Williams Color Chip
20th Century 16192

PREPARED BY	CODE IDENT. NO.: 34576	NUMBER: [illegible]-14500-01
J. W. Booth/G. H. Smith	ROCKWELL INTERNATIONAL CORPORATION MICROELECTRONICS DIVISIONS	TYPE: [illegible]ECT
APPROVALS	SPECIFICATION	DATE: January 28, 1976
		SUPERSEDES SPEC. DATED:
		REVISION LTR.: PAGE 1 of 35

TITLE

PRODUCT DESCRIPTION FOR WILLIAMS GAME CONTROLLER SYSTEM

CONTENTS

1.0 SCOPE

2.0 APPLICABLE DOCUMENTS

3.0 GENERAL REQUIREMENTS

4.0 MECHANICAL REQUIREMENTS

5.0 ELECTRICAL REQUIREMENTS

6.0 FUNCTIONAL DESCRIPTION

7.0 FIGURES

1.0 SCOPE

The purpose of this specification is to define the mechanical, electrical, and functional description of the Williams Game Controller System as supplied by Rockwell. This controller system is designed around the MOS/LSI devices and is a special microprocessor system which will perform control sequences for a commercial pinball machine game.

The controller system shall consist of the following items:

1. Control Board
2. Score-Driver Board
3. Price Board

2.0 APPLICABLE DOCUMENTS

1. Williams 1974-5 Parts Catalog
2. Williams Document "New Credit System"
3. Williams handwritten description of the "Aztec" game front page title 466 sample instruction sheet (11 pages), revised December 8, 1975.
4. Rockwell PIS 4/2 specification 11660 N40
5. Rockwell GPMD specification 10788 N40
6. Rockwell GPI/O specification 10696 N22

3.0 GENERAL REQUIREMENTS

3.1 Assembly and inspection of the controller system shall be to best commercial practice and Rockwell may substitute equivalent parts or procedure as it deems necessary to design and develop the controller system.

3.2 Handling of the controller system during shipping and installation shall be the responsibility of both Rockwell and Williams as applicable. Rockwell shall provide sufficient information to Williams to handle MOS/LSI devices and other components of the

controller system which require special handling.

3.3 Ventilation to the controller system (to be determined) is to be convection cooling and Williams shall provide a vent or opening as necessary to circulate outside air.

3.4 Shielding of the controller system (Detail design or necessity to be determined later) shall be the responsibility of Williams to provide a faraday shield or other shielding technique to minimize the effects of electromagnetic and electrostatic pickup. Rockwell shall provide whatever component data or other advice to help design shielding. (3 Wire Line Cord)
3.5 (Power Supply Schematic)

4.0 MECHANICAL REQUIREMENTS

4.1 The controller system shall consist of 3 printed circuit modules which have been designated control board, score-driver board, price board.

Both modules will be mounted vertically behind the display panel of the pinball machine. The approximate size and outline is shown in Figure 1.

4.2 Electrical interconnections between the 2 modules to be printed circuit edge connector type or other equivalent means of quick disconnect.

4.3 Electrical connections to lamps, solenoids, and displays shall be feedthrough hole mount suitable for wafer type connector or individual solder terminations as determined by Williams.

4.4 The ROM or PROM Game Program device shall be a DIL type socket on the Price Board.

Also, Rockwell shall provide the edge type of connector (or equivalent) mounting for the Price Board and this to be on Control Board. The matrix selection to be flexible through jumper patching to determine game paramenters. ROM supplied by Rockwell

4.5 Mounting for the Control Board and Score-Driver Board shall be determined when final printed circuit board dimensions have been established and location shall be determined by mutual agreement between Rockwell and Williams.

4.6 Approx. dim.= 8x10, Score-Driver 8x8, Price 4x4

5.0 ELECTRICAL REQUIREMENTS

5.1 The controller system shall be implemented from the standard Rockwell PPS-4 MOS/LSI microprocessor device family which will be specifically coded to meet the Williams requirement. A custom interface will be added to provide a compatible interface with the existing Williams peripheral hardware. The block diagrams shown in Figures 2 and 3 the input-output signals relating to each module.

5.2 The Control Board will contain all the Rockwell PPS-4 devices and most of the low power circuits. Also, the Game Program and Price Board functions will mate to this module. Decoding, timing, and logic control or driving signals will be output from this module to the Score-Driver Board.

5.2.1 Sixteen pins are provided on the module interface to input contact closure information from the pinball machine. Functionally, these lines are structured to scan up to 64 sets of switch contacts in an 8 x 8 matrix configuration. These contact closure interface lines designated as "a", "h", "1", "8" electrically connected to the Rockwell GPKD device, part number 10788. The detailed electrical and timing specifications are given in the document 10788 NHO. Assignments of the contact closures to be monitored are yet to be determined.

5.2.2 The ball outhole switch status will be monitored and input to the **Control Board** No other contact closure status is known to be required at this time.

5.3 Score-Driver Board Outputs

5.3.1 The **Score-Driver Board** shall have the output capability to drive the following components located on the pinball machine.

- Panaplex numeric displays
- Incandescent Status or Indicator lamps
- Solenoid for switching, steppers and sound controls

5.3.1.1 Numeric Displays

Two options are provided for driving the numeric display information: The basic 1 or 2 player system will have an output drive capability for up to 16 display digits. An expanded 3 or 4 player system will have additional output circuitry for driving up to 30 display digits. Functionally, the numeric displays are grouped as follows:

4 PLAYER GAME

4 Scores of 6 Digits
No. of Players 1 Digit
Ball In Play 1 Digit
Number Match 2 Digits
Replays electro-mechanical

2 PLAYER GAME

2 Scores of 6 Digits
No. of Players 1 Digit
Ball In Play 1 Digit
Number Match 2 Digits
Replays electro-mechanical

SINGLE PLAYER GAME

Score of 6 Digits
Ball In Play 1 Digit
Number Match 2 Digits
Replays electro-mechanical

Paragraph 5.3.1.1. Numberic Displays (Neon Drivers)

1. When multiplexing a 16-digit display, the scan rate should be specified. If the rate is too slow, flicker results, if too fast, the brightness of the display is reduced.

2. A blanking pulse should be specified to prevent the smearing of digits.

3. Maximum and minimum drive currents should be specified to insure that the life of the display is not affected.

4. Maximum and minimum drive voltages should be specified to insure that the display turns on and also that the interface can withstand these voltages.

