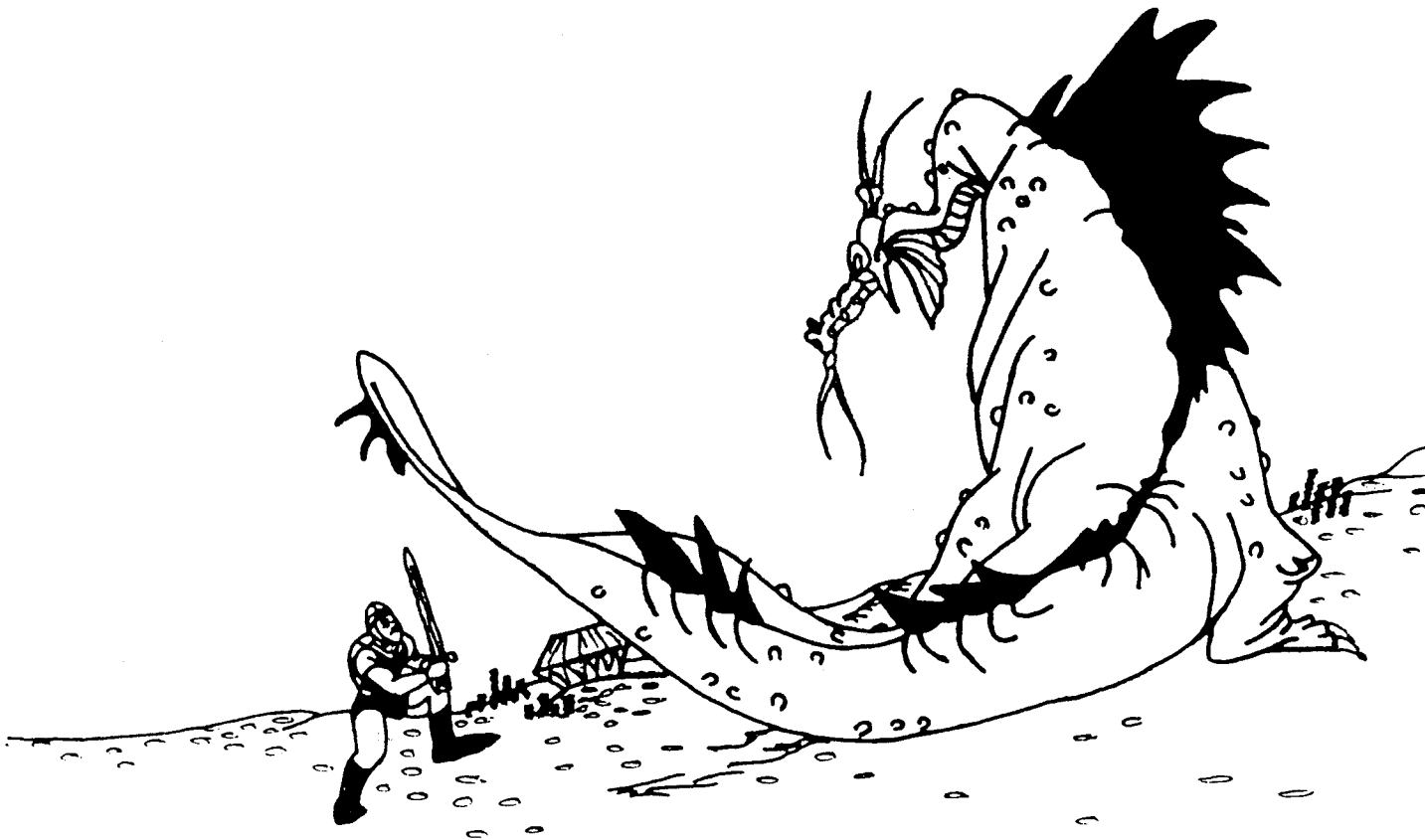




DRAGON'S LAIR™



DRAGON'S LAIR
OPERATION AND MAINTENANCE
MANUAL

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CHAPTER 1

GENERAL INFORMATION FOR OPERATORS

Part I: GAME SET UP

A. WARNINGS:

For safety and reliability, Cinematronics does not recommend or authorize any substitute parts or modifications of Cinematronics equipment. Such alterations may adversely affect game play, cause injury, or void Warranty. Substitute parts, modifications, and non-Cinematronics game "conversions" may also void FCC compliance.

Cinematronics' games are protected by Federal copyright, trademark, and patent laws. Therefore, non-Cinematronics game "conversions" or game modules may be illegal under Federal law.

Both models of the video disc player should be kept in a horizontal position at all times. If tilting is required during transport or repair, keep the period of inclination to a minimum.

The monitor's picture tube encloses a high vacuum and due to the large surface area is subject to extreme force. Take care not to bump or scratch the picture tube as this may cause the tube to implode, resulting in personal injury and property damage.

To prevent fire or shock hazard, DO NOT EXPOSE THE MONITOR TO RAIN OR MOISTURE.

B. RF INTERFERENCE

Cable harness placements and ground strap routing on this game have been designed to keep RF radiation and conduction within levels accepted by FCC regulations. To maintain these levels, reposition harnesses and reconnect ground straps to their original placements if they should be disconnected during maintenance.

C. PRELIMINARY EXAMINATION

Each game should undergo a brief inspection upon arrival to ensure that no damages occurred during shipping. The following list may be used as an inspection guideline:

1. Inspect the outside of the shipping carton. Damage to the outside carton may indicate damage to the game cabinet.
2. Unlock and set aside the back panel to check the circuitry. Reconnect any loose connectors. The connectors are keyed--do not force them together. Prevent damage to the PC boards by taking care not to reverse edge connectors.
3. Make sure that all socketed integrated circuits are firmly seated.
4. Unwrap the power cord supplied with the game, and plug it into the receptacle found on the rear of

the cabinet. DO NOT PLUG THE GAME INTO THE WALL AT THIS TIME.

5. Observe the major subassemblies: monitor, control panel, transformer board, and power supply. All should be securely mounted.
6. Open the drawer at the bottom of the cabinet by removing the wing nuts and screws on the sides of the cabinet. Make sure that the video disc player is securely mounted.

Part II: GAME OPERATION

A. POWER REQUIREMENTS

CAUTION: To prevent shock hazard and ensure proper game operation, plug this game into a properly grounded outlet: unless otherwise specified, your game was shipped to operate at 115 VAC, 60 hz.. Do not use a cheater plug or cut off the ground pin to defeat the ground through the line cord.

B. OPERATOR CONTROLS

1. **ON/OFF Switch:** This switch is mounted on the rear of the cabinet next to the AC input receptacle. Pull the switch out to turn on the game.

2. **COIN COUNTER:** Mounted on the operator convenience panel behind the coin door, this mechanism is software controlled and counts credits rather than coins. If, for example, one game costs fifty cents, the coin counter increments once for every two coins.

3. **VOLUME:** Two volume controls, one for the left channel and one for the right, adjust the game's stereo sound.

4. **RESET Switch:** Located on the left side of the Z80 Controller Board near the amplifier heat sinks, the RESET switch forces the Z80 and other registers on the board into their proper initial states and prevents the generation of unwanted sounds. See the Theory of Operation chapter of this manual for a more thorough explanation of this switch.

