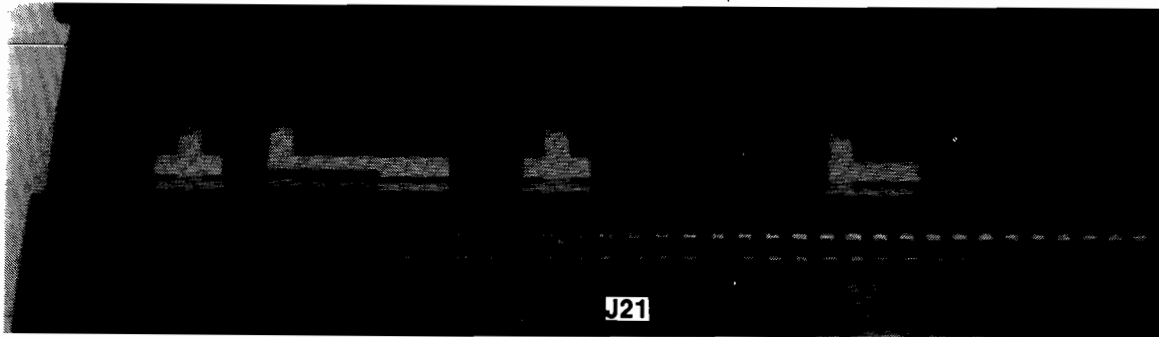
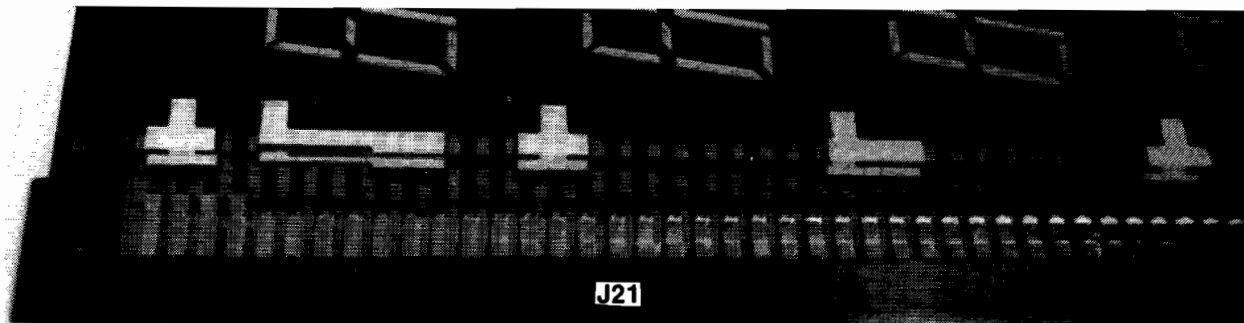


Figure 20 Score Panel Terminals



**CORRECT**  
 Note that terminal strips of Score Panel do line up with terminal pins in score panel connector.



**WRONG**  
 Note that terminal strips of Score Panel do not line up with terminal pins.

Figure 21 Line-up of Terminal Pins and Terminal Strips

You will note some free space on each side between the panel and the brackets. At the factory a rubbery substance called RTV was placed between the bracket arms and the score panel. This substance provides a cushion between the glass panel and the metal arms and positions the panel so that connector J21's terminal pins line up exactly with the panel's terminal strips. Be sure that they are aligned correctly as shown in Figure 21.

- 2) Replace the metal clips that fasten the score panel to the bracket arms.

#### Removal of Display Assembly

Certain portions of the PCBs are accessible for troubleshooting when the display assembly is left mounted on the playfield. However, to gain access to the remaining portions, or to replace components or an entire PCB, use the following procedure.

- 1) Turn off AC power to the game, preferably by pulling out the power plug.
- 2) Disconnect connectors J17, J18, J19, and J20.
- 3) Use a Phillips-head screwdriver to loosen the four screws that fasten the assembly to the playfield, and then remove the screws.
- 4) Lift the entire assembly up and remove it from the playfield.

#### Replacement of Display Assembly

After repair and/or replacement of the display boards and displays, use the following procedure to re-attach the assembly to the playfield.

- 1) Lower the assembly down into its final position and line up the four mounting holes **with their**

mating holes in the playfield. Be careful not to pinch the lamp wires that are routed through a slot at the lower right corner of the assembly (refer to Figure 22).

- 2) Insert the four mounting screws and use a Phillips-head screwdriver to tighten them down.

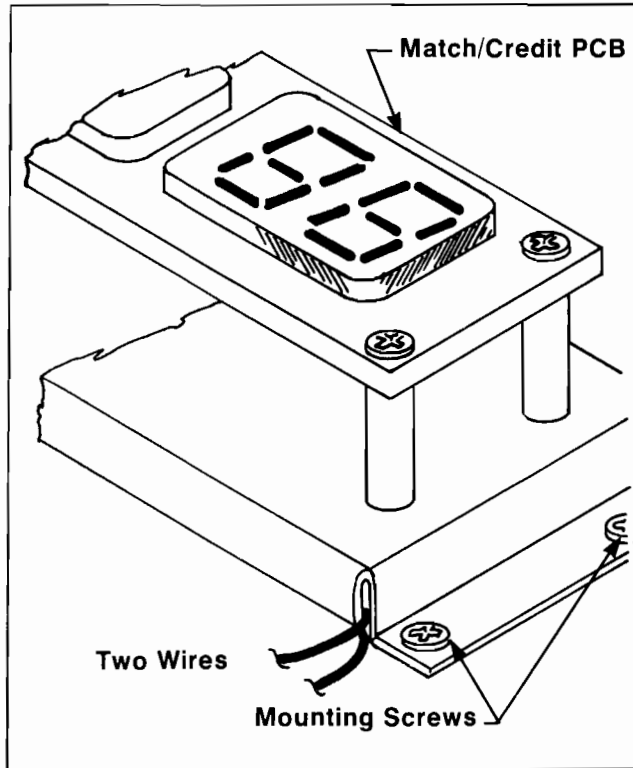


Figure 22 Lower Right Corner of Display Assembly

- 3) Connect connectors J17, J18, J19, and J20.

#### Replacement of Lower Arch Panel

- 1) First examine the display assembly to make sure that all four mounting screws are tightened down, and that the score panel is positioned correctly and is fastened in place. Also verify that no foreign objects (screws, washers, etc.) have been left behind.
- 2) Place the lower arch panel over the playfield and position it so that its mounting holes are aligned with those in the playfield brackets.
- 3) Install the screws and use a Phillips-head screwdriver to tighten them down.
- 4) To close the cabinet, perform steps 13 through 17 given in Figure 2.

## F. LAMP REPLACEMENT

To insure continued player appeal for the game, you should periodically check for burned-out playfield and back box lamps, and replace defective ones *immediately*.

### Playfield lamps

#### CAUTION

When replacing playfield lamps use #47 bulbs only; other bulb types may cause damage to the lamp driver circuits.

A quick, easy method for detecting defective lamps is to use the lamp test portion of the self-test. For specific procedures refer to Chapter 1, Section D.

#### WARNING

Make sure game power is turned off before replacing lamps. This is especially important if the lower arch panel has to be removed to gain access to the lamps beneath it. Whenever AC power is applied to the game, voltage potential differences as large as 180 volts are present at the bare terminals of the score panel's edge connector J21, and at various other points on both display printed circuit boards.

### Back Box Lamps

The procedure for opening and closing the back box is given in Figure 2. When replacing these lamps use 7.5-watt bulbs. If the lamp is to flash on and off, remember to place a flasher unit (button-shaped disc) in the socket before inserting and tightening down the bulb.

## G. ADJUSTMENT OF SPEAKER VOLUME

A simple potentiometer adjustment has been provided so that volume of game sounds can be manually adjusted to suit the background noise level existing at the game location. The potentiometer is mounted on the Auxiliary PCB inside the cabinet at the left rear corner. Use the following procedure to make this adjustment.

- 1) Perform steps 1 through 8 given in Figure 2 to open the cabinet and prop up the playfield.

**WARNING**

Make sure AC power to the game is shut off before making this adjustment, because voltage potential differences as great as 180 volts are present on the surface of the Auxiliary PCB when power is applied.

**CAUTION**

While moving the stud be careful to keep your hand and arms away from the large heat sink in one corner of the board. Otherwise, if the heat sink is still hot or very warm, touching it may cause a burn.

2) See Figure 23 for location of volume adjustment. To make the adjustment move the stud to give the desired volume increase or decrease.

3) Lower the playfield and close and lock the cabinet by performing steps 9 through 17 given in Figure 2.

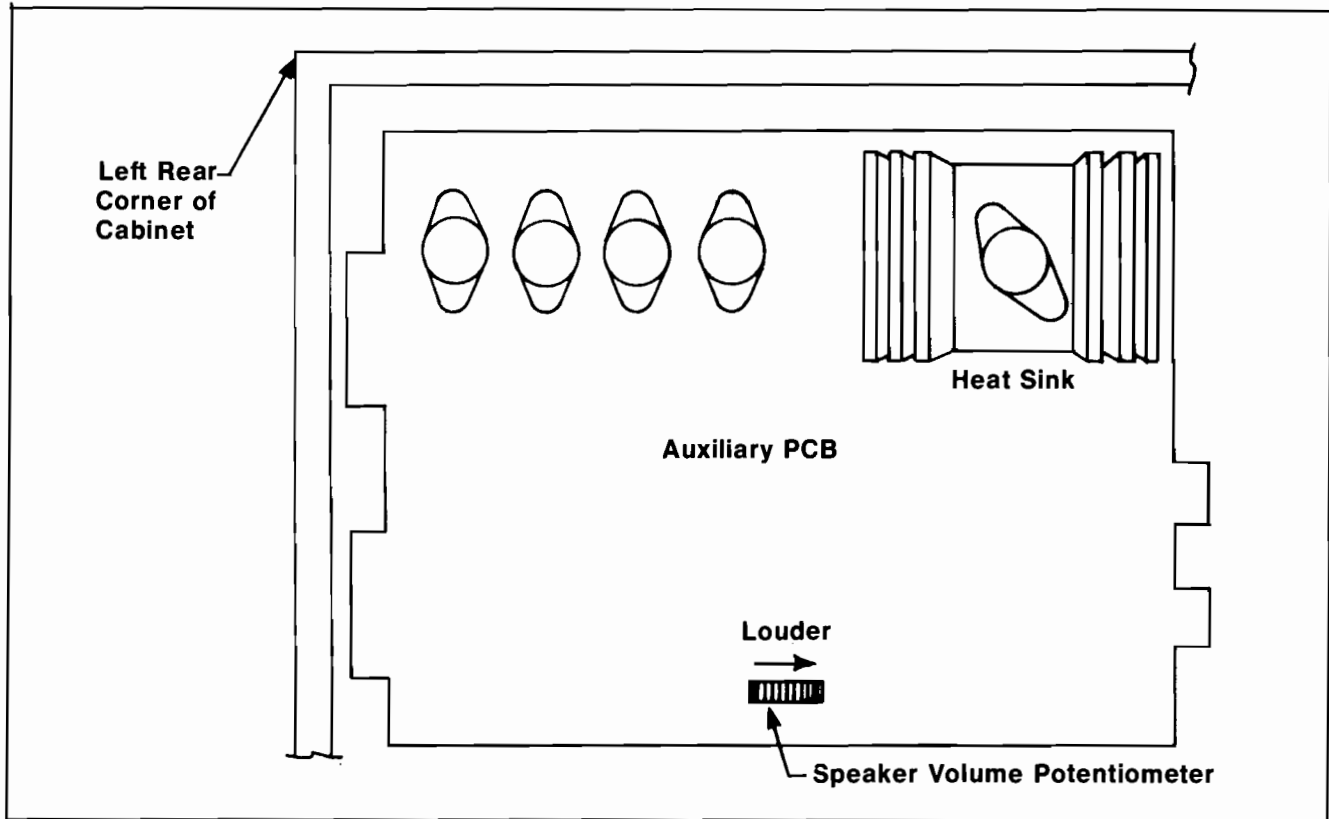
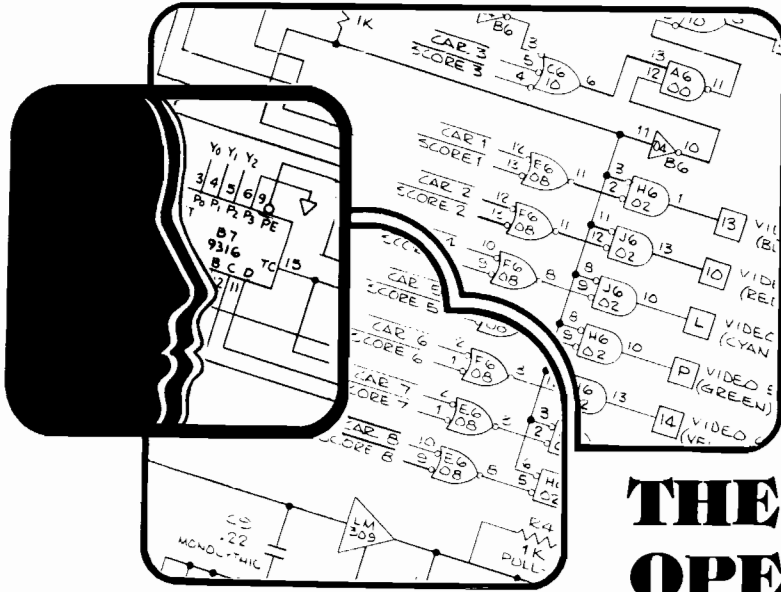


Figure 23 Location of Speaker Volume Adjustment

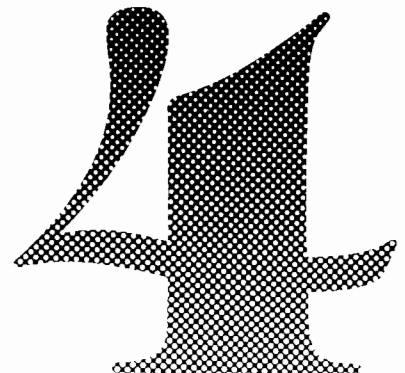


# THEORY OF OPERATION

## A. FUNCTIONAL DESCRIPTION OF GAME

The block diagram in Figure 24 shows the game's major functional elements and depicts their interconnections. The central element is the microcomputer, which consists of a microprocessor, memories and control logic.

By means of a switch sensing circuit, the player-operated switches, playfield switches and operator option switches produce Switch Data for the microcomputer. Switch closures occur when a player deposits money in the game, depresses the START pushbutton, operates the ball shooter so the ball goes onto the playfield and interacts with playfield objects, and depresses the flipper buttons. Switch closures also result when a player tilts the game. Executing the instructions stored in the pre-programmed portion of its memory, the microcomputer then responds to the Switch Data by energizing various solenoids, lighting various lamps, and producing Sound Data for the speaker and Display Data for the Score, Credit and Ball/Match Displays.