SAME PLAYER SHOOTS

P1 LC	P1L	P1T	P1K	P1C	P1D	0

P2 LC	P2L	P2T	P2K	P2C	P2D	0

RP

CREDIT UNIT

P3 LC	P3L	P3T	P3K	P3C	P3D	0

P4 LC	P4L	P4T	P4K	P4C	P4D	0

GAME OVER

NUMBER MATCH

B	OFF	N	0	OFF	0

TILT

BALL IN PLAY

#CAN PLAY

INSERT DISPLAY

Function	No. of Digits	Size of Digits
Score Player 1	6	0.7"
Score Player 2	6	"
Score Player 3	6	"
Score Player 4	6	
Number Match	2	0.7"
Replay Credit	2	Optional
Number of Players	1	0.7"
Ball in Play	1	0.7"

NOTE: The score and the number match, the least significant digit is always zero.

5.3.1.2 Incandescent Status Lamps

A total of 64 functional lamp drivers are available at the interface of the Score-Driver Board, (the system can be expanded to 64 lamp devices without redesign). Each lamp driver output circuit shall be an NPN type of transister switch under control of the microprocessor program. Two types of output drive circuits will be provided: A type 1 driver capable of driving a single #55 lamp, and a type 2 driver capable of driving up to three #55 lamps in parallel. Functionally, the incandescent lamp display drivers are grouped as follows:

	Function	Driver Type
Scoreboard Lamp	Tilt	2
	Game Over	2
	Same Player Shoots	2
	Credit Ok	1
	Player Up (4 ea.)	1
Playfield Lamps	Series String (10 ea)	2
	Feature	1
	Bonus Doubler	1

5.3.1.2 (cont'd)

	Function (cont)	Driver Type
*	Jet Bumper 1	2
*	Jet Bumper 2	2
*	Jet Bumper 3	2
*	Left Bonus 1	1
	.	.
	.	.
	.	.
*	Left Bonus 10	1
*	Triple Bonus when lit	1
*	Left Indicator	1
*	Right Indicator	1
	Right Bonus 1	1
	.	.
	.	.
	.	.
	Right Bonus 10	1
	Double Bonus When Lit	1

* Note: Optional 1 thru 16. The lamp driver circuits may be assigned as required by the game designer depending upon the specific requirements of each new game.

Paragraph 5.3.1.2 Incandescent Status Lamps (Lamp Drivers)

1. Since #55 lamps can short out, it should be specified how drivers are to react to a short circuit. Will they be damaged or will there be built in protection?

2. How many status lamp circuits must be on at the same time?

3. A definite voltage and current that the drive must supply across a fixed load should be specified.

4. A definite number of how many Type 1 and Type 2 circuits should be supplied with complete interface specifications.

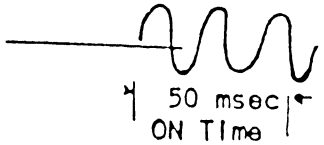
Paragraph 5.3.1.3 Solenoid Type Controls (Coil Drivers)

1. A definite voltage and current that the driver must supply across a fixed load should be specified.

2.. A duty cycle of the circuit should be specified

5.3.1.3. SOLENOID TYPE CONTROLS

A total of 20 Solenoid drive circuits are available at the interface of the Interface Driver Module. Each drive circuit shall be a TRIAC type of solid state switch with the capability of driving a single 28V AC solenoid. The solenoid Drive output will be pulsed type signal. Specifically, a TRIAC will be turned on at or near the zero crossing for 50M sec.



TYPICAL TRIAC TIMING

COIL DRIVERS CONTROLLED BY PROGRAM

1. COIN LOCKOUT
2. TOTAL PLAYMETER
3. BALL RETURN
4. SMALL CHIME
5. MEDIUM CHIME
6. LONG CHIME
7. SOUND DRUM
8. REPLAY UP - AND KNOCKER
9. REPLAY DOWN
10. BELL
11. BALL ACTUATOR #1
12. BALL ACTUATOR #2
13. BALL ACTUATOR #3
14. BALL ACTUATOR #4
15. BALL ACTUATOR #5
16. BALL ACTUATOR #6
17. BALL ACTUATOR #7
18. FREE BALL GATE
19. MONEY METER
20. RESET DROP TARGET #1
21. RESET DROP TARGET #2
22. RESET DROP TARGET #3
23. RESET DROP TARGET #4
24. AUXILIARY TEN STEP UNIT #1
25. AUXILIARY TEN STEP UNIT #2
26. AUXILIARY TEN STEP UNIT #3
27. AUXILIARY TEN STEP UNIT #4

NO MORE THAN 20 COIL DRIVERS WILL BE USED IN ANY ONE GAME.

COILS #1 TO #10 ARE USED ON EACH GAME.

TEN OF THE COILS LABLED #11 TO #27 MAY BE USED IN ANY COMBINATION AS REQUIRED BY GAME DESIGN.

OTHER COILS NOT CONTROLLED BY THE GAME CONTROL WILL BE TRIAC DRIVEN AND SYNCHRONIZED BY A ZERO CROSSING SIGNAL TO MINIMIZE RFI AND TRANSIENT GENERATION AND TO USE LOW CURRENT SWITCH CONTACTS.

THE GAME CONTROLLER SYSTEM MUST PROVIDE AN OUTPUT TO DISABLE FLIPPERS, JET BUMPERS, AND KICKERS WHEN THE GAME IS IN TILT OR GAME OVER CONDITIONS.

SUGGEST DISABLE ZERO CROSSING SIGNAL.

5.3.1.3 (continued)

The above TRIAC timing will be used for momentary solenoids. On and off times for line frequency is as follows:

Frequency	On
@ 50 Hz.	2.5 cycles
@ 60 Hz.	3 cycles

Functionally, the solenoid drive circuits are grouped as follows:

	Function	Solenoid Type
Sounder Coils	*Bell	TBD
	*Chimes-lo-med-hi	
	Sound Drum	
	Credit Knocker	
Credit Control	Coin Lockout	
	Total Play Meter	
	*Money Meter	
Ball Control	*Free Ball Gate	
	*Reset Drop Targets	
	*Ball Actuator	
	*Ball Ejector 1-2 & 3,4, 5 & 6	TBD
	CREDIT UNIT UP	
	CREDIT UNIT DOWN	

*NOTE: These coil driver circuits may be assigned as required by the game designer dependent upon the specific requirement of each new game.