5. **COVER-OPEN Switch:** The left-most switch on the front panel of the disc player, this switch opens the cover of the disc player. Power must be on and the laser disc in reject position before this switch can operate.

6. **DIP SWITCHES:** For an explanation of the Dip Switch settings, settings, see Part III of this chapter.

C. VIDEO DISC PLAYER CARRIAGE MECHANISM

The carriage mechanism on either disc player must be locked in place during shipping or moving. An unlocked carriage may result in disc player alignment problems.

Pioneer PR-7820: (Brown Player Enclosure)

After the game is in the desired location, unlock the carriage mechanism on the disc player by inserting a small flathead screwdriver into the hole just below the cover on the front-left side of the disc player. Turn the screw counterclockwise until it releases. The carriage mechanism is now free, the disc player ready to operate.

Pioneer LDV-1000: (Black Player Enclosure)

The locking screw for the carriage is located inside this player. After the game is in the desired location, momentarily turn the power on and press the COVER-OPEN switch to open the disc player cover. Located on the right side of the disc cavity is a large 3/8" flathead screw. Remove this locking screw and its washer plate, and save them, along with the lens cap, in the bag on the back door of the game cabinet. The disc player is now ready to operate.

ALWAYS SECURE THE CARRIAGE MECHANISM PRIOR TO SHIPPING OR MOVING THE GAME.

D. LASER DISC INSTALLATION

Turn the power on momentarily and press the COVER-OPEN switch to open the disc player. The cover should open as soon as the disc is in reject position.

Pioneer PR-7820:

Now turn the power off. Data-side (reflective) up, set the laser disc on the spindle of the player. Press the "Lock" buttons on the spindle to hold the disc in place. Close the cover of the disc player.

Pioneer LDV-1000:

Turn the power off. Data-side down, set the laser disc onto the spindle of the player. Close the cover of the disc player to automatically lock the disc in place.

DO NOT OPERATE EITHER DISC PLAYER UNTIL THE DISC IS LOCKED ONTO THE SPINDLE.

E. POWER UP

When the carriage mechanism is unlocked and the laser disc installed, replace the back panel and plug in the game. Pull out the ON/OFF switch to turn the power on. Three tones should be heard, about fifteen seconds apart. The first indicates that the laser disc is in reject position, the second that the laser disc has begun to play. The third tone indicates that the game is ready to play. If any or all of the tones are not heard, return to beginning of this GAME OPERATION section and start over.

F. COIN OPERATION

One credit = one single player game. The number of coins required for one credit is operator programmable. Two or more credits initiate a two player game. Credits are displayed in the LED display above the CRT monitor.

G. PLAYER CONTROLS

1. SWORD/ACTION button: Causes Dirk to draw and use his sword.

2. EIGHT POSITION JOYSTICK: Controls Dirk's movements. Dirk moves in the direction that the joystick is pointed. In some instances, moving Dirk to an object causes him to do something with that object.

H. GAME PLAY

In DRAGON'S LAIR, Dirk the Daring enters the enchanted castle of an evil wizard to rescue Princess Daphne. As Dirk fights his way through the monsters and traps the wizard has set for him, he must find the secret passages which lead to the caverns below the castle. There, in a deep dungeon, the princess is held captive in a magic cage guarded by a gigantic Dragon. Dirk must ultimately slay this Dragon to free the princess.

Because the monsters and traps to be overcome are so numerous and constantly changing, it is not possible to list the range of scores awarded for each one. Generally, as Dirk progresses deeper into the castle, he encounters more difficult obstacles and is accordingly awarded greater numbers of points for overcoming them.

Part III: REVISED GAME OPTIONS (To be used with games containing Revision A, B, C, or D PROMs).

The following game options are controlled by Dip Switches 1 and 2 on the main CPU board:

- I. Attract Mode and Joystick Sound
- II. Number of Coins Required for One Credit
- III. Number of Dirks per Credit and Length of Play
- IV. Playtest and Diagnostic
- V. Difficulty Level
- VI. Pay-As-You-Go Play

Some options are controlled by individual switch settings, others by combinations of switch settings. Points B0 through B7, marked in white on the PC board, correspond to switches 1 through 8 respectively on Dip Switch 1. Points A0 through A7 correspond to switches 1 through 8 respectively on Dip Switch 2. BEFORE ADJUSTING SWITCHES, TURN POWER OFF AND UNPLUG POWER CORD.

A. ATTRACT MODE AND JOYSTICK SOUND

POINT	POSITION	FUNCTION
B0	OFF	Sound on every 8th attract mode sequence.
B1	OFF	No sound during attract mode sequences.
B3	OFF	Joystick feedback sound on.

B. NUMBER OF COINS REQUIRED FOR ONE CREDIT

NOTE: one credit = one game

SWITCH COMBINATION		NUMBER OF COINS REQUIRED FOR ONE CREDIT
A1	A0	
ON	ON	2
ON	OFF	3
OFF	ON	4
OFF	OFF	Not used.

C. NUMBER OF DIRKS PER CREDIT and LENGTH OF PLAY

POINT	POSITION	NUMBER OF DIRKS PER CREDIT
A5	ON	3
A5	OFF	5
B2	OFF	Unlimited Dirks for testing purposes.
A4	OFF	2 credits at all times/free play.

D. PLAYTEST AND DIAGNOSTIC

POINT	POSITION	FUNCTION
A3	OFF	Playtest Switch for engineering use.
A7	First ON, then OFF.	Diagnostics. To run diagnostics, set A7 to the ON position, and power up the game. Wait until you hear two beeps. The second beep indicates that the disc player has been initialized. After the second beep, turn A7 to OFF, and run diagnostics. To rerun diagnostics, press the RESET button, Sw 3 on the PC board.

E. GAME DIFFICULTY LEVELS

SWITCH COMBINATION			DIFFICULTY LEVEL
A2	B4	B7	
ON/OFF	ON/OFF	OFF	Easy.
ON	OFF	ON	Difficulty is dependent upon player's ability. Easy at the onset of every game, play automatically increases in difficulty when a player survives 9 consecutive sequences of challenges.
ON	ON	ON	Difficulty is dependent upon player's ability. Easy at the onset of every game, play automatically increases in

difficulty when a player survives
5 consecutive sequences of
challenges.

OFF ON ON Hard.

F. PAY-AS-YOU-GO PLAY OPTIONS

SWITCH COMBINATION

A0	A1	A6	B5	B7	OPTION
ON/OFF	ON/OFF	ON	ON/OFF	ON/OFF	Pay-as-you-go setting is off. A specific number of coins must be deposited before game play begins. Game then plays from start to finish without interruptions.
ON	ON	OFF	ON	ON	Game play stops once, 2/3 of the way to the dragon's lair. At this time, the player must deposit more money if he wishes to continue. After the required amount of money is deposited, play resumes from the interruption point. If the player has less than three Dirks at the point of interruption, he receives one additional Dirk when play resumes. In this option, the game ends when the player finishes the dragon's lair sequence.
ON	ON	OFF	ON	OFF	Game play stops once, 2/3 of the way to the dragon's lair. At this time, the player must deposit more money if he wishes to continue. After the required amount of money is deposited, play resumes at the interruption point.