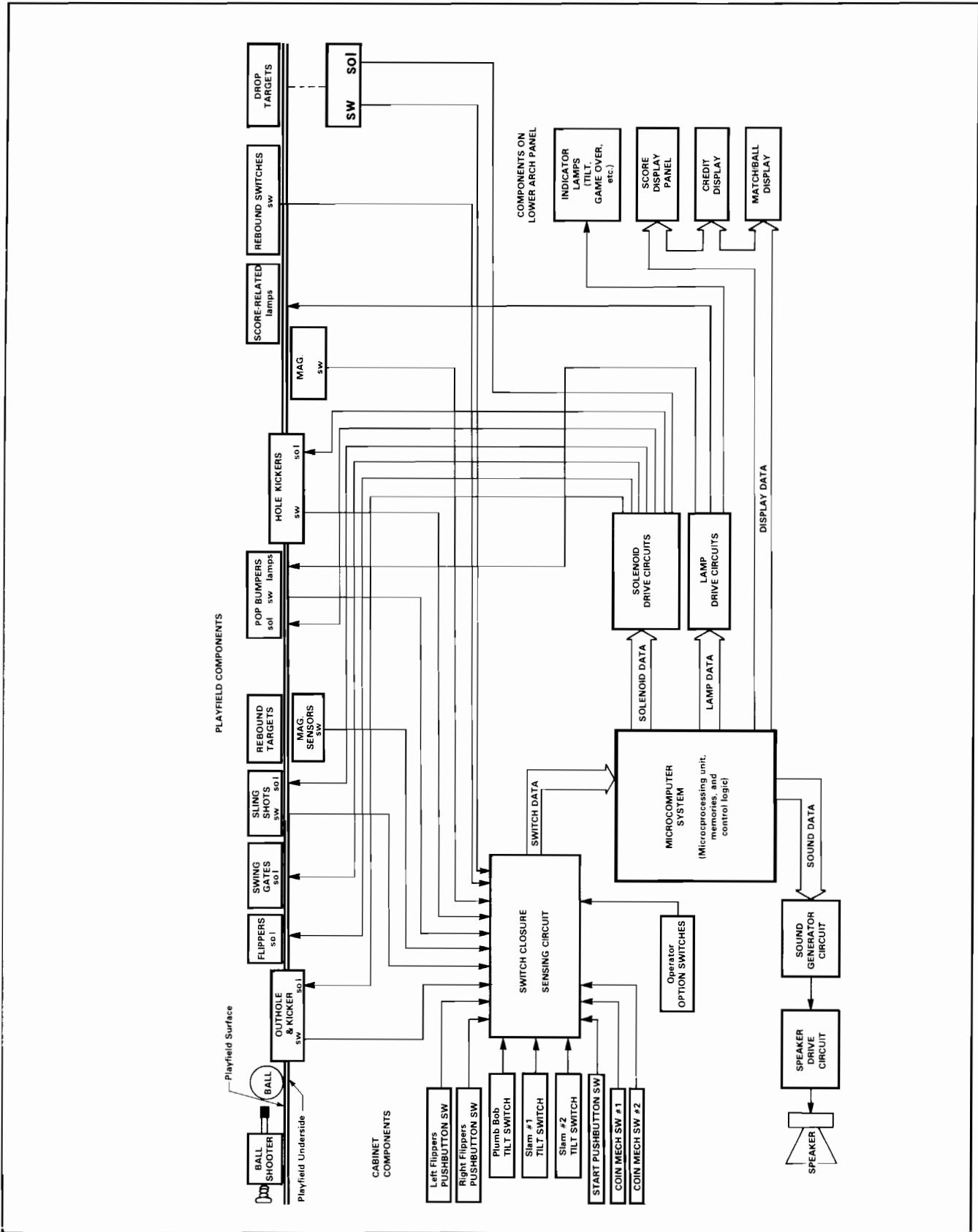


Figure 24 Functional Block Diagram of Time 2000™ Pinball Game



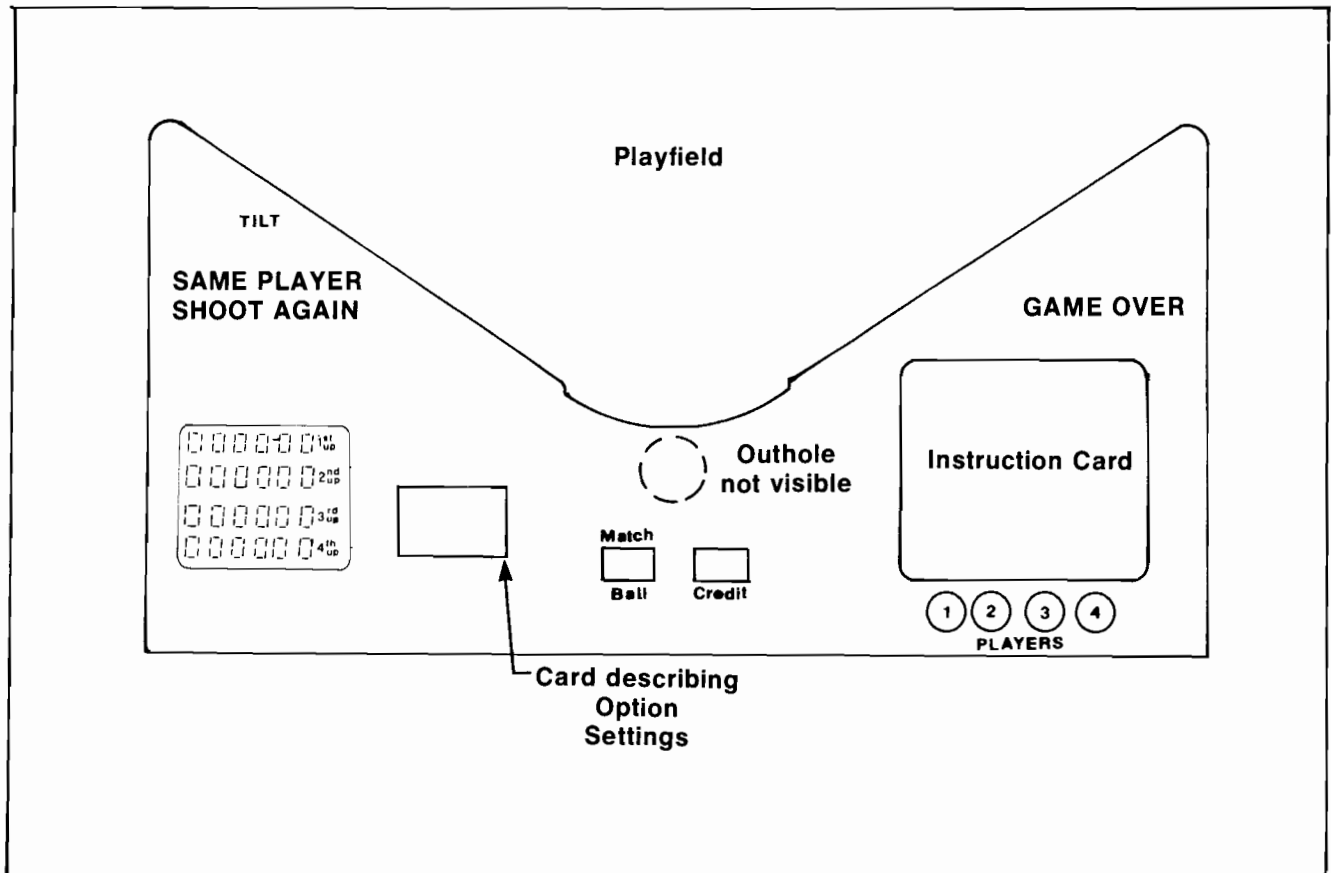


Figure 25 Lower Arch Panel

The game's electronic displays are of the gas-discharge type that provide their own illumination. Individual digits are formed out of bar segments, with a total of seven segments per digit (See Figure 38).

The displays are located near the bottom of the playfield, beneath the Lower Arch Panel (see Figure 25), along with four player lamps labeled 1, 2, 3 and 4) and three other indicator lamps (Tilt, Same Player Shoot Again, and Game Over). The player lamps tell how many persons are participating in a game. For example, in a one-player game only the 1 lamp is lighted, in a two-player game only the 1 and 2, and so forth.

Early games utilize magnetic sensor switches that are sealed units having only two leads. They are mounted on the underside of the playfield and are activated (switch contacts closed) when the ball passes over them. Labels on the playfield graphics indicate their locations to players. Later games use rollover switches in place of magnetic sensor switches.

The game's tilt switches include a pendulum switch, two slam switches, and eight anti-cheater magnetic switches. Both slam switches are mounted inside the cabinet, one in a horizontal plane on the flat panel that forms the underside of the cabinet, and the other in a vertical plane on the backside of the coin access door. The anti-cheater switches are mounted in various places beneath the playfield. The microcomputer will put the game into the "tilt" condition if it senses that any one of these switches has been closed.

The game's back box operates independently of the microcomputer system. Its illumination is provided by 7.5-watt, 117-volt AC lamps. To cause a lamp to blink on and off, a button-shaped flasher unit is inserted in the lamp socket and then the lamp is screwed down snugly in the socket. No displays or indicators are mounted on the back box, and the fuse circuit for its lamps is separate from the game's other fuse circuits.

## B. COMPONENTS OF THE MICROCOMPUTER SYSTEM

The microcomputer system carries out complex tasks of the game by performing a large number of simple tasks. Figure 26 shows a block diagram of the microcomputer system and its various interconnecting data, addressing and control buses. The Microprocessing Unit causes the system to perform the desired operations by addressing the Program Memory for an instruction (via the Address Bus), reading that instruction (via the bidirectional Data Bus), and then executing the simple task dictated by that instruction. The Microprocessing Unit uses the Data Memory for temporary storage of data necessary for the execution of future instructions, such as arithmetic operations. The Microprocessing Unit uses the Memory Output Latches for storing the data that is used for producing game sounds, energizing solenoids and lighting lamps.

The following paragraphs describe the game's microcomputer system in more detail. The drawing references are to the Processor PCB schematic shown in Figure 27.

On the schematic the symbol *P* (which appears at various inputs to logic gates and other integrated circuits) indicates a connection to +5 volts through a pull-up resistor.

As an aid for locating integrated circuit devices referred to in the schematics and assembly drawings, and on the boards themselves, each IC position is given a letter/number designation. On the PCB the IC devices are arranged in columns (along the short dimension of the board) and rows (along the long dimension). The letter refers to a column, and the number refers to a row.

Thus, for example, the type-9321 IC device given the designation D2 and drawn near the upper left corner of sheet 1 is found as the second device in the "D" row of devices mounted on that board.

### Microprocessing Unit

The large block drawn along the left side of sheet 1 of the schematic represents the Microprocessing Unit. The signal names for the various Data Bus, Address Bus and Processor Controls are labeled inside the block.

### Program Memory

The eight ROM devices in locations E1, E2, E7, E8, E5, E6, E4, and E3 form the program memory. Note

that the address inputs of all ROMs are connected in parallel and are tied to the A0B through A9B signals. These signals are produced by buffer logic connected to the Microprocessing Unit's Address Bus (signals A0 through A9). Also note that all CE2 inputs (pin 10) are tied together and driven by a common signal, and that the CE1 inputs are driven by signals derived from A10 and A11 produced by the Microprocessing Unit. All ROM data terminals are connected in parallel to the Data Bus (D0 through D7).

Although all eight devices are ROMs, they should never be interchanged (that is, E1 unplugged and plugged into the E2 position, and vice versa), because different data has been programmed in each ROM.

Inside each ROM the data is organized in a 1K x 4 format (1024 bits by 4), giving each ROM a capacity of 4096 data bits.

### Data Memory

The four type-2111A devices in locations D7, D6, D8, and D5 form the Data Memory. Note that all address inputs are connected in parallel (together with the ROMs) to the A0B through A9B signals, and that all RAM data terminals are connected in parallel (together with the ROMs) to the Data Bus. The Microprocessing Unit's R/W bus control signal is buffered and then connected to all RAM R/W inputs.

### Memory Output Latches

The eight type-9334 devices along the right side of the sheet form the Memory Output Latches. The addressing signals applied to each latch (at pins 1, 2, and 3) are derived from the A2, A3, and A7 Address Bus signals. One Data Bus bit is applied to each latch device (for example, bit D0 is applied to the latch in location C20, Bit D1 to C19, and so forth). The  $\overline{\text{REG LD}}$  (Register Load) signal, produced by the Control Logic, is applied to the E (Enable) input of every latch device (at pin 14).

Each latch device has eight outputs, giving a total of 64 LATCH signals. Twelve of these (the signals LATCH 1080 BIT 0 through 4, LATCH 1084 BIT 0 through 4, and Latch 1084 BIT 0 through 4), provide the Sound Data, 32 provide the Lamp Data, and the remaining 20 provide the Solenoid Data.

### Clock Generator

The circuit is shown along the bottom of the sheet. The basic frequency source is a 4-MHz crystal-controlled oscillator. Its output is then shaped, divided down, and buffered to produce the  $\Phi 1$  and  $\Phi 2$  signals (phase 1 and phase 2). These are the non-overlapping, non-symmetrical square wave comple-

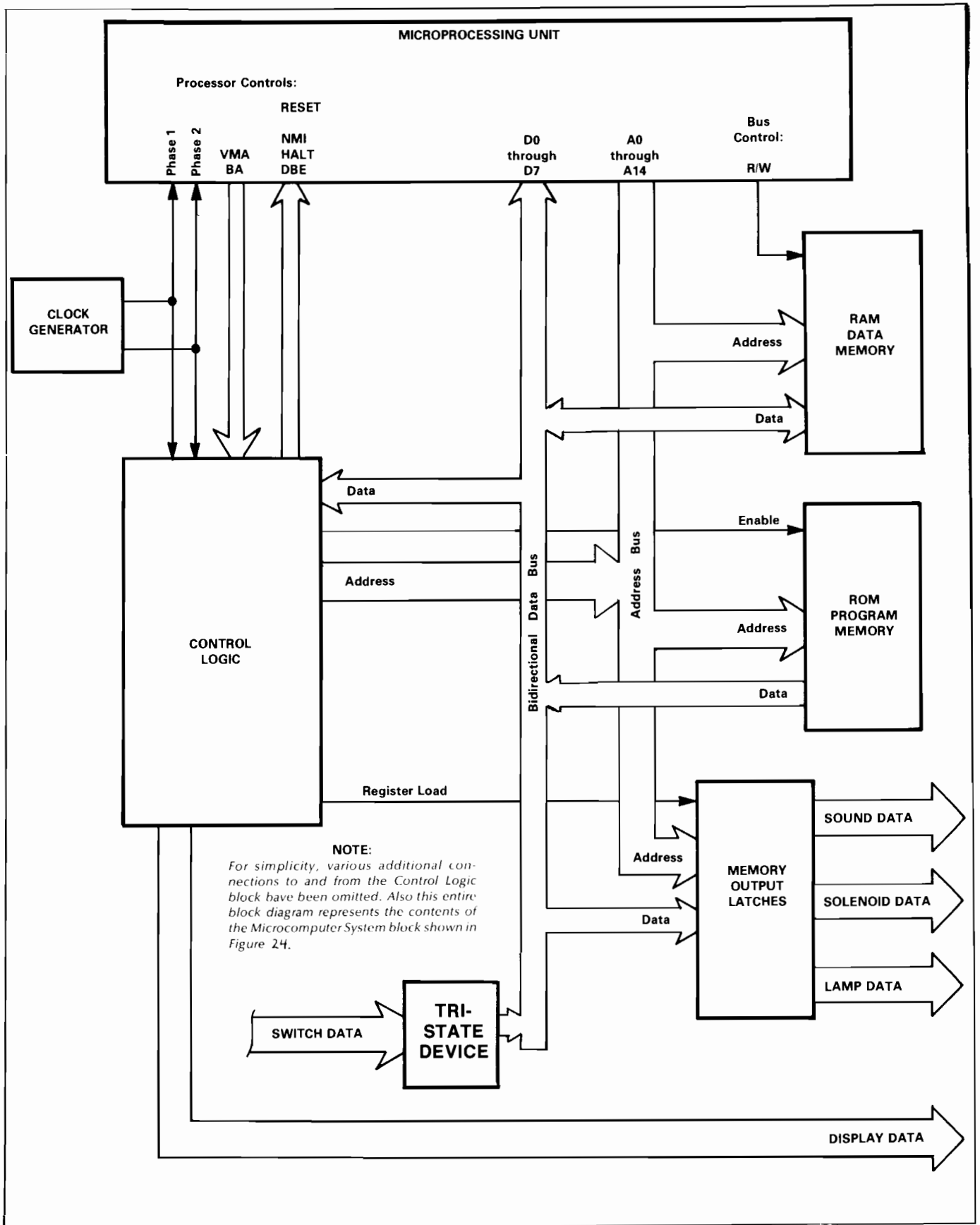


Figure 26 Block Diagram of Microcomputer System

ments required by the Microprocessing Unit. They are also used in the Control Logic.

### Tri-State Buffers

The two type-8097 devices in locations C4 and C5 on sheet 2 connect Switch Data, power line phasing information, display address information, and other Control Logic signals to bits D6 and D7 of the Data Bus, and to bits A0 through A5 and A12 through A14 of the Address Bus. Keep in mind that these are Tri-State devices. When its control line is in the disable state, a tri-state device's data connections become a high impedance, the equivalent of removing the device from the circuit. But when the control line is in the enable state, the device's data connections are capable of having normal high and low ("1" and "0") levels.

### Control Logic

The portion of the Control Logic that produces the  $\overline{\text{RESET}}$  signal for the Microprocessing Unit is shown at the top of sheet 2. The five type-7493 Counter devices form a single, simple binary counter configuration that is driven by the phase 1 clock signal. The AUDIO CLOCK signal produced by the first 7493 device (at A6 pin 8) is used in the Sound Generator circuit.

If, at any time after power is applied to the game, the count advances far enough to bring the last stage high (A10 pin 9 high), then the  $\overline{\text{RESET}}$  signal will be brought low. ( $\overline{\text{RESET}}$  can also be brought low by manually depressing the RESET pushbutton mounted on the surface of the Processor PCB.)  $\overline{\text{RESET}}$  going low causes the Microprocessing Unit to begin the restart sequence. The execution of a routine to initialize the processor from its reset condition will be started.

In normal game operation the RESET signal stays low, however, because the WAKE-UP RESET signal (applied at A9 pin 2 and A10 pin 2) periodically goes high, preventing the last counter stages from going high. If some abnormal circumstance occurs, such as a momentary interruption in game power caused by severe transients on the AC power line, then the program sequence inside the Microprocessing Unit may be disrupted and the WAKE-UP RESET signal may remain low for longer than 100 milliseconds. In such a case, a high-to-low level transition (positive-going edge) on the  $\overline{\text{RESET}}$  signal is produced, and the microcomputer system resets itself.

Another signal associated with the Control Logic is the PHASE signal that connects to the Processor

PCB at J10 pin K and, after an inversion, is applied at pin 14 of the tri-state buffer in location C5. The PHASE signal is derived from the waveform of the AC power applied to the game. This is done by means of a simple diode-resistor circuit on the Auxiliary PCB.