5.3.1.4 ADJUSTMENT TO SHORTEN ON AND OFF TIMES TO

@ 50 HZ - 1.5 Cycles

@ 60 HZ 2 Cycles

5.3.1.5 - The Score Driver Board shall provide a broad band radio frequency detector to disable the credit system when subjected to a five watt RF signal one half foot from the pinball game.

The Score-Driver Board shall provide an electro-static discharge detector to disable the credit system when a spark discharge is applied to exposed metal game parts.

The Score-Driver Board shall have an output of one TTL Compatible Load to reference zero voltage crossing triac coil drivers other than those controlled by the Game Control.

5.4 Power Requirements

The following power supply levels will be required to operate System logic must be free from failure for line voltage from 95 to 125 VAC

1. + 5 VDC ± 5% MOS - TTL drive 600 MA
2. -12 VDC ± 5% 200 MA
3. -100 VDC ± 10% 200 MA Panaplex Display Drive
4. +100 VDC ± 10% 200 MA
5. 6 volts ± 10% 3A For status lamps and full wave rectified with no filtering.
6. 28 VAC ± 10% For solenoid drive.
7. -5VDC ± 5% 200 MA

NOTE: Current capability shall be determined at a later date.
AC line transients - noise shall be supressed by Williams.
Line regulation shall be defined to Williams when firm power requirements are known.
The first failure due to low line voltage must be the coin lockout coil.

5.5 Environment

The controller system shall operate to maximum temperature of 60°C with no change in performance.

6.0 FUNCTIONAL DESCRIPTION

The Williams Game Controller has two basic functions, the game control functions and the operator adjustable functions set by diode jumpering between points on the Price card.

6.1 Operator Adjustable Functions

Operator adjustable functions are accomplished by the operator Adjusting current Williams adjustment jacks, the leads for which are provided on the Price Board. Between specific contacts available on the Price Card, the jumber will define the following operator adjustable parameters:

A. Price units per play: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10. Each game credit increment is specified by jumpers inserted at appropriate points. For example, jumpers inserted at points A5, A9, and A10 would indicate that 1 play would cost 5 units, 2 plays would cost 9 units, and 3 plays would cost 10 units. Furthermore, when reaching the highest number of units represented by the jumper position, the appropriate number of play credits would be allocated and the number of price units accumulated would be reset to zero for further coin inputs.

B. Relative Coin Values as follows:

Jumpered Points B1	B2	B3	Smallest Coin	Ratio of 2nd Coin Value to Smallest	Ratio of 3rd Coin Value to Smallest
none	none	none	1	-	-
none	none	yes	1	2	-
none	yes	none	1	2	4
none	yes	yes	1	2	5
yes	none	none	1	4	-
yes	none	yes	1	5	-
yes	yes	none	1	5	10

Example: U.S. nickle, dime, and quarter values would be represented by 1, 2, 5, and jumpers would be installed at points B2 and B3.

C. Relative coin value multiplier: Multiplies coin value by a constant to establish the price units as follows: X1 thru X10. Jumpers would be installed at points C1, C2, C4 and C8 to form a binary coded decimal number which indicates the value of the multiplier.

D. Number of balls served per game as follows: 1 thru 15 jumpers would be installed at points D1, D2, D4 or D8 to give binary value.

E. Replay limits which identify maximum number of game credits, Electro-mechanical - Up & Dn Coil Drivers - Zero & Last Position Sws.

F. Score values for which game credits will be issued as follows:
1 extra game for score defined between 100,000 and 990,000 points (lower value). Jumpers would be installed at points FL100K, FL200K, FL400K, FL800K, FL10K, FL20K, FL40K, FL80K, to provide 2 binary coded decimal digits.
1 extra game for score defined between 100,000 and 990,000 points (middle value) similar set jumper FM100K to FM800K, FM10K to FM80K.
1 extra game for score defined between 100,000 and 990,000 points (upper value) similar set of jumpers for FH100K to FH800K, FH10K to FH80K.

G. Awards for player making score values defined in F: extra game award for lo, med & hi limit score install jumper at point G1, extra ball no jumper.

H. In the one or two/four player version of the game controller, the definition of this each is defined by the score-driver board.

6.2 Control Board

6.2.1 General

The Control Board performs the following functions in the Williams Game Controller:

1. Controls operation of the specific game as defined by the operator adjustable parameters.
2. Credits games based upon coin inputs or playfield scoring.
3. Monitors tilt devices to disable illicit scoring.
4. Monitors anti-cheating devices to disable credit system.
5. Performs general tests of playfield and scoring systems.
6. Controls play based upon credit and game status.
7. Accepts inputs from status, credit, and playfield switch contacts.
8. Generates signals for driving external displays, external indicator lamps and external coils.

6.2.2 Game Definition

The specific game definition for any game using the Control Board is a function of four areas. These four areas are:

1. The specific capabilities of the hardware interface provided in the Control Boards. These include

the number of switch contacts which may be sensed, the number of lamp drivers, display drivers, and coil drivers which are provided. The current, voltage, etc. parameters also define the specific application capability of the Control Board. Once designed, this capability is fixed unless growth capability is provided for on the module or add on modules can be accommodated or redesign is allowed.

2. The specific capabilities of the program of the microcomputer and the game program circuit which is installed on the module. The microcomputer program may allow for many optional capabilities for different games which may be selected by the specific game program circuit which interprets playing field contacts and controls driving the lights in any one game definition. The functions common to all game configurations are programmed in the microcomputer memory.
3. The ingenuity of the game designers. The game designers may possibly make use of the provided inputs, outputs and program characteristics by using them in an unconventional way to do other functions than those preplanned. The game designer also always has the option of adding hardware outside of the Game Controller Module to add new features which also make use of the hardware and software in the Game Controller Module.

For example, if it is desired, it would be possible to add a contact sequencing mechanism to sequentially close a number of contacts which performed the desired function by sequentially selecting combinations of other contact closure functions.

4. Selecting specific options from those provided by the Operator adjustable parameters. The game designer has the options available to him which have been defined by inputs from operator adjustable parameters on the Game Price.

It is anticipated that although these options are fixed, they cover all contingencies in the areas covered.

6.2.3. Game Control Functions.

The game control functions are those functions which may be used in configuring a unit for a single production run. Specific functions within that run are defined by inserting an appropriately programmed Game Program device.

6.2.3.1 After power is applied to the Williams Game Controller and the microcomputer sets the outputs to the desired state, a general check is made that all contacts are in their proper state. The microcomputer then reads all of the parameter encoding information into memory. The microcomputer then decodes the information and stores it as appropriate in memory for use as the different functions are carried out. The microcomputer then sets all neon displays to eight, then resets to zero. The microcomputer then completes a ten second delay period and then enters a "ready" state.