The player receives no additional Dirks in this option.

The game ends when the player finishes the dragon's lair sequence.

ON ON OFF OFF ON

 Game play stops at three regular intervals. At each pause, the player must deposit more money if he wishes to continue. After the required amount of money is deposited, play resumes at the interruption point.

If the player has less than 3 Dirks at a point of interruption, he receives one additional Dirk when play resumes.

In this option, the game does not end after the dragon's lair sequence. Instead, after the dragon's lair sequence, the player may deposit additional coins to prolong play. Play begins again at the first sequence. (No extra Dirks are awarded after the dragon's lair sequence).

ON ON OFF OFF OFF

 Game play stops at three regular intervals. At these times, the player must deposit more money if he wishes to continue. After the required amount of money is deposited, play resumes at the interruption point.

In this option, the player receives no additional Dirks at any time. The game does not end after the dragon's lair sequence. Instead, after the dragon's lair sequence, the player may deposit additional coins to prolong play. Play begins again at the first sequence.

Part IV: ROUTINE MAINTENANCE AND SERVICE

Because of its solid state electronic circuitry, this game should require very little maintenance and only occasional adjustments. Several measures should, however, be taken to ensure as few problems as possible.

Laser Disc Cleaning and Handling: The laser disc should be cleaned weekly with a soft cloth and an ammonia-based cleaning solution, e.g. a non-aerosol window cleaner. Do not use any cleaner containing alcohol. To prevent fingerprints and smudges, hold the laser disc by its edges.

Video Monitor: Though the video monitor is properly adjusted before shipping, occasional minor adjustments may be necessary. Adjustment controls are located at the rear of the monitor. Do not attempt to modify any circuit on the monitor. See Chapter 5 for additional information on the monitor.

Power Supply: The power supply is also adjusted before shipping. The computer boards in this game operate most efficiently and reliably when the power supply is set so that the voltage on the board is +5V. To check this, place a meter across +5V and ground at the edge connector. If necessary, adjust the screwdriver control on the power supply till the meter reads between 4.9 and +5V.

This game should be serviced only by qualified technicians. For service information, contact:

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CHAPTER 2
THEORY OF OPERATION
FOR THE SYSTEM CONTROLLER

A. Z80

The microprocessor used in this system is a 4 MHz Z80. All of the Z80's address, data, and control outputs are buffered by bus drivers: U2, U9, U15, and U23. These buffers are always enabled.

B. DATA BUS DIRECTION CONTROL

A high Read signal RD- at U15-1 allows the Z80 to write into the RAMs and other external devices. A low RD- signal allows the transfer of data from the RAMs, ROMs, and other external devices to the Z80.

The Z80 generates sixteen address lines. After buffering, these lines are referred to as A0 through A15. A0 is the least significant bit, A15 the most significant.

Similarly, after buffering by data bus driver U15, the eight data bus lines are referred to as D0 through D7.

U23 buffers the following four control signals generated by the Z80:

SIGNAL	OCCURRENCE
M1- MACHINE CYCLE 1	During instruction fetches.
MREQ- MEMORY REQUEST	When the Z80 reads or writes data from or to memory-mapped devices.
RD- READ	When the Z80 reads data.
WT- WRITE	When the Z80 writes data.

NOTE: Bus Acknowledge signal BUSAK- may be wired on some boards, but it is never used.

C. Z80 CONTROL LOGIC

This section describes the generation of three control inputs to the Z80: CLOCK+, RESET-, and WAIT-. The control input Bus Request (BUSRQ-) may be wired on some boards, but it is never used.

1. CLOCK CIRCUIT

The Clock Circuit provides the Z80 Controller Board with a stable source of timing, thus insuring, among other things, that all audio sounds remain in tune. Composed of U24, U29, Y1, and other discrete parts, the Clock Circuit consists of an oscillator and several dividers and drivers.

The oscillator is composed of U24, pins 1 through 6, Y1, R45, R46, C54, and C63. The output of the oscillator circuit is 16.000 MHz clock at U24-6. This signal is fed into divider U29-3.

The dividers reduce the oscillator frequency by a factor of four, yielding a frequency of 4.00 Mhz at U29-9. After the frequency undergoes an additional division by two, the dividers generate the clock for the GI sound chip by supplying 2.00 Mhz at U26-5: the 4.00 Mhz output of divider U29-9 is fed to the Z80 at U1-6 after being redriven by U23, pins 7 and 13.

2. RESET CIRCUIT

The Reset Circuit forces the processor and other registers on the Z80 Board into their proper initial states and prevents the generation of unwanted sounds. The Reset Circuit is activated automatically at power up and manually by pressing the RESET button on the Z80 Controller Board.

The Power-up Reset Circuit is composed of CR1, CR2, R43, R44, C62, Q1, U23, pins 11 and 9, U22, pins 1 through 3.

At power up, the positive side of C62 is very close to 0 volts. This causes Q1 to be turned on and the output of the circuit, U23-9, to be high. C62 now begins to charge; i.e., the voltage on its positive side goes from ground to +5V. When the positive side of C62 reaches a potential of approximately 1.4 volts, Q1 turns on, forcing U23-9 low. To provide a clean output pulse at U23-9, the pulse width at U23-9 should be in excess of 50 milliseconds.

A Schmidt-Trigger device, U23 has built-in hysteresis. U22, pins 1 through 3 provide an active low RESET at U22-3.

When the RESET button is depressed, C62 de-charges, initiating the RESET Circuit activity described above.

3. WAIT LOGIC

When reading or writing to GI Sound Chip U19, the Z80 must wait for one Time State, or T-State. For circuit simplicity, a signal generated by U25-6 determines when these states need to be inserted. Sometimes active for other reasons, this signal is always active low whenever the GI Sound Chip is addressed.

The Wait Circuit for the GI Sound Chip is composed of U28 and U25, pins 1 through 6. A T-State is generated as follows:

The signal at U25-6 is fed to U28-2. U28 is configured as a 2-Bit shift register. Normally, U25-6 remains high, causing U28, pins 5 and 9 to be held high and the WAIT signal at U25-3 to be high/inactive. When the GI Sound Chip is addressed, U25-6 drops low, causing U28-6 to go high, while U28-9 remains high. The WAIT signal then drops low for 250 ns or one T-State.

D. Z80 ADDRESS DECODING

Address decoding is performed by U4, U11, and U10. U4 decodes address lines 13, 14, and 15. The outputs of U4 select five different banks of ROM, one bank of RAM, and two banks of memory-mapped I/O devices. Each of these banks is 4K long. Address decoding at U4 is enabled when Memory Request signal MREQ+ is active high at U25-10. It is disabled during Refresh Cycles (RFSH-) by a low at U25-9.

U10 decodes address lines 3, 4, and 5. Its outputs are used to generate Write Strokes to memory-mapped I/O devices. Also used to decode address lines 3, 4, and 5, U11 generates Read Strokes for memory-mapped I/O devices.