The PHASE signal is a symmetrical squarewave having a frequency equal to that of the AC power source. With this arrangement solenoids are energized, starting at the very beginning of the power source's half-cycle, when the applied AC power is at a zero-crossing point (zero energy point). This feature of the game's timing eliminates the power transients that would be produced if the solenoids were suddenly energized or de-energized some time during the peak energy points in the power cycle.

Other portions of the Control Logic are covered under the Circuit Descriptions that follow.

## C. CIRCUIT DESCRIPTIONS

### Solenoid Driver Circuits

Twenty of the outputs from the Memory Output Latches constitute the Solenoid Data shown in Figure 26. These are the signals LATCH 1080 BIT 4 through 7, LATCH 1084 BIT 4 through 7, LATCH 1088 BIT 4 through 7, and LATCH 108C BIT 0 through 7 (shown on sheet 1 of Processor PCB schematic).

Two of these signals, LATCH 1080 BIT 4 and 5, connect to the Auxiliary PCB where they each drive a type-7407 Inverter followed by a 2N6044 Darlington-connected transistor pair. The remaining eighteen LATCH signals connect to the same types of devices (7404 and 2N6044) on the Processor PCB.

Figure 32 shows a simplified diagram of the basic solenoid drive circuit for all solenoids. One side of the solenoid coils connects to the collectors of the 2N6044 transistors; the other side is brought, together with all the other coils, to an unregulated, full-wave rectified DC power supply of about 35 volts amplitude. This power supply is located in the Power Supply Assembly in the right rear corner of the cabinet. Note that a suppression diode is placed across each coil; the diode protects the 2N6044 from reverse inductive kickback (back emf) when the coil is de-energized. The emitters of all 2N6044 devices and the ground side of the 35-volt supply are returned to SOLENOID GRD (at J9, pin 3).

Remember that the microcomputer, by means of the PHASE signal, is able to synchronize the turning on of the solenoids so that it will start only at a zero

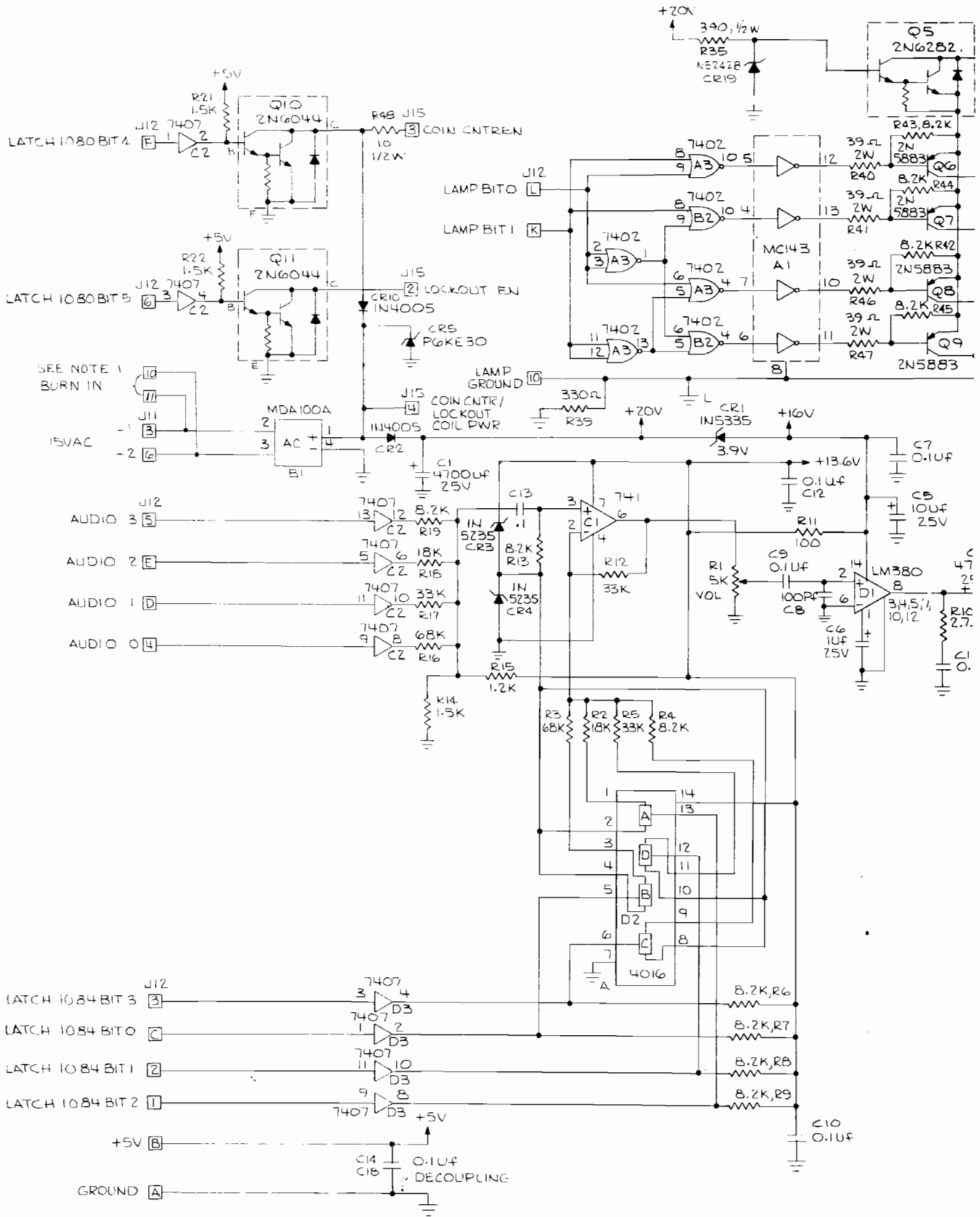
Item	Part Number	Qty.	Description
1	006021-01	1	Printed Circuit Board
2	10-5201	14	Res., Car Comp., 1/4W, 5% 200 OHM R6-11, 13-20
3	10-5471	5	" " " " " 470 " R27-29, 31, 32
4	10-5102	7	" " " " " 1K " R2-5, 26, 33, 36
5	10-5822	1	" " " " " 3.2K " R35
6	10-5223	1	" " " " " 22K " R34
7	10-5105	1	" " " " " 1M " R30
8			
9	19-007	2	Res., Network 10K A3/4, A4/5
10	19-808W4P0	1	Res., Wirewound, 10W, 4 OHM R1
11			
12	24-250227	1	Cap, Electrolytic, 220uf, 25V C2
13	27-250104	27	Cap, Ceramic, 0.1uf, 25V C3,5,9-33
14	28-101390	3	Cap, Mica, 39pf, 100V C4, 6, 8
15	28-101151	1	Cap, Mica, 150pf, 100V C7
16	29-006	1	Cap, Tantalum, 1uf, 35V C1
17	29-007	1	Cap, Tantalum, 22uf, 15V C34
18			
19	31-1N914	15	Diode, 1N914 CR2-16
20	32-P6KE18	1	Diode, Transient Supp. P6KE18 CR1
21	34-2N6044	14	Transistor, 2N6044 Q1-8, 11-13, 15-17
22			
23	37-7400	1	I.C. 7400 D10
24	37-7402	2	I.C. 7402 A2, C7
25	37-7403	1	I.C. 7403 D9
26	37-7404	2	I.C. 7404 D4, E10
27	37-74L04	1	I.C. 74L04 D11
28	37-7407	4	I.C. 7407 D14, D16, D18, D20
29	37-7408	3	I.C. 7408 B2, D2, D3
30	37-74LS08	2	I.C. 74LS08 B/C8, C/D8
31	37-7414	3	I.C. 7414 B11, C9, E9
32	37-7420	1	I.C. 7420 B8
33	37-7427	1	I.C. 7427 B7
34	37-7432	1	I.C. 7432 C8
35	37-7437	1	I.C. 7437 C10
36	37-7474	2	I.C. 7474 B6, B9
37	37-7493	10	I.C. 7493 A6, A7, A8, A9, A10, A11, B3, C11, E12, E13
38	37-74145	7	I.C. 74145 F3, F5, F6, F9, F10, F11, F12

Figure 27 Processor PCB Schematic and Assembly

Item	Part Number	Qty.	Description
39	37-74157	1	I.C. 74157 B5
40	37-8097	2	I.C. 8097 C4,C5
41	37-9301	2	I.C. 9301 C6,E11
42	37-9316	2	I.C. 9316 B4,D13
43	37-9321	1	I.C. 9321 D1
44	37-9334	8	I.C. 9334 C13,C14,C15,C16,C17,C18 C19,C20
45	37-9602	1	I.C. 9602 B10
46	37-IM323	1	Regulator LM323
47	37-MC1413	7	I.C. MC1413 (2003) A17,A18,A19,A20,B18,B19 B20
48	37-MC14050	3	I.C. MC14050 A3,A4,A5
49			
50			
51	62-001	1	Switch, Push Button SPST
52	66-118P1T	2	Switch, DIP, 8 Position F2,F4
53	66-12FP1T	1	Switch, Hex
54	72-1608S	2	Screw, Mach., Pan Hd. Ph. #6-32 x 1/2"
55	75-016	2	Washer Flat #6
56	75-056	2	Washer, Lock, Int. Tooth #6
57	75-916C	2	Nut, Hex #6-32
58	78-06001	1	Heatsink, LM323
59	78-16005	1	Silpad
60	79-42416	1	Socket, 16 Position
61	79-42518	8	Socket, 18 Position
62	79-42040	1	Socket, 40 Position, Med insertion
63	79-58122	1	Header, 4 Pin
64	90-108	1	Crystal, 4.000 MHZ Y1
65	90-6001	1	I.C. C1
66	90-7015	2	Ram, 2111A D5,D8
67			
68			
69	020046-01	1	Program Prom 1LSB E1
70	020047-01	1	" " 1MSB E7
71	020048-01	1	" " 2LSB E2
72	020049-01	1	" " 2MSB E8
73	020050-01	1	" " 3LSB E4
74	020051-01	1	" " 3MSB E5
75	020052-01	1	" " 4LSB E3
76	020053-01	1	" " 4MSB E6
77	007028-01	1	Audio Prom D12

Figure 27 Processor PCB Schematic and Assembly







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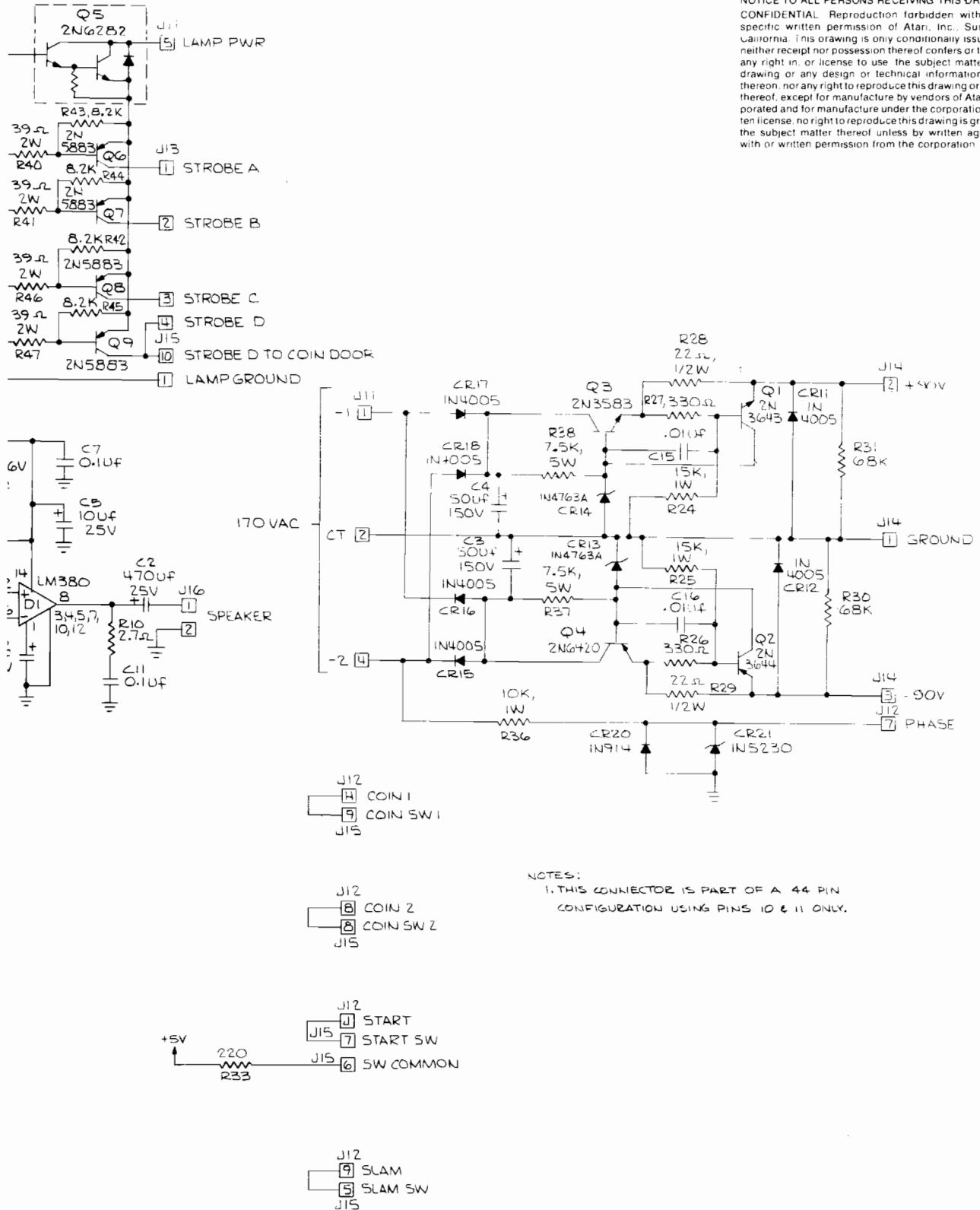


Figure 28 Auxiliary PCB Schematic and Assembly

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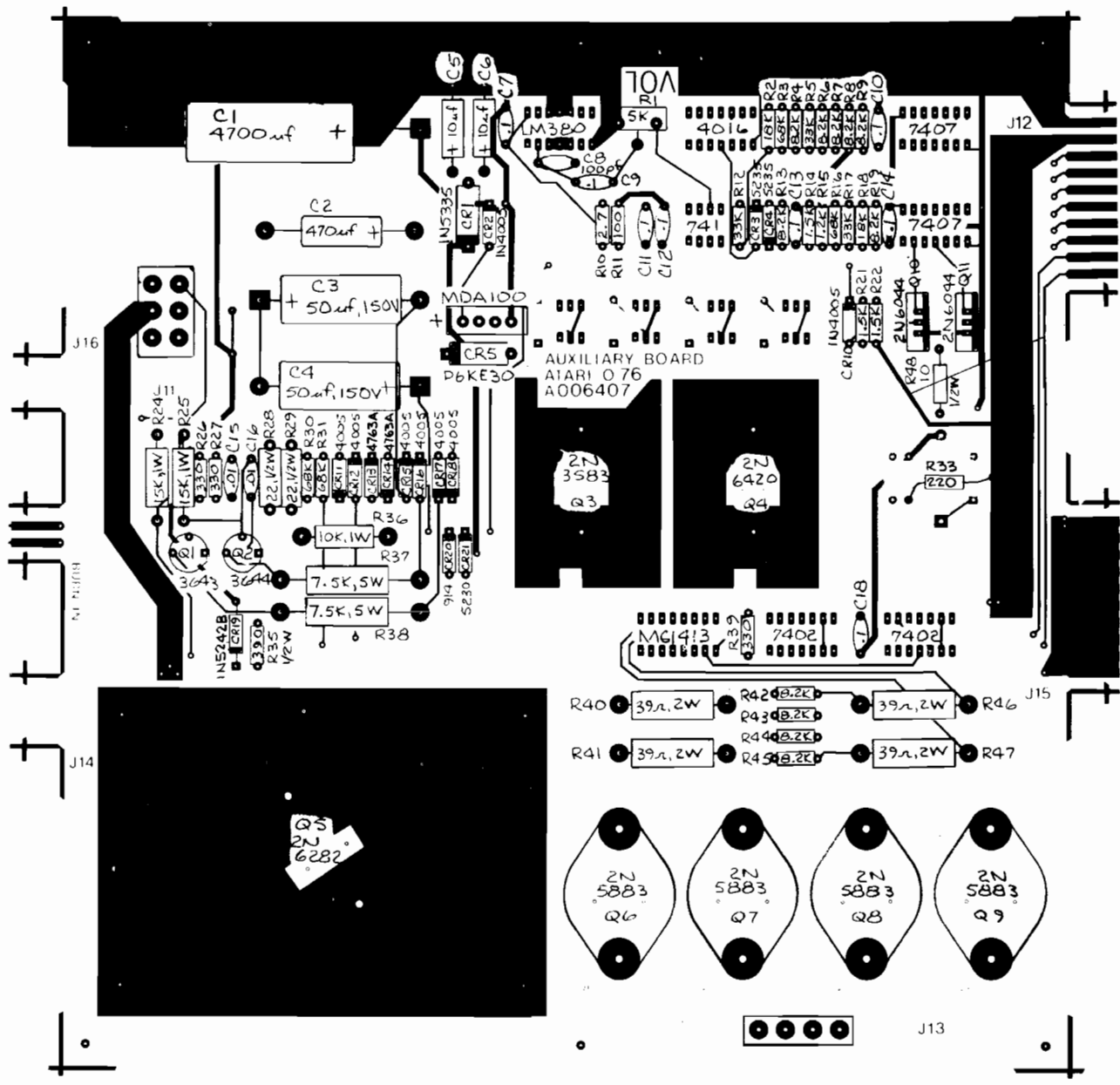