6.2.3.2. Ready State Functions. (Game over)

In the ready state the microprocessor sets the coin lockout so that coins may be accepted and the coin information converted to play or replay credits. When credits are available the credit OK lamp is turned on and the microcomputer interprets all contact switch information.

6.2.3.3. Credit System Functions.

Coins of different value are appropriately converted to price units. As the price units accumulate, the sum is compared with the price units per play (as it has been stored), and the replay credits incremented. When the last price unit in the sequence (up to 10) is encountered, the credit is advanced and the price units count reset. This process repeats until no more coins are input and the start button contact closure is sensed. Coins may be accepted up to the operator selected maximum replay counter value. When this value is reached, coins will be locked out.

6.2.3.4. Start Function

When the start contact is sensed, the following events occur:

A. Any game credit computation from price per game operation is transferred and the price units count is reset -- any partial game credit is lost.

B. No action takes place unless at least one play credit is available.

6.2.3 1 START PUSH BUTTON OPERATING TABLES

6.2.3.4.2 4 PLAYER GAME

	# Can Play Coin Unit	Ball In Play Ball Count	Player Up Player Unit	Game Over	Scores	Credit Unit Replays	Number Match
Power on Game Over	Off	Off	Off	On	Zero Power on only	N	Off
Press #1	1	1	1	Off	Zero	N-1	Off
Press #2	2	1	1	Off	Zero	N-2	Off
Press #3	3	1	1	Off	Zero	N-3	Off
Press #4	4	1	1	Off	Zero	N-4	Off
Press #5 or more	4	1	1	Off	Zero	N-4	Off
Normal game over	Last game	Off	Off	On	Last Game	N-4	On
Press #6	1	1	1	Off	Zero	N-5	Off
Reset Game Press #7	1	2	1	Off	Zero	N-6	Off

A TWO PLAYER GAME # CAN PLAY LIMIT IS TWO

6,2,3,4,3 SINGLE PLAYER GAME

	BALL IN PLAY	GAME OVER	SCORE	REPLAYS	NUMBER MATCH
Power on Game Over	0	Lit	Zero	N	Off
PRESS #1	3 or 5	Off	Zero	N-1	Off
PRESS #2	--- No	Change	----------	----------	----------
Game Over	Zero	Lit	Last Score	N-1	On-Off Adj.

COIN LOCKOUT ENERGIZED AND CREDIT BUTTON HOT ONLY AT GAME OVER OR AFTER FIRST SCORE IS MADE.

6.2.3.5 Ready to Play Status

On each subsequent contact closure of the start button, the following events occur:

A. If credits available, advance number of players by one (up to maximum number of players entered by matrix for 1 or 2 player games (or from the game program circuit for more players) - If more than maximum number of players, ignore contact closure).

B. Reduce number of credits by one count.

6.2.3.6. Play Status

When ball is shot, it enters the playfield. When it closes any contact on the playfield, the playfield operation starts. If ball is returned to outhole, the outhole switch contact is closed without closing any contact on playfield, serve ball again. During the time of play for the first ball of the first player depressing the start button will allow additional players to participate in the game using the procedure defined in the ready to play status section (6.2.3.5). When the ball closes the outhole contact switch no more players can be added to the current game.

6.2.3.6.1.

6.2.3.7. Playfield Operation

Closing any contact on the playfield will cause the scoring, bonus, or control operation as defined in Section 6.2.3.8. To stop flashing (a player up digit will be displayed).

6.2.3.7.1 Scoring

When the ball encounters any of the playfield contacts which indicate a score is to be added, the following sequence of events occur if tilt is not on:

A. The microprocessor determines the amount of score to be added to the score of the player up.

B. The appropriate digit position is selected and one count is counted into the position (10,100, 1,000, 10,000, 100,000)

Multiple scores shall be advanced in single steps. Example: 5000 shall be scored as 5 advances of 1000 each, with a time delay between each advance.

C. Display new score.

D. The appropriate sounding device (particular chime or bell) coil is driven for 50 ms depending upon value being added.

10,000 requires bell
1,000 requires large chime (#1)
100 requires small chime (#2)
10 requires medium chime (#3)
or
100,000

6.2.3.7.1 Scoring (continued)

E. Concurrent with above, activate coil and sound drum for 50 ms.

F. Repeat steps 2 through 5 until total score for that contact has been added.

G. Increment ball index register (which counts from 0 through 9 and then repeats) for subsequent number match comparison.

H. Interrogate contacts relating to contact matrix and outhole. If any contact in the matrix has been closed, respond to that contact as defined in Section 6.2.3.8 and/or the Game Program Circuit. If no matrix contact has been closed, continue interrogating the contact matrix and outhole contacts. If outhole contact is closed, go into end of ball in play sequence described in Section 6.2.3.7.3.

6.2.3.7.2. Increment Bonus

If playfield contact closure indicates bonus should be incremented, or optionally, when ball is served, the microprocessor will carry out the following steps:

A. Identify which bonus register is active.

B. Determine if that bonus register is at maximum value. (Up to 15 as determined by parameters read from Game Program Circuit).

C. If not at specific maximum value, increment bonus register or, if at maximum, do not advance bonus count.

D. Display new bonus situation.

6.2.3.7.2 Increment Bonus (continued)

E. If any scoring action is required, perform scoring function as in Section 6.2.3.7.1.

F. If no scoring action is required, continue contact scanning as in Step II of Section 6.2.3.7.1 Scoring.

6.2.3.7.2.1 Special Playfield Functions

The special functions are those playfield functions as described in Section 6.2.3.8., Contact Matrix Definition, which perform other functions than just scoring or incrementing the bonus. These functions include bonus multiplier selection, gate manipulation, ball activator operations coupled with delays or other functions (jet bumper coil drives or other non-delayed coil drives are not microcomputer functions), scoring or bonus functions which are functions of playfield events, etc.

After performing the designated function, the microprocessor will continue contact scanning.

6.2.3.7.3. End of Ball in Play Sequence

When the ball leaves the playfield and comes to rest, the outhole contact will close indicating that play for that ball is complete. This signal initiates a sequence of actions as follows:

A. If same-player-shoots condition is on, count down bonus and reset targets as optionally specified by program then serve ball and verify ball is served, then go to play status (Section 6.2.3.6.) except that when ball index occurs (first contact) turn off same player shoots light.