E. PROM MEMORY

Located on the Personality Board, PROM Memory U1 through U5 contain the program for the game.

F. RAM MEMORY

RAM Memory U3 stores the variables for the Z80 Controller Board. U3 = one 2K block of memory.

G. REAL TIME CLOCK

Interrupts occurring at a rate of approximately 33 milliseconds are required to keep the Z80 in sync with the video disc player. The signal RTC+ (REAL TIME CLOCK) at U26-11 is a square wave with a 33 millisecond period. In early models, this signal is generated by the 68705, U7-12. In later models, U6 and U13 are cascaded to form a 16-Bit binary counter. The output of this counter circuit, U6-6 is a 33 millisecond square wave.

In either case, U26-8 is forced low every 33 milliseconds, thereby generating an interrupt signal to the Z80. When the Z80 recognizes the interrupt signal, it forces both M1- and the IORQ- signals low simultaneously, causing CLR INT- (CLEAR INTERRUPT) to go low at U25-11, thus removing the interrupt generated at U26-8.

H. GI SOUND CHIP

GI Sound Chip U19 generates the boops and beeps for the coin drop and joystick feedback.

Both address words and data words are written by the Z80 to the GI Sound Chip. However, only data words are read from the Sound Chip. Two control inputs on the Sound Chip control all reading and writing between the Z80 and the Sound Chip. When an address word is written into U19, the Write Address signal generated at U10-13 falls low at U22, pins 4 and 10, forcing both control inputs, pins 18 and 20 on U19 high. In a similar fashion, the Write Data signal at U22-5, and the Read Data signal at U22-9 are encoded at U22 to control data transactions between the Z80 and U19.

The GI Sound Chip's input/output ports A and B are always programmed as inputs and are used to read option switches SW1 and SW2.

I. AUDIO AMPLIFIERS

There are two audio channels on the disc player. Channel 1 contains all of the talking: Dirk and Daphne's words and the voice of the attract mode narrator. Channel 2 contains all of the general game sounds: Dirk's grunts, screams, the creatures' noises, and all other background sounds.

U29 amplifies the sounds on Channel 1, U30 the sounds on Channel 2 and the sounds generated by GI Sound Chip U19.

J. COLOR MONITOR

The monitor used in this system is ELECTROHOME model 19MON/NTSC. 115V from the power supply's Isolation Transformer reach the monitor through a 2-pin flying lead. Video signals travel through a COAX cable from the video disc player to P103 of the monitor's NTSC decoder board.

See Chapter 5 for additional information on the monitor and the NTSC Decoder.

K. POWER SUPPLY

There are three versions of the power supply. All of the versions have outputs of +5V DC regulated and +25V unregulated power. The +25V is regulated down to +14V by the Z80 Controller for usage with audio amplifiers U29 and U30. All versions also output of 6.3V AC to the coin door lamps. Some versions have -25V and other outputs that are not used.

The three versions of the power supply differ also in the number of fuses, circuit breakers, and capacitors:

Version I: 1 five amp MDL fuse
2 circuit breakers

Version II: 1 five amp MDL fuse
1 circuit breaker
2 capacitors

Version III: 1 five amp MDL fuse
1 two amp AGC fuse for the +25V output
1 two amp AGC fuse for the 6.3V AC output
2 capacitors

NOTE: The first fuse on all versions (F1) should be a five amp MDL, even if the white silkscreen markings on the PC board say otherwise. If a game appears to lose power, make sure that F1 is a five amp MDL fuse.

L. AUDIO AMPLIFIER POWER SUPPLY

Composed of VR1, Q3, and other discrete components, the Audio Amplifier Power Supply circuit supplies approximately 14 volts to Audio Amplifiers U29 and U30. A 3-terminal voltage regulator chip, VR1 is used to drive the base of Q3 with +15V. Q3 is configured as an emitter-follower. The output of the circuit is the emitter Q3. The voltage at the emitter of Q3 is normally 14.3V.

M. PLAYER INTERFACE

All player controls and the coin switches are read by the Z80 via input registers U8 and U14. All player control inputs are furnished with pull-up resistors and RC de-coupling networks.

N. DISC PLAYER INTERFACE

The disc player interface is composed of U20, U21, and U16. In games with Pioneer 7820 disc players, U16 feeds both the ENTER+ and the INT/EXT signals to the disc player. The signal OUT DISC DATA+ at U16-5 is fed to the output enable pin at U21-1. U21 is used to send control words to the disc player. U20 is not required when communicating with the Pioneer player. Jumper W1 should be installed with the Pioneer player.

In games with the Pioneer LDV-1000 player, the only signal sent to the player from the Z80 is the INT/EXT signal generated at U16-9. The ENTER+ signal is returned from the disc player and is fed to U14-6. U16-5, the output disc data signal, goes high, disabling U21, when the Z80 wishes to read data words from the disc player via U20. Jumper W1 should be removed when using the LDV-1000 player.

O. COIN COUNTER

The mechanical coin counter is controlled by U16-2. When U16-2 is high or disabled, no base current is drawn thru Q2. (Q2 is the coin counter driver transistor). This keeps the coin counter de-energized. When the Z80 wishes to register a coin count, it will drop U16-2 low, thereby drawing base current through Q2, turning Q2 on, and bringing the collector of Q2 to approximately 4.7 volts. After a delay of at least 50 milliseconds, the Z80 will force U16-2 high.

To prevent false coin counts on power-up, U16-1 is connected to RESET+. This connection disables U16 until the program can start running, forcing U16-2 high and de-energizing the coin counter.

P. LED DISPLAY BOARD

The LED Display Board is composed of two identical circuits. Each circuit has eight common anode displays and one multiplexer chip. The following is a description of one of these identical circuits.

The multiplexer chip has a memory of eight words, with four bits to each word. The Z80 writes into any location of this memory by setting appropriate highs and lows on address lines A0 through A2. The Z80 selects the character to be written into the memory by placing data on D0 through D3, thereby supplying a WRITE pulse to pin 8 of the multiplexer chip. Address lines A0 through A2 and data lines D0 through D3 are connected to the Z80's address and data bus by a 16-ribbon cable attached to the two boards. Display enable signals DEN 1 and DEN 2 are generated by address decoder U10, pins 7 and 9 on the Z80 Board.

CHAPTER 3

ON-BOARD DIAGNOSTICS

The on-board diagnostics are a series of tests performed on the system's hardware to verify whether or not the hardware is fully functional. Resident in the Z80A game program EPROM, the diagnostic software routines are initiated by having A7 on Dip Switch 2 in the OFF position when the game is powered up.

Once initiated, the diagnostic program cycles through the following tests. The results of these tests flash consecutively on the monitor display. If further troubleshooting proves to be necessary, see the Service Diagnostic and Signature Analysis Tests in Chapter 4.

A. RAM TEST

Each RAM cell is loaded with 55H and read to insure that all of the cells retained the data. The RAM is then reloaded with 0AAH, which causes every bit in every cell to be inverted. The RAM is then read again to verify data retention. If all cells are operating properly, the diagnostics proceed to the EPROM Test. If a bad cell is found, the system displays "RAM test failed" on the monitor and halts until it receives a reset.