Figure 28 Auxiliary PCB Schematic and Assembly

Item	Part Number	Qty.	Description
1	006408-01	1	PCB, Blank, Auxiliary Board
2	10-5122	1	Res. CC, 1.2K, 1/4w, 5% R15
3	10-5152	3	Res. CC, 1.5K, 1/4w, 5% R14, 21, 22
4	10-5183	2	Res. CC, 18K, 1/4w, 5% R2, 18
5	10-52P7	1	Res. CC, 2.7 ohms, 1/4w, 5% R10
6	10-5331	3	Res. CC, 330 ohms, 1/4w, 5% R26, 27, 39
7	10-5333	3	Res. CC, 33K, 1/4w, 5% R5, 12, 17
8	10-5683	4	Res. CC, 68K, 1/4w, 5% R3, 16, 30, 31
9	10-5822	11	Res. CC, 8.2K 1/4w, 5% R4, 6-9, 13, 19, 42-45
10	11-5220	2	Res. CC, 22 ohms, 1/2w, 5% R28, R29
11	12-5153	2	Res. CC, 15K, 1w, 5% R24, R25
12	13-5390	4	Res. CC, 39 ohms, 2w, 5% R40, 41, 46, 47
13	16-5752	2	Resistor, w. w., 7.5K ohms, 5w, 5% R37, R38
14			
15	19-311502	1	Trimpot, 5000 ohms R1
16	24-151506	2	Capacitor, Electrolytic, 150WVDC, 50ufd, C3, C4
17	24-250106	1	Capacitor, Electrolytic, 25WVDC, 10ufd, C5,
18	24-250478	1	Capacitor, Electrolytic, 25WVDC, 4700ufd, C1
19	24-250477	1	Capacitor, Electrolytic, 25WVDC, 470ufd, C2
20	24-250105	1	Capacitor, Electrolytic, 25WVDC, 1.0ufd C6
21	27-250104	8	Capacitor, Ceramic, 25V, 0.1ufd C7, 9-14, 18
22	27-250103	2	Capacitor, Ceramic, 25V, .01ufd C15, C16
23	28-101101	1	Capacitor, Mica, 100V, 100pfd C8
24	3A-MDA100A	1	Rectifier Assembly, Bridge, MDA100A
25	31-1N914	1	Diode, 1N914, CR20
26	31-1N4005	8	Rectifier, 1N4005 CR2, 10-12, 15-18,
27	32-P6KE30	1	Transient Suppressor Diode, P6KE30 CR5
28	32-1N5235	2	Diode, Zener, 1N5235 CR3, CR4
29	32-1N5242B	1	Diode, Zener, 1N5242B CR19
30	32-1N4763A	2	Diode, Zener, 1N4763A CR13, CR14
31	33-2N3644	1	Transistor, PNP, 2N3644 Q2
32	33-2N5883	4	Transistor, PNP, 2N5883 Q6-Q9

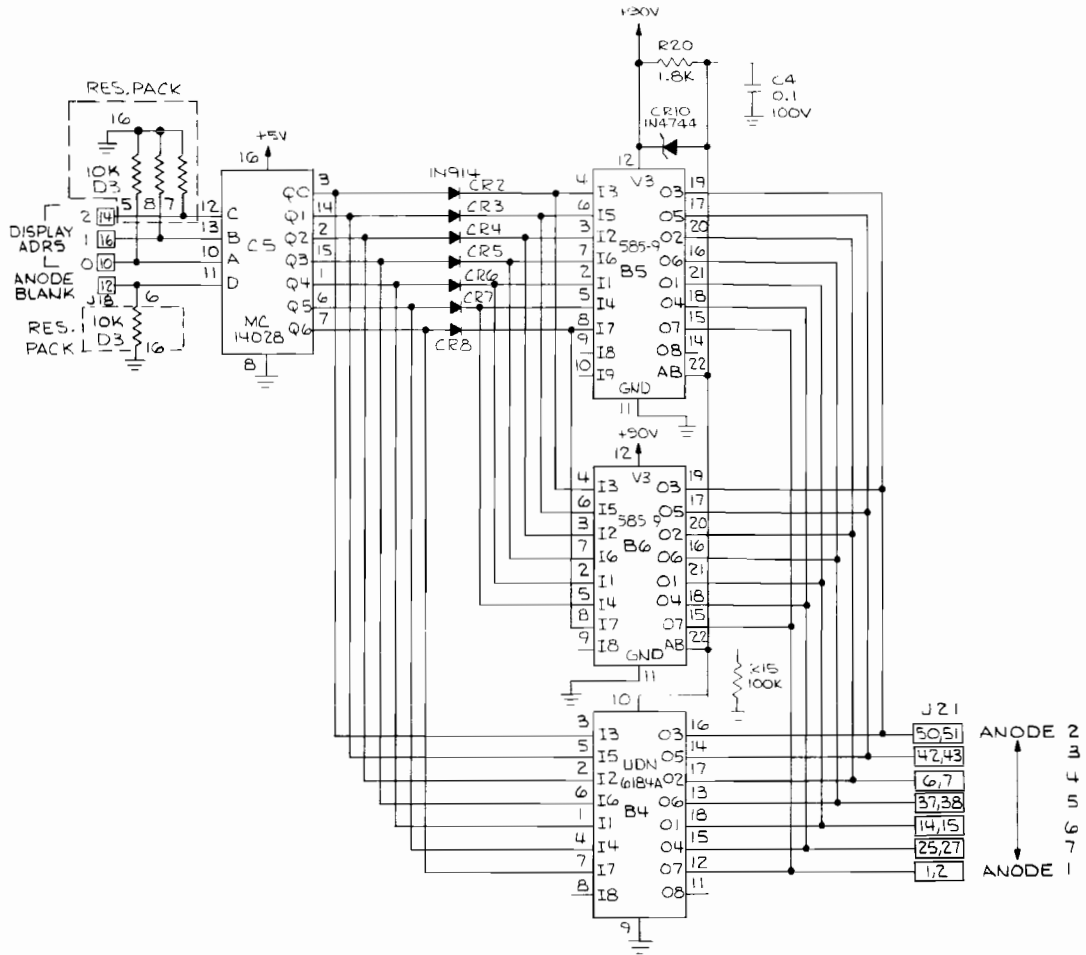
continued on sheet 2/2

Figure 28 Auxiliary PCB Schematic and Assembly

Item	Part Number	Qty.	Description
33	34-2N3643	1	Transistor, NPN, 2N3643 Q1
34	34-2N3583	1	Transistor, NPN, 2N3583 Q3
35	34-2N6044	2	Transistor, NPN, 2N6044 Q10, Q11
36	34-2N6282	1	Transistor, NPN, 2N6282 Q5
37	33-2N6420	1	Transistor, PNP, 2N6420 Q4
38	37-LM380	1	Integrated Circuit, LM380 D1
39	37-MC1413	1	Integrated Circuit, MC1413 (ULN2003) A1
40	37-741	1	Integrated Circuit, 741 C1
41	37-4016	1	Integrated Circuit, 4016 D2
42	37-7402	2	Integrated Circuit, 7402 A2, A3
43	37-7407	2	Integrated Circuit, 7407 D3, C2
44			
45	11-5391	1	Resistor, Carbon Comp., 390 ohms, 1/2 w, 5% R35
46	72-1608C	10	Screw, Mach., Pan Hd., Phillips, 6-32 x 1/2" Lg.
47	75-016S	10	Washer, Flat, Regular Pattern, #6
48	75-056	10	Washer, Lock, Internal Tooth, #6
49	75-916C	10	Nut, Hex, Regular Pattern, 6-32, Steel
50	12-5103	1	Resistor, Carbon Comp., 10K ohm, 1w, 5% R36
51	78-06002	2	Heatsink, Thermalloy #6111B-66
52	79-58123	1	Header, 6-pin, Amp #350431-1
53	79-58124	1	Header, 4-pin, Amp #350761-4
54	78-06012	1	Heatsink, Modified Wakefield #641
55	32-1N5335	1	Diode, Zener, 1N5335 CR1
56	32-1N5230	1	Diode, Zener, 1N5230 CR21
57	10-5101	1	Resistor, Carbon Comp., 100 ohms, 1/4w, 5% R11
58			
59	78-16011	2	Silpad, TO-66
60	72-1408C	4	Screw, Mach, Pan Hd Phil., #4-40 x 1/2 Cres
61	75-014S	4	Washer, Flat, Reg Pattern #4
62	75-054	4	Washer, Lock, Int. Tooth #4
63	75-914C	4	Nut, Hex, Reg Pattern #4-40 Cres
64	75-09012	4	Washer, Shoulder
65	78-0A01	2	Cover, Insulating, to-66 (Q10,11)
66	11-5100	1	Res. CC, 10 OHMS, 1/2 W 5% R48
67	10-5221	1	Res., C.C. 220 OHMS, 1/4 w, 5% R33
68	75-09015	3	Shoulder Washer (Seastrom 5605-25)

Figure 28 Auxiliary PCB Schematic and Assembly

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NOTE:  
 1. IF B4 (UDN6184A) IS USED, THEN B5 & B6 (EBS-9),  
 AND CR2-CR8 (1N914) ARE OMITTED.

Figure 29 Score Panel Drive 2 PCB Schematic and Assembly

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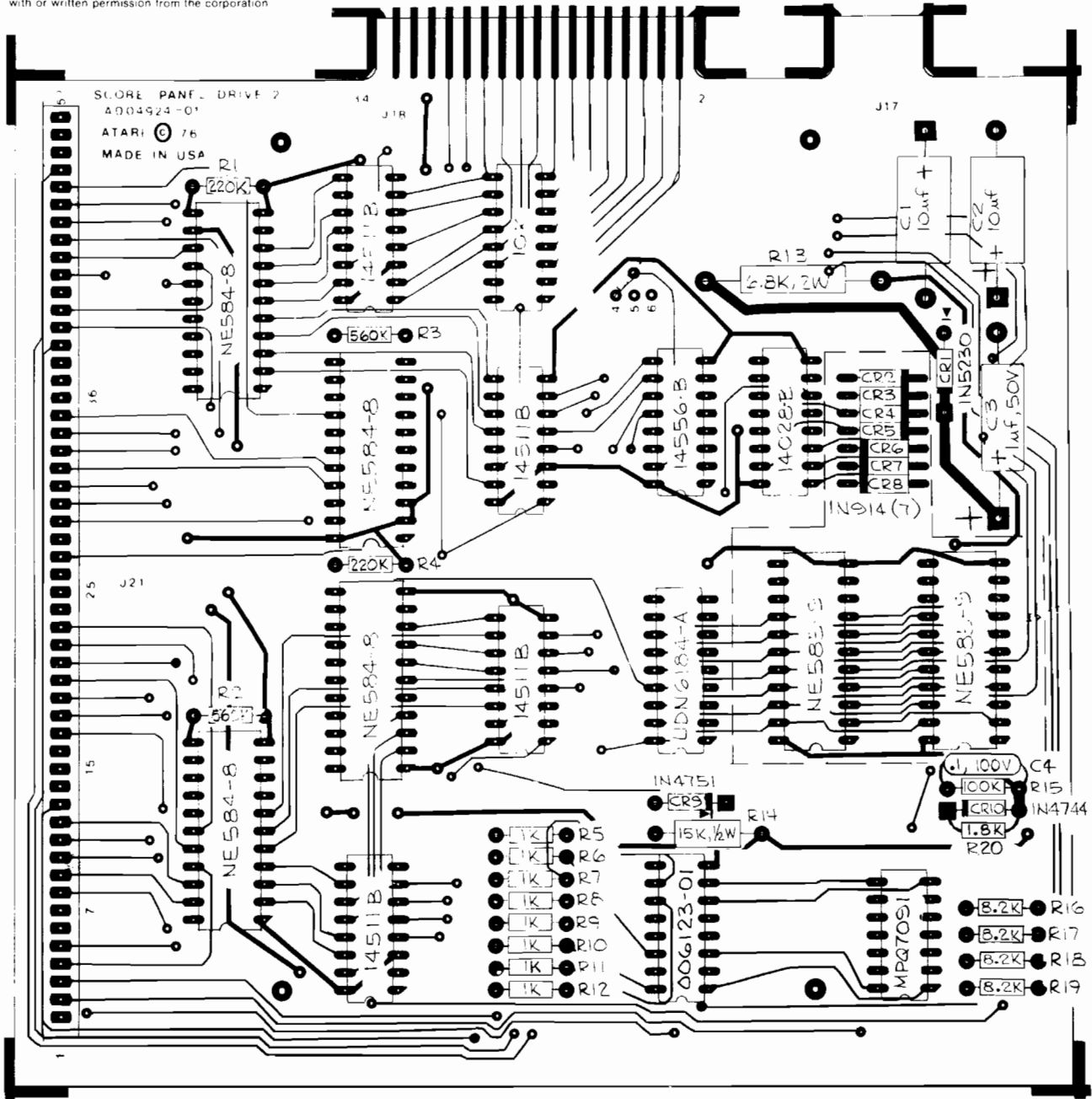


Figure 29 Score Panel Drive 2 PCB Schematic and Assembly

Item	Part Number	Qty.	Description
1	004922-01	1	PCB, Blank, Score Panel Drive
2	10-5102	8	Res., Carbon Comp., 1000 ohms, 1/4w, 5% R5-12
3	10-5224	2	Res., Carbon Comp., 220K ohms, 1/4w, 5% R1, 4
4	10-5564	2	Res., Carbon Comp., 560K ohms, 1/4w, 5% R2, 3
5	10-5822	4	Res., Carbon Comp., 8200 ohms, 1/4w, 5% R16-19
6	11-5153	1	Res., Carbon Comp., 15K ohms, 1/2w, 5% R14
7	13-5682	1	Res., Carbon Comp., 6800 ohms, 2w, 5% R13
8	24-101106	2	Capacitor, Electrolytic, 100WVDC, 10ufd C1-2
9	24-500105	1	Capacitor, Electrolytic, 50WVDC, 1.0ufd C3
10	32-1N4751	1	Diode, Zener, 1N4751 CR9
11	32-1N5230	1	Diode, Zener, 1N5230 CR1
12	19-008	1	Res. Network, 10K ohms, CTS# 761-1-R10K
13	37-MC14028	1	Integrated Circuit, MC14028
14	37-MC14511	4	Integrated Circuit, MC14511
15	37-MC14556	1	Integrated Circuit, MC14556
16	37-MPQ7091	1	Integrated Circuit, MPQ7091
17	37-UDN6184A	1	Integrated Circuit, UDN6184A
18	37-584-8	4	Integrated Circuit, 584-8
19	006123-01	1	Integrated Circuit, MC1413, 75V (Atari Custom)
20	004770-01	1	Connector, Score Panel
21	72-1408S	4	Screw, Mach., Pan Hd., Phil., 4-40 x 1/2" Lg., Stl
22	10-5104	1	Res., Car Comp 100K OHMs 1/4W 5% R15
23	32-1N4744	1	Diode, Zener 1N4744 CR10
24	10-5182	1	Res. Car Comp 1.8K OHMs 1/4W 5% R20
25	27-10104	1	Cap, Ceramic Disc 0.1uf 100V C4

Figure 29 Score Panel Drive 2 PCB Schematic and Assembly

Item	Part Number	Qty.	Description
1	004922-01	1	PCB, Blank, Score Panel Drive
2	10-5102	8	Resistor, Carbon Comp., 1000 ohms, $\frac{1}{4}$ w, 5% R5-12
3	10-5224	2	Resistor, Carbon Comp., 220K ohms, $\frac{1}{4}$ w, 5% R1,4
4	10-5564	2	Resistor, Carbon Comp., 560K ohms, $\frac{1}{4}$ w, 5% R2,3
5	10-5822	4	Resistor, Carbon Comp., 8200 ohms, $\frac{1}{4}$ w, 5% R16-19
6	11-5153	1	Resistor, Carbon Comp., 15K ohms, $\frac{1}{2}$ w, 5% R14
7	13-5682	1	Resistor, Carbon Comp., 6800 ohms, 2w, 5% R13
8	24-101106	2	Capacitor, Electrolytic, 100 WVDC, 10ufd C1,2
9	24-500105	1	Capacitor, Electrolytic, 50 WVDC, 1.0 ufd C3
10	32-1N4751	1	Diode, Zener, 1N4751 CR9
11	32-1N5230	1	Diode, Zener, 1N5230 CR1
12	19-008	1	Resistor Network, 10K ohms, CTS# 761-1-R10K
13	37-MC14028	1	Integrated Circuit, MC14028
14	37-MC14511	4	Integrated Circuit, MC14511
15	37-MC14556	1	Integrated Circuit, MC14556
16	37-MPQ7091	1	Integrated Circuit, MPQ7091
17			
18	37-584-8	4	Integrated Circuit, 584-8
19	006123-01	1	Integrated Circuit, MC1413, 75V (Atari Custom)
20	004770-01	1	Connector, Score Panel
21	72-1408S	4	Screw, Mach., Pan Hd., Phil., 4-40 x $\frac{1}{2}$ " Lg., Steel
22	32-1N4744	1	Diode Zener 1N4744 CR10
23	10-5104	1	Res., Car Comp, 100K OHMs $\frac{1}{4}$ W 5% R15
24	31-1N914	7	Diode, 1N914 CR2-8
25	37-585-9	2	Integrated Circuit, 585-9
26	10-5182	1	Res., Car Comp, 1.8K OHMs $\frac{1}{4}$ W 5% R20
27	27-101104	1	Cap., Cer Disc 0.1uf 100V C4