6.2.3.7.3 End of Ball in Play Sequence (continued)

B. If not-on, identify bonus value multiplier to get score value.

C. Identify active bonus register

D. Test to see if any value in bonus register

E. Count bonus down one unit.

F. Count score value into players score as in Section 6.2.3.7.1 except that Steps G and H are not used.

G. Repeat steps C through F until bonus register is reset.

H. Clear second bonus register.

I. If player up is not equal to last player, increment player up, display player up, serve ball, verify ball served and go to play status, (Section 6.2.3.6)

J. If player up is equal to last player, check to see if last ball was played. If not, increment ball counter, reset player up to player No. 1, display player 1 up serve ball, verify ball served, and go to play status (Section 6.2.3.6). Note that for one player game, ball in play display counts down.

K. If player is last player and last ball played was last ball, scan scores for match of ball index register with 10's digit. For each match, credit one free game (increment credit counter, and drive credit knocker coil with 50 ms pulse). Turn on game over light.

6.2.3.8. Contact Matrix Definition

The function of each of the 64 possible contact closure sets between the eight strobe lines and the eight return lines is defined in Figure - 4. All of these contacts are of the normally open type.

6.2.3.9. Lamp Driver Conditions

The following lamp drivers are required .

Tilt - Set by tilt roll, door slam, playfield slam, tilt, door open, or improper playfield contact sequence (bonus up contact prior to ball index).

Game Over - Defined in Section 6.2.3.7.3.

Same player shoots (2 or 4 player only) - Activated after specific group of contacts closed.

Credit OK - Set by one or more replay credits available.

The following lamp drivers are set as required for specifically defined program steps from the game program circuit or game conditions.

Feature - (20) spinners, etc.
Double Bonus -
Triple Bonus -
Jet Bumper Score X10 when lit #1 -
Jet Bumper Score X10 when lit #2 -
Jet Bumper Score X10 when lit #3 -
Left Bonus #1 -
Left Bonus #2 -
Left Bonus #3 -
Left Bonus #4 -
Left Bonus #5 -
Left Bonus #6 -
Left Bonus #7 -
Left Bonus #8 -
Left Bonus #9 -
Left Bonus #10 -

6.2.3.9. Lamp Driver Conditions (continued)

Right Bonus #1 - Optional and not used when left bonus is used
Right Bonus #2 -
Right Bonus #3 - Right Bonus #11
Right Bonus #4 - #12
Right Bonus #5 - #13
Right Bonus #6 - #14
Right Bonus #7 - #15
Right Bonus #8 -
Right Bonus #9 -
Right Bonus #10-

Left Bonus Selected -
Right Bonus Selected -
Tilt - set by any tilt condition
Game Over - set by game conditions
Same player shoots - set by game program circuit (2 or 4 player only)
Player 1 up - set by game conditions } (2 or 4 player only
Player 2 up - set by game conditions }
Player 3 up - set by game conditions }
Player 4 Up - " " " " }-(4 player only)
Letter No. 1 -
Letter No. 2 -
Letter No. 3 -
Letter No. 4 -
Letter No. 5 -
Letter No. 6 -
Letter No. 7 -
Letter No. 8 -
Letter No. 9 -
Letter No.10 -

6.2.3.10. Coil Driver Conditions

(No more than 20 drivers will be required in any one specific game). S = Standard O = Optional

1. Coin Lockout - Locked out when in power on sequence delay, anti-cheating circuit functions, and when credit counter is at maximum selected value. S

2. Money Meter - Pulsed for each coin increment. (Optional)

6.2.3.10. Coil Driver Conditions (continued)

5. Total Play Meter - Pulsed for each play credit earned or paid for. (S)

4. Ball Return - Pulsed to serve ball (S)

5. Ball Actuator #1 - Pulsed by Optional Sequence from Game Program
6. Ball Actuator #2 - Pulsed by Optional Sequence from Game Program
7. Ball Actuator #3 - Pulsed by Optional Sequence from Game Program
8. Ball Actuator #4 - Pulsed by Optional Sequence from Game Program
9. Ball Actuator #5 - Pulsed by Optional Sequence from Game Program
10. Ball Actuator #6 - Pulsed by Optional Sequence from Game Program
20. Ball Actuator #7
11. Free ball gate - held by condition determined by game program (Optional).

12. Small Chime - pulsed by score 100 (S)

13. Medium Chime - pulsed by score 10 (S) or by 100,000

14. Large Chime - pulsed by score 1000 (S)

15. Reset Drop Target - Pulsed by Game Program (Optional) (200 MS. Drive Pulse)

16. Sound Drum - Pulsed by any score (s)

17. Replay Up Count - pulsed by earned or bought credit Standard

18. Replay Down Count - pulsed by spend credit. Standard

19. Bell - Pulsed by score 10,000 Standard

10 of the coil outputs will be required for all game configurations and the 10other coil drivers will be allocated to as many as10 of the remaining 10 optional functions.

NOTE: Ball Actuators #1 thru #6 - Drive pulse may be increased to 200 MS as necessary.

6.3 Programming the Price Board

The Price Board which plugs into a socket on the Game Control Board is used to define parameters which are set by Williams to define the parameters pertaining to the particular game being produced and define the function for all of the optional contacts on the contact matrix.

6.3.1 Williams defined Game Parameters

The first section of memory in the Game Program circuit is allocated to parameters as follows:

PINBALL SHUFFLE
0000 1000
↓
1111 1111
1-4BIT WORD DEFINES A & B

A. Number of Players: 1 through 6 encoded as binary number in three bits of 4-bit word on Score-Drive Board

B. Identification of Game type: Pinball or shuffle alley: encoded as 4th bit of same 4-bit word as in A above.

1-4 BIT WORD C. Value of N for scoring in Column 3 of Contact Matrix.

36-4 BIT WORDS D. Other parameters to be defined.

(This could include a series of 36 constants depending upon trade offs between program memory in the microcomputer, data memory in the microcomputer, and memory available on the Price Board.

E. Identification as to whether or not playfield conditions will be retained from one ball play to another in multiplayer games.

F. Maximum value (up to 15) for L bonus register.

G. Maximum value (up to 15) for R bonus register.

H. Maximum value for register associated with number of letters lighted (up to 15).

6.3.1. Q FEATURE ADJUSTMENT (NOTE: Under 6.1.1 I)

On many games a feature adjustment is required to allow the operator to change the percentage of the game to make the game playable for different types of locations. (A shopping arcade where children play to a truck-stop where adults play) the adjustment usually changes the requirements for lighting extra ball and special targets. For example, on AZTEC, the center targer awards an extra ball when lit and becomes lit when other targets are made, the other targets required are adjustable.