B. EPROM TEST

There are five 8K-byte EPROMs within the system. The Diagnostic program calculates each EPROM's checksum and compares it to pre-stored correct checksum values. If all of the checksums match, the program continues with the security device test. If an EPROM fails, the monitor displays the words "ROM Test Failed" and the address location of the bad EPROM. The correct address locations are listed in the following table:

Checksum no.	Address Location	EPROM Address
1	0FFF6H	0000H-1FFFH
2	0FFF8H	2000H-3FFFH
3	0FFFAH	4000H-5FFFH
4	0FFFCH	6000H-7FFFH
5	0FFFEH	8000H-9FFFH

C. SECURITY DEVICE TEST

Disregard this test.

D. SOUND TEST

The program outputs a tone scale to each of the three channels of the GI Sound Chip. Check the volume control while these sounds are playing. If no sound is heard, check the AY-3-8910 Sound Chip.

E. DISPLAY TEST

The seven segment Player 1 and Player 2 displays now cycle through all of their available digits: each display should progress through the numbers 0 through 9. No rating of PASS or FAIL appears on the monitor. Simply watch the displays themselves to ensure that they are operating properly.

F. KEYBOARD TEST

This test checks the operation of the player controls. During the fifteen second period of the test, push all of the player control buttons and operate the joystick. One seven segment display corresponds to each of the controls and to each direction of the joystick. Each time a control is operated, a zero should appear in its corresponding display. The monitor displays the diagram shown below, a table indicating which display corresponds to each control.

PLAYER 1 SCORE

	ACTION	RIGHT	LEFT	DOWN	UP	
--	--------	-------	------	------	----	--

PLAYER 2 SCORE

P1	P2	COIN1	COIN2			
----	----	-------	-------	--	--	--

G. COLOR TEST

The program now displays the image of a dead Dirk. Adjust the video monitor till the colors in this image are satisfactory. This image stays on the monitor until the A7 on Dipswitch 2 is turned to the ON position.

CHAPTER 4

SERVICE DIAGNOSTICS AND SIGNATURE ANALYSIS
FOR THE Z80 CONTROLLER BOARD

The following troubleshooting procedures assume a relatively advanced level of technical expertise.

The first eight tests utilize Diagnostic PROMs and/or a test harness not included in the game package. The Diagnostic PROMs may be purchased from Cinematronics' Customer Service Department. The test harness may be constructed quickly and easily using the guideline below. The last three tests require an Hewlett-Packard 5004A Signature Analyzer.

Diagnostic PROMs: LAIR 3
LAMPCYC2
MEMB3
INT TEST 5
DISC INT 5
GITF
GI SCOPE

TEST HARNESS

Use any available wire to assemble a harness with the cable connections listed on the following page. Plug P1 into the Z80 Controller Board, and P2 into the Power Supply.

P1 = Molex 03-09-1364

P2 = Molex 03-09-1122

P1	to ---->	P2	to ---->	J1 CPU Disc Interface
1				4
2				11
3		9		
4		10		
5				3
6				17
7				
8				
9				2
10				
11				
12				
13				1
14				
15				
16				
17				16
18				
19				
20				
21				15
22				
23		4		
24				
25				14
26				
27				
28				
29				13
30		7		
31		11		
32				
33				7
34				
35				
36				

The following pages describe the Diagnostic and Signature Analysis tests. The write-up for each individual test includes:

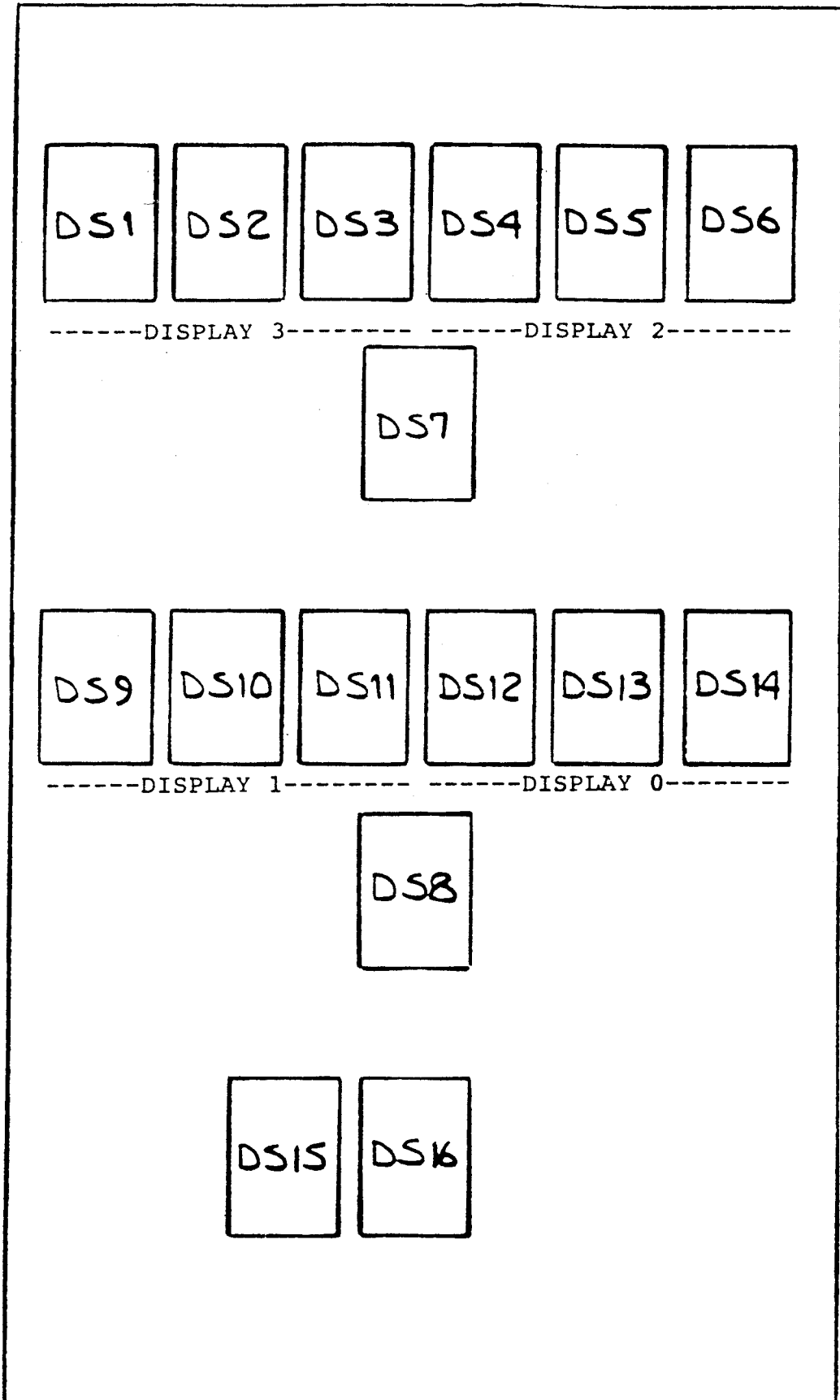
- a.) Reason(s) for running the test.
- b.) Instructions for setting up and conducting the test.
- c.) Description/explanation of the test itself.