Figure 29 Score Panel Drive 2 PCB Schematic and Assembly



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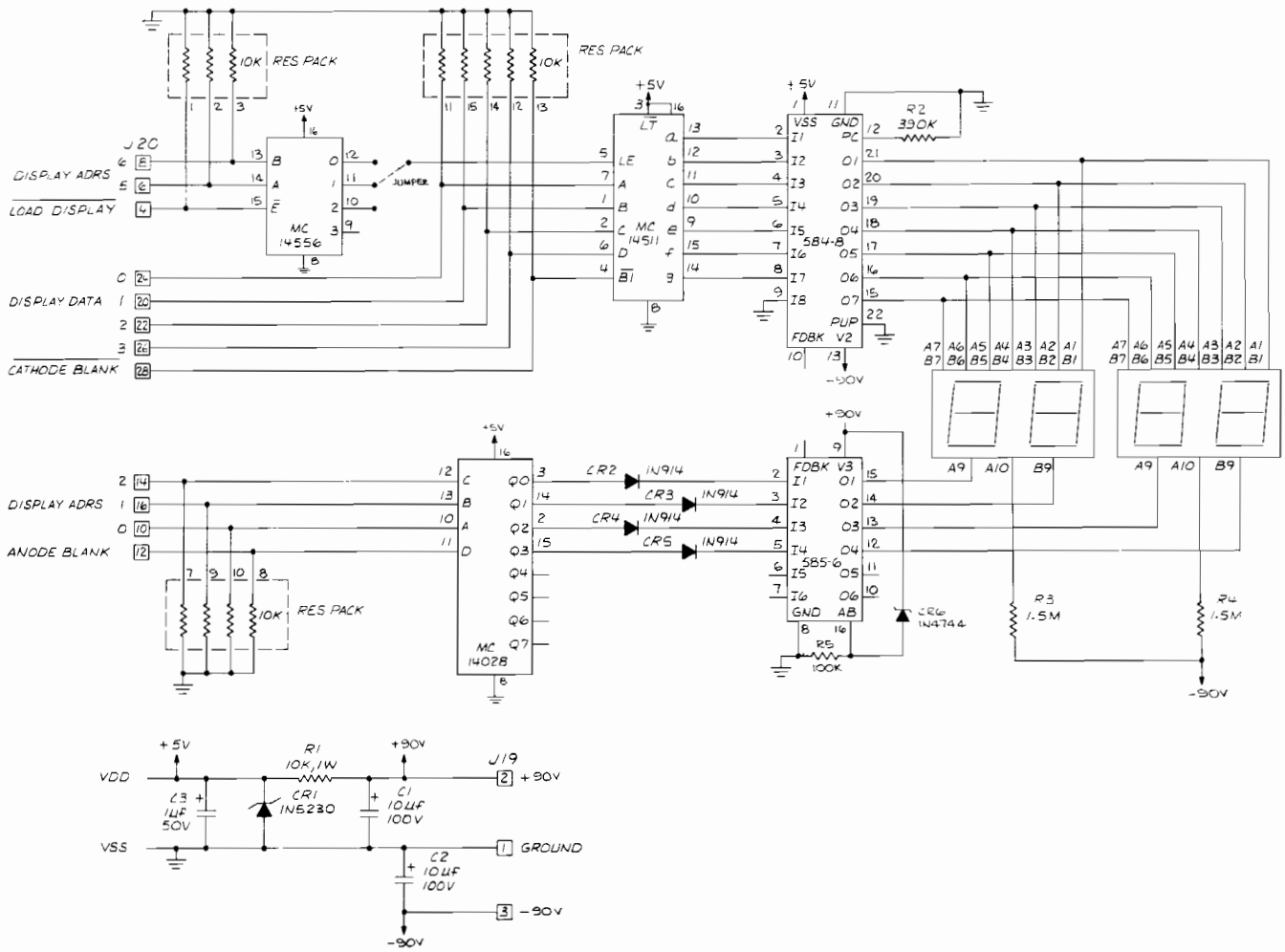
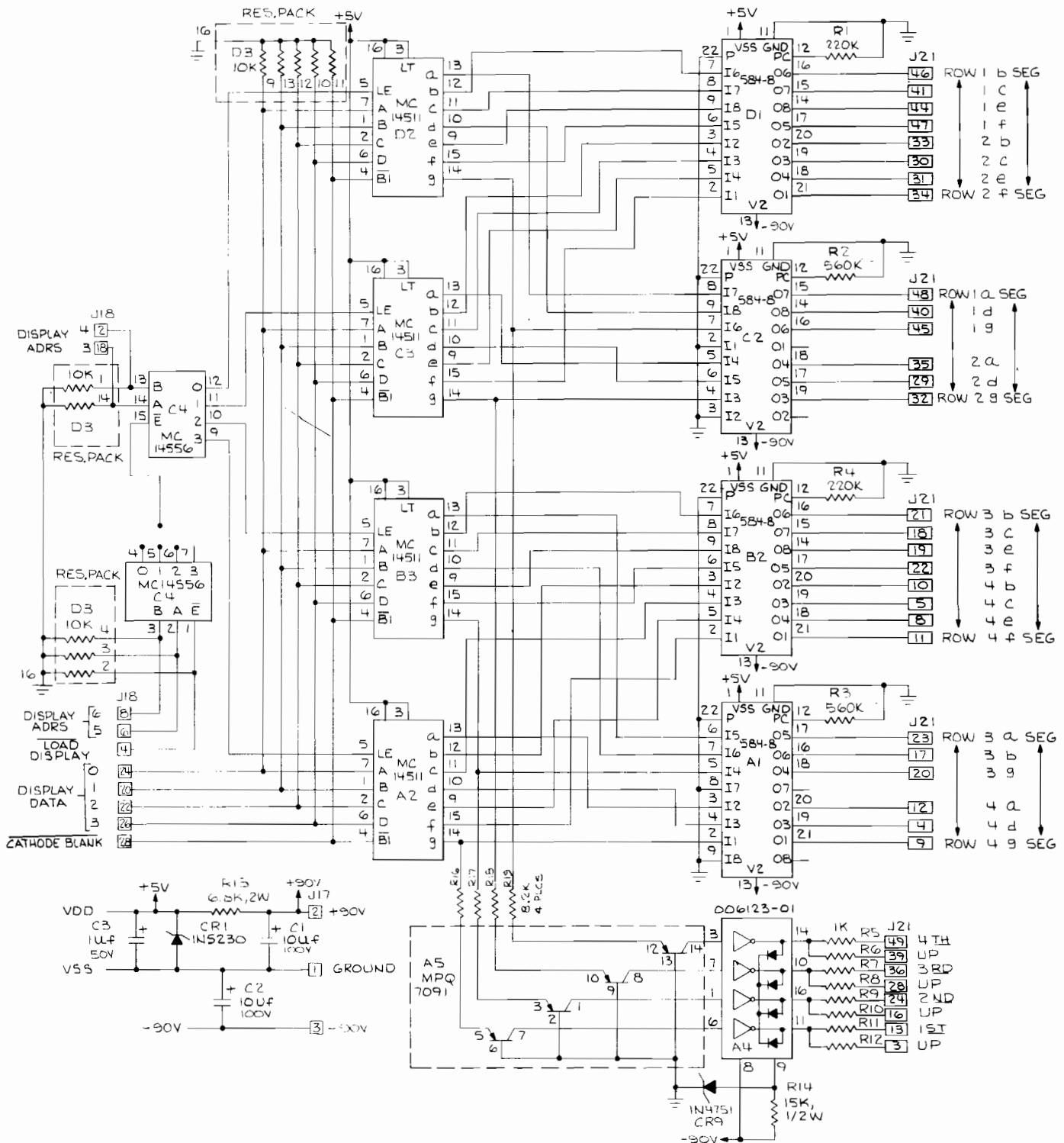


Figure 30 Match/Credit PCB Schematic and Assembly



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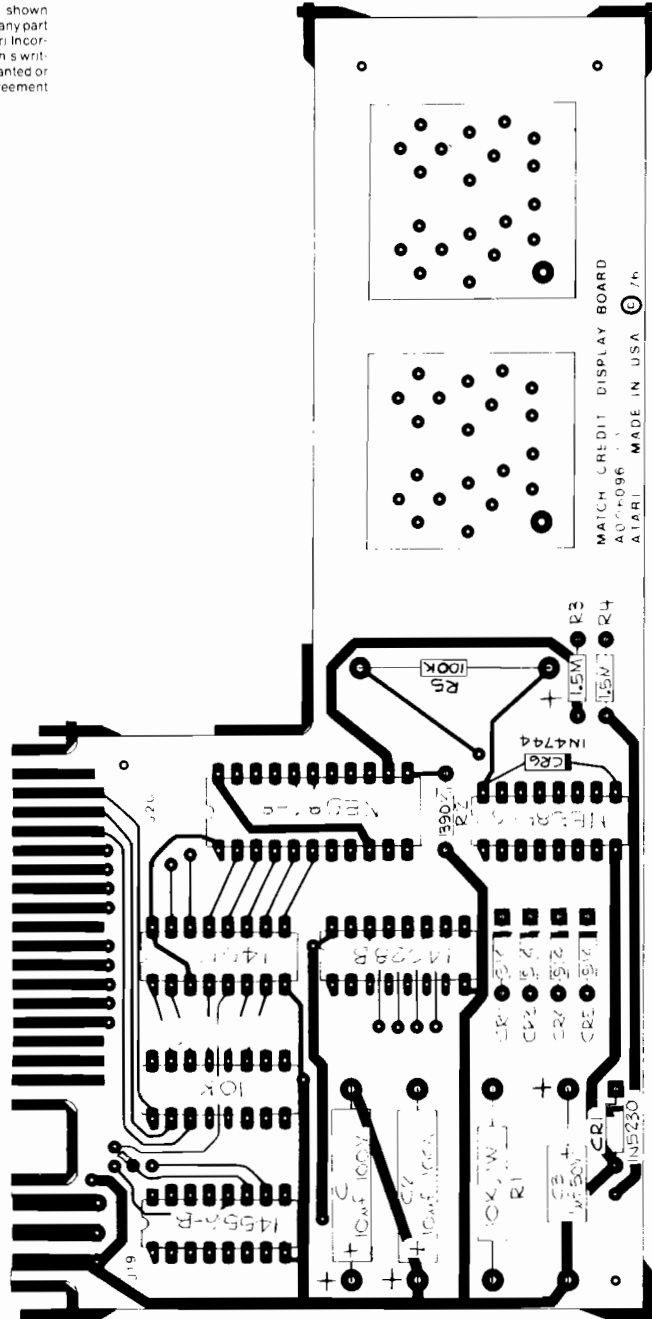
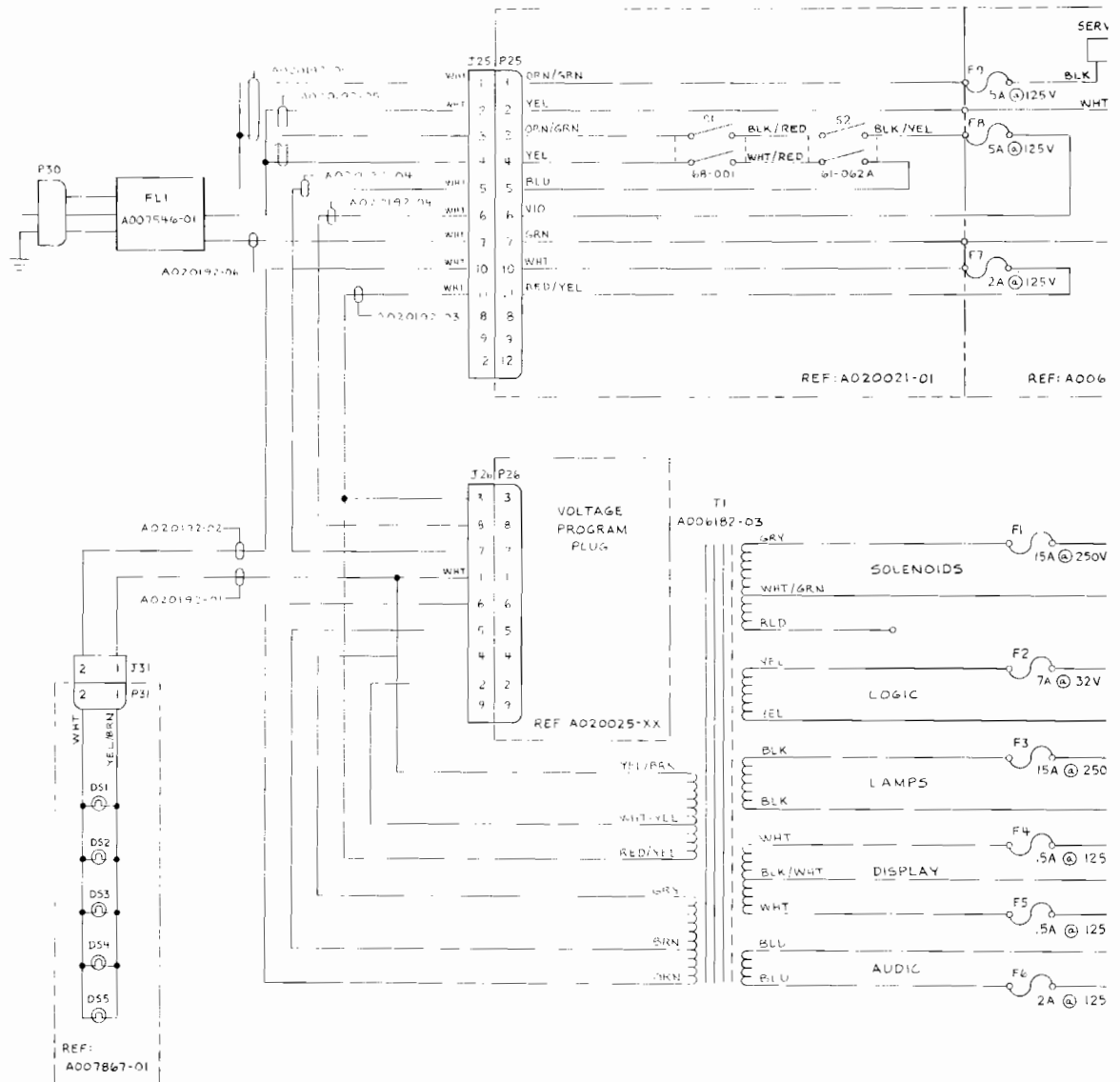


Figure 30 Match/Credit PCB Schematic and Assembly

Item	Part Number	Qty.	DESCRIPTION
1	006104-01	1	PCB, Blank, Match/Credit Display Board
2	10-5155	2	Resistor, Carbon Comp., 1.5 Megohms, 1/4w, 5% R3, 4
3	10- 5394	1	Resistor, Carbon Comp., 390K ohms, 1/4w, 5% R2
4	12-5103	1	Resistor, Carbon Comp., 10K ohms, 1w, 5% R1
5	24-500105	1	Capacitor, Electrolytic, 50 WVDC, 1.0 ufd C3
6			
7	24-101106	2	Capacitor, Electrolytic, 100 WVDC, 10 ufd C1, 2
8	32- 1N5230	1	Diode, Zener, 1N5230 CR1
9	37-MC14028	1	Integrated Circuit, MC14028
10	37-MC14511	1	Integrated Circuit, MC14511
11	37-MC14556	1	Integrated Circuit, MC14556
12	37-584-8	1	Integrated Circuit, 584-8
13	37-585-6	1	Integrated Circuit, 585-6
14	19-008	1	Resistor Network, 10K ohms, CTS # 761-1-R10K
15	31-1N914	4	Diode, 1N914 CR2-5
16	79-41001	2	Socket, Beckman Type CS-352
17	10-5104	1	Res, Carbon Co ., 100K, 1/4W, 5% R5
18	32- 1N4744	1	Diode, Zener 1N4744 CR6