Conservative - Requires: A, Z, T, E, & C.

Medium - Requires: A, Z & T

Liberal - Requires: A,Z, & T OR A,E, & C

This same adjustment also controls the special lanes because WHEN THE CENTER TARGET IS LIT FOR EXTRA BALL AND THE BONUS IS AT 50,000 THE SPECIAL LANES ARE LIT.

Separate registers for bonuses and number of letter lights on are tentatively planned for each player if there is memory capacity for these parameters.

6.3.2 Williams Defined Game Functions for Contact Matrix

When a specific contact is closed on the contact matrix, the microcomputer will automatically go to a specific program to execute the desired program function. For the contact functions not designated as optional in the contact matrix, the specifically defined function will occur. For all contacts identified as optional, the program will call up sequences of instructions from specific portions of the Price Board to perform the desired function. These sequences of instructions will be defined by Williams by using instructions which are coded by Williams into the Price Board.

6.3.3 Pinball Game Oriented Language (PGOL)

The approach is to define a pinball game oriented language, PGOL, (based upon a Rockwell Controller Language) which defined the scoring, bonus manipulation, and logical interrelationships between all of the contacts which go into making up a specific

6.3.3 Pinball Game Oriented Language (PGOL) (continued)

game as the instructions in the language are read from the Game Program Circuit.

Each contact closure, on the right four columns of figure 4, defines a specific location in the PROM for the first command of a sequence of commands which define the specific operation of the game for that specific contact under the specific conditions existing at the time the ball closed the contact.

Single bit positions in memory may be set, reset, or tested to define which lights are lit, which logic conditions have been met, etc.

When the sequence of interpretive instructions is started, a flag bit initially is set to the "one" state and is then manipulated by logical relationships between the individual bits as required to define the operation of subsequent instructions. A few of the instructions will always be executed independently of the state of the Flag bit. However, most of the instructions will be executed only if the Flag bit is "1" and will be ignored if the Flag bit is "0". This will become more clear as the instructions are described and examples of their usage is given.

The specific bits set may turn on lights, cause coils to be pulsed or may merely indicate status. The function of each bit will be defined later.

6.3.4 Tentative PCOL Instruction Set

COPY ( ): If Flag bit is "1" Copy addressed bit to Flag bit. This allows the Flag bit to be set to the same condition as the bit being interrogated. If Flag bit is zero ignore this instruction. This instruction requires 3 words.

COPY COMPLEMENT ( ): If Flag bit is "1", copy complement of addressed bit to Flag bit, otherwise ignore. This instruction requires 3 words.

AND ( ): If Flag bit is "1", perform logical AND between Flag bit and addressed bit and put result in the Flag bit, otherwise ignore. This instruction allows a running determination of the result of ANDing two or more bits. Example: bit 1 and bit 5 AND bit 9 would be programmed as follows: COPY BIT 1, AND BIT 5, AND BIT 9. Note that if any of the bits are zero the resulting Flag bit is set to zero. This instruction requires 3 words.

AND COMPLEMENT ( ): If Flag bit is "1", perform a logical AND between the Flag bit and the complement of the addressed bit and put the result in the Flag bit, otherwise ignore. Example: (B1) $(\overline{B6})$ $\overline{B9}$ is programmed as follows: Copy B1, AND COMPLEMENT B6, AND COMPLEMENT B9. This instruction requires 3 words.

6.3.4 Tentative PGOL Instruction Set (continued)

OR ( ): Independent of Flag bit status, perform a logical OR between Flag bit and addressed bit. Example: Bit 3 or Bit 4 or Bit 12. Program: Copy B3, or B4, or B12. This instruction requires three words.

OR COMPLEMENT ( ): Independent of Flag bit status perform a logical OR between flag bit and complement of addressed bit. Example: B3 + B14 + B22. Program: Copy B3, or B14, or complement B22. This instruction requires three words.

SET ( ): If Flag bit is "L", set addressed bit to 1, otherwise ignore. Example: Set bit 14 if $\overline{B} \cdot B3 + B6 = 1$. Program: Copy complement B1 and B3, or B6, set B14. Note that the sequence is important because if the sequence is reversed (Copy B6, OR B3, and complement B1, set B14) the logical function which sets B14 is (B6 + B3) $\overline{B}$. This instruction requires three words.

RESET ( ): If Flag bit is "1", set addressed bit to 0, otherwise ignore. This instruction requires three words.

ADD ( ): If flag bit is "1", count indicated score into score of player - up, otherwise ignore. This instruction requires three words. Example: If (B14) (B15) (B16) is true, add 4000 to score. Program: copy B14, and complement B15, and B16, add 4000. The score may be defined as a count and the digit position to which

6.3.4 Tentative PGOL Instruction Set (continued)

the count is to be added. This instruction requires 3 words.

SUB ( ): If Flag bit is "1", count indicated score down from score of player-up (do not count below zero) otherwise ignore. This provides a new capability for games which may be useful, particularly if a "raspberry" sound could be generated when a negative score occurs. This instruction requires 3 words.

FLAG ON Set Flag bit on. This is a 1 word instruction.

TOGGLE Independent of Flag bit, change Flag bit to opposite state. Example: If bits B3 and B4 are set, score 5000, if not, score 500. Program: COPY B3, AND B4, ADD 5000, TOGGLE, ADD 500, STOP. Note that if B3 or B4 are zero, the ADD 5000 instruction is ignored. The TOGGLE instruction turns on the Flag bit so the ADD 500 function is performed before returning to the next instruction. This is a 1 word instruction.

GO TO ( ): Independent of Flag bit, take next instruction from PROM address indicated by instruction. Do not disturb flag bit. This instruction is used to save PROM space when a common sequence of steps follows a unique set of beginning steps. This is a 4 word instruction.

6.3.4 Tentative PGOL Instruction Set (continued)

L BONUS UP: If Flag bit is one and the Left Bonus register is set at present (by PROM) maximum value increment Left Bonus register of player by one count. Otherwise ignore. If Bonus counts to Max, set bit. This is a 1 word instruction.

L BONUS DN: If Flag bit is one and the left bonus register is not at zero, decrement Left Bonus register of player up by one count, otherwise ignore. This is a 1 word instruction.

R BONUS UP: Some as L BONUS UP except applies to Right Bonus Register of player up. This is a 1 word instruction.