The first test, the "LAIR" GO/NO GO Test, surveys the entire Z80 Controller Board, indentifying general problem areas. The seven "Stand-Alone" Diagnostic tests that follow isolate and troubleshoot the individual problem areas.

All of the Diagnostic tests utilize the game's Credit Display Board in different ways. See Figure 4-1 for a reference illustration of the Credit Display Board.

The two Signature Analysis Procedures that conclude this chapter of the manual serve to locate and correct especially hard-to-find problems in the board, tracing the problems to specific lines, PROMs or circuits.

FIGURE 4-1:



"LAIR"

GO/NO GO TEST

To prepare for testing, connect the Disc Control Output Cable (24 DIP ribbon) from J1 of the Z80 Controller Board to J1 of the test harness. Remove U1 from the PROM board, and insert the LAIR 3 PROM in the U1 socket. Leave Game PROMs U2-U5 in the board. Power up the boards.

The program in the LAIR 3 PROM automatically cycles through the following series of Go/No Go tests, thus isolating specific problem areas of the Z80 Controller Board for further testing.

DISPLAY DATA TEST:

Each display progresses through the same sequence of characters at the same time: the numbers 0 through 9, a dash, the letters E, H, L, P, and a blank. All displays should register identical characters at any given time. Note that a blank is considered to be a character.

If this test fails, the problem may be traced to either the Z80 Microprocessor, the ROM Board, or the displays themselves. Use the Z80 Controller Board Signature Analysis Procedures to find and correct the problem.

DISPLAY ADDRESS TEST:

The numbers 0 through 9, a dash, the letters E, H, L, P, and a blank should appear, in this consecutive order, in displays DS1 through DS16. 0 appears in DS1, 1 in DS2, etc..

Maintaining this order, the entire sequence of characters should then rotate, with a pause between each rotation, until each character has appeared in every display.

If this test fails, the problem may be traced to either the Z80 Microprocessor, the PROM Board, or the displays themselves. Use the Z80 Controller Board Signature Analysis Procedures to find and correct the problem.

After the DISPLAY ADDRESS TEST, the test program automatically runs through the tests coded 00-50. The general areas examined by each of these tests are named in TABLE 1.

While a specific test is running, the two digit code for that test appears in three locations: on DS1 and DS2, on DS9 and DS10, and on DS15 and DS16.

When a specific test passes, a "P" appears on both DS7 and DS8. The remaining eight displays (DS3-DS6 and DS11-DS14) show dashes.

When a test fails, a two digit error code replaces the test code number on DS1 and DS2, on DS9 and DS10, and on DS15 and DS16. The message "HELP" is displayed on DS3-DS6 and on DS11-DS14. And, DS7 and DS8 show dashes.

The type of errors represented by the error codes are outlined in TABLE 2. The solutions to these errors are listed in TABLE 3. Note that TABLE 2 breaks down some of the general problem areas listed in TABLE 1. This breakdown occurs automatically within the program to help isolate any problems in the board. If further breakdown, and/or exploration, of a specific area is necessary, TABLE 3 suggests the running of the "Stand-Alone", or individual, tests of those areas. The Stand-Alone tests require programs other than that stored in the LAIR 3 PROM.

TESTS 00 through 50:

TABLE 1: TEST NAMES

TEST CODE	TEST
00	Processor Tests
10	ROM Check Sum Test
20	RAM Tests, Data and Address
30	Interrupt Test
40	Disc Interface Test
50	GI Sound Chip Test

TABLE 2: TEST ERROR CODES

TEST NAME	ERROR CODE	TYPE OF FAILURE
Processor Test 1	02	Processor or ROM
Processor Test 2	04	Processor, ROM, or RAM
ROM Check Sum Test of U1	10	Processor or ROM
ROM Check Sum Test of U2	11	U2 on ROM Board
ROM Check Sum Test of U3	12	U3 on ROM Board
ROM Check Sum Test of U4	13	U4 on ROM Board
ROM Check Sum Test of U5.	14	U5 on ROM Board
RAM Test	20	Data Lines
RAM Test	22	Address Lines
Interrupt Test	30	Interrupt too late or nonexistant
Interrupt Test	32	Interrupt too soon
Disc Interface Test	40	Output Enable Error
Disc Interface Test	42	Disc Local Error
Disc Interface Test	44	Disc External Control Error
Disc Interface Test	46	Disc External Data Error
GI Sound Test	50	GI Sound Chip Data Error

TABLE 3: SOLUTIONS

ERROR CODE	SOLUTION
02	Replace the Z80. If problem still exists, conduct Z80 Controller Board Signature Analysis Procedures.
04	Replace the Z80. If problem still exists, first conduct Z80 Controller Board Signature Analysis Procedures, then run RAM Test.
10	Same as for 02.
11	Check U2 on ROM Board and U4 on Z80 Controller Board.
12	Check U3 on ROM Board and U4 on Z80 Controller Board.
13	Check U4 on ROM Board and U4 on Z80 Controller Board.
14	Check U5 on ROM Board and U5 on Z80 Controller Board.
20 and 22	Replace RAM. If problem still exists, run Stand-Alone RAM test.
30 and 32	Run Stand-Alone Interrupt Test.
40, 42, 44, 46	Run Stand-Alone Disc Interface Test.
50	Run Stand-Alone GI Sound Test, and, if necessary, the GI SCOPE Program.

If the program fails to run any tests at all, either the processor is incapable of running the diagnostics, or the display board itself is bad. Perform board substitution to isolate the problem.

TEST 60: DIPSWITCH TEST

Immediately following Test 50, the program runs Test 60. First set to OFF all of the bits on Dipswitches 1 and 2, causing a dash to appear on both Dipswitch displays. The dashes indicate that no

bits are grounded.

NOTE: Grounded = Closed = low

Dipswitch 1 = B = DS4
Dipswitch 2 = A = DS5

Now ground one bit at a time, starting with those on Dipswitch 1. The bit number for each successively grounded bit should appear in its respective Dipswitch display:

For Dipswitch 1:

BIT	BIT NUMBER on DS4
0	B0
1	B1
2	B2
3	B3
4	B4
5	B5
6	B6
7	B7

For Dipswitch 2:

BIT	BIT NUMBER on DS5
0	A0
1	A1
2	A2
3	A3
4	A4
5	A5
6	A6
7	A7

If an "E" appears on a display, more than one bit is grounded on the Dipswitch under test. There may be a short on that Dipswitch. If an "L" appears, all bits are grounded.

After testing ALL of the bits on both Dipswitches, use the above process to make sure that all of the test points on the test fixture are operating correctly. First turn all of these switches to OFF. Then ground each of them, one at a time to produce the following displays on DS6:

BIT	DISPLAY on DS6
0	-----
1	-----
2	Coin 1
3	Coin 2
4	Aux 4
5	Aux 5
6	Fan
7	-----

A display of "E" indicates that two bits are grounded at the same time. Test 60 is the last test of the LAIR 3 PROM. Press the RESET button if it is necessary to repeat the test cycle.