Figure 30 Match/Credit PCB Schematic and Assembly





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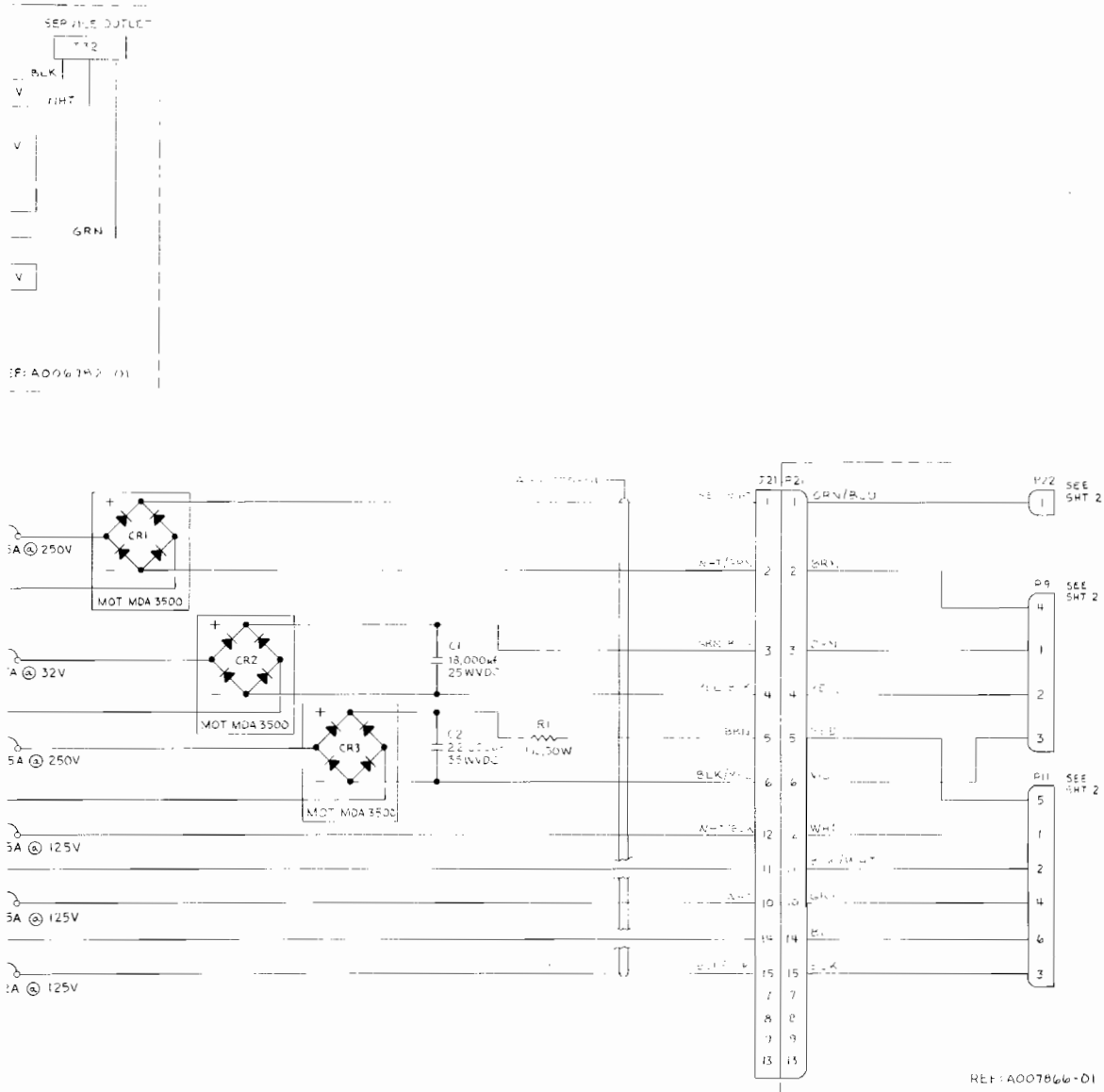
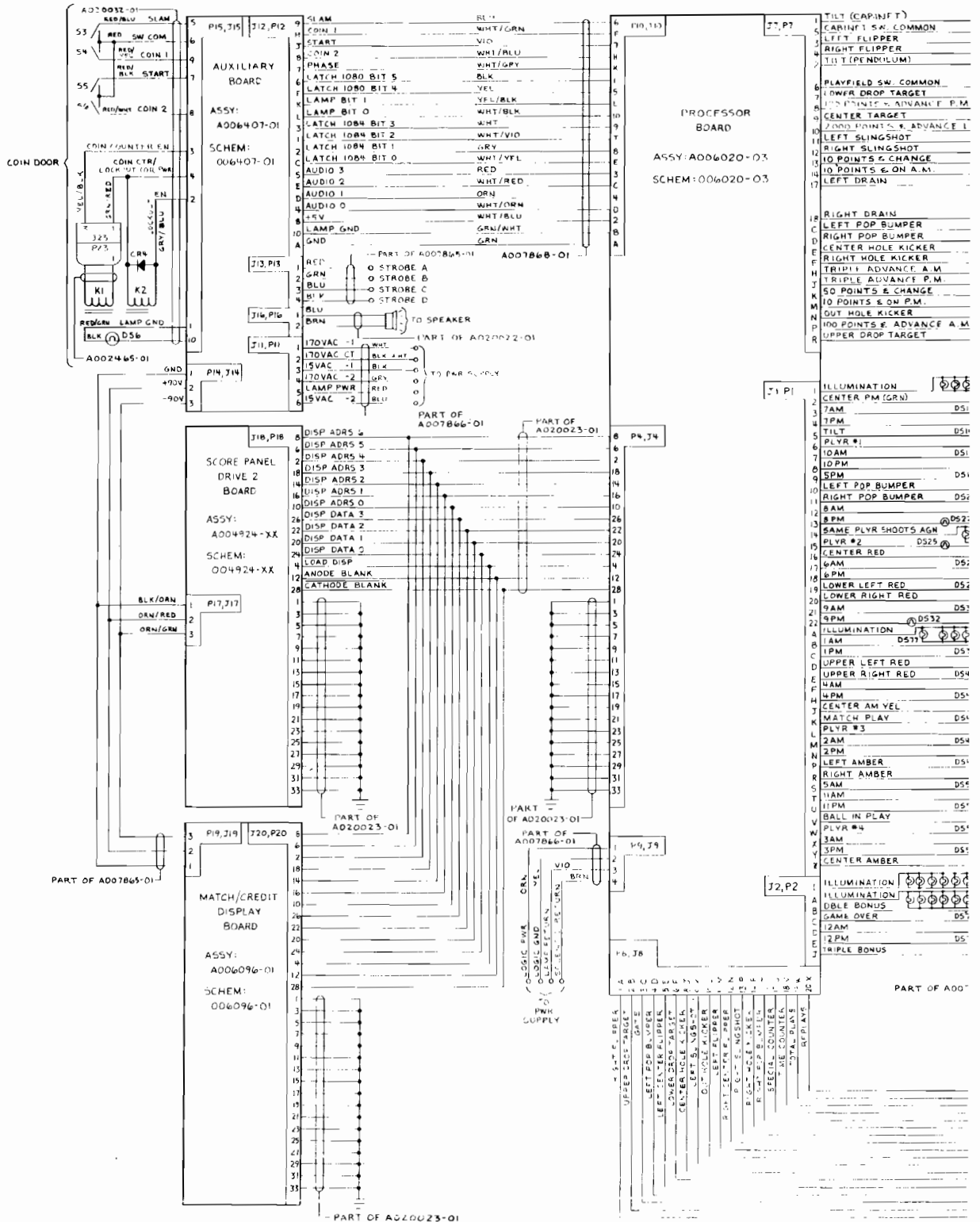


Figure 31 Interconnect and Wiring Diagram





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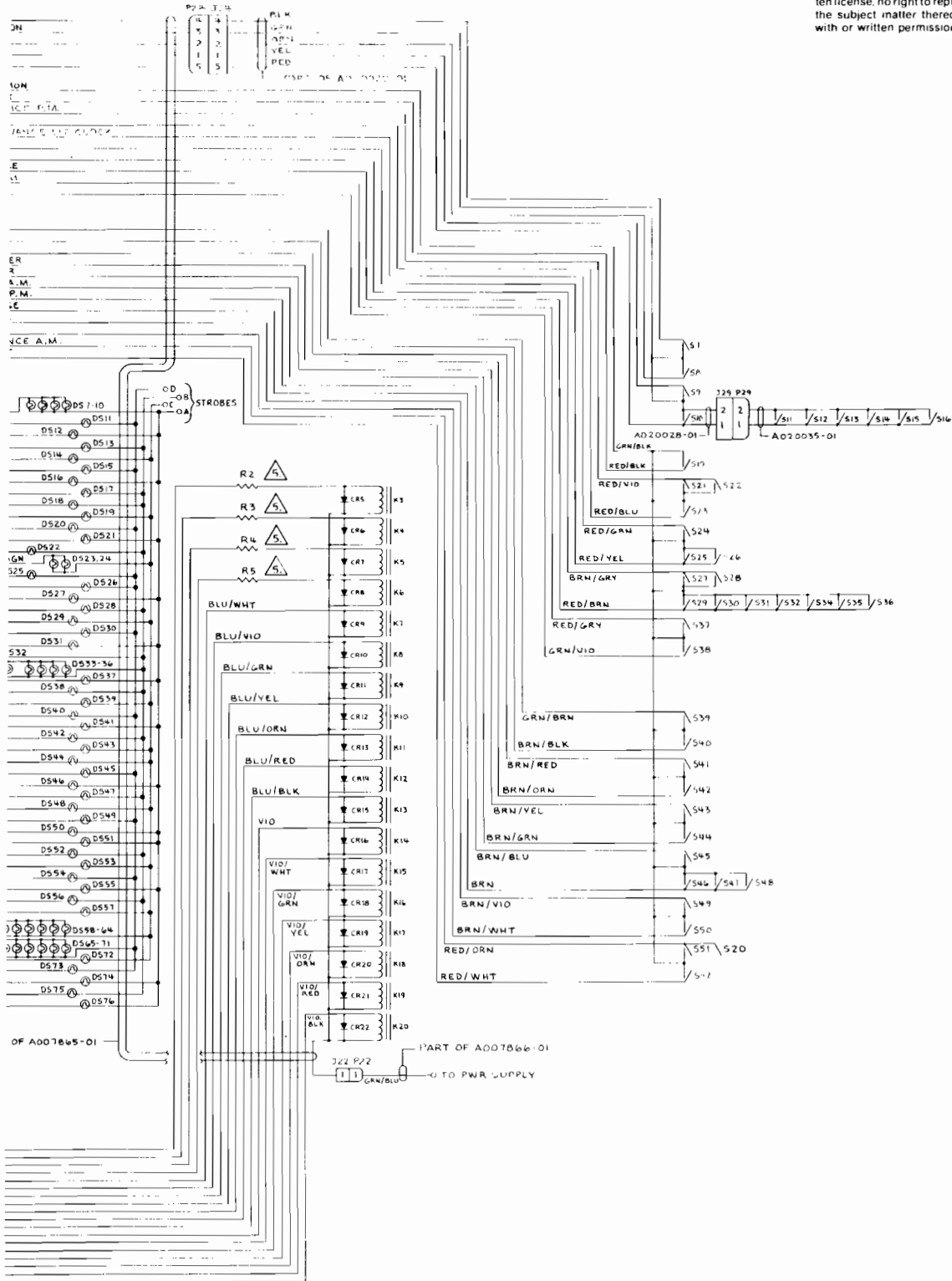


Figure 31 Interconnect and Wiring Diagram

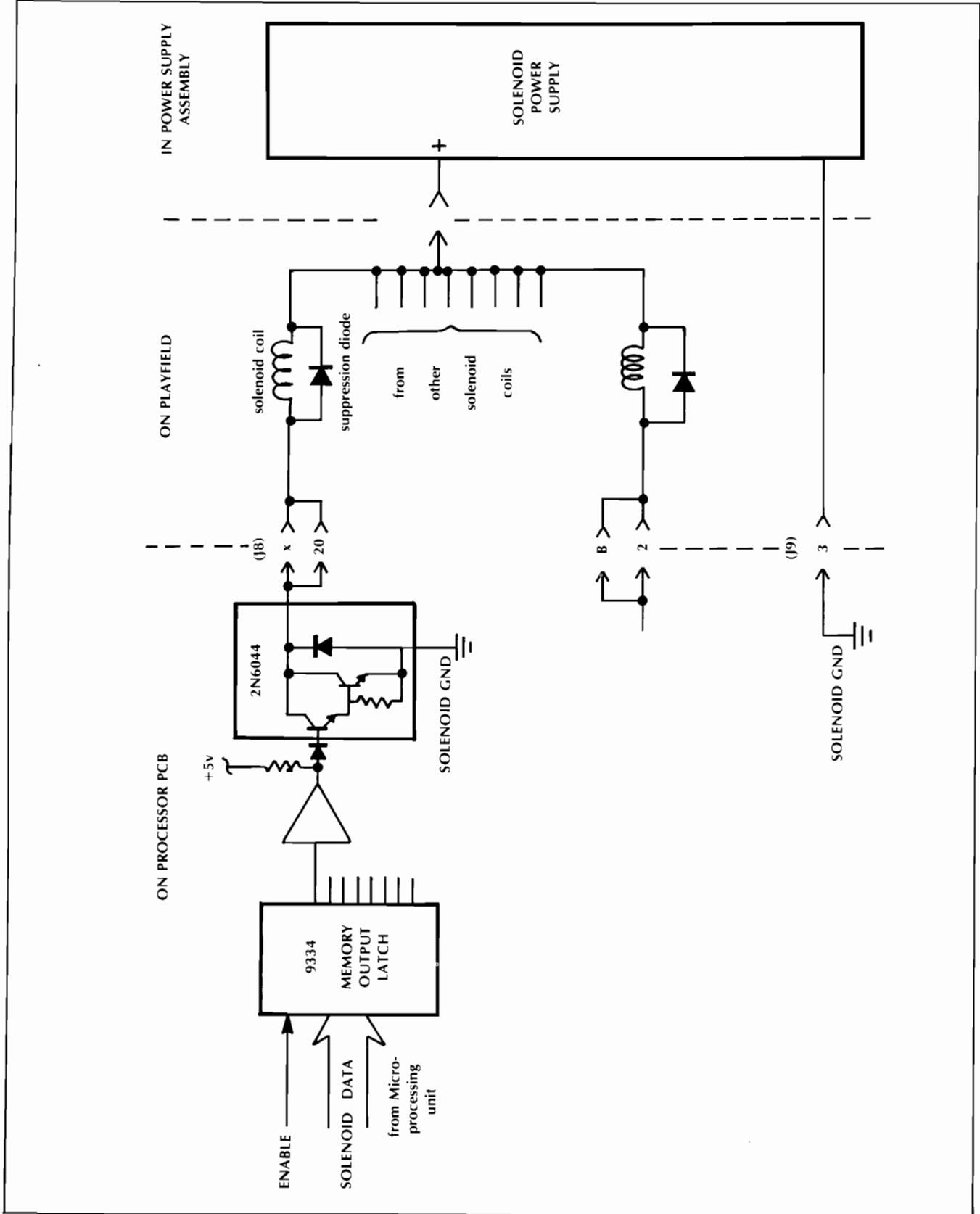


Figure 32 Simplified Diagram of Basic Solenoid Driver Circuit

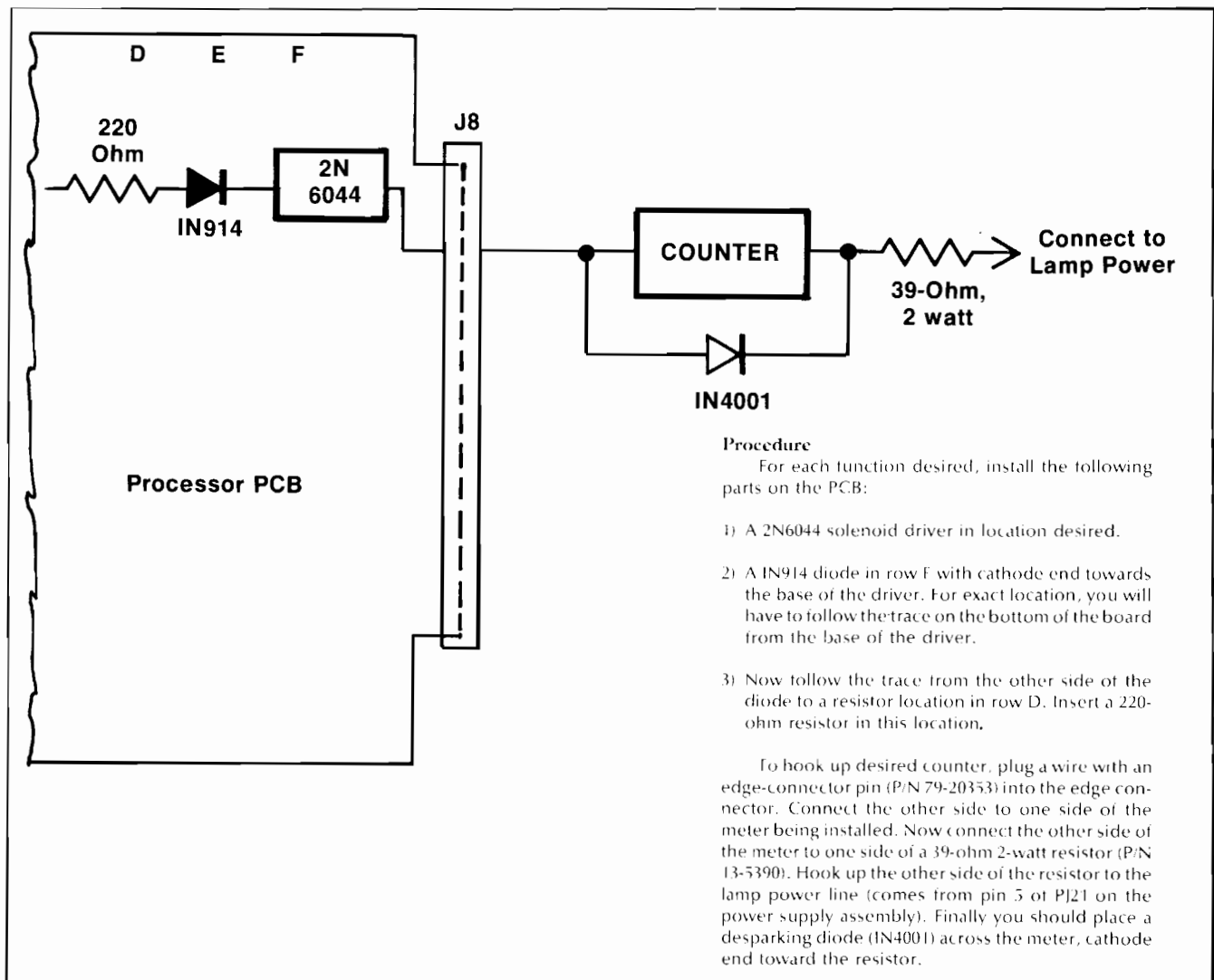
Drive components for the coin counter metering function are installed on the Processor PCB at the factory. Also provided are signals from the microcomputer and spaces on the board for additional drive components, so that owners wishing to have

four additional functions can do so by installing additional components. The four functions, components required, and their circuit designations are listed in Table 7. Figure 33 shows the circuit for each metering function to be added.