R BONUS DN: Same except Right Bonus Register. This is a 1 word instruction.

STOP: Independent of Flag bit, end sequence of interpretive program steps and return to main program.

INCR: If Flag bit is "1" and register is not at preset maximum, increment working register, otherwise ignore. This register is used when scoring is a function of number of lights lit, etc. Example: If B4 is not set, set it and increment register. If B4 is set, ignore this instruction. PROGRAM: COPY B4, SET B4, INCR, TOGGLE, STOP. This is a 1 word instruction.

6.3.4 Tentative PGOL Instruction Set (continued)

DECR: If Flag bit is "1" and register is not at zero count decrement working register, otherwise ignore. This is a 1 word instruction.

REG EQUALS ( ): If Flag bit is "1", reset Flag bit if working register does not equal indicated value, otherwise ignore.

Example: Score 3000 if 3 lights are lit, 2000 if 2 lights are lit, 1000 if 1 light is lit or 500 if no lights are lit.

Program: REG EQUALS 3, ADD 3000, TOGGLE, REG EQUALS 2, ADD 2000, TOGGLE, REG EQUALS 1, ADD 1000, TOGGLE, REG EQUALS 0, ADD 500, STOP. Note that although all instructions are scanned only the proper score will be added. This is a 2 word instruction.

RESET FLAG

RESET ALL FLAGS.

6.3.4.1 IDENTIFICATION

Control Board chips to be stamped with appropriate Williams Logo Identification.

7.0 FIGURES

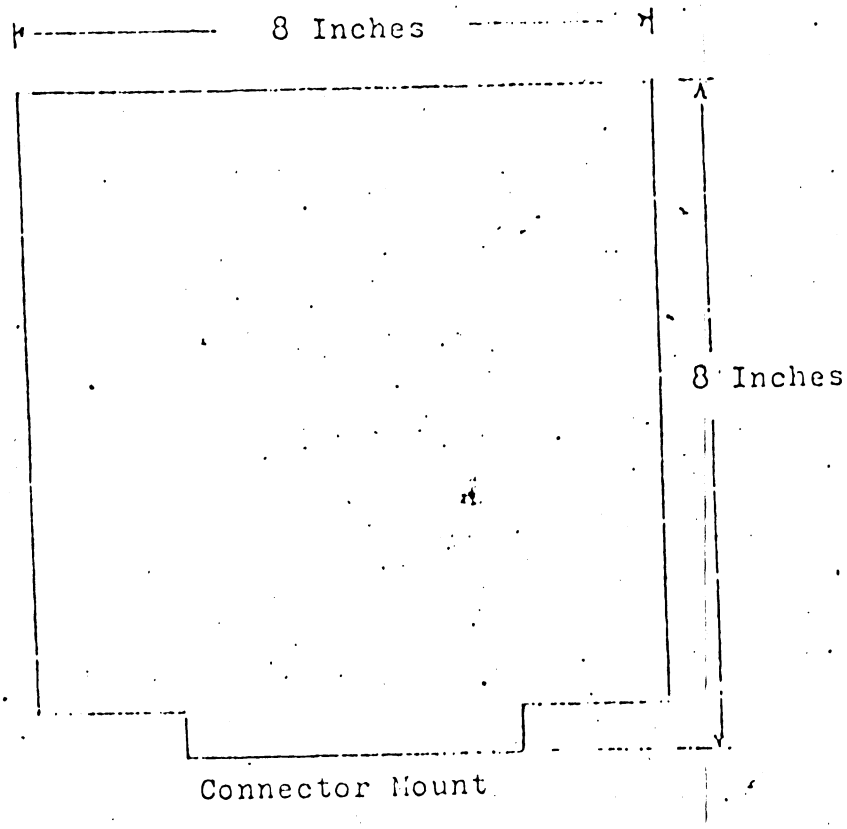
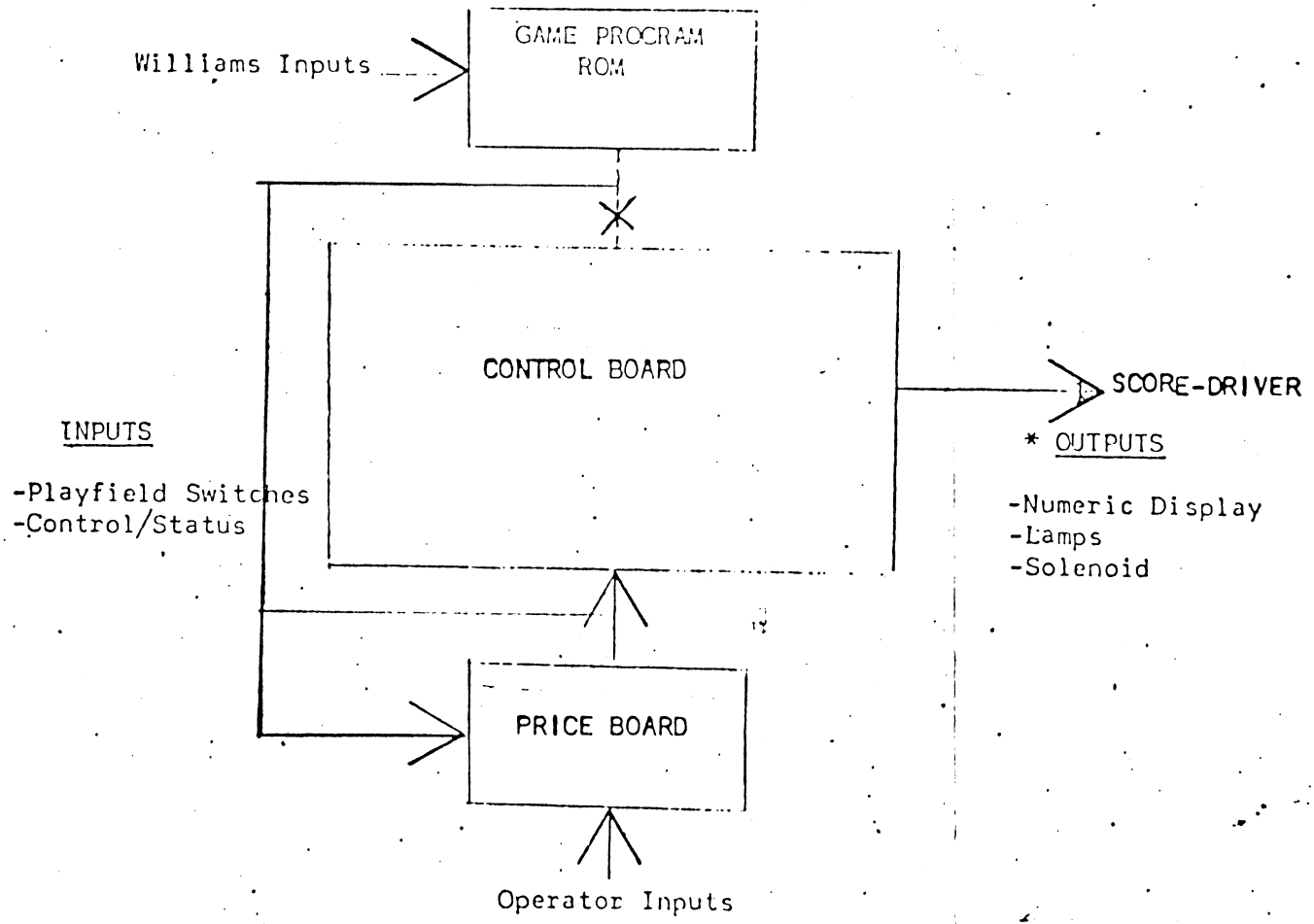


FIGURE -1. Control and Score Driver Boards.

7.0 FIGURES



*Note: Command signals for these functions.

FIGURE - 2. Block Layout of Game Controller Module

7.0 FIGURES

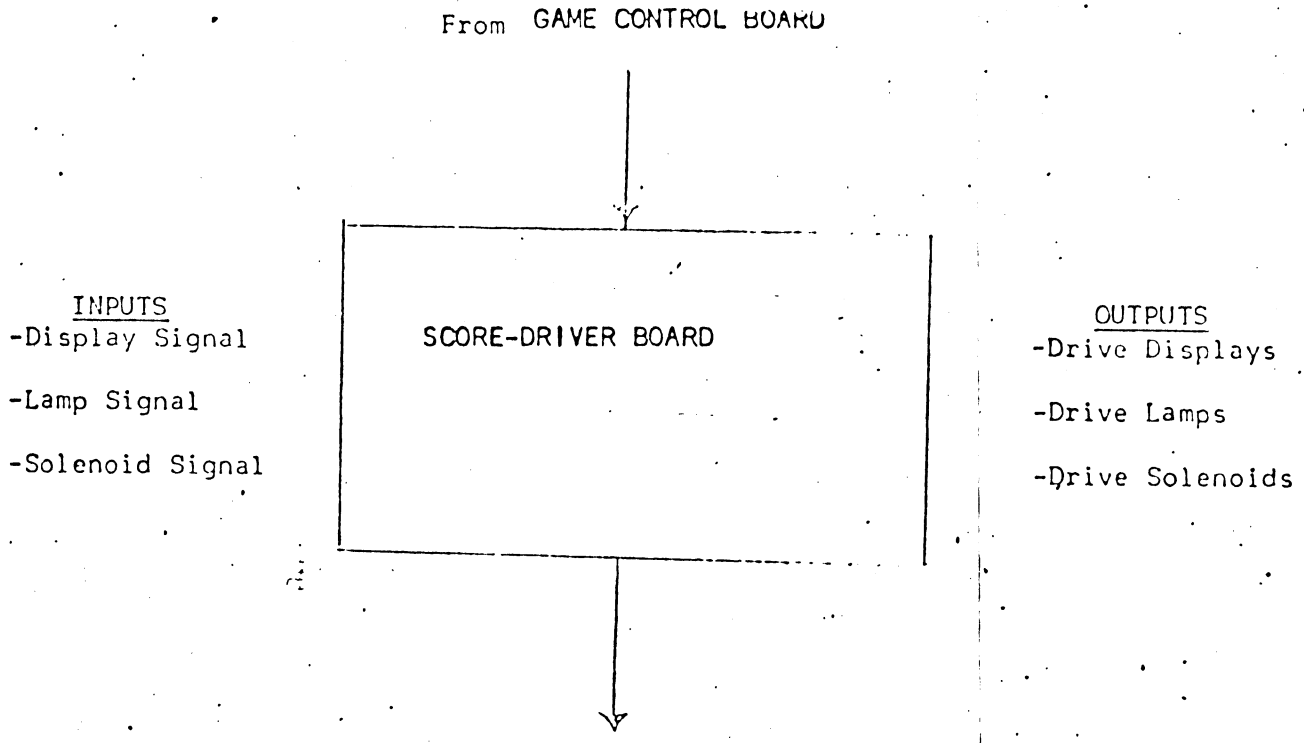


FIGURE -3. Block Layout of SCORE-DRIVER BOARD

	1	2	3	4	5	6	7	8
A	Start Push Button	Score 10	Score 50	Score N x 10	*Lite A	*Lite I	* #2 Extra Ball When Lit	*Count down Bonus & Eject When Lit
B	25¢ Switch	Score 100	Score 500	Score N x 100	*Lite B	*Lite J	* #1 Replay CR when lit	*Count down Score & Eject
C	10¢ Switch	Score 1000	Score 5000	Score N x 1000	*Lite C	* # 1 Score Extra w/lit	* # 2 Replay CR when lit	* Open Gate when lit
D	5¢ Switch	Score 10,000	Score 50,000	Score N x 10,000	*Lite D	* # 2 Score Extra w/lit	* # 3 Replay CR when lit	*Provisional Tilt
E	Tilt Contacts	Score 10 & Increased bonus	Score 50 + up bonus count	Score N x 10 + up bonus count	*Lite E	* # 3 Score Extra w/lit	* Advance Bonus	* Program Feature No. 1
F	*Stepper No. 1 P_1 Pulses	Score 100 & up bonus count	Score 500 & up bonus count	Score N x 100 & up bonus count	*Lite F	*Double Bonus when lit	* Advance Bonus when lit #1	* Program Feature No. 2
G	*Stepper No. 2 P_2 Pulses	Score 1000 & up bonus count	Score 5000 & up bonus count	Score N x 1000 & up bonus count	* Lite G	* Triple Bonus when lit	* #2 Advance Bonus when lit	* Program Feature No. 3
H	*Stepper No. 3 P_3 Pulses	Score 10,000 & up bonus count	Score 50,000 & up bonus count	Score N x 10,000 & up bonus count	* Lite H	* Extra Ball when lit	* # 3 Advance Bonus when lit	* Program Feature No. 24

*These are optional assignments.

CR is Credit

FIGURE -4. Contact Matrix Assignments