LAMP TEST

If the Lamp Test portion of the LAIR Test fails, or if the displays fail to operate correctly in any other tests, conduct this Lamp Test.

Begin by connecting a 16-pin ribbon cable from J3 of the Z80 Controller Board to J1 of the game's display board. Insert the LAMPCYC2 PROM into U1 of the PROM board, and power up the boards. It does not matter how/if J1 is hooked up.

This test is composed of two parts. The first is a Display Data Test, the second a Display Address Test.

Note that the LAMPCYC2 program does not automatically halt on errors. Error detection is the job of the technician. Any variance from the expected output should be corrected.

DISPLAY DATA TEST

This test begins as soon as one of the control panel inputs is grounded. Each display progresses through the same sequence of characters at the same time: the numbers 0 through 9, a dash, the letters E, H, L, P, and a blank. All displays should register identical characters at any given time. Note that a blank is considered to be a character.

DISPLAY ADDRESS TEST

The numbers 0 through 9, a dash, the letters E, H, L, p, and a blank should appear, in this consecutive order, in displays DS1 through DS16. 0 appears in DS1, 1 in DS2, etc..

Maintaining this order, the entire sequence of characters should then rotate, with a pause between each rotation, until each character has appeared in every display.

If the tests fail to function at all, one of the following is true:

1. The Z80 is incapable of running any of the diagnostics.
2. The display board is malfunctioning.
3. The PROM board is defective.

Perform board substitution to isolate the problem.

If, however, the tests indicate a problem on the Z80 Controller Board, check the: data lines, address lines, control lines, address decoding, power, reset, and clock. After locating and solving all problems, repeat the LAIR Test.

RAM TEST

When the LAIR Test indicates a RAM failure, conduct the following RAM test. Begin by connecting a 16-pin ribbon cable from J3 of the Z80 Controller board to an operating game display panel. Insert the MEMB3 PROM into U1 of the PROM card, and attach the card to the Z80 Controller board. The test harness is not used in this test. Power up the board.

In this test, DS9-DS11 in Display 1 monitor the output data sent by the Z80 to the RAM. Assuming that the Z80 is functioning properly, this data should be "good" data. DS12-DS14 in Display 0 monitor the data being returned from the RAM to the Z80--the data transfer under test, the potentially "bad" or malfunctioning data. DS7 and DS8 are not used in this test.

The RAM Test passes if, after power up, all twelve working displays change rapidly and continuously. The data displayed in Display 1 and Display 0 should be the same at all times. The RAM Test fails when all of the displays stop changing.

The MEMB3 PROM runs through the RAM test continuously, stopping only to indicate a failure. The "pass count"--the number of times the test is completed successfully--is registered in Displays 3 and 2, DS1 through DS6.

Each RAM Test may be broken down into two parts: a test of the data lines from the RAM to the Z80, and a test of the address lines from the RAM to the Z80. The data lines are always tested first, the address lines second. Consequently, a successfully completed RAM test always registers an even number on the pass count. For example, as the MEMB3 program runs, the pass count counts "1" for the first data line test passed, "2" for the first address line test passed and for the first entire RAM test passed. "3" indicates a second successful data line test, and "4" a second successful address line test/second successful RAM test.

The source of a failure can thus be narrowed down by the pass count. If the pass count fails to begin, remaining at 00, the board has failed the data line half of the RAM test. If the pass count halts at 01, there is a faulty address line. Always allow the pass count to reach at least 3 to ensure that no problems are missed.

After correcting any problems, repeat the RAM Test by pressing the RESET button on the Z80 Controller board or by turning the power off, then on again. After repeating the RAM Test, repeat the LAIR Test to make sure all problems have been eliminated.

INTERRUPT TEST

When the Interrupt portion of the LAIR Test fails, conduct the following Interrupt Test. Begin by connecting the Z80 Controller board to the test harness. Plug the INT TEST 5 PROM into the U1 socket of a working PROM board. Connect the PROM board and a working display panel to the Z80 Controller Board. And connect J1 of the Z80 Controller Board to J1 of the test harness.

NOTE: In order to function properly, this test must have good RAM.

This test monitors the length of time between the interrupts generated by the 68705 at U7. The time between interrupts should be 33 milliseconds. The test may be conducted in either of the following modes:

1. HALT ON ERROR: Here, the test halts when it detects an error. DS8 displays a "5" if the time between interrupts is too short, a "1" if the time between interrupts is too long. To conduct the test in this mode, simply follow the directions above. An "H" in DS7 indicates that the HALT ON ERROR mode is in use.
2. LOOP ON ERROR: Here, the test program runs continuously, counting and classifying any errors as it progresses. DS8 displays a "5" if the time between interrupts is too short, a "1" if the time is too long. Displays DS9 through DS11 record the number of times the intervals between interrupts are too short. Displays DS12 through DS14 record the number of times the intervals are too long.

To conduct the test in this mode, ground any one of the control panel inputs at the test fixture, and press the RESET button on the Z80 Controller Board. An "L" in DS7 indicates that the LOOP ON ERROR mode is in use.

For both modes, the number of times the test passes-- the "pass count"--is recorded in DS1 through DS6. Note that a verdict of too-long intervals may indicate that no interrupts are being generated at all.

DISC INTERFACE TEST

Begin by connecting J1 of the Z80 Controller Board to J1 of the test harness. Connect the 16-pin ribbon cable from J3 of the Z80 Controller board to J1 of the display panel. Insert the DISC INT 5 PROM into the U1 socket of the PROM board.

ON-BOARD LOGIC

Part I: Output Enable

The test program writes a series of zeros to output latch U21. This write and a high on U21-1 should disable the output enable of U21, causing a series of ones to be read back by video disc input latch U20.

If the test fails, an "e" for "error" appears in DS7, and a zero appears in DS8, indicating that an on-board problem is hindering or preventing the disablement of interface between the Z80 Controller Board and the video disc.

Part II: Logic

Here, the test program writes data to video disc output latch U21. This data is read back into video disc input latch U20. The input data should match the output data. If the test passes, a "P" appears in DS8, and a dash appears in DS7.

If the test fails, an "L" appears in DS8 to indicate a local error, and an "E" appears in DS7.

EXTERNAL CABLE CONNECTIONS

Now the test program writes to video disc output latch U21, to the INT/EXT control line, to the coin counter output of miscellaneous output register U16, and, in games with serial numbers 1-4999, to the ENTER output. From these locations, the data is then routed through the test fixture to Control Panel A's and Control Panel B's input registers U8 and U14. If the inputs at U8 and U14 match the original outputs, a "P" appears in DS8.

If the inputs fail to match the outputs, an "E" appears in DS7 and in DS8. Ones signify high signals, zeros low, for the "good" output signals in DS1 through DS3. The same is true for the bad input signals in DS9 through DS11.

The problem causing the discrepancy between the output and input signals may be traced down to a single signal line. Output and input signals from D0 through D7 are recorded in octal in displays DS4-DS6 and DS12-DS14. Base eight makes it possible for

more than one signal line to be monitored in a single display. This is best understood through an example:

Note that DS4 monitors the signal outputs at D7 and D6. The output signals are both registered or recorded in one octal display number. Now suppose, for example, a 3 appears in DS4. 3 in base eight broken down into binary notation = 2 to the zero power + 2 to the first power = 1 + 2. 2 to the zero power, or 1, is the output signal at D7. And 2 to the first power, or 2, is the output signal at D6. For an illustration of this example, see the display chart for this test.