**Table 7 Components Required for Special Metering Functions**  
(Available at edge connector J-8 on the main processor PCB)

Function Being Metered	J8 Edge Connector Pin	2N6044 Driver Number	1N914 Designation	Resistor Designation
Total replays	X, 20	10	CR20	R25
Total specials awarded	U, 17	19	CR17	R21
Total game time (min)	V, 18	9	CR18	R24
Total plays	W, 19	20	CR19	R23

NOTE: DRIVERS INDIVIDUALLY NUMBERED ON BOARD AND LOCATED NEAR LARGE HEAT SINK.



**Figure 33 Additional Components to be Installed for Each Metering Function Added**

crossing point (zero power point) of the power line waveform.

### Lamp Driver Circuits

Thirty-two of the outputs from the Memory Output Latches constitute the Lamp Data shown in Figure 26. These are the BIT 0 through BIT 7 signals LATCH 1000, LATCH 1004, LATCH 1008 and LATCH 100C. All thirty-two signals connect to the type-ULN-2003A devices shown on sheet 2 of the Processor PCB schematic. These are open-collector interface devices that accept TTL input levels, and produce the high current outputs needed to light the lamps. Note that these devices connect to a lamp ground (J9, pin 4).

Figure 34 shows a simplified diagram of the basic lamp driver circuit. One side of each lamp connects to a ULN-2003A output terminal, and the other side connects to a strobe line on the Auxiliary PCB (STROBE A, STROBE B, etc.). In the wiring harness beneath the playfield black wires are used for lamps connecting to STROBE A, green wires for those to STROBE B, blue wires for STROBE C, and red wires for STROBE D.

The Control Logic decodes the LAMP BIT 0 and LAMP BIT 1 signals to produce four transistor based-drive signals, one for each 2N5883. (LAMP BIT 0 and LAMP BIT 1 come from the same circuit that produces the DISPLAY ADRS 1 and DISPLAY ADRS 2 signals on the Processor PCB schematic.) The timing of the four signals driving the 2N5883 transistors is such that any one transistor is brought into conduction only 25% of the time (25% duty cycle). This means that the playfield lamps, which appear to the eye to be of uniform brightness when lighted, are in reality blinking on and off.

During troubleshooting of the game by service technicians, while operating the game with the cabinet open and power applied, *do not* hold down the RESET pushbutton (mounted on the Processor PCB) for long periods of time. Doing this will cause one of the 2N5883 transistors to be brought into conduction 100% of the time. Lamp current is very high in this situation, and can lead to premature burning out of the lamps.

### Switch Sensing Circuit

The switch sensing circuit accepts switch closure information as an input, and produces Switch Data as an output. This Switch Data is sent to the microcomputer system on a single signal line. Figure 35 shows a simplified diagram of the switch sensing circuit.

The normally open (NO) contacts of the various playfield switches and certain cabinet switches are connected together in the playfield harness wiring, and then a common lead is brought to the Processor PCB at connector J7 (pins 5 & 6). (Refer to sheet 2 of the Processor PCB schematic.) On the board's artwork, the NO contacts from the Operator Option Switches (along with signals derived from the rest of the cabinet switches—COIN 1, COIN 2, START, and SLAM), are also connected electronically to this point. Also, this point is connected to a resistor tied to +5 volts, and to the pin-13 input of the type 7414 Inverter in location C9. The output of this Inverter, C9 pin 12, is the Switch Data line, which is applied to pin 12 of the type-8097 tri-state buffer in location C5. The device terminal at C5 pin 11 is connected to bit D7 of the Microprocessing Unit's bidirectional Data Bus.

By means of a multiplexing technique, the switch closure information being sent on the Switch Data line is derived from the timing of addressing signals being sent out by the Microprocessing Unit over the Address Bus. To determine whether or not a specific switch is closed, the Microprocessing Unit compares the timing of that switch's address code with the state of the Switch Data signal being received at that moment on bit D7 of the Data Bus.

Figure 36 shows simplified waveform diagrams that illustrate this timing comparison multiplex technique for an example circuit having only eleven switches.

In the actual game, anytime that the Microprocessing Unit addresses a specific switch, and that switch is closed at that moment, the SWITCH COMMON line will be low. The 7414 Inverter changes this to high, and a high goes out on the Data Bus on bit D7. So when the Microprocessing Unit reads back a high in that location on the Data Bus, it knows that that specific switch had been closed.

The control logic used for decoding the Microprocessing Unit's addressing information is shown on the left side of sheet 3 of the schematic. One SWITCH DECODE line is produced for each switch (SWITCH DECODE 200B, SWITCH DECODE 200A, etc.).

### Displays and Display Data

The Score Display consists of a glass plate panel that plugs into an edge connector, and a printed circuit board beneath that plugs into a second connector. The two connectors are hard-wired together.

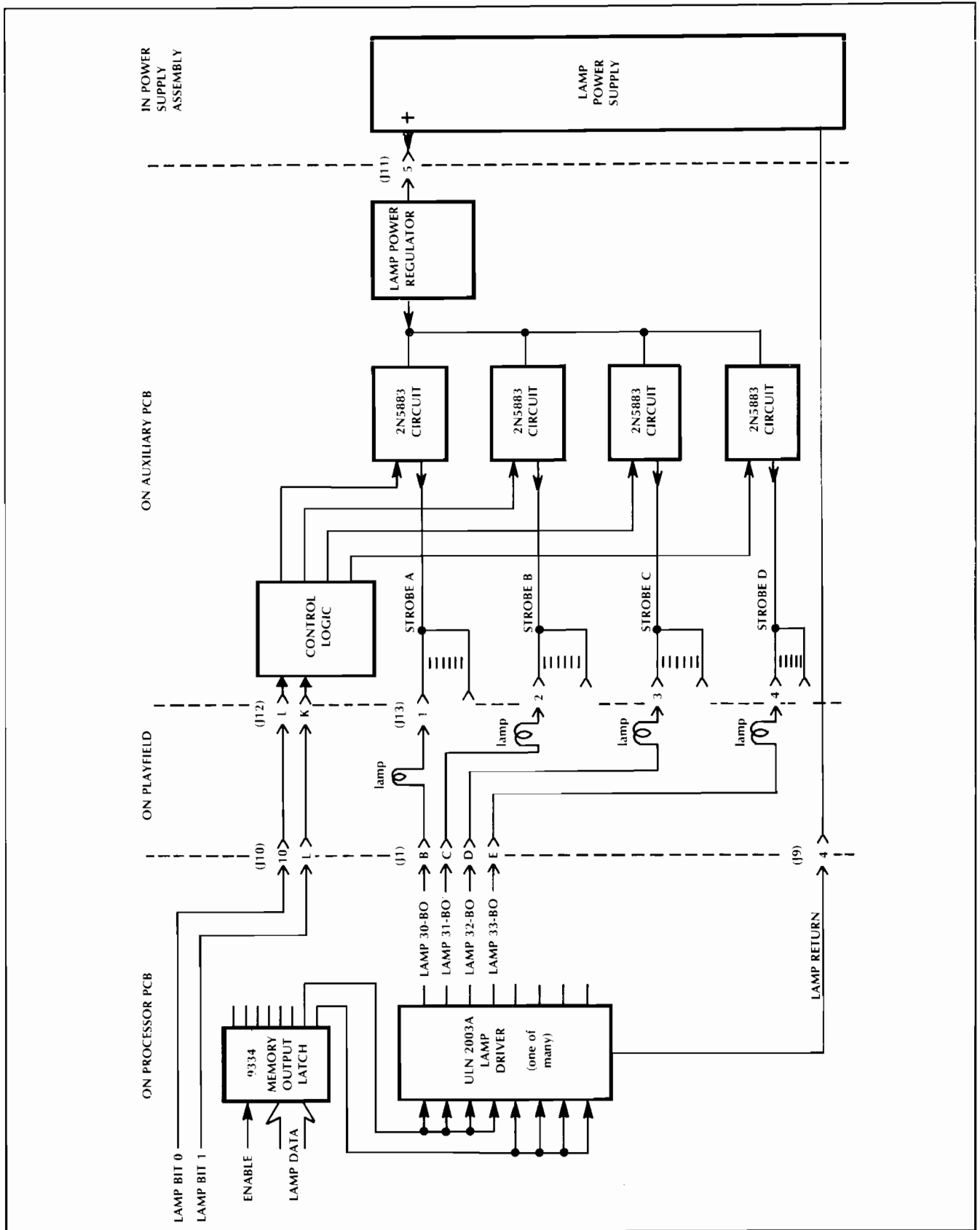


Figure 34 Simplified Diagram of Basic Lamp Driver Circuit

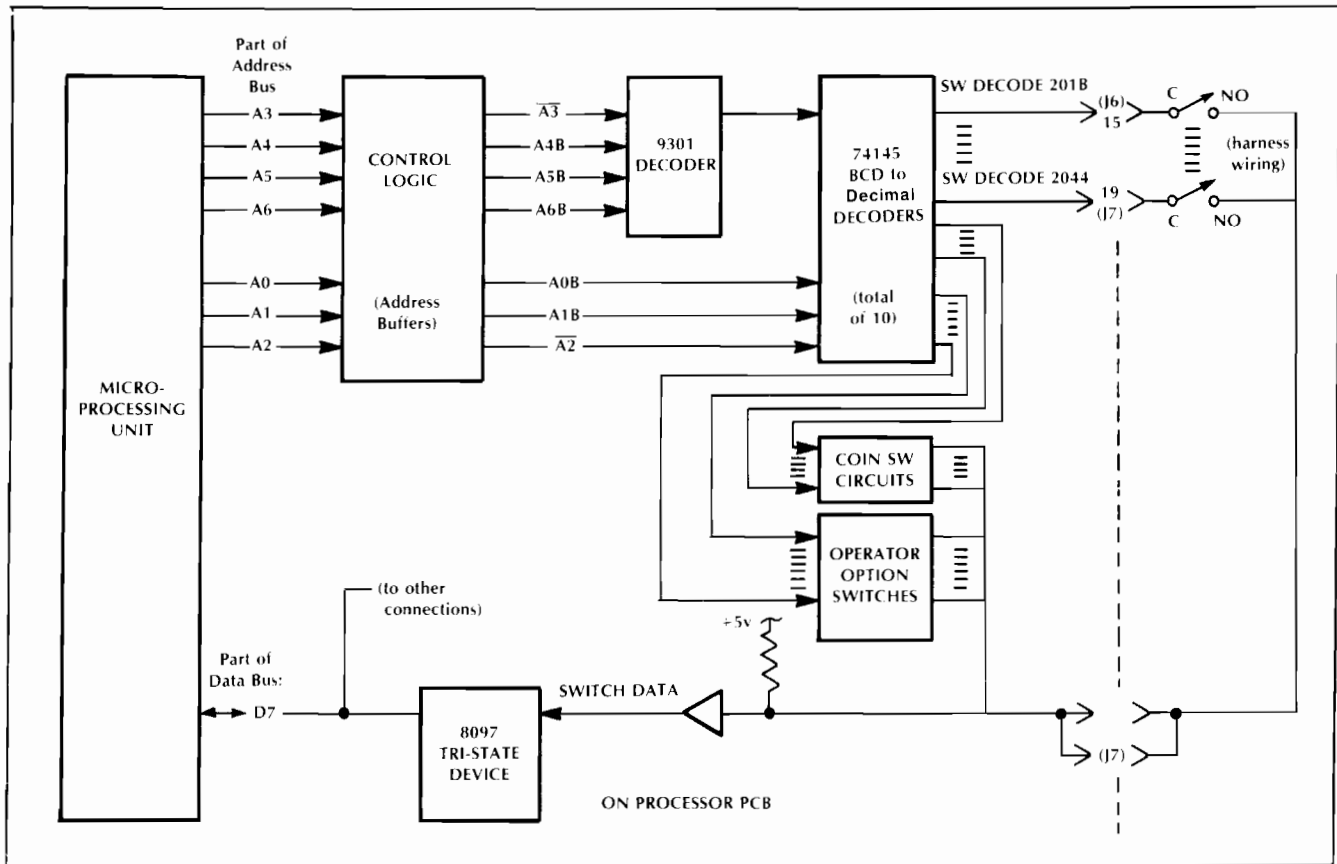


Figure 35 Simplified Diagram of Switch Sensing Circuit

The Credit and Ball/Match displays are both built on a separate PCB.

**WARNING**

Whenever AC power is applied to the game, voltage potential differences as large as 180 volts are present at the bare terminals of the glass plate's edge connector, and at various other points on both printed circuit boards.

All three are gas-discharge-type displays with the following principle of operation. If a sufficiently high voltage is applied to a gas, a point will be reached at which the gas ionizes, producing a conduction current and giving off radiation (which can be in the form of visible light). Fluorescent lamps are common examples of illumination sources that also make use of the gas-discharge phenomenon.

A display segment lights up when +90 volts is applied to the anode at the same time that -90 volts is applied to the cathode, as illustrated by the waveforms in Figure 37.

Although to the human eye a lighted segment seems to be uniformly bright, in actuality the segment is being turned on and off at a rate faster than the eye can detect. This technique is called *segment multiplexing* and is used because of economy in drive circuitry.

The Microcomputer System block diagram in Figure 26 shows how the microprocessing unit addresses the RAM Data Memory (via the Address Bus) and passes data to this memory (via the Bidirectional Data Bus), and how the Control Logic also shares these buses.

The microprocessing unit brings its BA (Bus Available) signal at C3 pin 7 to high when it is off the buses. During game operation the microprocessing unit periodically writes new display data into the RAM Data Memory and then gives up the buses. Subsequently the Control Logic takes over the buses, addressing the RAM Data Memory and then reading its display data off the Bidirectional Data Bus. The Control Logic then produces the four signals DIS-

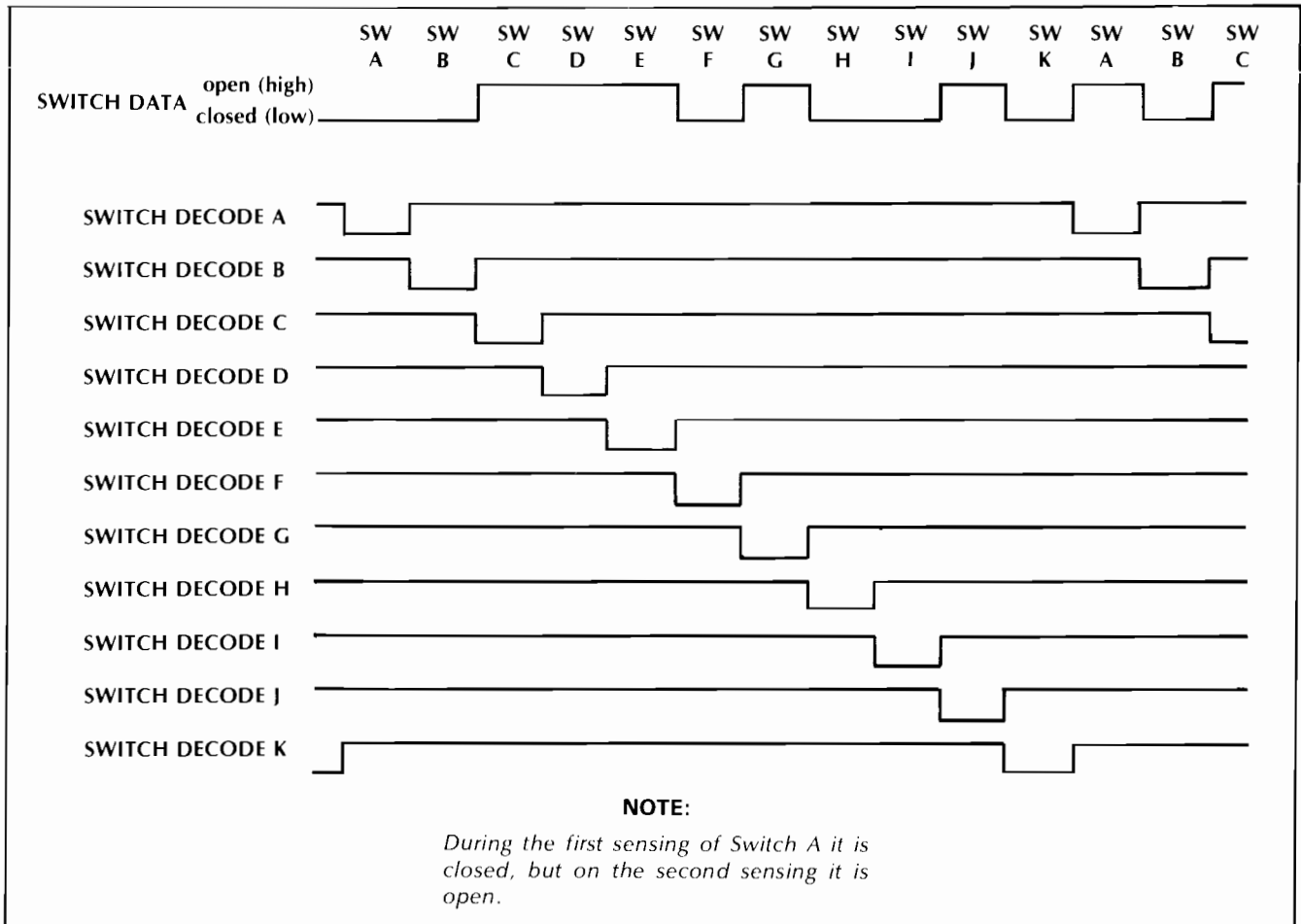


Figure 36 Simplified Diagram of Switch Sensing Circuit Waveforms

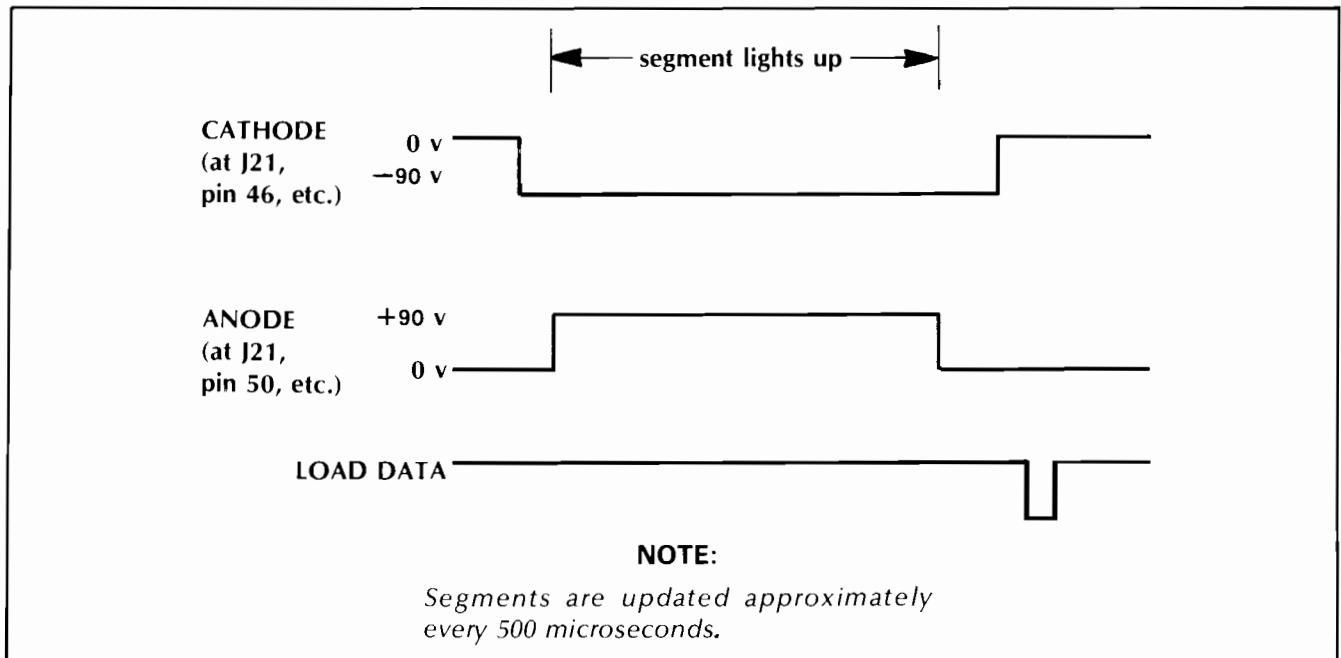


Figure 37 Waveforms for Gas Discharge Displays

PLAY DATA 0 through DISPLAY DATA 3. It also produces seven addressing signals DISPLAY ADRS 0 through DISPLAY ADRS 6, and three control signals ANODE BLANK, CATHODE BLANK and LOAD DISPLAY.

The addressing signals are used to identify which displays are to accept data at any given moment. The control signals are used to blank the displays while the microprocessing unit is on the buses, and to strobe in new display data, respectively.

The circuitry for the Control Logic is shown on the right side of Figure 27, sheet 2. The type-74157 2-line to 1-line multiplexer in location B5 produces four DISPLAY DATA signals from the eight inputs D0B through D7B. (These eight signals come from the type-LS08 buffers BC8 and CD8 on sheet 1; the buffers are driven directly from the Data Bus signals D0 through D7.) The seven DISPLAY ADRS signals are produced by counters B4 and B3, whose outputs also drive the Address Bus through the type-8097 Tri-State devices C4 and C5. The three display control signals are produced by timing logic driven also by counters B3 and B4, as well as by the  $\overline{BA}$  signal from the microprocessing unit, and by the  $\overline{RESET-A}$  signal from the microcomputer reset circuit.

The circuit for each display consists of an anode drive portion and a cathode drive portion. The anode portions derive timing signals from the DISPLAY ADRS 0 through DISPLAY ADRS 2 signals and the ANODE BLANK control signal. The cathode portions perform three functions: storage of data derived from the DISPLAY DATA signals (under control of the  $\overline{LOAD DISPLAY}$  signal), decoding of this data into 7-segment format, and keeping the segments turned off part of the time (under control of the  $\overline{CATHODE BLANK}$  signal).

The +90 volts and -90 volts required by the displays is produced in a regulated power supply circuit built on the Auxiliary PCB. The 170 VAC input to this circuit comes from the power transformer located in the Power Supply Assembly.

### Credit and Match/Ball Display Circuit

Refer to PCB schematic in Figure 30, where the top half shows the cathode portion of the circuit and the bottom half shows the anode portion.

The type-14556 device examines the DISPLAY ADRS 5 and DISPLAY ADRS 6 signals to determine when new data is available for these display digits. The output from the 14556 device is applied to the LE

(Latch Enable) input of a type-14511 device. The four signals DISPLAY DATA 0 through 3 are applied to the inputs of a type-14511 device. This device has a latching capability and it also performs segment decoding.

The 14511 device's segment outputs are applied to a type-584-8 device that performs an interfacing function; it accepts TTL logic level inputs and produces a 90-volt swing (from 0 volts to -90 volts) at its output. The seven outputs from this device are applied to the cathode terminals of all display segments. The CATHODE BLANK signal, applied to the B1 inputs (pin 4) of the 14511 device, will cause all segments to be blank, regardless of what data is stored, when the multiplex timing calls for that digit to remain unlighted.

The type-14028 device, in the anode portion of the circuit, examines the three signals DISPLAY ADRS 0 through 2 to determine which of the display digits to turn on. The outputs from the 14028 are applied through series-connected diodes to a type-585-6 interface device that drives the anode terminals of the display digits with a voltage swing from 0 volts to +90 volts.

### Score Display Circuit

The connections to the score display panel are made in the form of a rectangular matrix, with seven anode connections on one side and 28 cathode connections on the other. Figure 38 illustrates the arrangement of these connections. In the multiplex timing the six vertical rows of digits, plus the one vertical row of *player up* indications, are driven one at a time. All the anodes in the *player up* indications are brought together electrically to J21, pins 1 and 2, the ANODE 1 signal. All the anodes for the right-most digits (the least significant digits), are brought to J21, pins 50 and 5, the ANODE 2 signal, etc. The sequence of lighting the anodes is: ANODE 2, then 4, then 6, then 3, then 5, then 7, and finally ANODE 1.

Likewise, the cathodes of all segments of the digits in a row are tied together. For example, all the "b" segments in the top row are tied together and brought to J21, pin 46.

For the circuit descriptions that follow, refer to the schematic in Figure 29. The four display address signals (DISPLAY ADRS 3 through 6) are applied to type-14556 devices which produce four outputs. One of these outputs is applied to the LE input (pin 5) of each of the type-14511 Latch/Segment Decoder devices in locations D2, C3, B3, and A2. The 14556 devices decide which of the Latch/Segment Decoders



are to receive display data (are to be loaded) at any one moment.

The individual segment outputs (“a” through “g”) produced by the Segment Decoders are applied to four type-584-8 Cathode Driver devices in locations D1, C2, B2, and A1. These Cathode Drivers perform an interfacing function; they accept TTL logic level inputs and they produce a 90-volt swing (from 0 volts to -90 volts) at their outputs. A separate circuit

(formed by four 8.2K-ohm resistors, a 4-transistor MPQ 7091 device in location A5, and the 006123-01 device in A4), produces the signals applied to the “Player Up” cathodes (4TH UP, 3RD UP, etc.)

The circuitry for driving the anodes of the display shown on the right half of the sheet. The type-14028 device examines the DISPLAY ADR0 through 2 signals to determine which of the seven ANODE lines are to be turned on. The outputs of the 14028 are applied to

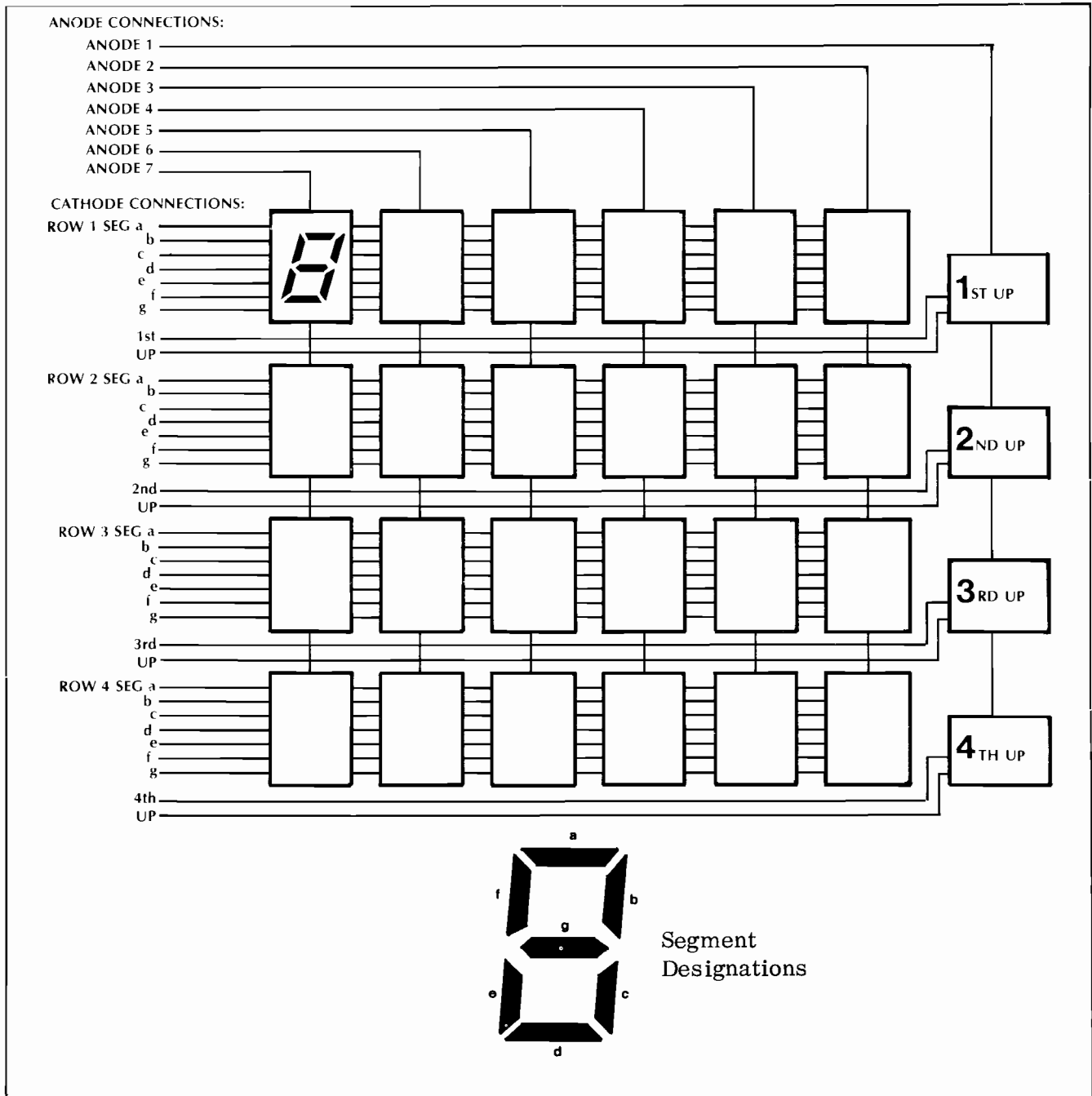


Figure 38 Arrangement of Connections to Score Panel

interface device or devices that will produce the 90-volt swing (from 0 volts to +90 volts) at their outputs. This PCB is laid out in such a way that two choices of device type are possible. (A board will be built using only one choice.) The choices are: one type-UDN 6184A device, or two type-585-9 devices.

### **Sound Generator and Speaker Driver Circuits**

The initial portion of the Sound Generator circuit is built on the Processor PCB: the final portion and the Speaker Driver are built on the Auxiliary PCB. In the lower left corner of sheet 2 of Figure 27 four Memory Output Latch signals (LATCH 1088 Bit 0 through LATCH 1088 Bit 3) are applied to the type-9316 counter in location D13. This counter is driven by the AUDIO CLOCK signal and serves as a frequency generator. The counter's TC (terminal count) output (at D13 pin 15) is applied to a second counter configuration formed by two type-7493 counter devices. The AUDIO ENABLE and AUDIO RESET signals (produced by Control Logic section shown on sheet 1) are applied to the R01 and R02 reset inputs of these counters (pins 2 and 3). These two signals control when the game's sound is allowed to come on and when it is kept off.

Five output signals from the 7493 counters, together with four more Memory Output Latch signals (LATCH 1080 BIT 0 through BIT 3), are applied to the address inputs of the ROM device in location D12. This ROM has been pre-programmed to perform a waveform shaping function. The ROM outputs, AUDIO 0 through AUDIO 3, are sent to the Auxiliary PCB.

On the Auxiliary PCB schematic these four AUDIO signals are connected to type-7407 open-collector buffers. The buffer outputs connect, via a "weighted" resistor network, to the pin 3 positive input of the amplifier in location C1. The network is called "weighted" because of the binary weighted values of the resistors; 68K ohms is double the value of the 33K-ohms resistor, which is double the value of the 18K-ohm resistor, etc. This weighted resistor-buffer arrangement performs a D-to-A (digital to analog) converter function. Note that other resistors, a 1.5K-ohm to ground and a 1.2K-ohm that connects to +13.6 volts, are also tied into this resistor network.

Four more Memory Output Latch signals (LATCH 1084 BIT 0 through BIT 3) are applied to the Auxiliary PCB. After buffering by type-7407 devices, these signals are applied to the gate inputs (pins 5, 6, 12, and 13) of the type-4016 Quad CMOS Analog Switch in location D2. These four latch outputs provide the amplitude modulation information portion of the Sound Data. The outputs of the type-4016 Analog Switch connect, via another "weighted" resistor network, to the negative input (pin 2) of amplifier C1. Thus the 4016 device provides amplitude or gain control for the amplifier. Amplifier C1 acts as a mixer stage for all the Sound Data, and its output (at C1 pin 6) is applied to the Speaker Drive circuit.

The LM380 amplifier in location D1 serves as the Speaker Driver. Potentiometer R1 provides the game's speaker volume adjustment described in Chapter 3, Section G. The LM380 output at D1 pin 8 connects, via harness wiring, to the speaker.





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