The same method is used to record the input signals to D7 and D6 in DS12. The outputs in DS4 should match the inputs in DS12. A problem may, by this method, be traced to the output or input of a single line. The rest of the signal lines/displays work the same way.

Once the malfunctioning line is identified, turn to the tables below. Here, the external connections for various output and input signals are listed. Use an oscilloscope probe at these connections to further narrow down the problem. The results for each signal should be the same at both connections.

NOTE: Output bit 6, ENTER, is not used in games with serial numbers 5000 and above.

OUTPUTS FROM MISCELLANEOUS
CONTROL REGISTER

INPUTS TO CONTROL PANEL B
REGISTER

OUTPUT SIGNAL NAME	Z80 BIT POSITION	CONNECTOR		CONNECTOR	INPUT SIGNAL NAME	Z80 BIT POSITION
INT/EXT	7	J1-17	-->	J4-6	P2	1
ENTER	6	J1-2		J4-2	P1	0
	5	--OUTPUT ENABLE FOR VIDEO DISC LATCH--				
COIN COUNTER	4	J4-33		J1-6,7	READY	7
	3-0	NOT USED	-->			

OUTPUTS FROM DISC CONTROL
REGISTER U21

INPUTS TO CONTROL PANEL A
REGISTER

OUTPUT			INPUT		
SIGNAL NAME	Z80 BIT POSITION	CONNECTOR	CONNECTOR	SIGNAL NAME	Z80 BIT POSITION
D7	7	J1-16	J4-17	AUX 3	7
D6	6	J1-15	J4-21	AUX 2	6
D5	5	J1-14	J4-25	AUX 1	5
D4	4	J1-13	J4-29	ACTION	4
D3	3	J1-9	J4-1	RIGHT	3
D2	2	J1-10	J4-5	LEFT	2
D1	1	J1-11	J4-9	DOWN	1
D0	0	J1-12	J4-13	UP	0

When all the tests pass, a "P" appears in DS8, the pass count begins to increment in DS15 and DS16, and the program starts over. To reset the pass count, press the RESET button or turn the power off, then on again.

GI SOUND TEST

When the GI Sound portion of the LAIR Test fails, conduct the following test. Begin by connecting a 16-pin ribbon cable from J3 of the Z80 controller board to an operating display panel. Insert the GITF (GI Test Rev F) PROM into the U1 socket of an operating PROM board. It does not matter how/if the test harness is hooked up. Make sure, however, that the RAM on the Z80 board are functioning properly. Hook up the test harness to the speakers.

Power up the board. Display 1, DS9 through DS11, monitor the "good" data, the data sent from GI Sound Chip U19 to the Z80. Display 0, DS12 through DS14, monitor the data transfer under test, the data transfer from the Z80 back to U19. Displays 3 and 2 show the pass count.

At power up, all of the data displays, DS9 through DS14, should be changing rapidly. All data displays, however, should show the same characters at any given time. If the displays halt, the test fails, indicating a problem with the Z80's reads from and writes to the GI Sound Chip.

As the displays change, three musical tones should be heard. Each of these tones come from a different GI Sound output. If any of the tones are missing, either the GI Sound Chip's sound outputs or the audio amplifier circuits are malfunctioning.

To repeat this test, press the RESET button on the Z80 Controller board or turn the power off, then on again. After correcting any problems, rerun the LAIR Test.

GI SCOPE TEST PROGRAM

Problems with the GI sound may be traced to the signal level with the aid of this test program and an oscilloscope. Carefully follow the guidelines for troubleshooting outlined below.

This troubleshooting procedure is dependent upon several assumptions:

- 1.) The LAIR Test runs all tests up to, but not including, Test 50: GI Sound Test.
- 2.) The GI Sound Test has failed, leaving the specific problem undiscovered and unsolved.
- 3.) The original GI Sound Chip has been replaced by a GI Sound Chip that is known to be in correct working order. The replacement failed to rectify the problem.

If all of these assumptions are true for the board presently under test, install the GI SCOPE PROM in the U1 socket of a known-working PROM board. Connect J4 to the main wiring harness. Then attach a 16-pin ribbon cable from J3 of the Z80 Controller Board under test to J1 of a properly functioning Display Board. And, use a 40-pin ribbon cable to connect J2 of the PROM board to J2 of the Z80 Controller Board. J1 of the Z80 Controller Board does not need to be connected.

Now power up the boards, and conduct the following preliminary tests:

- 1.) Check for grounds at U19, pins 1 and 24.
- 2.) Check for +5V at U19, pins 40, 28, and 25.
- 3.) Check for clock signal at U19-22. The signal should be a square wave and have a period of 500ns.
- 4.) Check for a reset pulse at U19-23. This line is normally high, but should drop low when the reset button is depressed.

Do not continue until the above four conditions are met. When all is satisfactory, make sure that the Display Board reads as follows:

Display 0: 125
Display 2: 252

If the displays are incorrect, or if there are no displays at all,

find the problem and correct it before continuing. Either the PROM is defective, the display itself is defective, or the Z80 Controller Board is malfunctioning.

INTRODUCTION TO THE TEST PROGRAM:

The program first sends a low-going sync pulse to U16-2. This pulse serves as an external trigger to the oscilloscope. The program then writes an address of 04 octal to the GI Sound Chip.

Next, the program sends a data byte of 125 octal to the GI Sound Chip. This test data is displayed in Display 0. The program also reads data from the GI Sound Chip. This data is displayed in Display 1. If all is functioning correctly, Display 1 should read 125.

Now the program writes first an address of 13 octal, then a data word of 252 octal, to the GI Sound Chip. The latter is displayed in Display 2.

Lastly, the program reads data from the GI Sound Chip and displays it in Display 3. If all is functioning correctly, Display 3 should read 252.

TROUBLESHOOTING PROCEDURE

STEP I:

Use an oscilloscope to compare the pulses occurring at U10, pins 13 and 15, and U11-15 to the corresponding pulses pictured in the GI Control Signal Timing Chart. If any pulses are missing, there is a problem in the address decoding section of the Z80 Board. In this case, check the inputs to U10 and U11 and both the inputs and outputs of U4.

If all of the pulses occurring at U10, pins 13 and 15, and U11-15 are shorter than those pictured in the timing chart, the Wait Circuit is defective. In this case, connect the external trigger of the oscilloscope to U16-2. Sync the scope to the rising edge of the pulse. Then place Channel 1 of the scope on U10-13. Use Channel 2 to compare the wave forms produced with those in the timing chart. Correct any problems before continuing.

STEP II:

If STEP I fails to locate the problem, proceed as follows. Connect the external trigger of the scope to U16-2, and sync the scope on the rising edge of the pulse. Connect Channel 1 to U10-13. Use Channel 2 to compare the following signals to the corresponding signals illustrated in the signal timing chart: