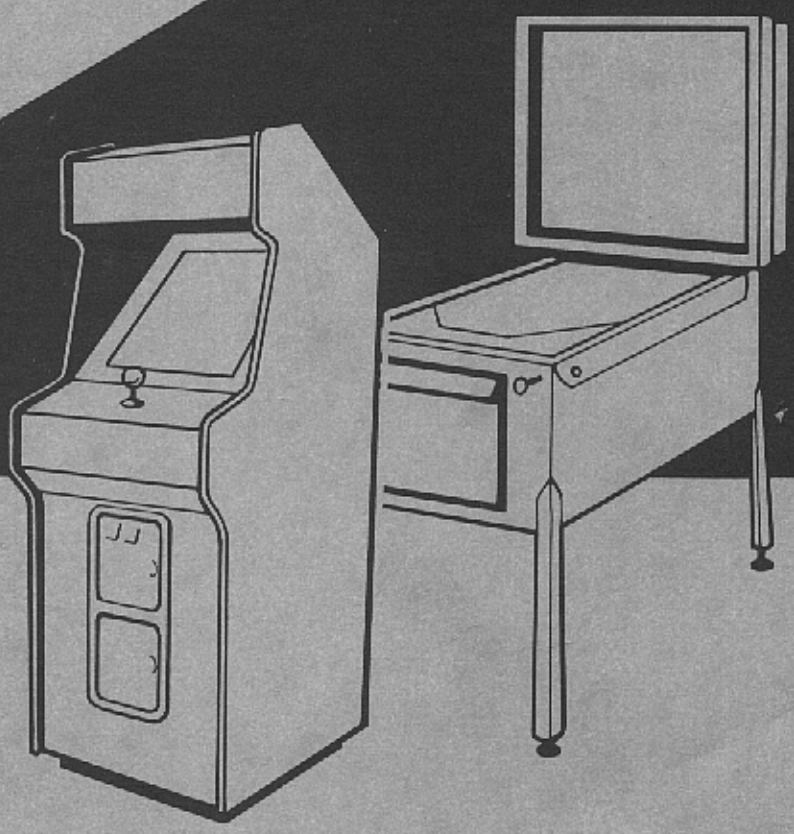
TECHNICAL SEMINAR WORKBOOK

Gottlieb™



Gottlieb™
AMUSEMENT GAMES

165 W. Lake Street Northlake, IL 60164
(312) 562-7400 Telex 72-8463

A Columbia Pictures Industries Company

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TABLE OF CONTENTS

I. INTRODUCTION

The objective of this manual is to provide operators and servicemen with a basic knowledge and understanding of Gottlieb's game systems. This knowledge will provide a better understanding of how to troubleshoot a Gottlieb game on location.

This manual concentrates on simple, fast maintenance for on-location troubleshooting. It also contains technical information that can be used to understand basic electronics and schematic reading. For all procedures covered in this seminar and most problems that will be encountered in the field, the test equipment required will be a multimeter and a pair of jumper wires.

GENERAL TROUBLESHOOTING GUIDE

1. Identify the symptoms. (Recognizing and establishing the symptoms early will narrow down the problem).

2. Determine in what operation mode(s) symptom(s) occur. (Different modes of the game are controlled by specific devices).

3. Use the Self-Test feature to help determine where the problem is.

4. Determine if problem is mechanical or electronic in nature, i.e., a short on a switch line can cause problems with the CPU board, but the solution is mechanical in nature.

5. Check for common or shared circuits, i.e., one display, two displays, or all displays have a common symptom.

6. After using the Self-Test to narrow down the problem, check the easy things first...fuses, wiring faults, burned out bulbs, etc.

7. Use wire color codes and plug numbers to guide yourself through the game. Gottlieb has a standardized numbering system to aid in troubleshooting and schematic reading.

8. Intermittent problems:
   A. Pinched or hanging wires (check near edges of playfield).
   B. Switch adjustments or defective diodes.

9. Check voltage levels at their destination points. Check the +5V DC at the A1 control board.

10. Call our toll-free number, 1-800-323-9121 (outside Illinois) and 1-800-942-1620 (in Illinois), with this background information to get the quickest and most complete answer possible.

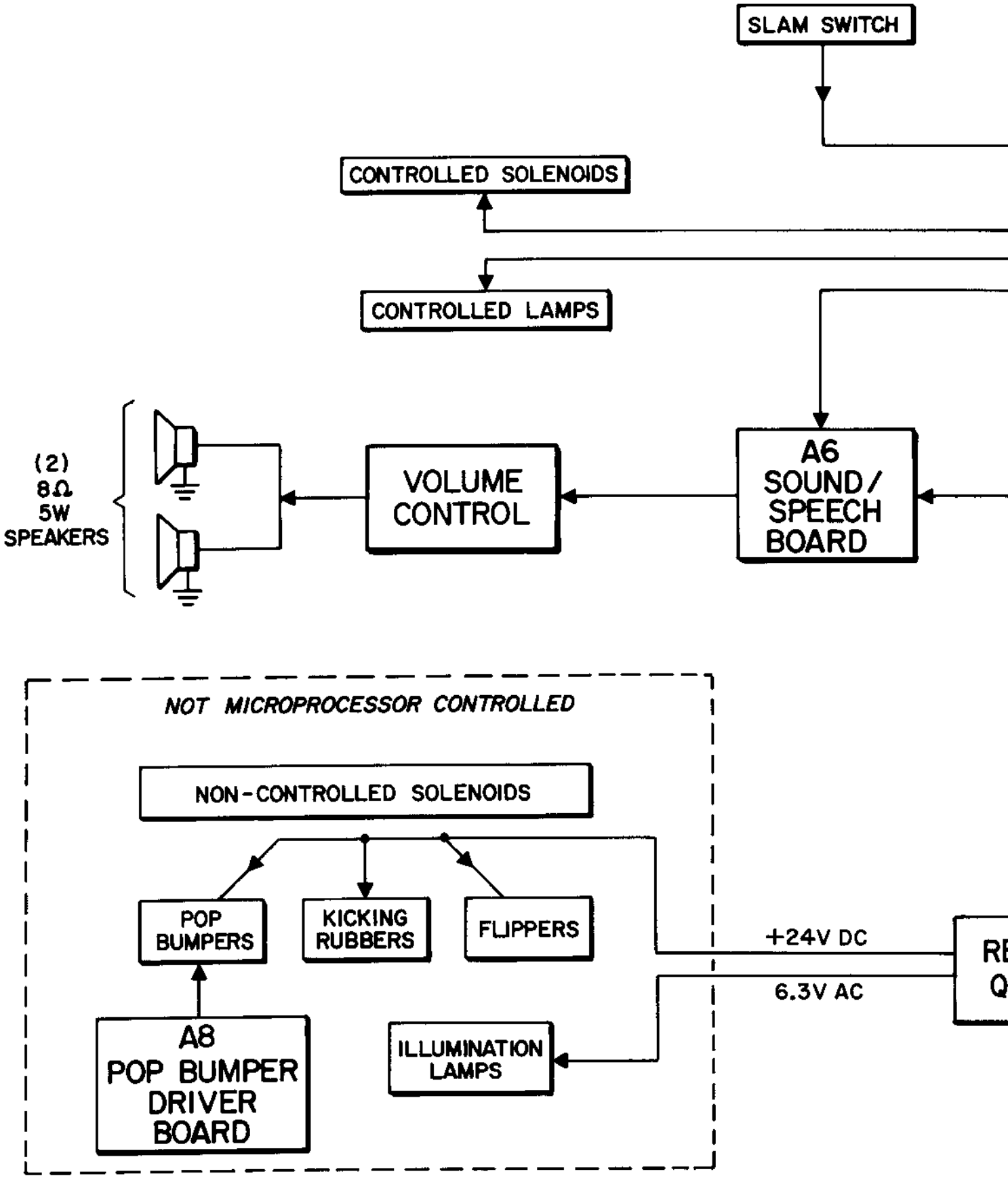
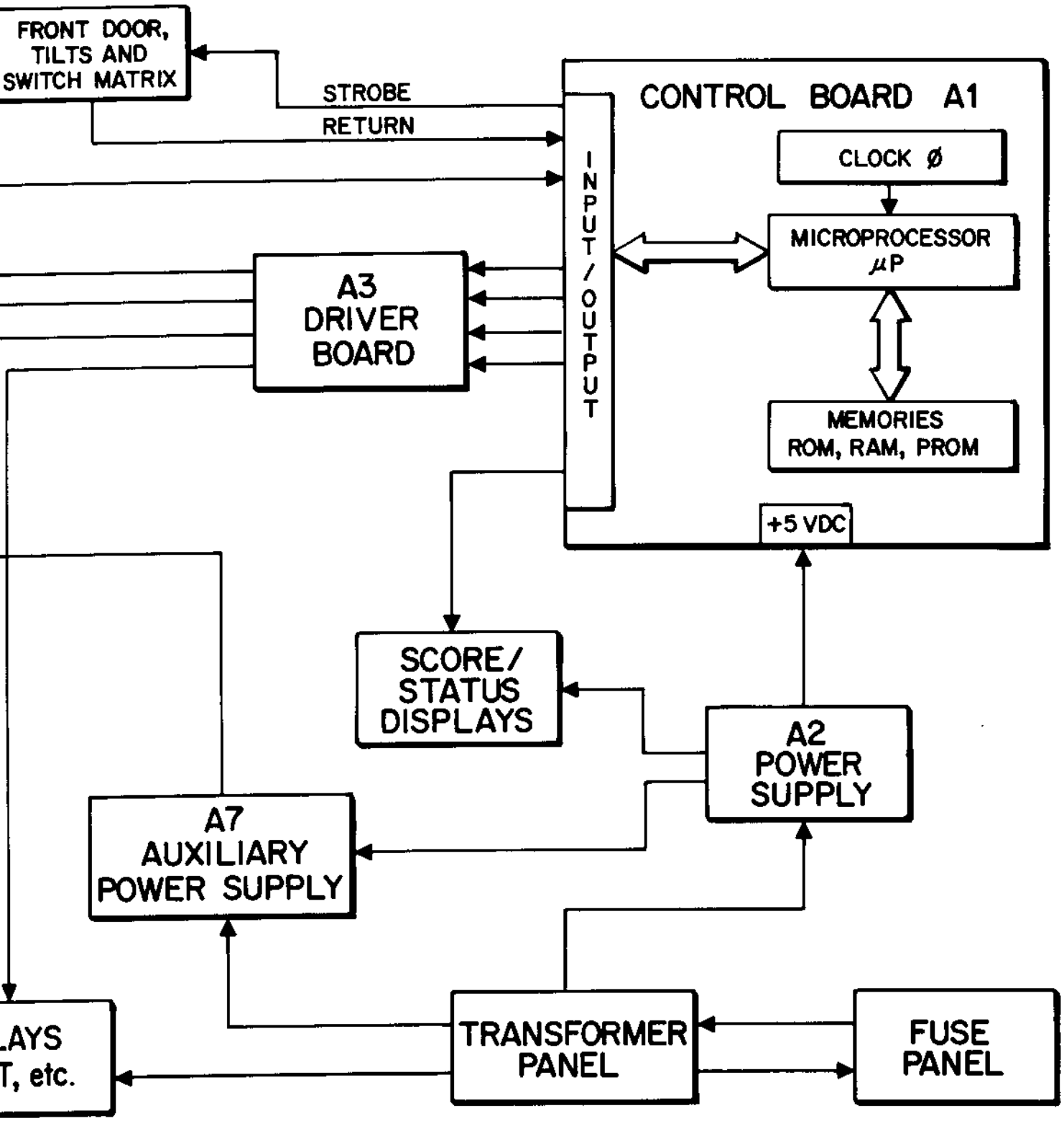
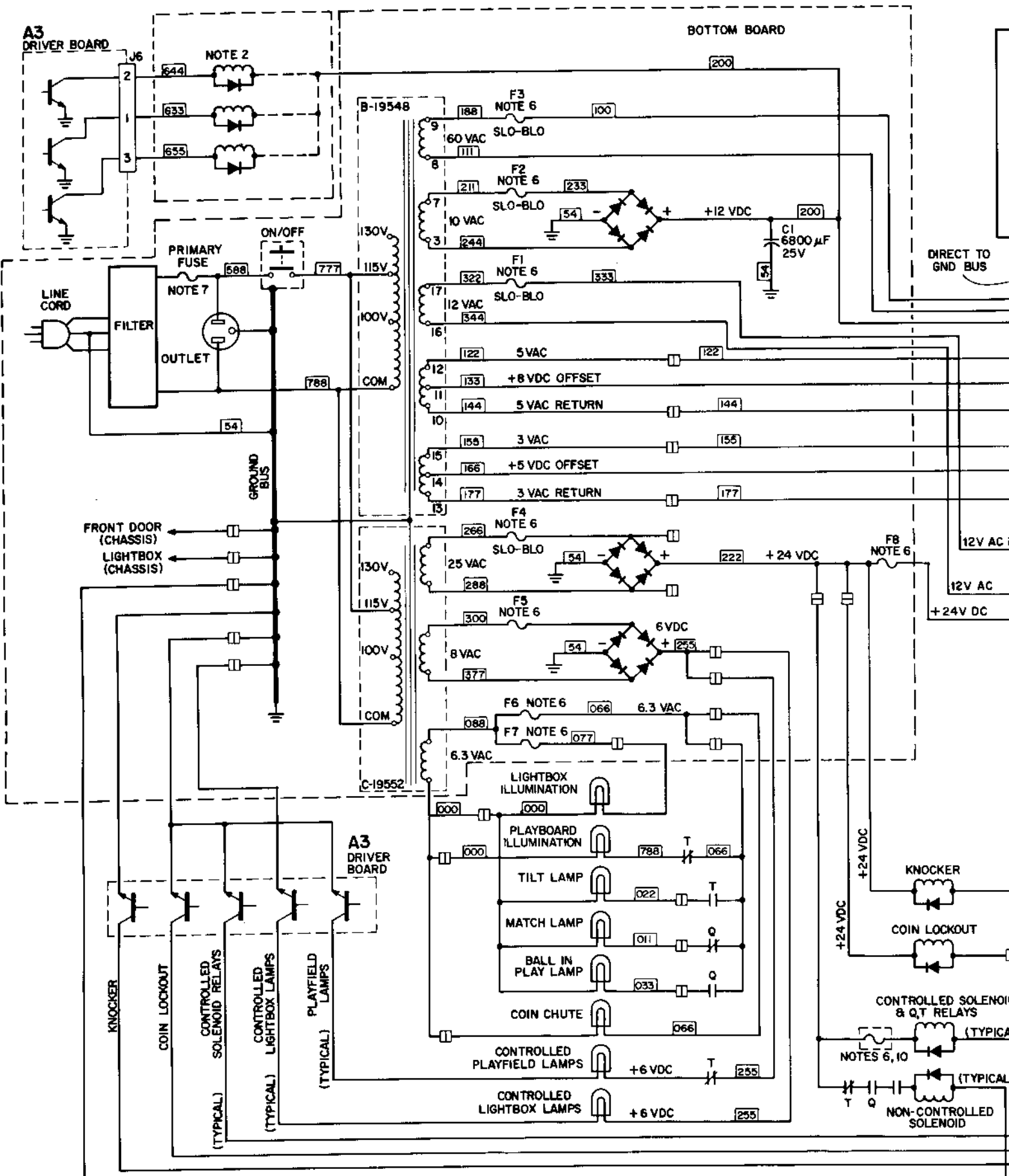
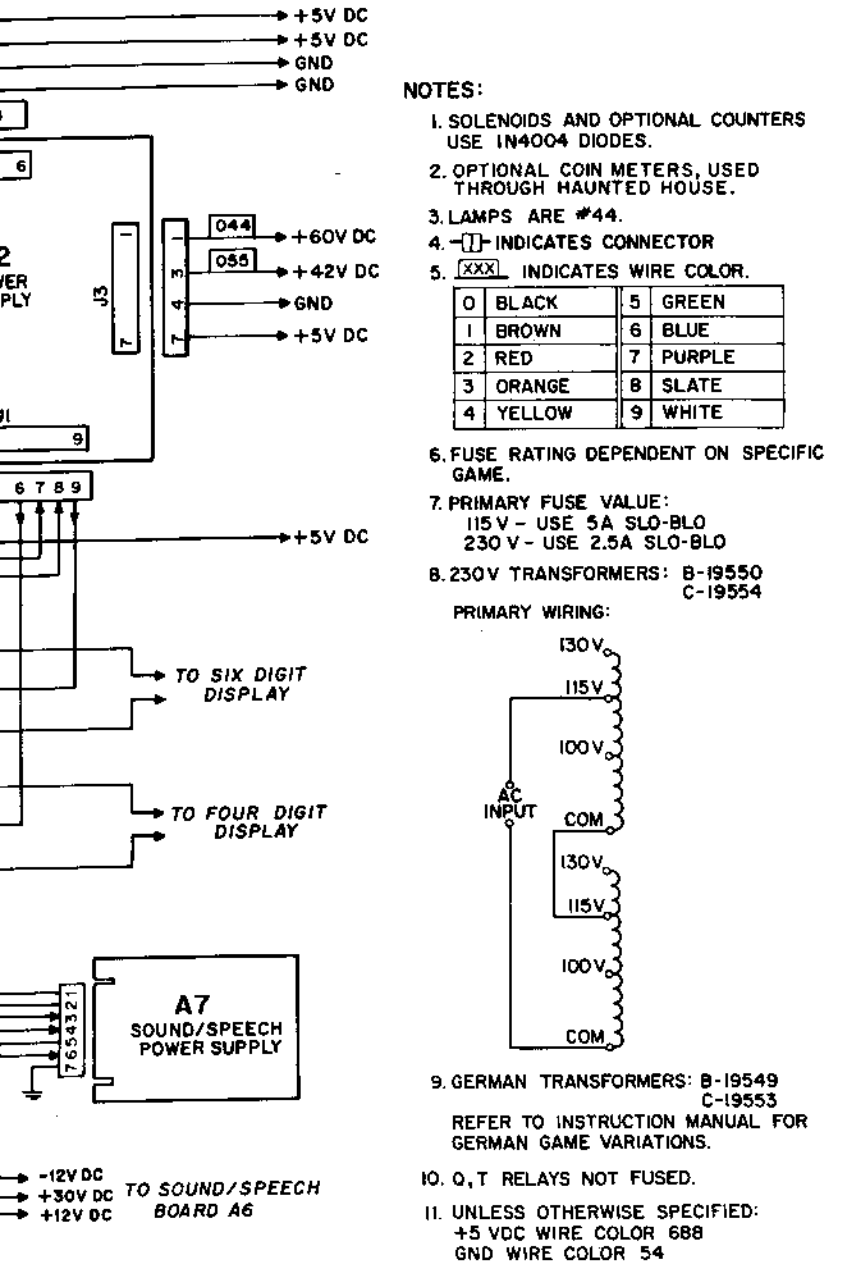


FIGURE 1. GOTTLI



1. Arrows point in direction of flow.
2. Display problems and switch matrix problems, do not involve (A3) DRIVER BOARD.
3. Non-Controlled Solenoids and Illumination lamps, are not microprocessor controlled (DON'T LOOK AT CONTROL BOARD).


A3
DRIVER BOARD
J6
NOTE 2
644
633
655
BOTTOM BOARD
200
B-19548
F3
NOTE 6
188
SLO-BLO
60 VAC
111
100
F2
NOTE 6
211
SLO-BLO
10 VAC
244
233
54
+12 VDC
200
C1
6800 µF
25V
DIRECT TO
GND BUS
F1
NOTE 6
322
SLO-BLO
12 VAC
344
333
PRIMARY
FUSE
588
NOTE 7
ON/OFF
777
130V
115V
100V
COM
788
LINE
CORD
FILTER
OUTLET
54
GROUND
BUS
5 VAC
122
+8 VDC OFFSET
133
5 VAC RETURN
144
3 VAC
155
+5 VDC OFFSET
166
3 VAC RETURN
177
FRONT DOOR
(CHASSIS)
LIGHTBOX
(CHASSIS)
F4
NOTE 6
266
SLO-BLO
25 VAC
288
222
+24 VDC
F8
NOTE 6
12V AC
+24V DC
F5
NOTE 6
300
8 VAC
377
6 VDC
255
F6 NOTE 6
066
6.3 VAC
088
F7 NOTE 6
077
6.3 VAC
C-19552
LIGHTBOX
ILLUMINATION
000
PLAYBOARD
ILLUMINATION
788
T
TILT LAMP
022
MATCH LAMP
011
Q
BALL IN
PLAY LAMP
033
COIN CHUTE
CONTROLLED
PLAYFIELD LAMPS
+6 VDC
CONTROLLED
LIGHTBOX LAMPS
+6 VDC
A3
DRIVER
BOARD
KNOCKER
COIN LOCKOUT
CONTROLLED
SOLENOID RELAYS
(TYPICAL)
CONTROLLED
LIGHTBOX LAMPS
(TYPICAL)
PLAYFIELD
LAMPS
(TYPICAL)
+24 VDC
KNOCKER
COIN LOCKOUT
CONTROLLED SOLENOI
& Q,T RELAYS
(TYPICA
NOTES 6, 10
(TYPICAL
NON-CONTROLLED
SOLENOID



NOTES:

1. SOLENOIDS AND OPTIONAL COUNTERS USE IN4004 DIODES.
2. OPTIONAL COIN METERS, USED THROUGH HAUNTED HOUSE.
3. LAMPS ARE #44.
4. -[]- INDICATES CONNECTOR
5. [XXX] INDICATES WIRE COLOR.

0	BLACK	5	GREEN
1	BROWN	6	BLUE
2	RED	7	PURPLE
3	ORANGE	8	SLATE
4	YELLOW	9	WHITE

6. FUSE RATING DEPENDENT ON SPECIFIC GAME.
7. PRIMARY FUSE VALUE:
   115 V - USE 5A SLO-BLO
   230 V - USE 2.5A SLO-BLO
8. 230V TRANSFORMERS: B-19550
   C-19554

   PRIMARY WIRING:

9. GERMAN TRANSFORMERS: B-19549
   C-19553
   REFER TO INSTRUCTION MANUAL FOR GERMAN GAME VARIATIONS.
10. Q,T RELAYS NOT FUSED.
11. UNLESS OTHERWISE SPECIFIED:
    +5 VDC WIRE COLOR 688
    GND WIRE COLOR 54

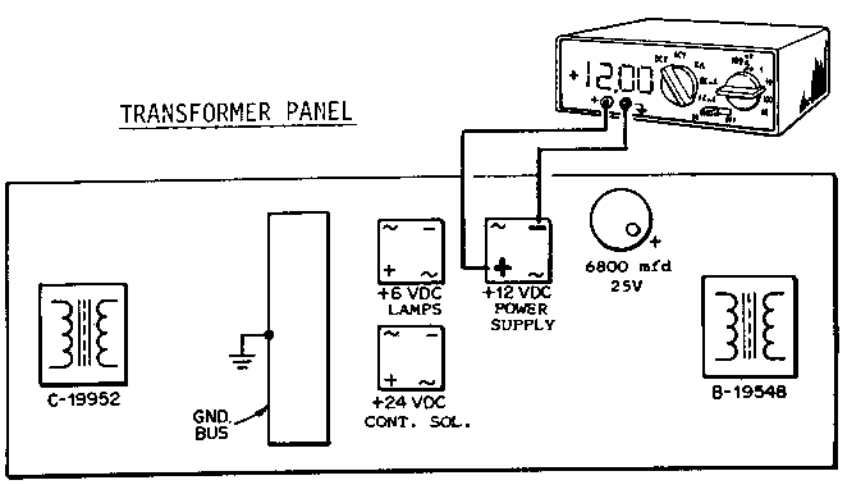


FIGURE 2. GOTTLIEB SYSTEM 80/80A POWER DISTRIBUTION

The transformer panel is the origin of all power to the game. The line filter, on-off switch, primary fuse and line cord are also vital parts of the bottom board assembly but not directly connected to it. The line power is applied to two transformers which create two main supply voltage groups. The large transformer supplies all the controlled and non-controlled device voltages for lamps and solenoids, and is protected by fuses F4 through F8. The small transformer supplies the voltages that drive the electronic devices in the game.

Fuses F1 through F3 protect each of these voltages. The only cross between the two power supply groups is the +24V DC from the large transformer. It is used by the A7 Sound/Speech Power Supply Board and is fused by F8.

The transformer panel also contains the bridge rectifiers and filters to produce the necessary unregulated +DC voltages. The unregulated +12V DC is filtered by a 6800 mfd capacitor to reduce A.C. ripple. It is then routed to the A2 Power Supply Board to produce the +5V DC logic supply.

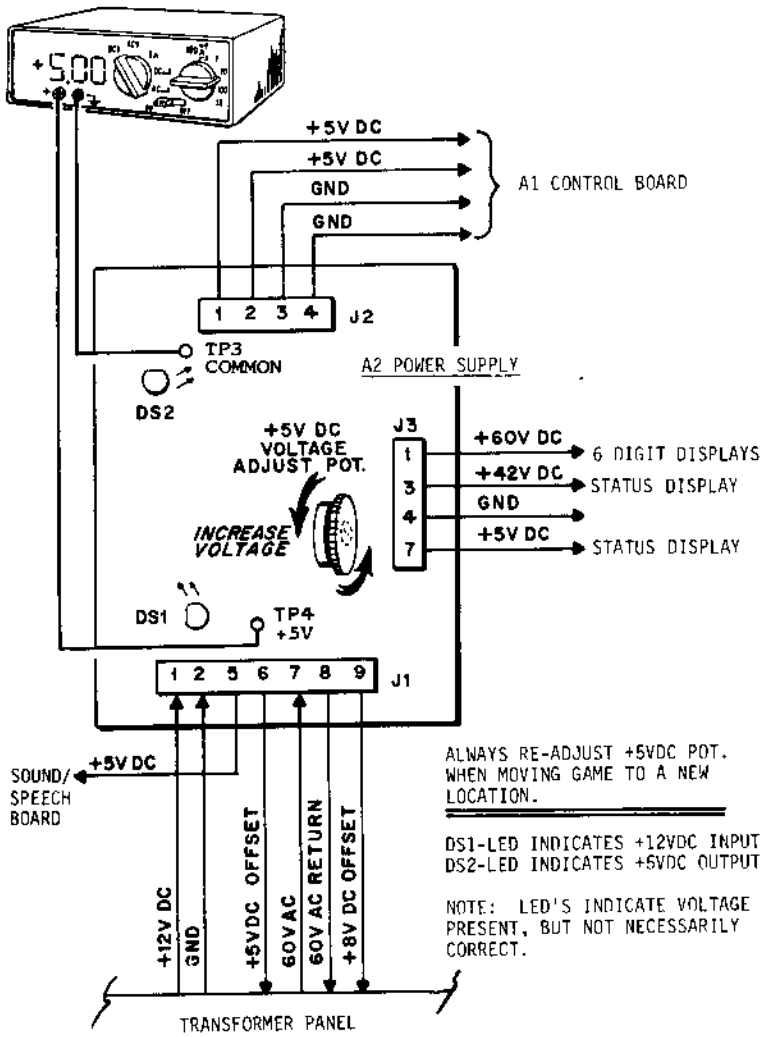


FIGURE 3.

POWER SUPPLY

The A2J1 connector, carries an unregulated +12V DC and a 60V AC supply for power supply regulation. It also contains three outputs: +5V DC logic for the Sound/Speech Board and +5V DC and +8V DC offset voltages for the status and player displays. The +5V DC offset is the same as the logic +5V DC supply. The +8V DC offset is pulled off of the +12V DC input by zener diode CR7 through resistor R10. The offset voltages return to center taps on the small transformer's 3V AC and 5V AC display filament supplies.

The A2J2 connector carries the +5V DC logic supply to the A1 Control Board. The unregulated +12V DC from A2J1-1 is applied to the collector of Q3, an emitter-follower pass transistor. The regulation for the base of the transistor is provided through an IC regulator, UA723CN. The voltage output level is established at a non-inverting input, pin 5, depending on the adjustment of the reference voltage through pin 6 and the potentiometer. Current regulation is sensed through R8, R9 and R12 at pins 2 and 3. Voltage stability is regulated at the inverting input pin 4 through R13.

The outputs of A2J3 are the display drive voltages. The 60V AC is rectified by bridge rectifier CR1 through CR4 and is filtered by capacitor C1. It is regulated by zener diode CR5, setting the voltage level at the base of Q1. The +63V DC output of Q1 is tied to the base of Q2. Any fluctuations of current across R4 will turn Q2 on or off to regulate the base of Q1. The +42V DC is generated from the +60V DC by zener diode CR6 and R5.

III. MODES OF OPERATION

A valuable tool that you can utilize to troubleshoot the game system is the modes of operation and the indicators they provide. In the different modes, certain areas of the game may or may not be used. Understanding the correct operation of the different modes can help to break down a problem to the most likely cause. For instance, in the attract (game over) mode, the "Q" relay de-energizes to cut off power to portions of the game. If the pop bumpers or the flippers are active during the attract mode, there is a short on the contacts or the wiring of the "Q" relay.

A. INITIALIZATION

B. GAME OPERATION
- GAME START
- FIRST PLAYER
- ADDITIONAL PLAYERS

C. GAME OVER

D. TILT AND SLAM

INITIALIZATION

The Initialization Mode and its power-up-to-attract sequence is detailed above. The Initialization Mode can tell a good deal of information about the game.

When the game is turned on, the playfield, lightbox and coin chute illumination lamps will turn on to indicate there are no serious problems with the operational power supplies. There should be a 103 msec. delay (for System 80A games) before the coin-lockout coil energizes and the scoring and credit displays light up, with any credits remaining in memory displayed.

After five seconds, the High Game to Date will be displayed in all player displays, and the controlled playboard lamps will strobe and flash. This initialization sequence indicated the Control Board and +5V DC are functioning correctly and there are no serious problems with the Input/Output portion of the game

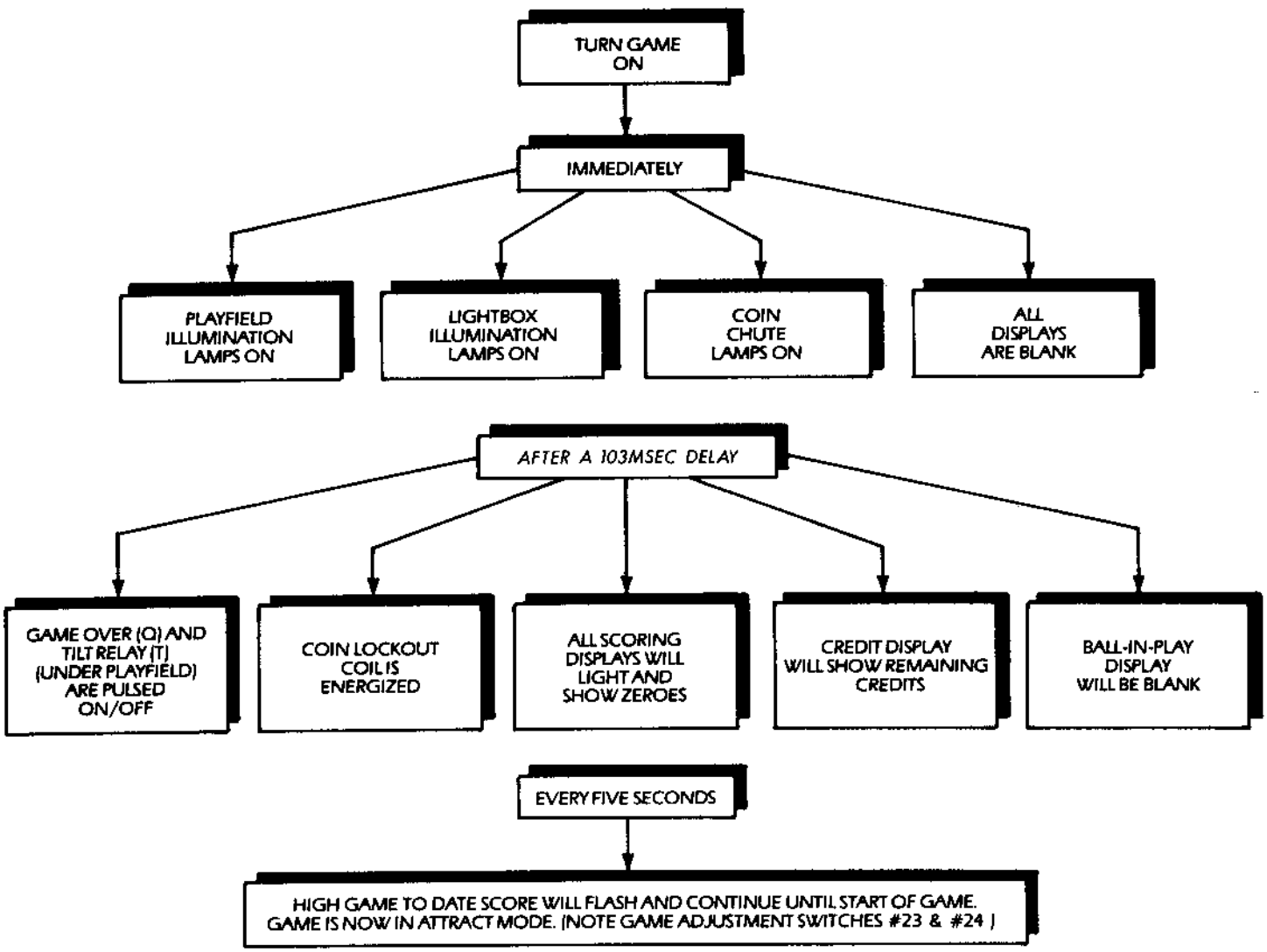


FIGURE 4.

III. MODES OF OPERATION

OPERATION

The balls must be in the ball return trough to start a game.

1. Insert coins into coin chute.
   a. Coin chute tune is played.
   b. Total credits are displayed in status display.
2. Press Credit Button to start game.
   a. Credit tune is played.
   b. Total credits displayed decrease by one.
3. All playfield features reset.
4. The first player score display flashes 2 zeros.
5. When the ball is released to the shooter, the playfield-controlled lamps flash.

FIRST PLAYER

1. First player's score display flashes two zeros.
2. The other player's displays are now blank.
3. A "1" appears on the ball-in-play display.
4. When the ball enters the outhole, any bonus earned is scored.

ADDITIONAL PLAYERS

1. Additional players are indicated by 2 zeros (not flashing) in each corresponding player's display.
2. After the maximum number of players are added, or no more credits remain, the Credit Button has no effect.
3. Additional players can be added anytime the first player's ball is still in play. If the Credit Button is pressed after the first player's first ball has entered the outhole, all players' scores will be erased with the first player's score display showing a flashing zero, indicating a new game only for the first player.

GAME OVER

1. When the last ball enters the outhole, the GAME OVER lamp continually flashes.
2. A random number appears in the ball-in-play display. If this number matches the last two digits in any player's score, a replay (dependent on Switch #27) is awarded.
3. HIGH GAME TO DATE is periodically flashed in all players score displays. When a score higher than HIGH GAME TO DATE is achieved, an award (dependent on Switches #23 and #24) is given.
4. All of the target banks will reset.

TILT MODE

1. Tilting the game results in a loss of ball in play.
2. When the game is tilted, all the playfield lamps go off.
3. All accumulated bonus and bonus multipliers are lost.

SLAM MODE

1. If the normally closed slam switch (located inside front door) is opened, the entire game is ended for all players.
2. The GAME OVER lamp comes on.
3. The entire switch matrix is inactive for three seconds.
4. All coins will be rejected if dropped into any coin chute during the three-second delay.
5. If the match feature exists (dependent on Switch #26), a replay can be won even if the game is slammed.
6. Game returns to the attract mode.

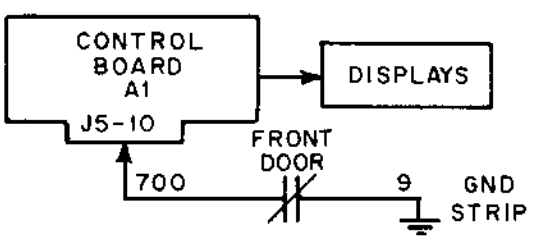


FIGURE 5.

IV. CONTROLLED DEVICES

An electronic pinball machine is operated and played through the use of controlled devices. The controlled devices are the majority of components in a game creating all of the input and output extensions of the A1 Control Board. These devices are the interface between the player and the Control Board computer that allows an assembly of I.C. components and programming to create a fast, interacting game for the player.

The controlled devices within a game consist of lamps, relays, solenoids, switches, displays and sounds. The following chapter examines each area of control and its specific devices. It will focus on the theories of how each type of device is controlled, the signals used to generate control, and how to use the Self-Test and troubleshoot in each category of controlled devices.

A. CONTROLLED LAMPS

B. CONTROLLED SOLENOIDS

C. SOLENOID OPERATION

D. NON-CONTROLLED SOLENOIDS

E. SWITCH MATRIX

F. DISPLAYS

G. SOUND/SPEECH

SELF-TEST

The Self-Test contained in the Control Board includes four steps that will exercise all Input/Output portions of the game and one step that will exercise all memory devices on the board.

Each test will be detailed in the following pages, but the specific devices that are tested in each game can be found in the individual game manuals. Points to remember are: After a test is finished, each test can be repeated by pressing the replay button on the front door; if the replay or Self-Test buttons are not pressed within 20 seconds after a test, the game will return to the attract mode.

The bookkeeping portion of the test can be bypassed if dealing with a service-related problem. Press the Self-Test button to enter the test mode. Next, press the replay button on the front door and Step 16 will appear in the credit display.

In the Self-Test/Bookkeeping Mode, one can use either portion to check the Control Board and game operation. The bookkeeping portion is all steps from 1 through 15, and each is a record of a particular function or event in the game that is important to an operator. The individual functions are detailed in each game manual along with any special notes. All bookkeeping information is checked against itself to make sure it is correct. If any steps in the bookkeeping portion display flashing information, the data may be invalid.

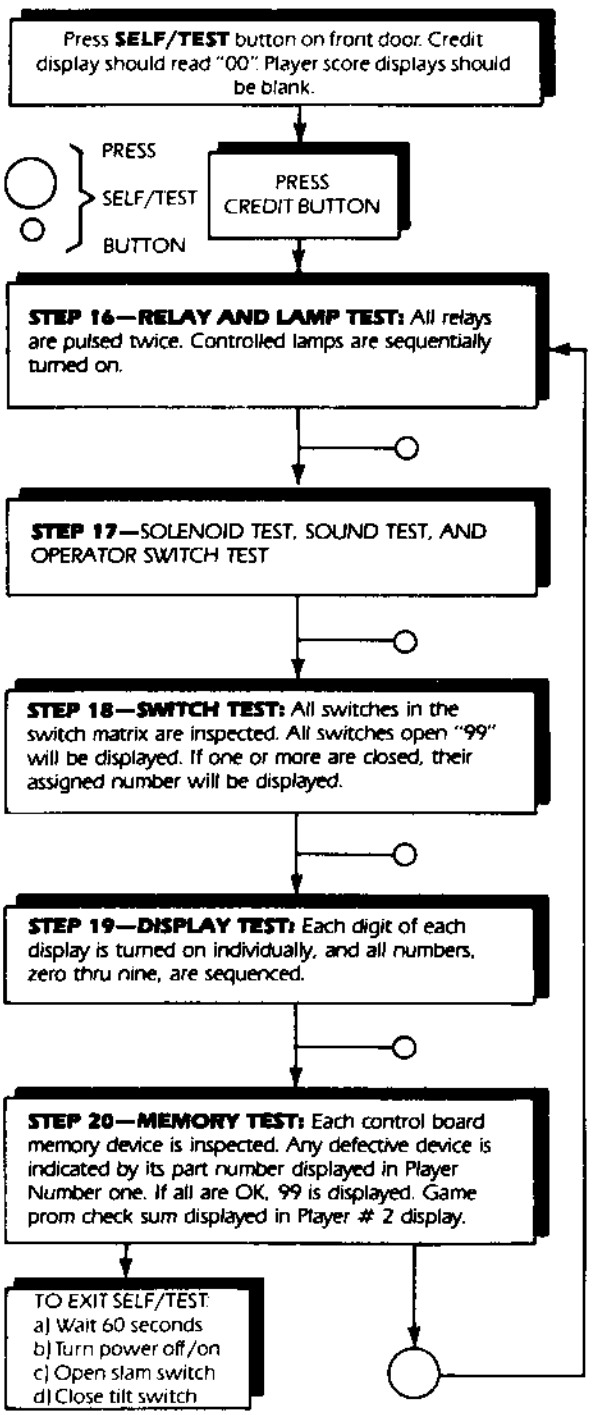


FIGURE 6.

DRIVER BOARD

The A3 Driver Board consists of all necessary circuitry to interface the Control Board to the playfield. It contains three types of driver circuits; lamps, solenoids, and sound signals. These circuits provide four sound enable signals and 61 individual transistor outputs for both low current and high current applications.

The Self-Test Steps 16 and 17 will exercise all Driver Board outputs to the playboard. Step 16 will pulse the "Q", "T", and Coin Lockout relays twice each, and then sequentially strobe all Controlled Lamps on the playboard and in the lightbox. All the Controlled Lamps used in a particular game will be turned on or off within 7 to 10 seconds and then cycle through again. This cycle will be repeated about 15 times within the 90-second test period, allowing each lamp to be turned on or off about 15 times for testing (cycle time and number of cycles depends on the particular game).

Step 17 of the Self-Test will pulse all Controlled Solenoids once, including any solenoids driven through the Controlled Lamp circuitry. The test will then pulse each of the Sound Enable lines once, and the Operator Adjustable Option switch settings will be displayed in hexadecimal format in the First and Second Player displays.

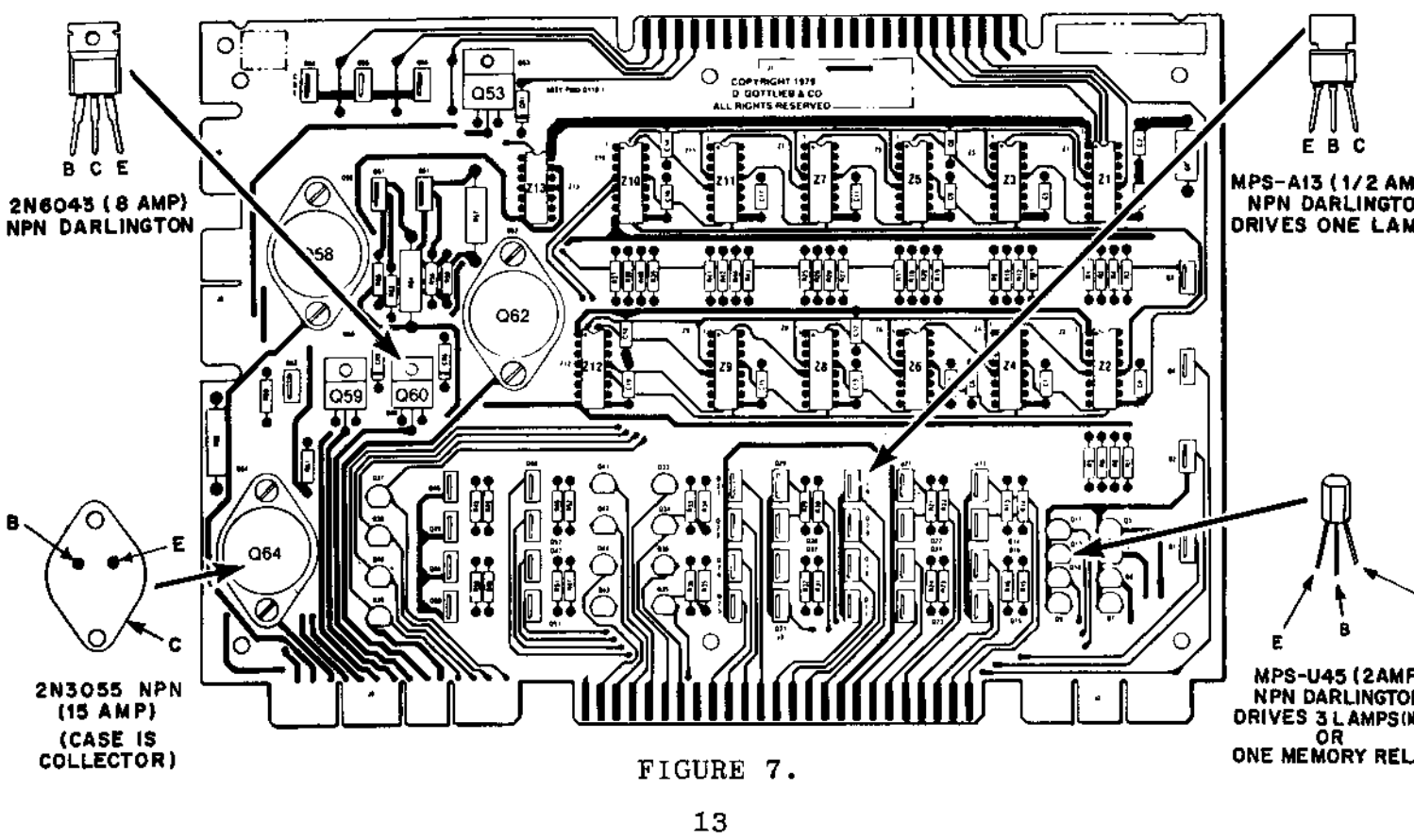


FIGURE 7.

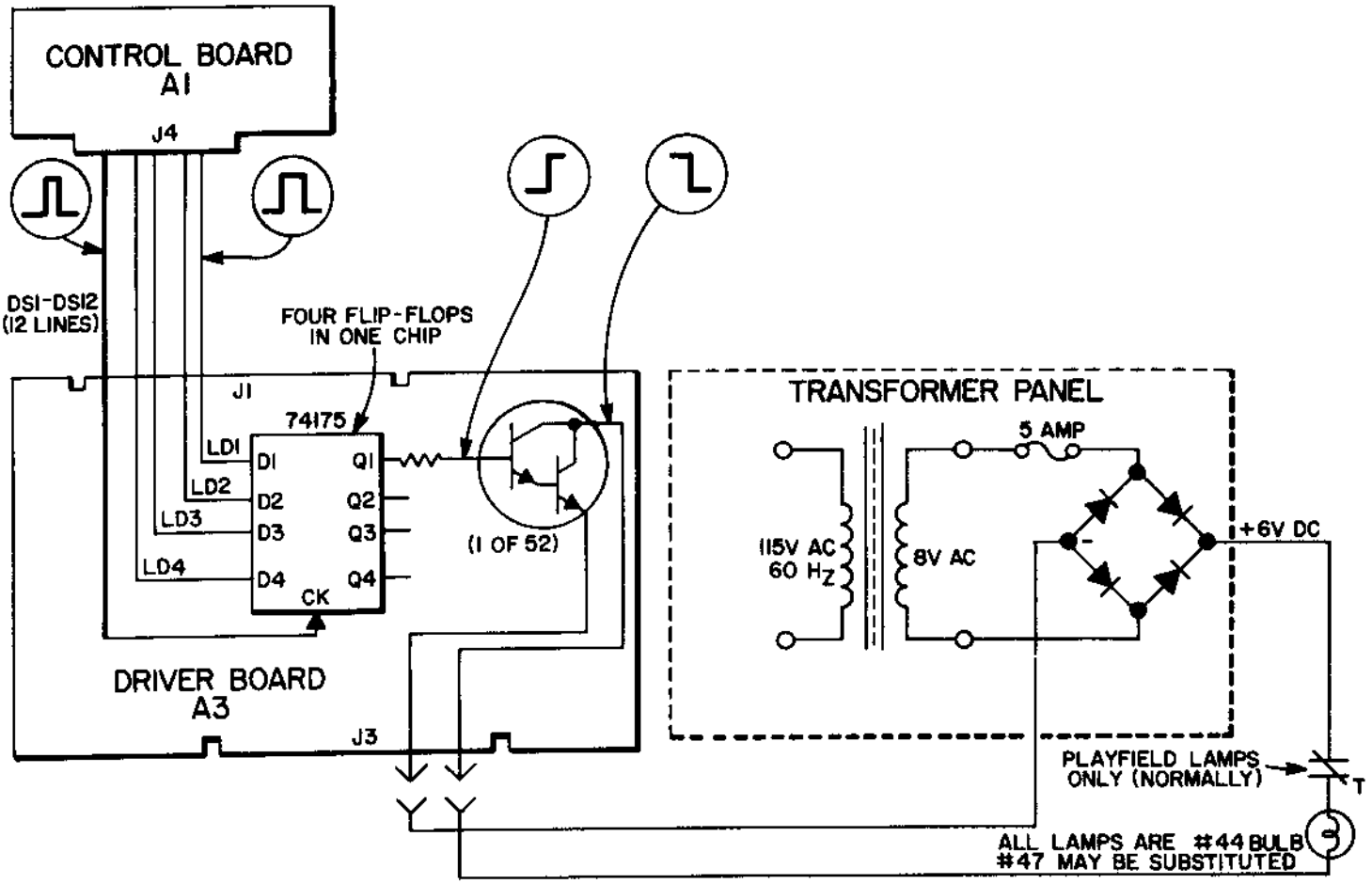
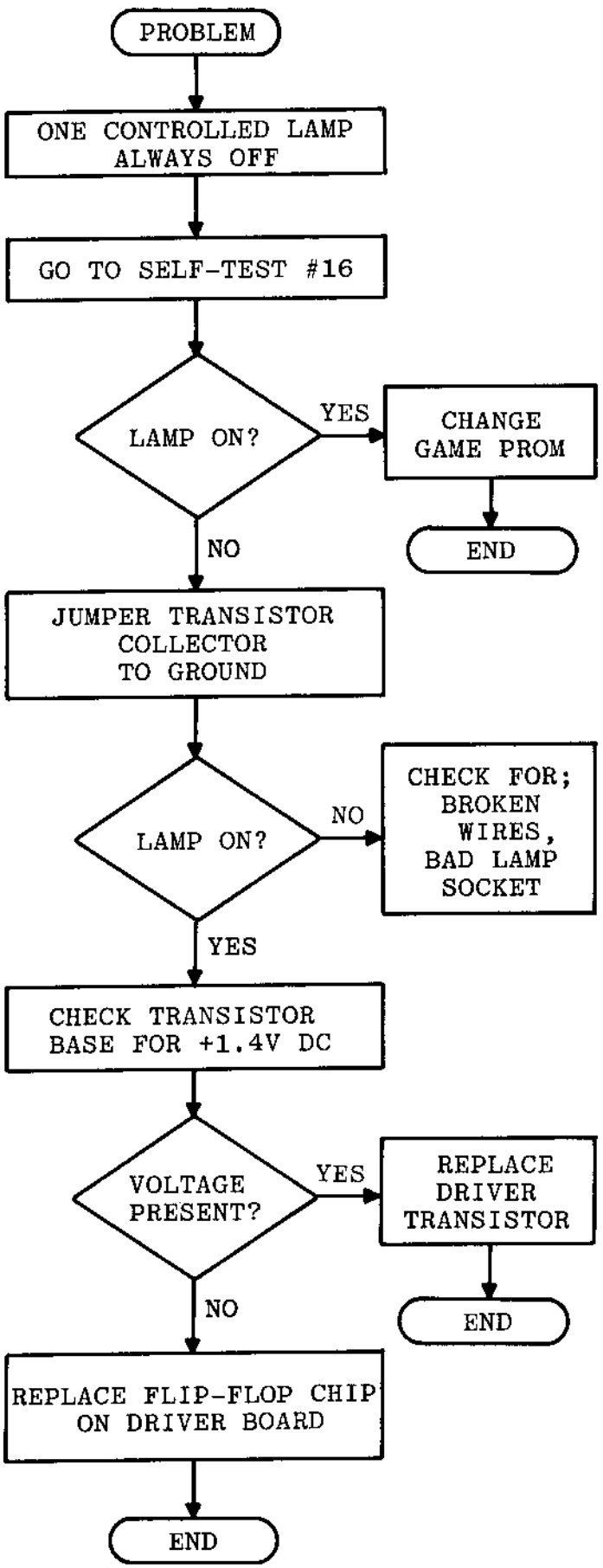


FIGURE 8.

CONTROLLED LAMPS

The circuitry of the Controlled Lamp section provides for the control of 52 individual transistors through the use of only 16 signal lines from the Control Board. Four of these signals are Lamp Data (LD) lines, each of which is applied to all 12 of the 74175 D-type Flip-Flops on the board. The remaining 12 signal lines are the Data Strobe (DS) lines, one each for the clock input (or output enable) connection on each of the 12 I.C.'s. When a DS line pulses high, any high signals at the LD inputs to that I.C. will be Flipped to the output gates, turning on one or more of the four output transistors.

The circuit for a typical lamp is shown in its entirety, including the Flip-Flop, the transistor, and all the signals required to turn on a given lamp. Note that the positive DC output of the bridge rectifier is connected directly to the bulb through a set of normally closed contacts on the "T" relay. All Controlled Lamps in the game are electrically "hot" and the circuit path to ground is completed through the transistor when it is turned on.



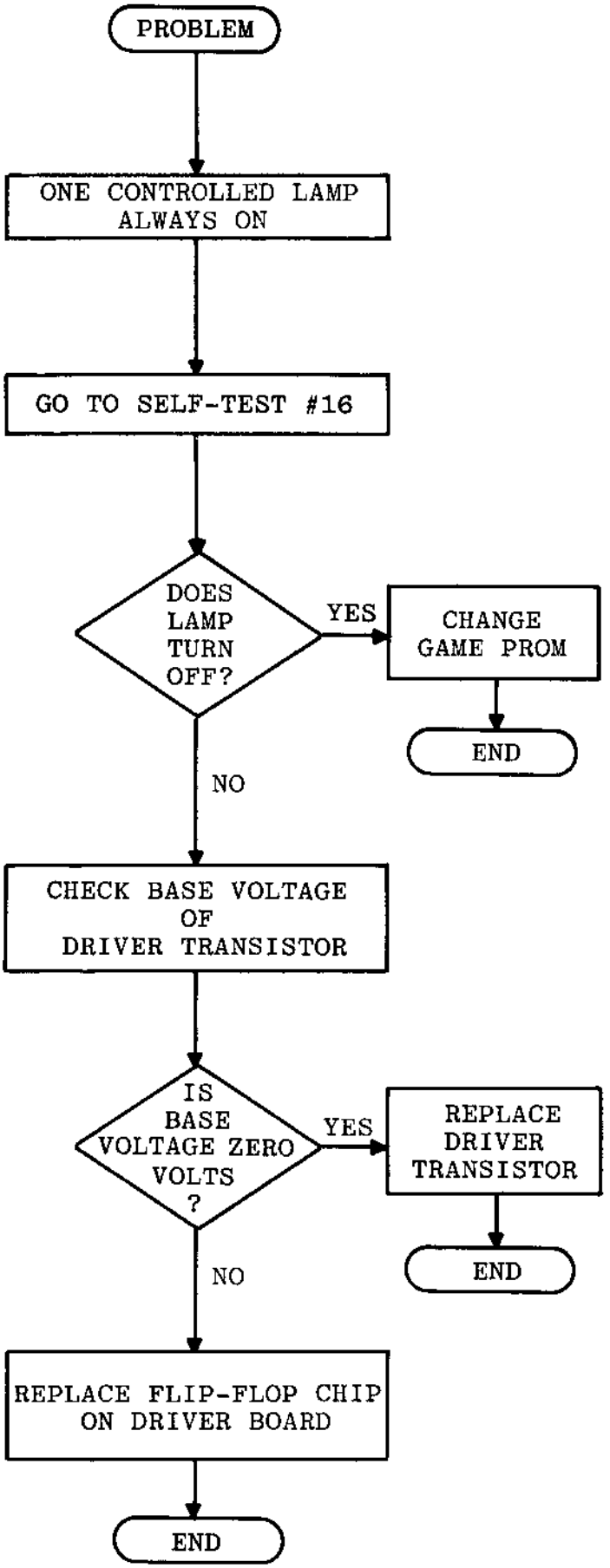


FIGURE 9. CONTROLLED LAMPS

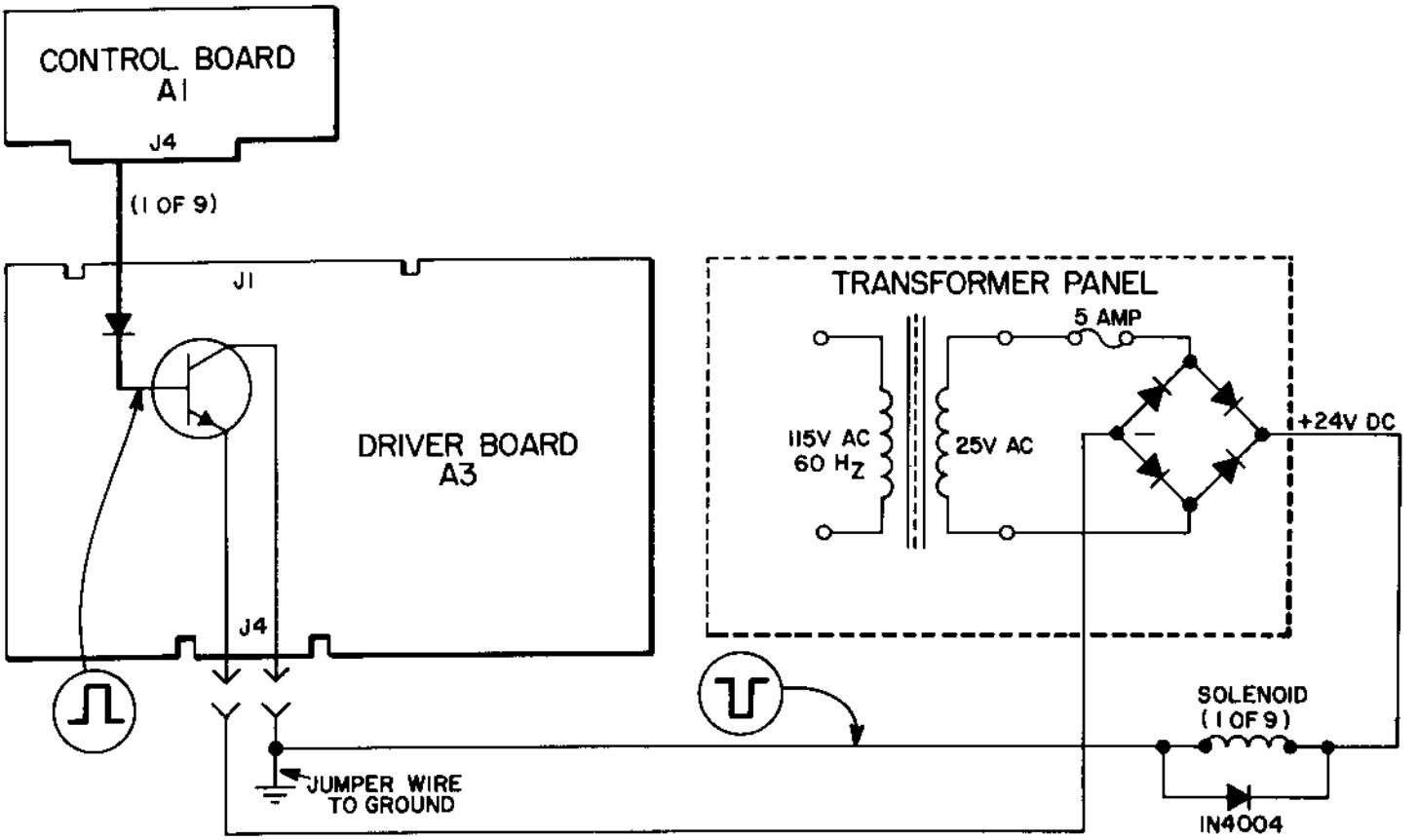


FIGURE 10.

CONTROLLED SOLENOIDS

The Solenoid Driver section of the board drives nine outputs. Six of these outputs are single transistors which receive a positive pulse from the Control Board. A positive voltage above +1.4V DC applied to the base of the transistor will turn on the transistor, completing the circuit path from the collector to the emitter,energizing the solenoid.

The other three Solenoid Driver outputs are designed for high current applications by using transistor pairs. The positive pulse from the Control Board turns on the first transistor, a MPS-U45, causing the +5V DC from the collector to pull the emitter high. The emitter of the MPS-U45 is tied to the base of the high current transistor, a 2N3055, which will then turn on and energize the solenoid. Solenoids 1, 8, and 9 are isolated by 1N4148 diodes, to protect the Control Board from switching transient or feedback voltages.

The Solenoid Driver outputs will be assigned to the necessary devices according to the needs of the game and the programmer. However, Solenoid 8 is always assigned to the cabinet knocker coil, and Solenoid 9 is always dedicated to the Outhole coil.

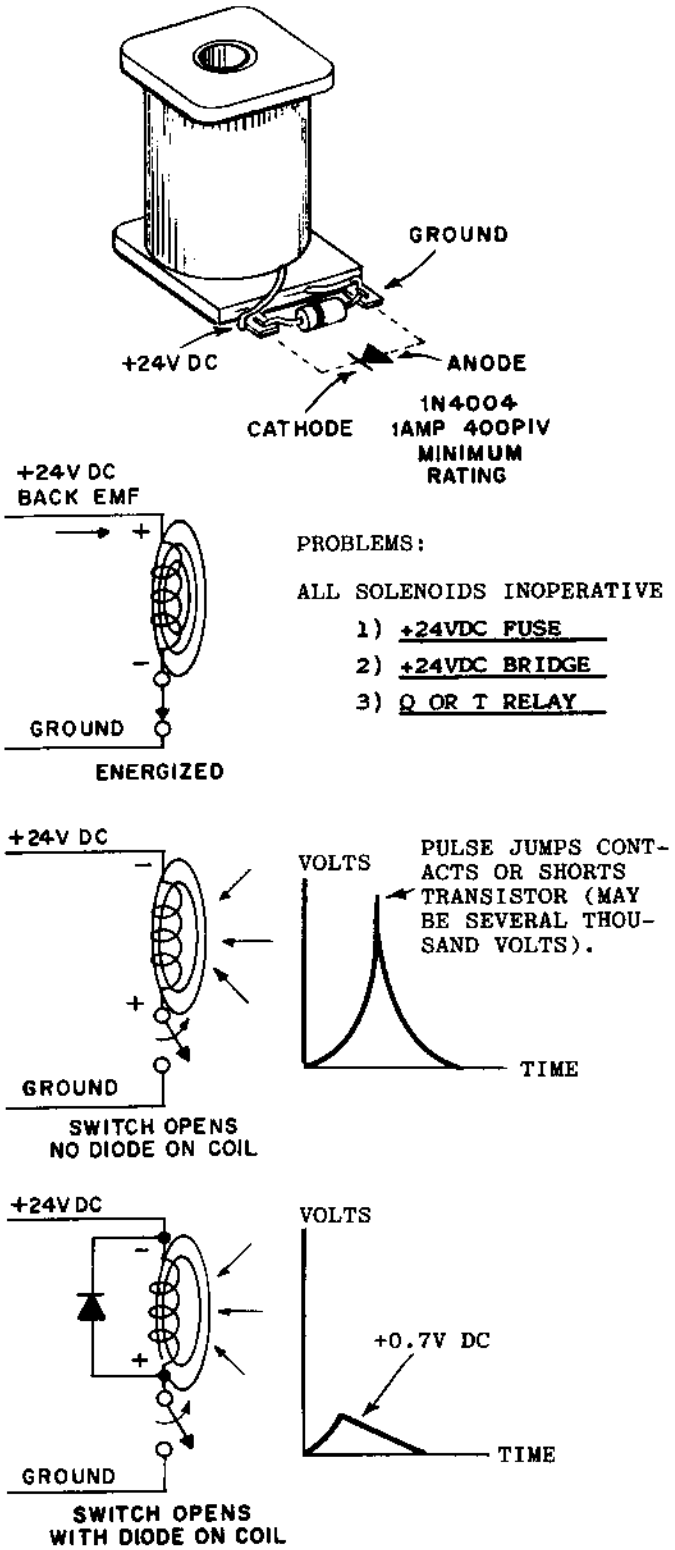


FIGURE 11.

SOLENOID OPERATION

Any current flow through a wire will produce a magnetic field around that wire. If the wire is tightly wound many times around a core (hollow or iron) then a large magnetic field is produced. This magnetic field is then used to pull in a solenoid plunger or to magnetize an iron core which pulls in a relay armature.

When a D.C. current (EMF or Electro Motive Force) is first turned on to a coil, energy is absorbed to create a magnetic field which is called Back EMF.

When the current is turned off, energy still exists in the magnetic field which collapses, releasing energy back to the circuit. The reverse current normally cannot flow anywhere when the switch is opened. The field collapses nevertheless, and the lack of current flow is made up for by the generation of a very large voltage. The reverse voltage creates a new magnetic field in the reverse direction and this process continues for several cycles until the energy is dissapated by the coil resistance.

The purpose of the diode across the coil is to dissapate these voltage spikes. When the current is turned on, the diode is reverse biased and no current flows through it.

As the current is turned off and the reverse voltage is generated, the diode becomes forward biased, and the resistance of the diode absorbs most of these voltage spikes.

NON-CONTROLLED SOLENOIDS

The Non-Controlled Solenoids are the coils in a game that are direct switch activated. They are not electrically "hot" like the Controlled Solenoids, rather the +24V DC is sent to them only when the switch for that coil is closed. The physical movement of the plunger will then pull or push close a separate scoring switch on the Switch Matrix.

The microprocessor does have some control over all these devices in the form of two relays which will switch voltages on or off as needed. The "Q", or Game Over, relay will energize when a game is started and close a set of normally open contacts to switch the voltage up to the playfield. The "T", or Tilt, relay will open a number of normally closed contacts to remove the playfield voltages.

The Pop Bumpers are driven by individual transistors on separate printed circuit boards mounted under the playfield. The Pop Bumper Driver Board has an RC time constant circuit setting the output pulse time from a 74121 Flip-Flop when the switch input is pulled low. This output pulse is inverted and then turns on a 2N6057 high current NPN transistor which insures a strong complete travel of the kicker ring attached to the Pop Bumper plunger.

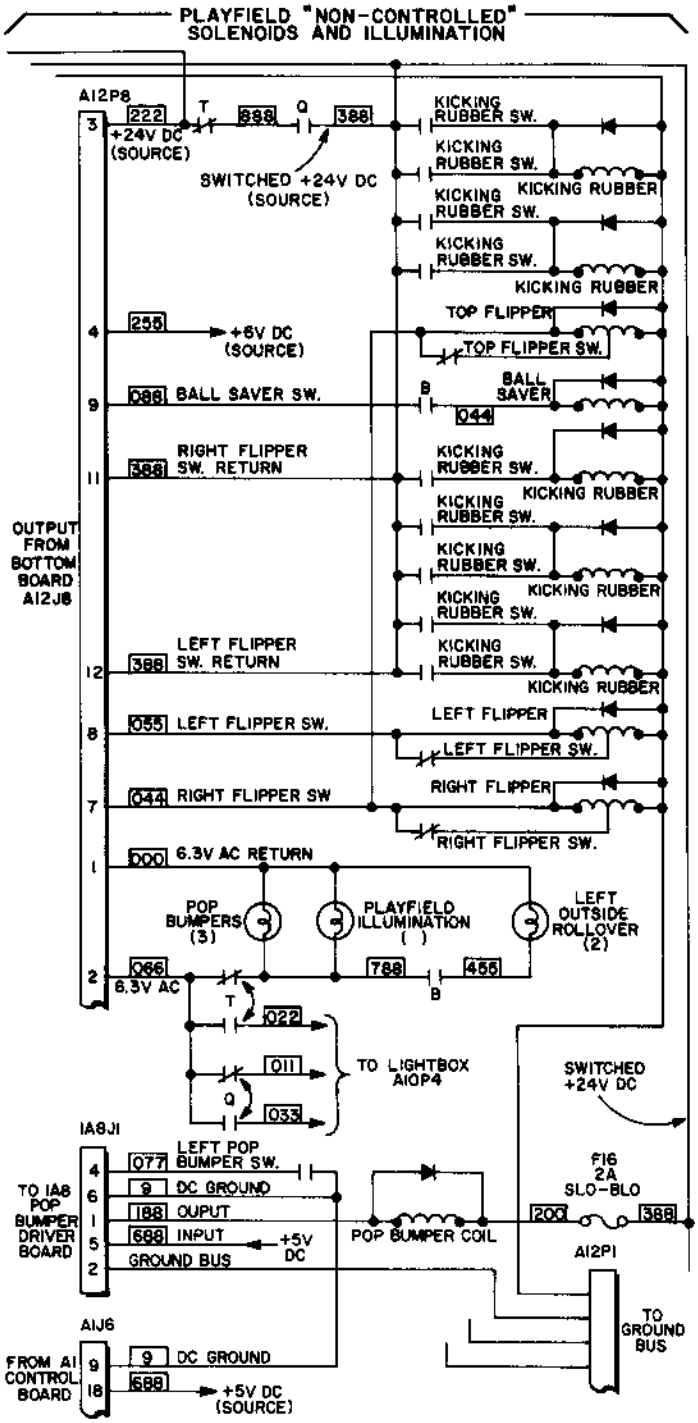


FIGURE 12.

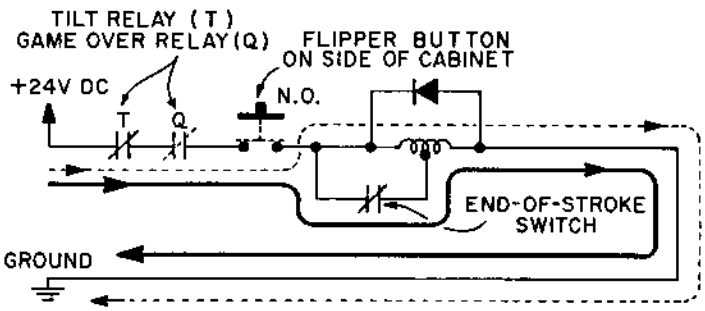


FIGURE 13.

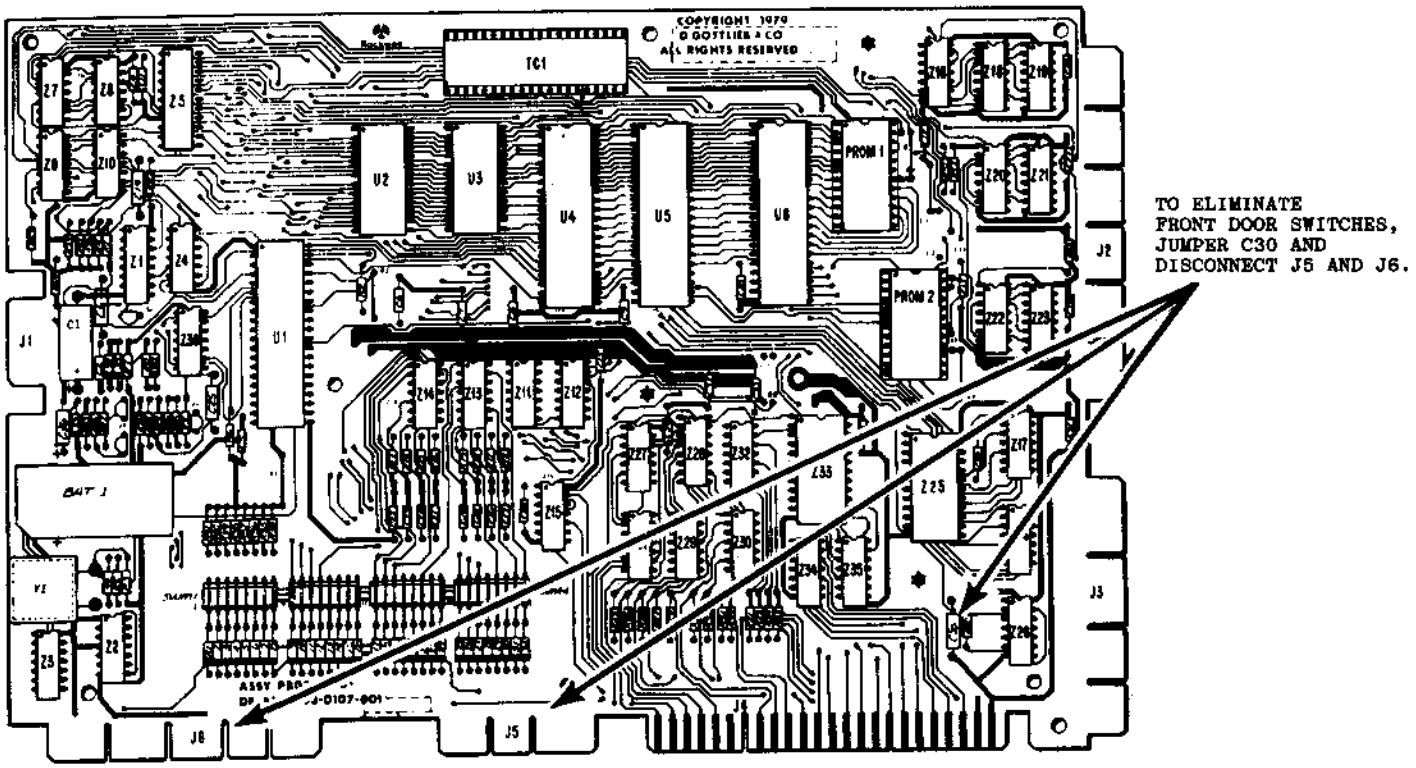


FIGURE 14

Strobes: Eight signals from the PB port of U4, a 6532-1 RIOT I.C. which are inverted by two 7404 I.C.'s, chips Z11 and Z12. (Control Board devices are examined in Section V.)

Returns: Eight return lines tied to one input each, of a two-input NAND gate 7400 I.C. The two NAND gate I.C.'s, chips Z13 and Z14, then send return information to the PA port of the U4 RIOT I.C.

Operator Adjustable Option Switches: Four signals from chip Z15, a 7432 two-input OR gate, are applied to eight DIP switches each, with diodes CR1 through CR32 providing switch isolation. The other input of the two-input NAND gates, chips Z13 and Z14, will read four DIP switches each.

SWITCH MATRIX

The switch matrix of a pinball game is a network of switches that allow the Control Board to monitor the conditions of 64 switch positions while using 16 strobe and return lines. All switches in the matrix are normally open. Eight of the 16 signal lines from the A1 Control Board are called strobe (STR) lines. The remaining eight are called return (RTN) lines.

This is the operation of a single strobe and single return line. The A1 Control Board places a negative pulse $\sqcap_{0V}^{+5V}$ on the STR Ø line. The Control Board examines the RTN Ø line and detects no logic level change (RTN Ø remains at a logic high, +5V DC). So, no action by the Control Board is taken. However, close the switch and a complete path for the negative pulse from STR Ø to RTN Ø is made. RTN Ø is pulled to a logic low $\sqcap_{0V}^{+5V}$ for the pulse duration.
The Control Board now responds to the RTN Ø signal change.

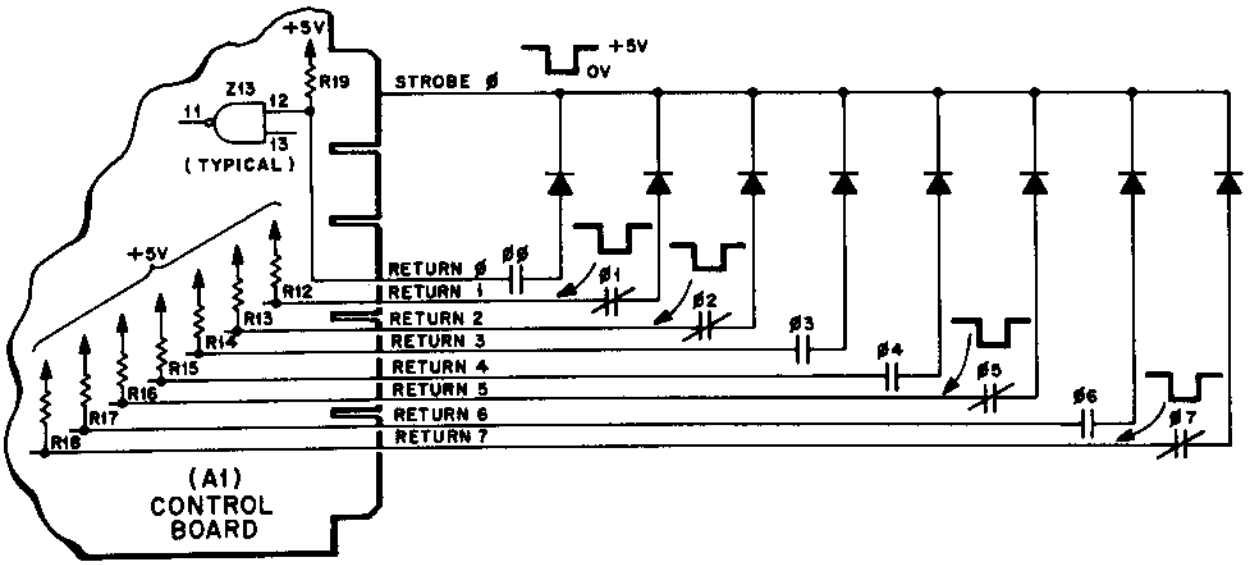


FIGURE 15.

Figure 15 illustrates the complete operation of the STR Ø line, connecting to eight switches. The other end of each switch is attached to a different return line. When STR Ø pulses low, eight switches are "looked at" by the Control Board at the return line inputs. Here, switches Ø1, Ø2, Ø5 and Ø7 are closed. RTN lines 1, 2, 5 and 7 will change their state to a logic low. The Control Board will accept all return line data simultaneously, store it, and then process each data bit (return line information) in programmed sequence.

Looking at a Switch Matrix Schematic Diagram in its entirety will show that eight switches are attached to each strobe line and each return line. This makes a total of 64 possible switch positions. Also observe that each switch is assigned a two-digit number, as in Figure 15. The left digit designates the strobe number and the right digit designates the return line number. Therefore, switch number 23 is connected from STR 2 to RTN 3, and so on.

STROBE SEQUENCING

Strobe lines are not pulsed at the same time. Each strobe line is sequentially pulsed from STR Ø to STR 7 (See Figure 16). All strobe lines are pulsed fast enough so that no switch closures anywhere in the matrix are missed. All switches are examined by the Control Board in 10 milliseconds. A strobe pulse width is 1.25 milliseconds. Switch debounce is handled by the system software. No debounce capacitors across switches are found on Gottlieb's pinball games.

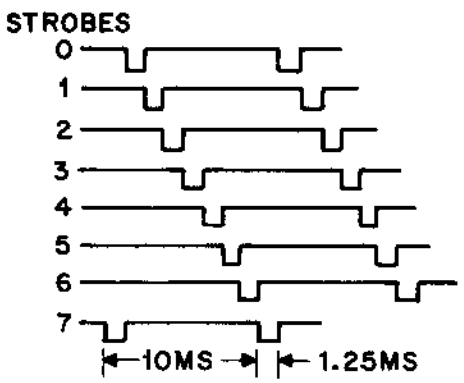


FIGURE 16.

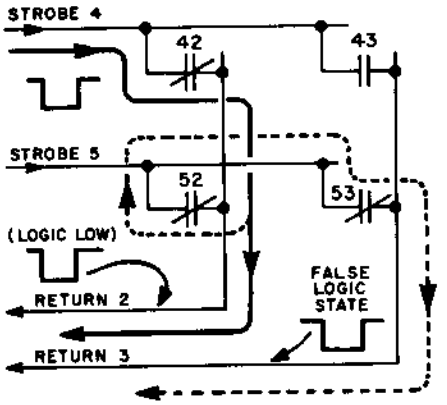


FIGURE 17A.

ISOLATION DIODES

Switch matrix isolation diodes give the matrix individual integrity for each switch. If all diodes are removed as shown in Figure 17A, false switch closures will be sensed by the Control Board. The illustration shows switches 42, 52, and 53 closed. A conductive path is made not only for RTN 2, but for RTN 3 as well. When STR 4 is pulsed, RTN 2 and RTN 3 lines will both change logic states. However, notice switch 43. It is open, and yet the Control Board will process a changed logic state as if it were closed. If a coin switch was assigned to the 43 switch position, a credit was just given without inserting a coin.

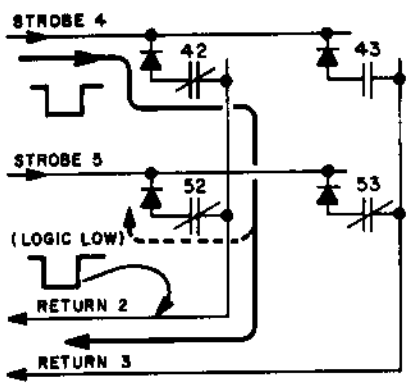


FIGURE 17B.

In Figure 17B, the diodes are placed back into the circuit. STR 4 pulses low, but because the diode becomes reversed biased, no completed circuit to RTN 3 is possible. With the diodes, no combination of switch closures will cause false signals.

The diodes used by Gottlieb are 1N270 germanium type. Using silicon diodes will not guarantee valid logic states when a switch matrix employs a negative strobe system. Do not replace these germanium diodes with silicon type diodes, such as the 1N4148 or 1N4004 diodes.

Dependent on how a diode fails, several different symptoms could appear.

If a diode internally opens, the effect will be isolated to that particular switch. Closing the switch will have no effect on game play, and Test #18 will not display a matrix number.

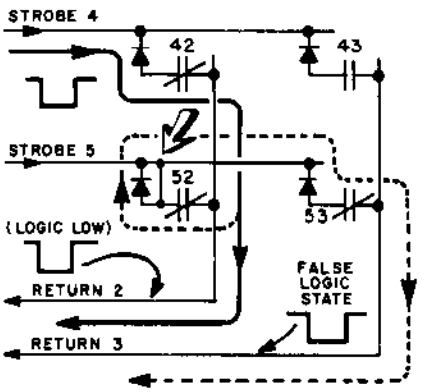
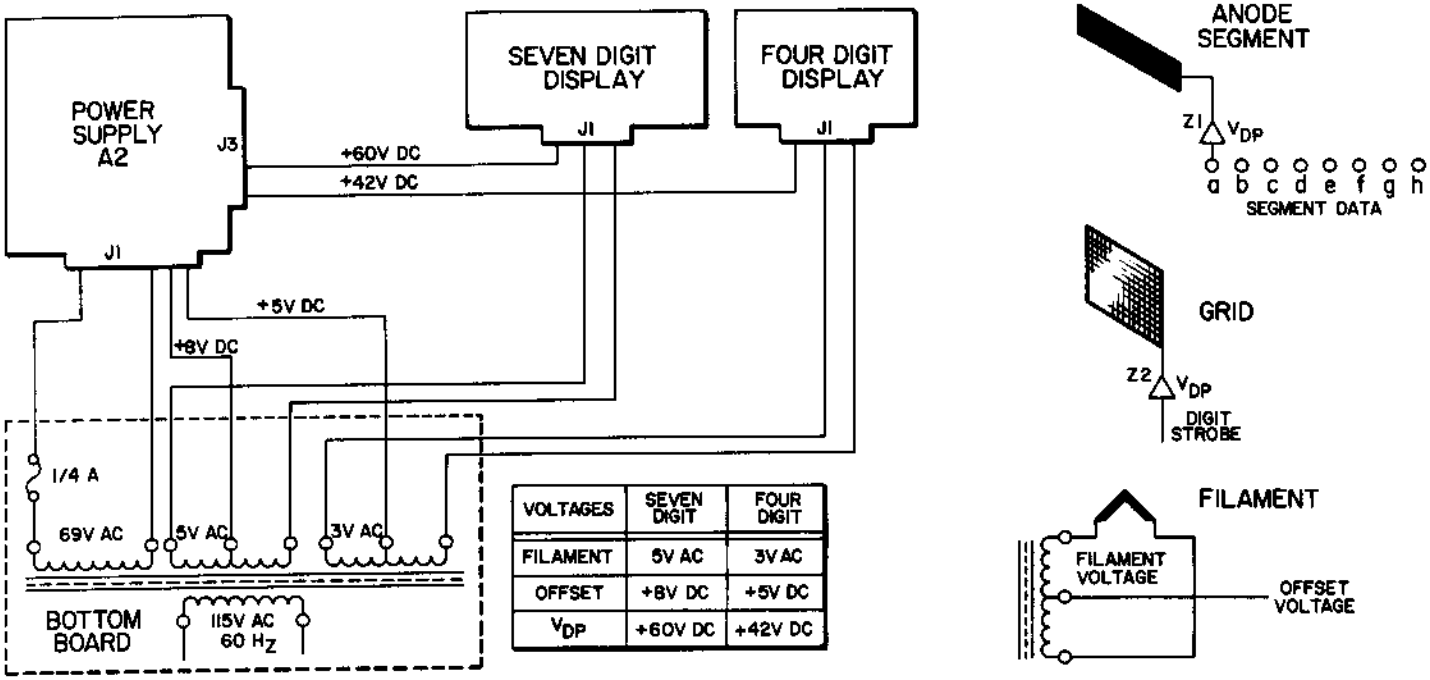


FIGURE 18.

If a diode shorts, the effect becomes more serious. Figure 18 demonstrates that the game loses its switch isolation, and that the return lines may detect false signals. This will cause the game to malfunction and may lead the technician to believe that a bad Control Board or Power Supply is the cause. Note that a reversed diode may generate the same problem as a shorted diode.

The Control Board will not respond correctly if a particular strobe or return line is either open or shorted from one to another. A short to ground or another voltage source on a strobe or return line would also make the Control Board respond incorrectly. In these cases, switches common to the bad strobe or return line will all be affected.



VOLTAGES	SEVEN DIGIT	FOUR DIGIT
FILAMENT	5V AC	3V AC
OFFSET	+8V DC	+5V DC
V_{DP}	+60V DC	+42V DC

FIGURE 19.

DISPLAYS

The theory of operation of a fluorescent digit display tube is similar to the vacuum tube theory. The filament acts as the cathode. When the filament is charged with electricity and heated, electrons are emitted. If a more positive voltage is applied to the anode and grid at this time, electrons emitted from the filament are drawn into the anode through the grid. These electrons striking the anode will excite the fluorescent substance on the anode and emit light. If the anode and grid voltages are dropped to zero or negative, no electrons will be drawn to the anode and no light will be emitted.

The filament, which acts as a direct heated cathode, works on AC power. The constant variation of the AC voltage provides uniform brightness across the face of the display and also assures that the filament wire will not get overheated and break or wear at any point. To cut off the flow of electrons to the grid and anode, a negative voltage (in reference to the filament) must be applied to the grid or anode. Since the filament AC voltage swings negative every half-cycle, just grounding the grid would still allow electrons to flow every half-cycle. For this reason, a low +DC voltage is applied to the filament in addition to the AC voltage. On the negative half-cycle the filament will still have a positive potential above the grounded grid or anode. This is the purpose of the offset voltages for the displays.

The 7-digit display filament offset voltage is +8V DC generated by the +12V DC input to the A2 power supply board by zener diode CR7 and R10. The 4-digit display filament offset voltage is +5V DC, which is the same as the logic supply voltage. The +8V DC is applied to the center tap of the 5V AC winding on the small transformer. The +5V DC is applied to the center tap of the 3V AC winding on the small transformer. The two pairs of AC offset voltages then go up to the displays in the lightbox via connector A12J4.

The display control signals originate at the A1 control board and are wired directly to the displays. There are 16 digit control lines and three groups of 8 segment lines that are common wired to three groups of displays. The common wiring is actually a combination of cross wiring between digits, segments, and displays.

The digit lines are always sequentially strobed, so only one line at a time will be high. The processor will fill each segment group with the data or blanking information that is necessary for each digit.

For instance, if there is a first and second player up, then the "B" segment group will always be filled with blanking information. So when the digits are strobed for the 3rd and 4th player, the segments will be low, and the display will be blank. If 1st player only is up, then the processor will fill the "A" group with blanking information when the digits D7 through D13 are high. The microprocessor scans each digit 61 times a second so displayed data will look constant to the eye.

The configuration of our display signal wiring is as follows:

	Group	Player Display
Segments:	A	1st & 2nd player
	B	3rd & 4th player
	C	Status (& Bonus if present)
Digits:	D1 - D6 & D16	1st & 3rd player (& Bonus if present)
	D7 -D12 & D13	2nd & 4th player
	D13-D16	Status

1. Segment problems will be shared by displays of Players 1 & 2 and 3 & 4.
2. Digit problems will be shared by displays of Players 1 & 3 and 2 & 4.
3. One bad display may cause other displays to appear defective; however, this may not be the case. Disconnect one display at a time and observe what happens to the other displays.

CAUTION: Do not plug or unplug displays with the power on. Damage to the control board will result.

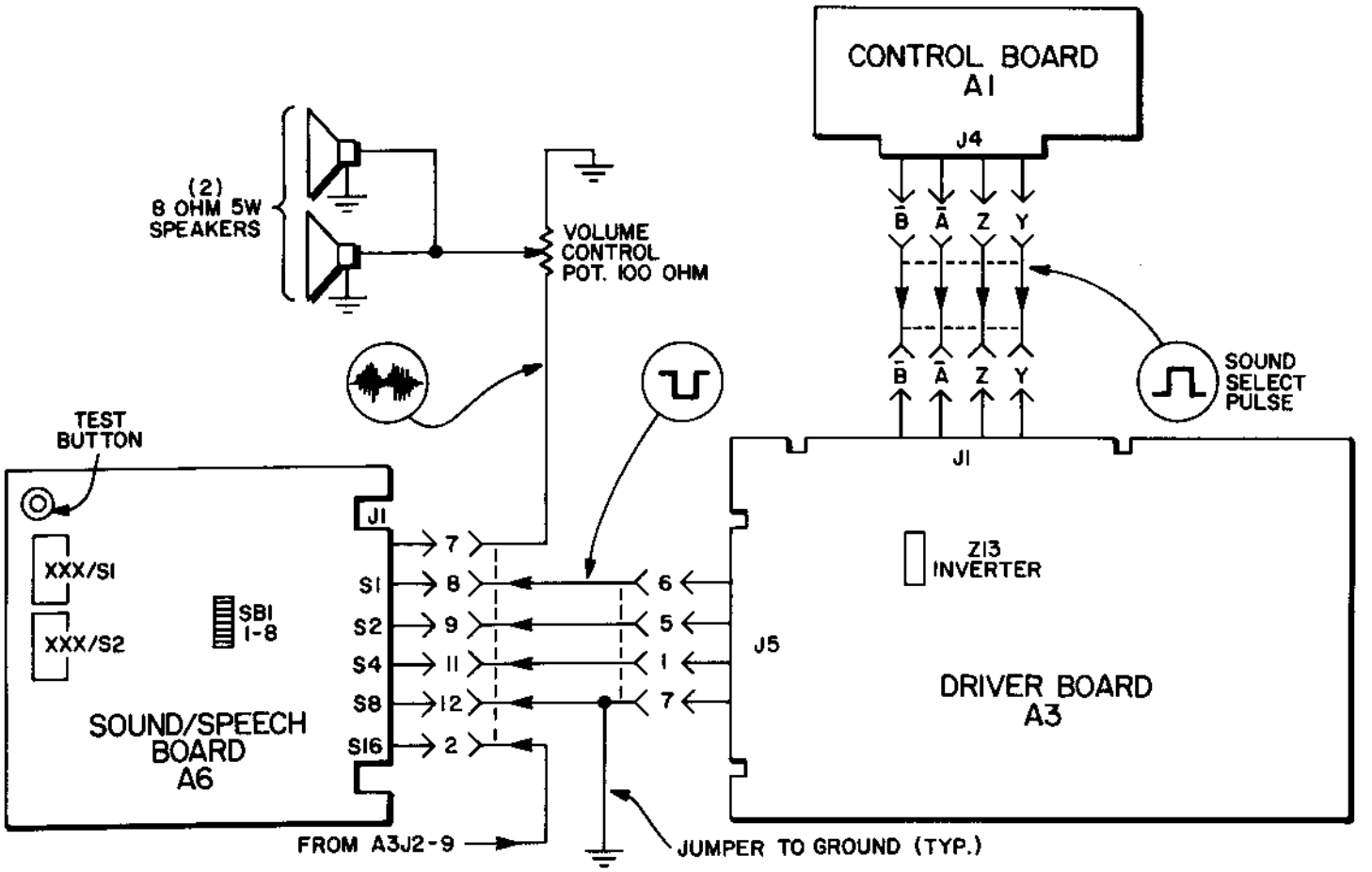


FIGURE 20.

SOUND/SPEECH

POWER SOURCE

Four input voltages are required for proper operation of the Sound/Speech Board. They are:

1. +30V DC - used for the LM379 Amplifier
2. +12V DC - used for the DAC's, the SC01A and the LM741's.
3. -12V DC - used for the DAC's and the LM741's.
4. +5V DC - used for the 6502 (CPU), the 6532 and all TTL.

The +30, +12, and -12 DC voltages are supplied to the A6J1 connector from the A7 Auxilliary Power Supply. The +5V DC originates at the A2 Power Supply.

SIGNAL SOURCE

The binary sound information originates in the A1 Control Board and is then sent to the A3 Driver Board to be inverted. The four signals, S1, S2, S4 and S8 go through Z13, a 7404 hex inverter and are then output to the Sound/Speech Board through connector A3J5. The Sound/Speech Board also receives a signal from Q10 (on the Driver Board) which is part of the Lamp Circuitry, and is output as S16 through connector A3J2.

A. MICROPROCESSOR

Gottlieb's System 80/80A Control Boards are built around a Rockwell 6502 microprocessor which operates on a single +5V DC supply voltage. A brief description of each LSI component follows.

The Rockwell 6502 is an 8-bit microprocessor which has many positive features: single supply voltage, full 16-bit address bus, two levels of interrupt priorities, and a two-phase clock which is generated on-board.

The microprocessor receives instructions off the data bus from peripheral devices; RAM, ROM, and PROM. It is an 8-bit bus, DBO-DB7, with the data being transferred while the $\phi 2$ clock is high. Addressing for all external memory is output from the microprocessor on the 16 address bus lines, AB0-AB15. In this particular application, AB14 and AB15 are not used. AB0 through AB6 are applied directly to the address bus. AB7 through AB13 are applied to the bus, however they are also combined through various gating combinations for PROM select, RAM select, RIOT enable, etc. These lines are buffered by Z7 and Z10 since they are capable of driving only one TTL load each.

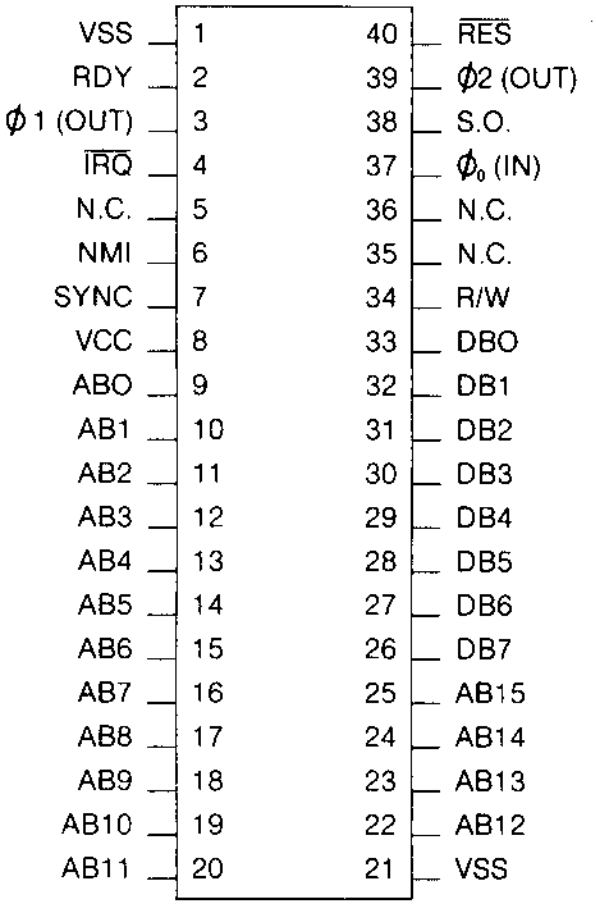


FIGURE 21.

A0 TO A15 — 16 address lines, designated in hexadecimal notation in 4 groups of 4 lines.

D0 TO D7 — 8 data lines—bi-directional—designated in hex in 2 groups of 4 lines.

$\overline{RES}$ — Low to reset system, high to run.

$\overline{IRQ}$ — Interrupt request—high for normal program sequence—low when one of the RIOT's requests an interrupt.

R/$\overline{W}$ — Read write line. High to read, low to write. Instructs RAM and RIOT's whether data on the bus is being written or being read.

ϕ0-ϕ2 — Clock circuit. ϕ0 is input from the crystal. ϕ2 is output to RIOTs.

The microprocessor receives an approximately .85MHz clock signal on pin 37, ϕ_0(IN) from Z2, pin 9. The clock signal is converted into a two-phase system clock internally and is output on pin 39, ϕ_2(OUT) to other devices which require system timing.

The reset line, $\overline{RES}$, pin 40, is held low when power is first applied. Once V_{CC} reaches a level determined by the reset hardware, $\overline{RES}$ goes high and remains high as long as power remains on. This reset insures that as the microprocessor starts to operate the program counter is initialized to zero, and execution of the program begins at the proper address.

Interrupt request, $\overline{IRQ}$, pin 4, receives low going signals from the three RIOT devices when an interrupt needs to be serviced. The microprocessor then completes its current instruction and goes directly to the designated interrupt routine. The non-maskable interrupt, $\overline{NMI}$, is not used and is tied high through R10.

Read/Write control, pin 34, determines whether data on the bus is read from RAM or written into RAM. This signal is high to read, low to write, and goes to the three RIOT devices and the bookkeeping RAM.

B. RAM I/O TIMER

All input-output functions of the microprocessor are handled by R6532 RAM INPUT-OUTPUT TIMER devices (RIOT). Each RIOT contains two 8-bit bidirectional data ports which can be used to transmit data from the microprocessor system to external circuitry or to receive data from external circuits and enter it into the microprocessor. The I/O lines are directly compatible with TTL or CMOS devices. Each line is capable of driving one TTL load.

Each RIOT also contains 1024 bits of RAM memory in a 128 x 8 configuration. Addressing is accomplished through the seven address lines, A0 to A6. $\overline{RS}$, pin 36, must be low for the RAM section to be enabled. When the READ/WRITE line, pin 35, is high, the RAM is in the read mode. When R/$\overline{W}$ is low, the RAM is in the write mode.

Two chip select lines CS1 and $\overline{CS2}$ are provided as enable lines for the RIOT. CS1 must be high and $\overline{CS2}$ must be low for the RIOT to be enabled. A reset input, $\overline{RES}$, pin 34, must be held low as the system is initialized to zero all internal registers and to prevent false data from being transferred out of the system during power up. Once the microprocessor has initialized, the $\overline{RES}$ line should go high and remain high.

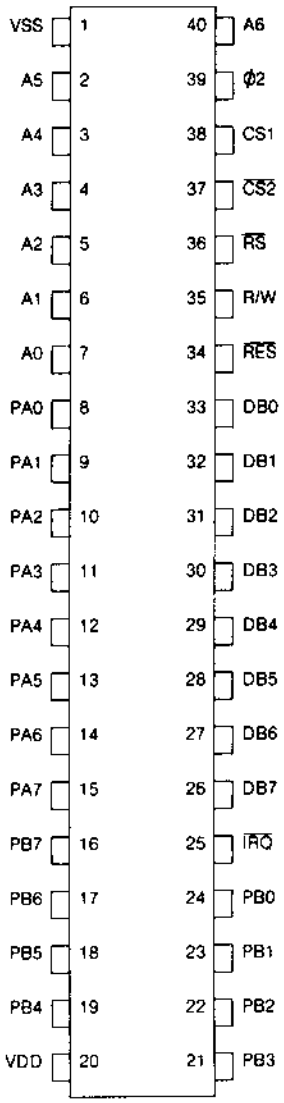


FIGURE 22.

CS1-CS2 — Chip select lines. CS1 high to select, CS2 low to select.

RS — RAM select—low to select the RAM section of the RIOT.

PB0-PB7 — A group of 8 lines which may be used as inputs or outputs from the system. PB ports are capable of direct drive of Darlington Transistors.

PA0-PA7 — A second group of 8 lines for input/output uses. PA7 can be used as an edge detecting input that generates an interrupt.

A0-A6 — Address bus.

D0-D7 — Data bus.

The interrupt request line, IRQ, pin 25, is normally high and goes low whenever the RIOT wants to transmit an interrupt to the microprocessor.

System timing is maintained by the Ø2 clock which enters the RIOT at pin 39. All data transfers on the bus take place when Ø2 is high.

One RIOT, U5, uses I/O port PA7 as an edge triggered interrupt for the slam switch input. This gives the slam switch a higher priority than other input functions.

C. BACKGROUND ROM (2332A)

Two ROMs, U2 and U3, each contain 4K bytes of memory in a 4K x 8 configuration. This is "background" memory and does not change from game to game. Addressing is received from the microprocessor and data is read directly onto the data bus. The S2 input, pin 21, is used to select which of the two ROMs is enabled at any given time.

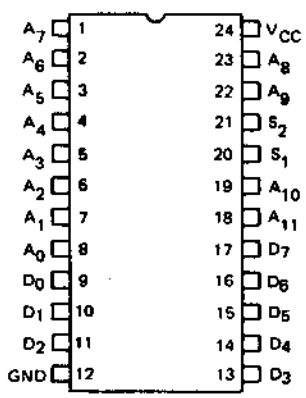


FIGURE 23.

A0-A11 — 12 address lines.

D0-D7 — 8 data lines.

S1-S2 — Chip select lines—both high to enable chip.

D. BOOKEEPING RAM

Data which must be retained when the game is turned off is stored in Z5, a P5101 CMOS RAM. The 5101 is a 256 x 4 RAM with low power consumption when the CE2 line, pin 17 is low. Since the 5101 is a 4-bit RAM, it is connected only to the lower four data bus lines, DB0 through DB3. Addressing is provided directly off the address bus from the microprocessor.

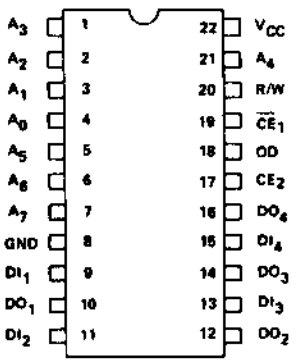


FIGURE 24.

$\overline{CE}$1 — Chip enable—low to enable RAM—does not disable input and output buffers.

CE2 — Chip enable—low to disable RAM and place it in low power standby.

OD — Output disable—places outputs in 3 state configuration "OFF"—high to disable.

R/W — Read/Write control. High to read RAM—low to write into RAM.

DI-1-DI-4 — Data in lines 1 thru 4.

D0-1-D0-4 — Data out lines 1 thru 4. The data in and data out lines are tied together in this system and the R/W and OD lines are used to control data direction flow.

A0-A7 — Address bus.

E. PROM

The other type of memory used is the programmable ROM (PROM) which is changed from game to game. The PROM is a 2K byte device with a 2K x 8 configuration. Address and data information is transferred on the microprocessor bus system. Chip Enable, $\overline{CE}$ at pin 18, is used as the PROM SELECT. As the R/$\overline{W}$ line is pulled high, then the Output Enable, $\overline{OE}$ at pin 20, will be pulled low so the data can be read out of the PROM onto the data bus.

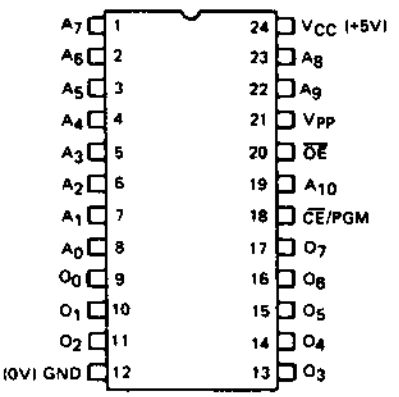


FIGURE 25.

$\overline{CE}/\overline{PGM}$ — Chip Enable - low to enable ROM - does not enable data outputs.

$\overline{OE}$ — Output Enable - low to enable data outputs after the address has been selected.

O0-O7 — Data bus.

A0-A10 — Address bus.

The remaining circuitry on the control board is standard TTL and CMOS. It is used primarily to buffer all inputs and outputs from the microprocessor to the external areas of the game. This prevents most external failures in the game from damaging any of the LSI devices.

F. CONTROL BOARD

Gottlieb has used three generations of the System 80/80A Control Board. The boards can be identified by the board assembly detail number in the lower left corner of the board underneath the DIP switches (See Figure 26).

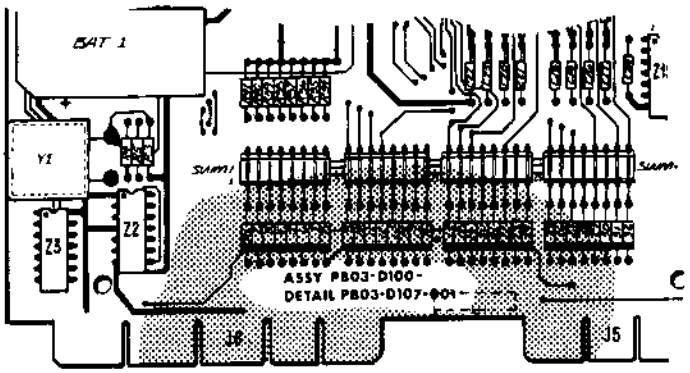


FIGURE 26.

The first generation of Control Boards used two HM7641 PROMs and can be recognized by the detail number following the assembly number. The number reads:

DET. PB03-D102-001 or
DET. PB03-D102-002
REV. A or REV. B

This board was used with the first System 80 game, Spiderman, and in Panthera, Circus, Counterforce, and Star Race. If there are four jumper wires and two traces cut on the non-component side of the board, then it has been modified to be used with the one PROM system.

The first single PROM Control Board used a 2K x 8 2716 EPROM. The second PROM socket was left in the board, but the trace changes left it unusable. The detail numbers are:

DETAIL PB03-D107-001 or
DETAIL PB03-D107-003

This Control Board was used with all remaining System 80 games from James Bond through Haunted House.

Beginning with the first System 80A game, Caveman, the Control Board incorporated four changes:

- The unused PROM 2 socket was removed.
- The Program Background ROMs at locations U2 and U3 were rewritten for our improved Self-Test, improved Option Switch settings, and new Seven Digit Display.
- The two ROMs at U2 and U3 were socketed.
- The Control Board assembly number was removed and replaced with the board's part number, D-20869.

By socketing the two ROMs the Control Board can be used with either System 80 or System 80A one PROM games, by simply using the appropriate set of ROM memory chips. Refer to your specific game manual to determine the system type.

However, for testing purposes, any System 80/80A Control Board will power-up normally in any Gottlieb System 80/80A game. Also, any Control Board will respond to the Self-Test switch, the coin switches, the Replay button, and the Tilt and Slam switches. All other switches will differ from game to game.

SYSTEM 80/80A MEMORY

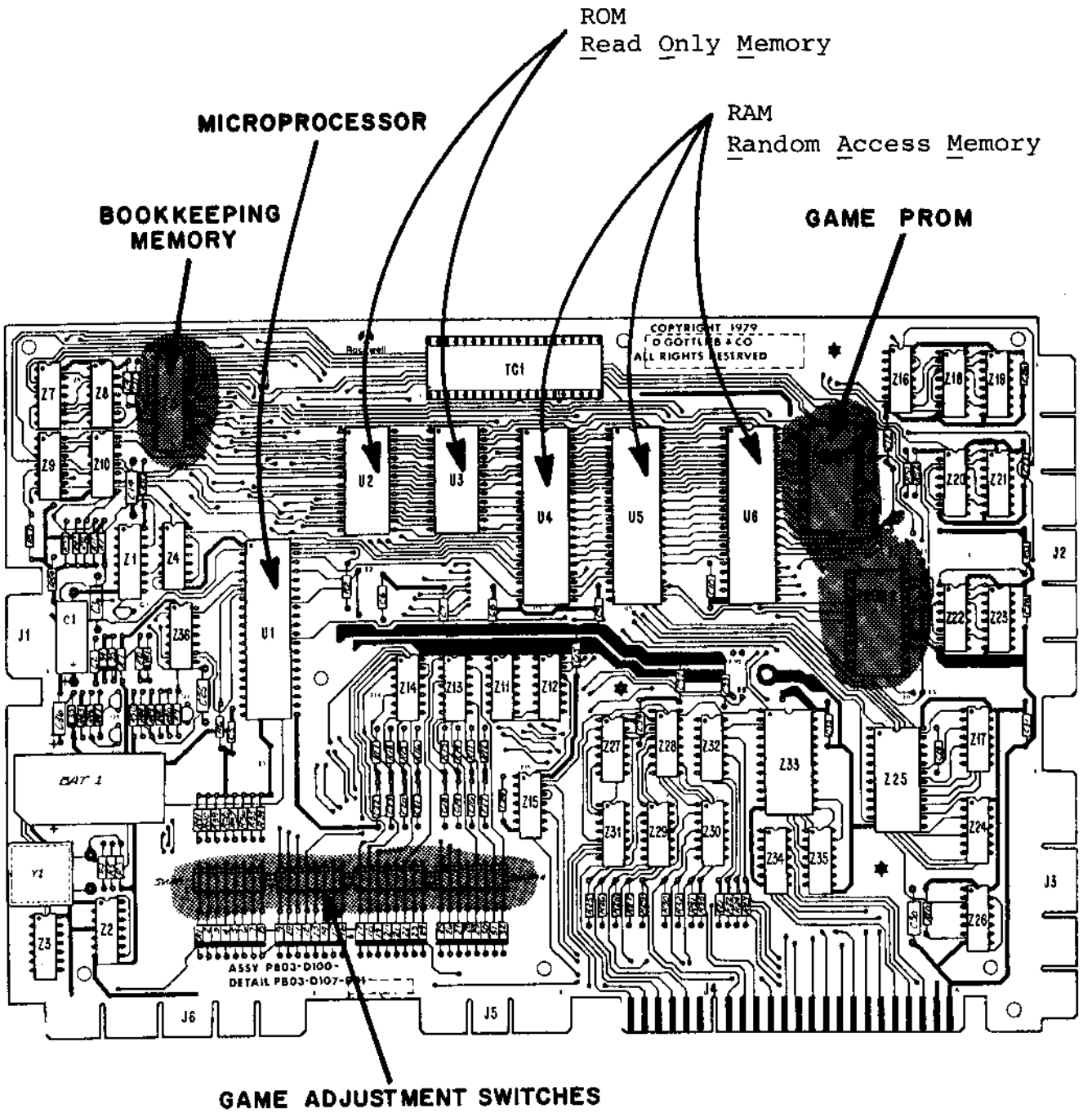


FIGURE 27.

VI. VIDEO TROUBLESHOOTING

A. INTRODUCTION

The Gottlieb video graphics generator system consists of the game printed circuit board, inputs and outputs to switches, speakers, and lamps, the video monitor, the power input and the transformer panel. Each of these devices has specific functions which can be defined as follows.

The 115V AC input and transformer panel receive the line voltage and break it down into the unregulated AC supplies to the Power Supply Assembly, and 115V AC isolated for the monitor and fluorescent illumination. There are two Bridge rectifiers on the panel to supply unregulated +5V DC for the Coin Door lamps and an unregulated +11.5V DC for the Logic Supply reference.

The video monitor is a Wells-Gardner 19" In-Line Color monitor providing a high resolution color display from the three color input signals and horizontal and vertical syncronization.

Inputs come from Coin switches 1 and 2, Self Test, and Control panel switches. The outputs from the CPU board control the coin meter, control panel lamps, and the sound codes to the Sound Speech Board.

There are also internal CPU Board input and output functions used to synchronize various portions of the system.

The A3 printed circuit board is the Power Supply Assembly which provides the regulated DC voltages to the electronics boards to control the game. There are regulated DC outputs of +5V DC, +30V DC, +12V DC, -12V DC, and an unregulated +20V DC for the coin meter.

The Sound/Speech Board contains it's own semi-intelligent processor, RAM, and Sound ROM's, which receive input sound codes from the A1 CPU Board and then outputs the appropriate signals to it's internal amplifier which directly drives the speaker system.

The Interface Boards allows one input port to interface to the track ball or rotary encoder. This device will decode the player control inputs into 8-bit binary information for the CPU board to read. Also after each read cycle the interface board resets the output buffers to logic 0.

The CPU/Video Board contains an Intel 8088 Central Processing Unit (CPU) microprocessor, Memory, Input/Output Ports, and the Video sub-system. The microprocessor performs the logic functions of accessing and using the system areas mentioned above, according to the game program. The Video sub-system is a semi-independent Video-State Machine generator, which is further sub-divided into three parts; A separate System Clock to generate the verticle, horizontal, enable and sync lines; An "object oriented" Foreground generator; And a "character-oriented" Background generator. The State machine address and data lines also access separate Video ROMs to generate the objects and characters that the microprocessor ROM program selects.

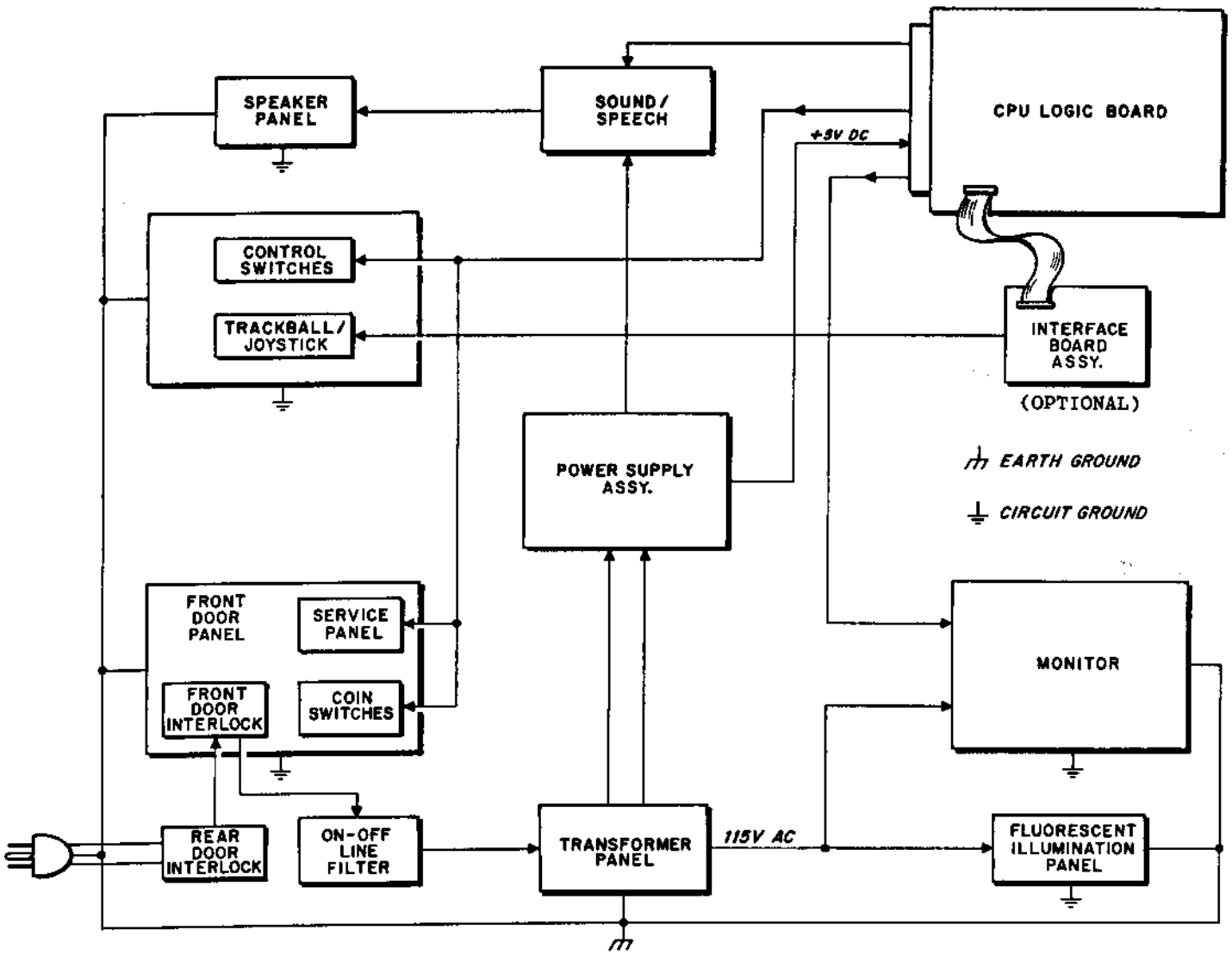
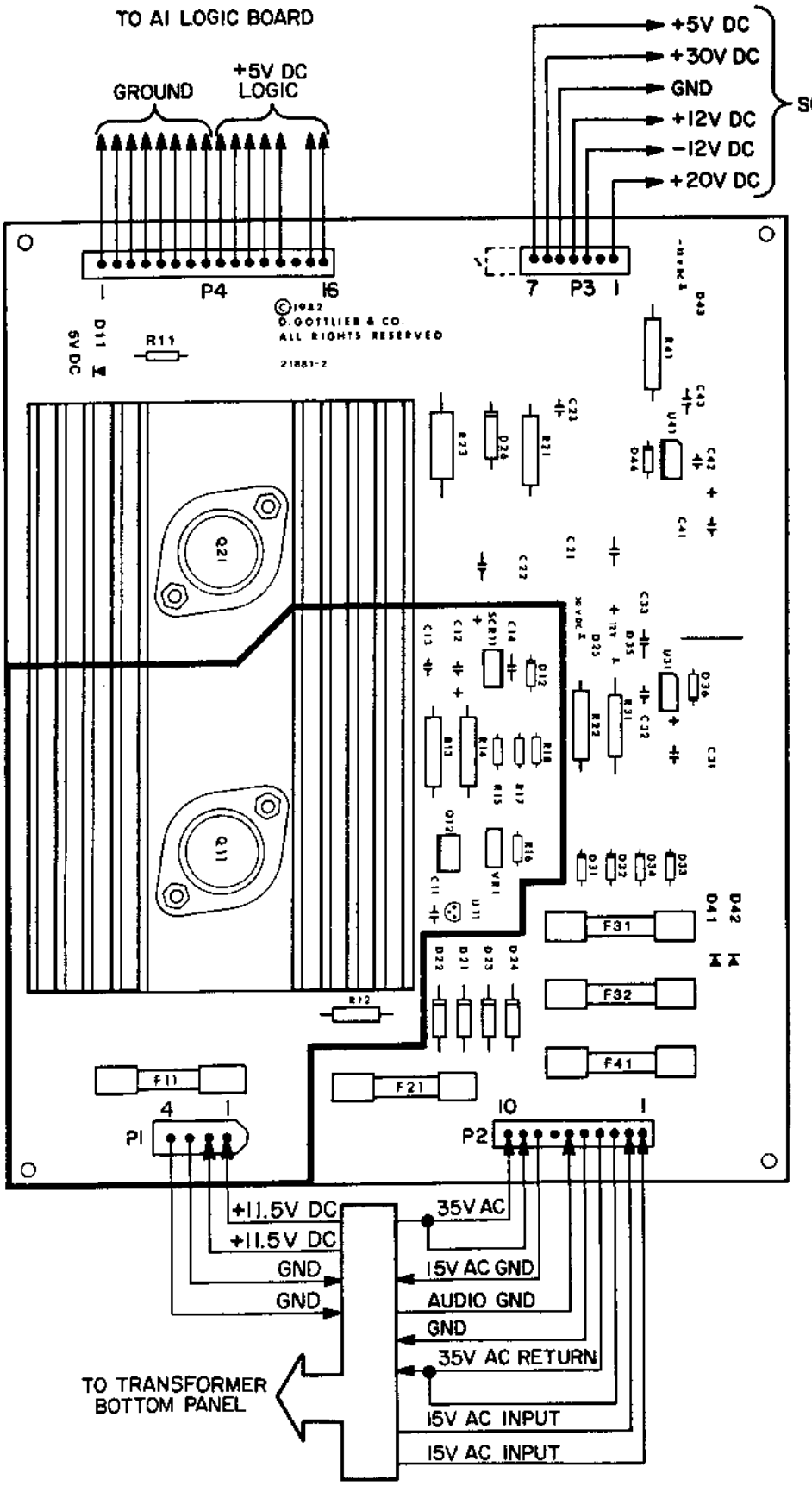


FIGURE 28.

POWER SUPPLY SPECIFICATIONS

DESTINATION OF VOLTAGE	VOLTAGE	PROTECTION AND REGULATION
Sound/Speech Board, Audio Amp Supply	+30V DC	2 Amps fused for over-current protection. The reference for this circuit is a 1N5363B +30V DC Zener controlling the base of an emitter follower pass transistor. The reference Voltage is a nominal 48V DC supplied from a bridge-rectified, fused 35V AC input.
Sound/Speech Board	-12V DC +12V DC	100 milliamps fused for over-current protection. The plus and minus 12 volts supplies are the 7812 and 7912 IC regulators respectively. Both devices have a reference voltage of + and -19.3V DC supplied from a bridge-rectified, fused 15V AC input.
Control Panel or Coin Chute Lights	+4.5V DC	Rectified unfiltered voltage, fused for over-current protection, taken directly off the bridge rectifier on transformer Panel.
Coin Meter	+20V DC	Full wave rectified unfiltered voltage, fused for over-current protection. The AC Input for the rectifiers is the 15V AC supply for ±12V above.
Monitor and Marquee	100V AC or 115V AC, 60HZ	Isolated, fused AC voltage. Supplied directly from the Transformer secondary on the bottom Panel.
Logic Board Assy.	+5V DC	Voltage adjustable. 5 Amps fused for over current protection and uses SCR "crowbar" over-voltage protection. The +11V DC input is supplied from a filtered, bridge rectified 9V AC on the Transformer Bottom Panel.

A3 POWER SUPPLY BOARD



LED'S INDICATE VOLTAGE PRESENT AT INPUT, BUT NOT NECESSARILY AT OUTPUT OR CORRECT

D11 INDICATES APPROX-IMATELY +5V DC OUTPUT

D25 INDICATES +48V DC RECTIFIED 35V AC INPUT

D35 INDICATES +19.3V DC RECTIFIED 15V AC INPUT

D43 INDICATES -19.3V DC RECTIFIED 15V AC INPUT

SEE POWER SUPPLY SPECIFICATIONS FOR FUSE RATING AND APPLICATION

FIGURE 29.

LOGIC SUPPLY CIRCUIT DESCRIPTION

The basic configuration of the circuit is an common-base series pass regulator with SCR crowbar over-voltage protection. The reference for the base of the regulator transistor is the TL431, an adjustable precision shunt regulator. The regulator output voltage at the cathode of this device is inversely proportional to the difference between the voltage at its reference pin and its internal 2.5V bandgap reference.

A current amplifier is formed by the two transistors, Q11 and Q12. The amplifiers voltage gain is fixed at approximately double with the resistor values shown. For a +5V DC output, the voltage at the cathode of the shunt regulator will be approximately +3.5V DC and will change little for all values of load current.

The over-voltage protection circuit uses a +5.6V DC Zener diode. If the Zener diode senses enough current to develop 1 volt across R18, a 20 ohm resistor, it will gate the SCR shorting the transistor output to ground.

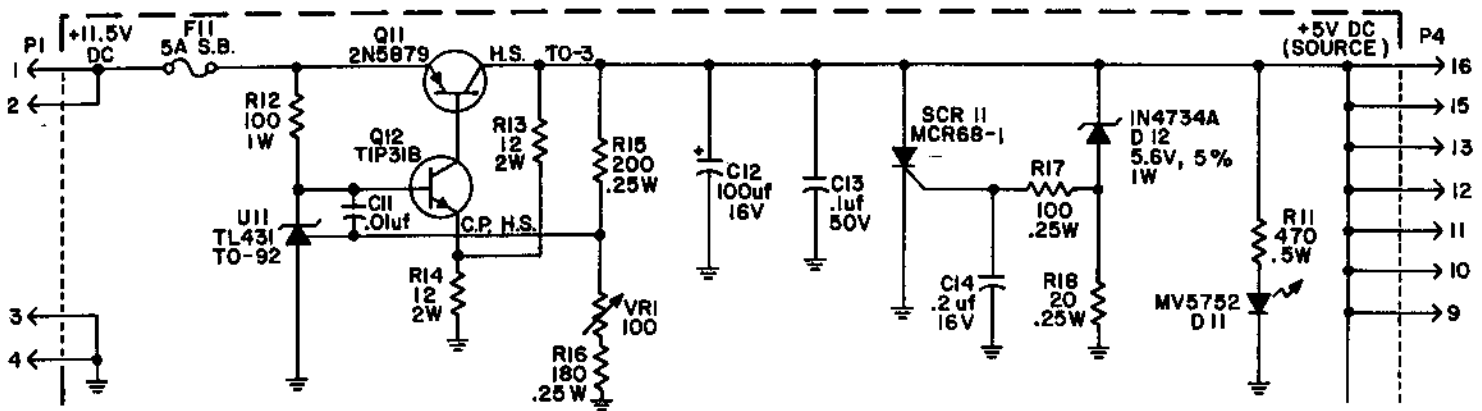


FIGURE 30.

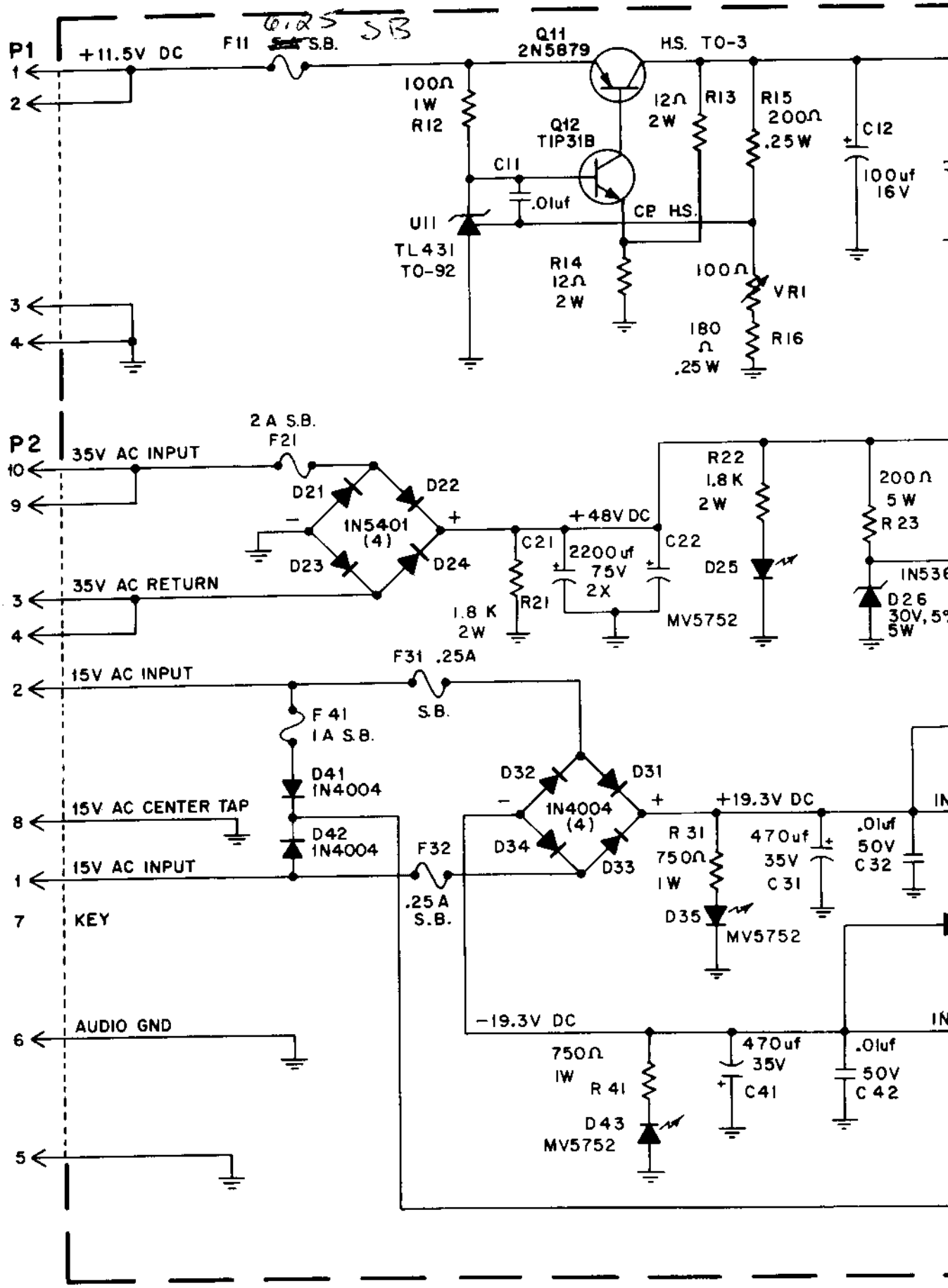
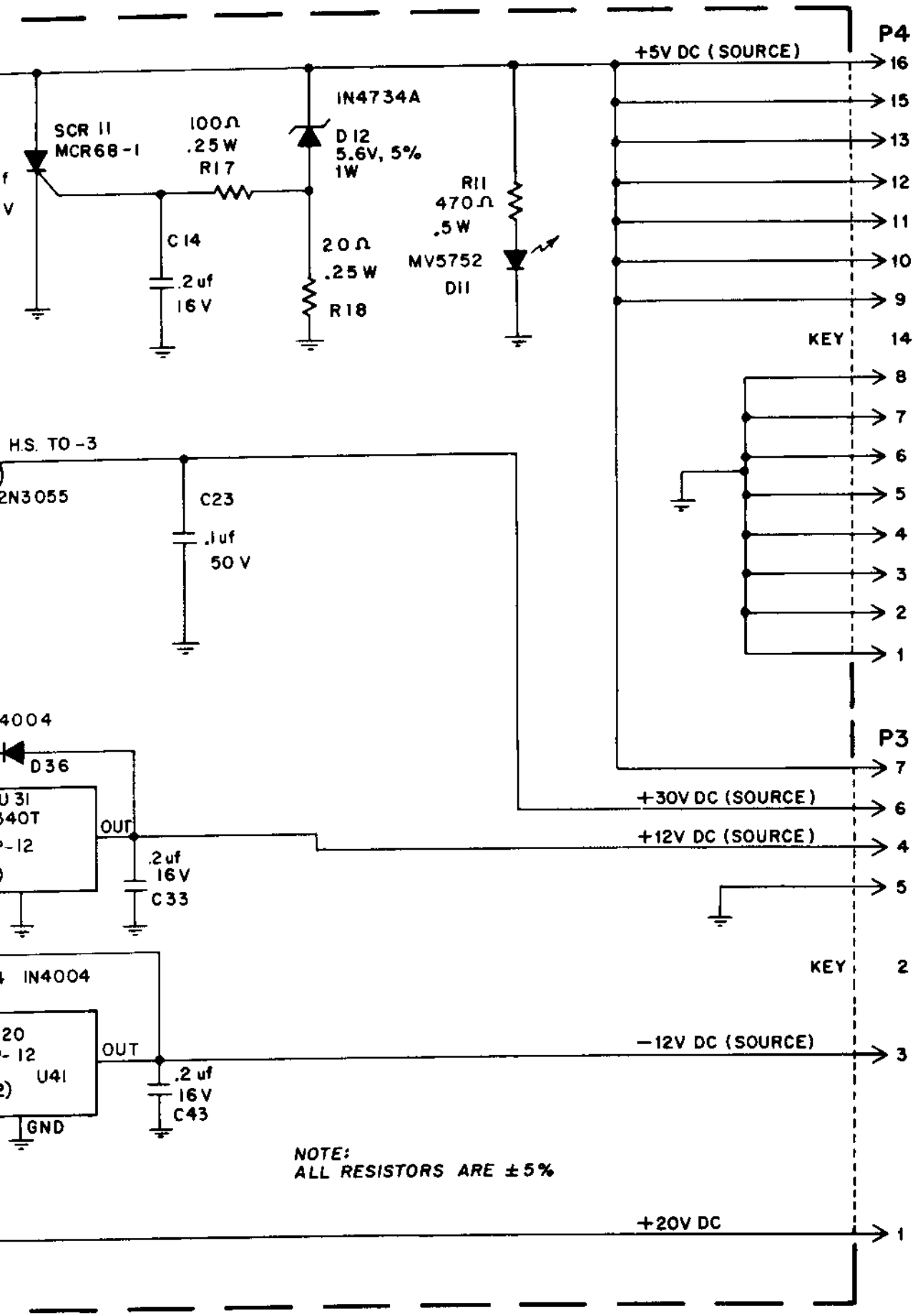


FIGURE 31. POWER SUPPLY



. (A3), SCHEMATIC DIAGRAM

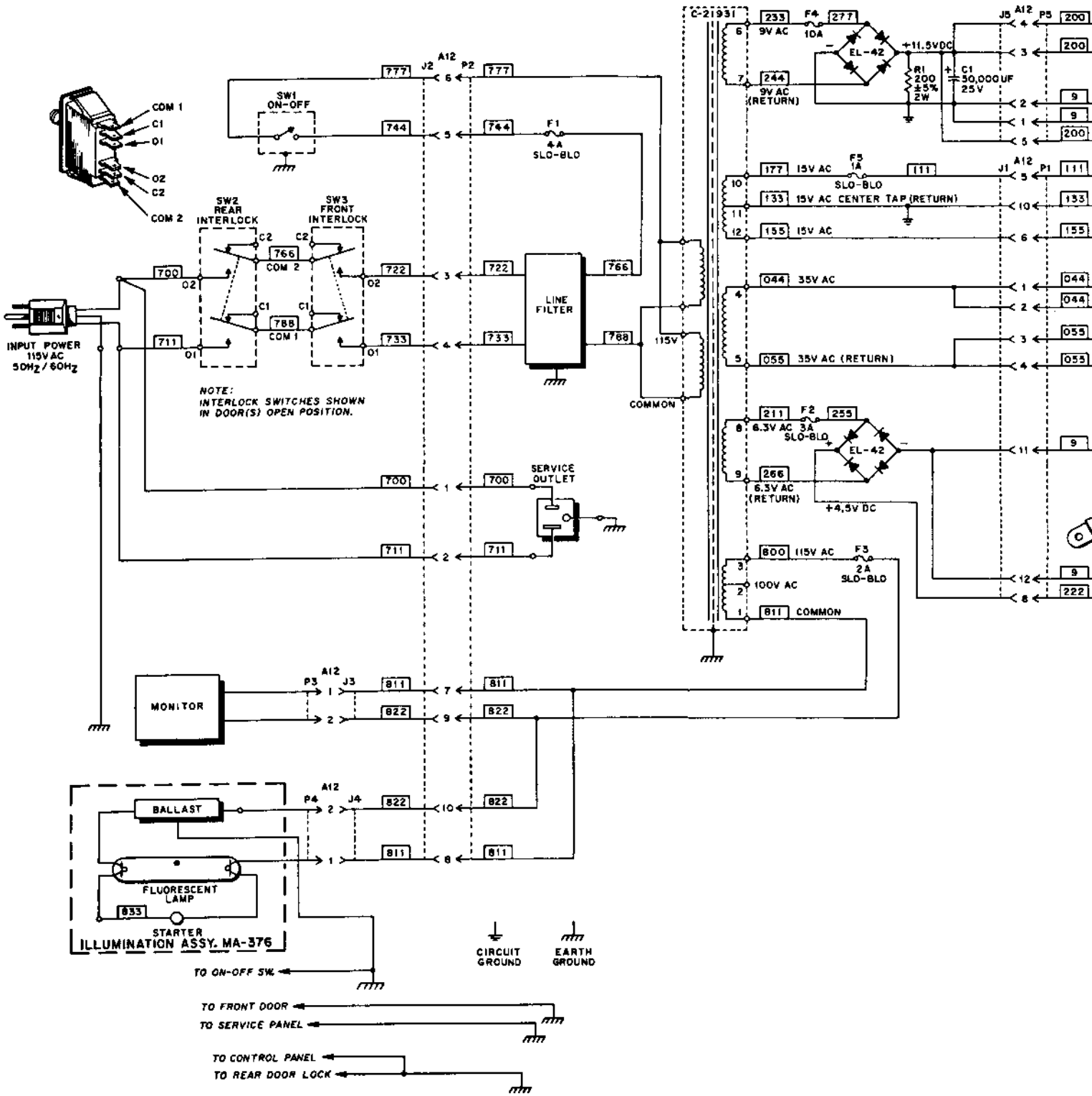
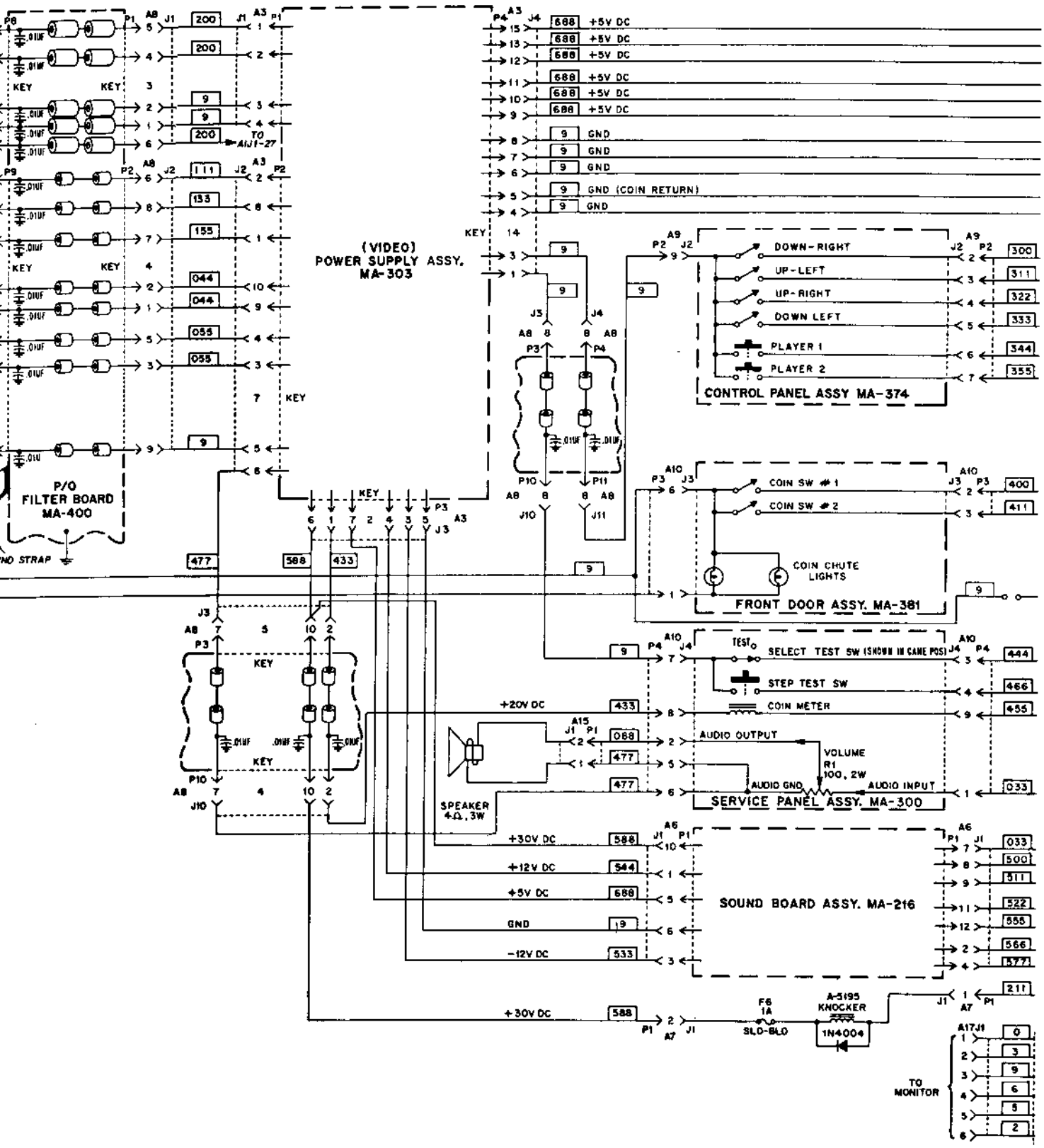

COM 1
C1
O1
O2
C2
COM 2
SW1 ON-OFF
SW2 REAR INTERLOCK
SW3 FRONT INTERLOCK
COM 2
COM 1
INPUT POWER 115V AC 50Hz / 60Hz
NOTE: INTERLOCK SWITCHES SHOWN IN DOOR(S) OPEN POSITION.
LINE FILTER
115V
COMMON
F1 4A SLO-BLO
SERVICE OUTLET
C-21931
9V AC
10A
EL-42
+11.5VDC
R1 200 ±5% 2W
C1 30,000UF 25V
9V AC (RETURN)
15V AC
1A SLO-BLO
15V AC CENTER TAP (RETURN)
35V AC
35V AC (RETURN)
6.3V AC 3A SLO-BLO
6.3V AC (RETURN)
+4.5V DC
115V AC
2A SLO-BLO
100V AC
COMMON
MONITOR
BALLAST
FLUORESCENT LAMP
STARTER
ILLUMINATION ASSY. MA-376
CIRCUIT GROUND
EARTH GROUND
TO ON-OFF SW.
TO FRONT DOOR
TO SERVICE PANEL
TO CONTROL PANEL
TO REAR DOOR LOCK

FIGURE 32. PC



DISTRIBUTION

The transformer panel in Gottlieb's video games has been redesigned and simplified to a modular single transformer system. The transformer, service outlet, line filter, bridge rectifiers and five fuses have all been mounted on one chassis grounded metal base.

The transformer secondary provides four AC supplies for regulation and one fused isolated 115V AC supply for the monitor. Two of the AC supplies have low current requirements and are fed directly to the A3 Power Supply Assembly. The 35V AC supply is fused on the A3 board and then rectified and regulated to +30V DC for the A6 Sound/Speech Board audio amp. A center tapped 15V AC supply uses three fuses on the A3 board to protect three circuits using that AC supply: the +12V DC and -12V DC for the Sound/Speech Board, and an unregulated +20V DC for the Coin Meter coil.

The other two AC pairs are fused on the transformer panel and wired to the two bridge rectifiers. One bridge rectifier supplies a fused unfiltered +4.5V DC for lamps in the game.

The second bridge rectifier creates an unregulated +11.5V DC for the Logic Supply reference. The filter capacitor on the output of the bridge rectifier is a 50,000 UF electrolytic to provide greater ripple filtering capability and increase system protection from switching surges. A 200 ohm resistor has been added across the capacitor which acts as a bleeder resistor when the game is turned off and gives a better load impedance to the +11.5V DC output when the game is on.

The character based graphics system designated GG-III has two main subdivisions. The first subdivision is the Central Processor Unit (CPU) which has three partitions:

a. Microprocessors
b. Memory
c. Input and Output ports (I/O)

The Intel 8088 microprocessor is used and 32K bytes of memory is reserved for programming space and has 5 input ports and 5 output ports. The second subdivision is the video state machine which generates and controls the video signal to the monitor. The state machine has three partitions:

a. System Clock (CLK)
b. Foreground generator (FGND)
c. Background generator (BGND)

The system clock is driven by a 20MHZ crystal, divided down for a 5MHZ dot clock.

All inputs and outputs including the video control and general purpose I/O are memory-mapped, (i.e. everything within the system can be addressed in a single segment of 64K addresses as memory).

The video control unit is divided into an "object-oriented" foreground driver and "character-oriented" background driver. The screen resolution is 256 pixels horizontally, and 240 lines vertically for both foreground and background. The CPU communicates with the foreground driver and background driver by writing data into the designated memory areas in a certain format. The foreground is designed to display moving objects on the screen with a minimum overhead to the processor. The game programs will only have to specify the vertical and horizontal position and the object select number to the foreground driver. The background video supplements the foreground with relatively static figures on the screen. The CPU specifies all the character positions on the screen with desired "character " patterns.

A 5MHZ system clock drives a 9 bit horizontal dot counter and an 8 bit vertical line counter. The horizontal counter counts from 0 to 255 during active scan line and 256 to 317 during horizontal blanking time. When the horizontal counter reaches 317, the horizontal counter resets to 0. At the beginning of the horizontal blanking time (horizontal counter = 256) it increments the vertical counter. The vertical counter counts from 0 to 239 during active vertical scan time and 240 to 255 during vertical blanking time.

The battery backup system supports two battery RAM's that store all of the bookkeeping functions. The battery is maintained at a +3.6V reference by a trickle charge supplied on the logic board regulated by a current limiting resistor. If the AC power to the game is interrupted, the battery allows the RAM's to store the data contained in the Distrubutors table and the Options/Parameters screen.

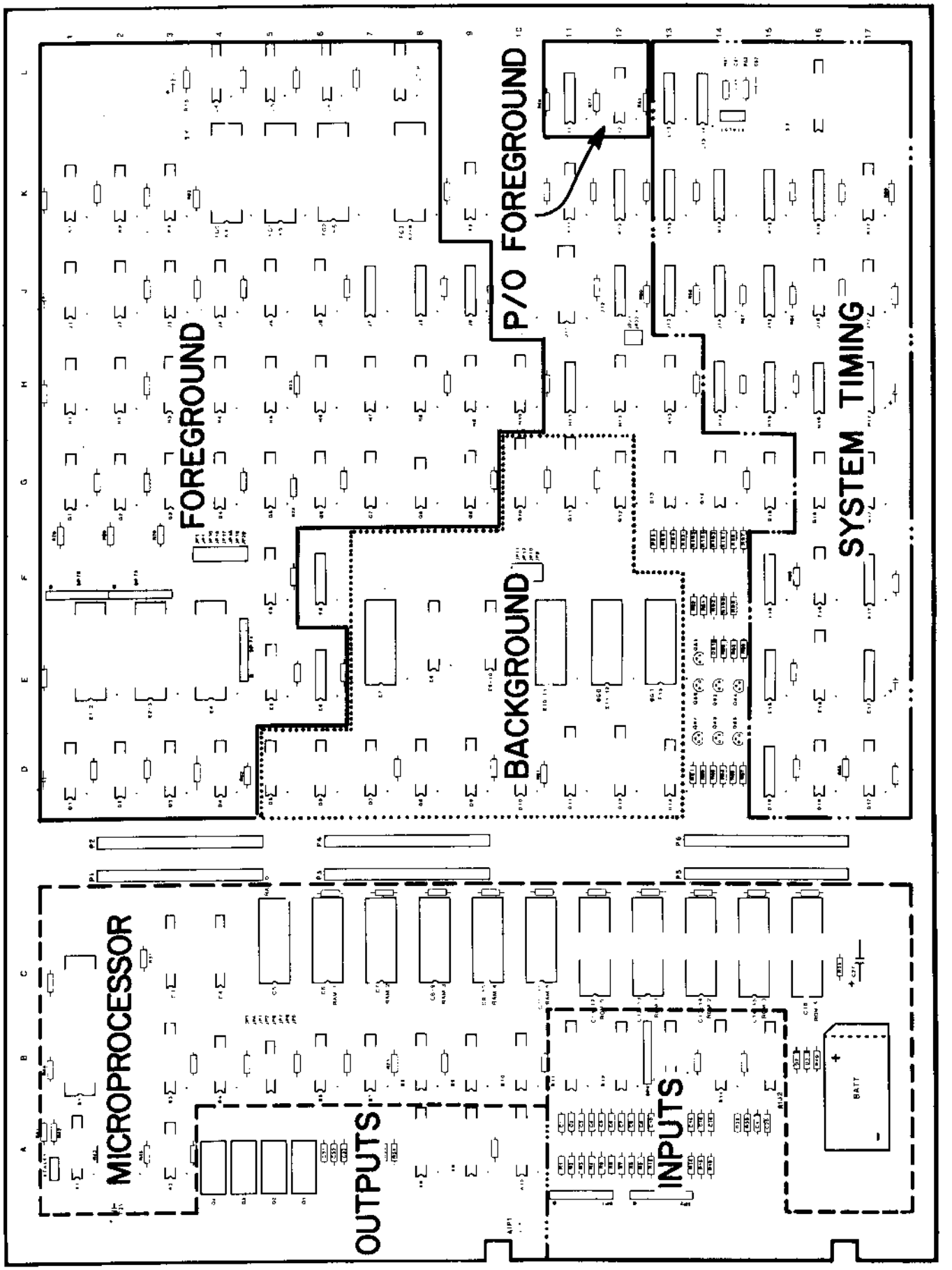

FOREGROUND
P/O FOREGROUND
BACKGROUND
SYSTEM TIMING
MICROPROCESSOR
OUTPUTS
INPUTS
BATT

FIGURE 33.

VII. GENERAL INFORMATION

A. MECHANICAL ASSEMBLIES

- DROP TARGETS
- POP BUMPERS
- FLIPPERS

B. CHARTS

- COILS
- TRANSISTORS AND DIODES
- GAME PROM CHART

C. BOOKKEEPING

D. GLOSSARY

DROP TARGETS PART I

A drop target is one which, when hit, drops down out of view through a slot in the playfield. Several drop targets are used together, mounted in a common frame. Gottlieb drop targets are made in units with three, four, five or seven targets; a three target unit uses a four-target frame. All targets are reset simultaneously by one or two solenoids, whereupon the targets reappear on the playfield. Behind the targets above the playfield is a rubber ring which when hit closes a scoring switch, exactly like other rubber contact switches elsewhere on the playfield. This switch is mounted to the rear of the bank.

Each target engages a target arm which pivots on a rod common to all arms. The target has a lip which rests on an edge of the frame and so is prevented from being pulled down by the arm until it is pushed off the edge when hit by the ball. Each target and arm has two springs, one to pull down the arm and the target when hit, and one to keep the target seated on the edge when reset. When the target drops, the opposite end of the target arm closes a scoring switch and possibly another switch operating another game feature.

Some banks have coils at the top of the bank which drop individual targets. These dropping coils are used with the game's memory for recalling the state of the targets from the previous ball or when targets are spotted by another game feature.

REPLACING TARGETS

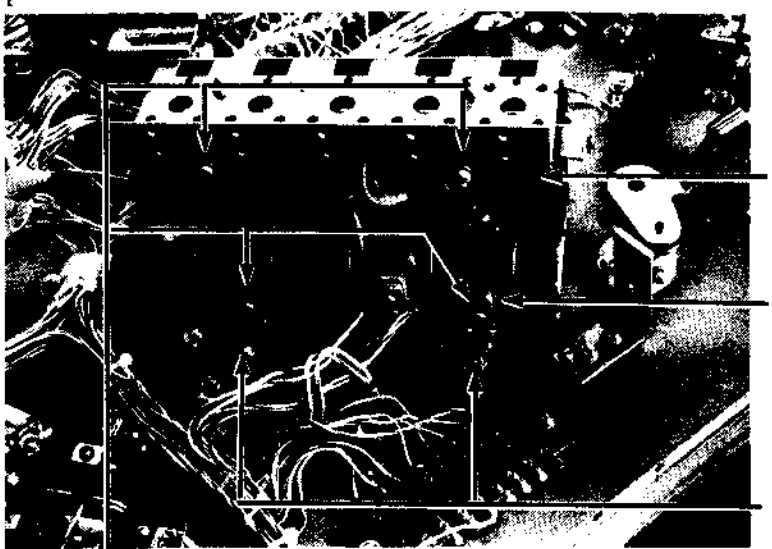
Breakage of the plastic target causes the majority of service calls on drop target banks. A broken drop target no longer means the major repair job it once did. Gottlieb's System 80 drop targets can be replaced with nothing more than a screwdriver, a long-nose pliers and a few minutes time.

Turn the playfield back so that its lower end is resting against the lightbox. This gives the best access to the rear of the bank, the side with no switches except the rubber contact switch. Place all targets in the dropped position.

There are four screws on the back plate of the bank, two of which hold securing brackets to the bank. Loosen, but do not remove, these four screws. Now remove the the screws holding the brackets to the bank. Do not loosen the screws that hold the bracket to the playfield. The bank is now held to the playfield by the brackets on the opposite side.

Unscrew the other two screws and carefully lift off the back plate. Unhook the spring from the target arm of the faulty target. Then move the target outward to disengage it from the arm. Remove the spring from the target and withdraw the target from the bank up through the playfield slot.

Insert the new target into the bank down through the playfield slot. Place the spring on the target and coat the target shank with White Lube. With a needle nose pliers, attach the other end of the target spring on to the target arm and place the target arm in the target shank slot. The target should now be in the proper position. Replace the back plate by tightening the bracket plate screws first. As in disassembly, this procedure ensures that the front plate brackets are neither bent not pushed out of adjustment from the force of the screwdriver.



DROP TARGETS

PART II

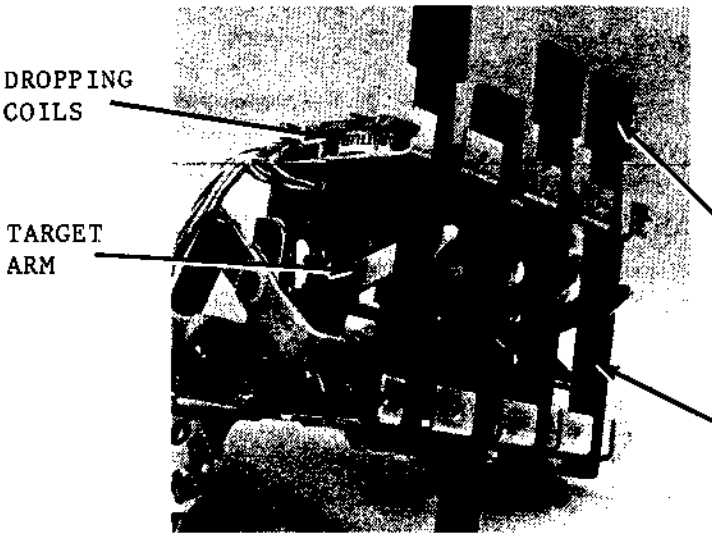
DROPPING COILS

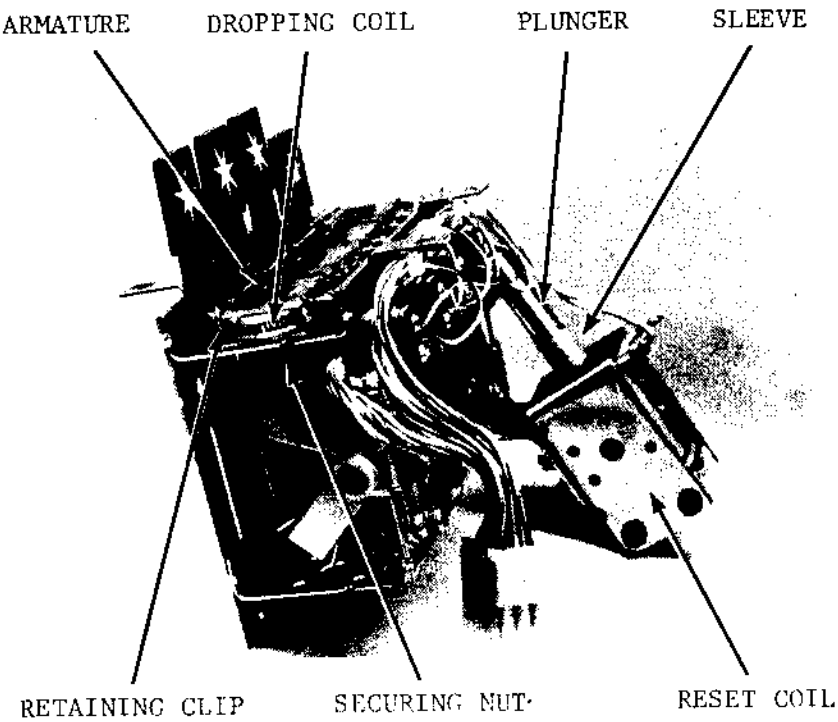
To replace a dropping coil the bank must be removed from the game. Disconnect the bank's Molex plug and remove the back plate as previously discussed. It is recommended that the brackets on the back of the bank be left screwed to the playfield, ensuring target alignment with the playfield slot upon re-installation. Unscrew the two playfield screws on the opposite side and remove the bank.

Unsolder the wires from the faulty coil. The securing nut under the coil must be removed because the screw in the drop coil is molded to the coil and cannot be removed.

With the back plate and the target of the defective coil removed, loosen the coil nut with an 11/32" wrench. After extracting the coil, remove the armature by carefully removing the wire retaining clip. Install both on the new coil. When soldering the wires to the new coil, be sure the diode is positioned correctly and is not defective.

Reassembly of the bank is the reverse of the above procedure. If the back plate brackets were removed or loosened from the playfield, the targets must be aligned in the playfield slot before the four securing screws are tightened. With the targets in the up position, there should be approximately a 1/32" clearance between the targets and the front of the slot. Check the spacing at each end of the target bank.





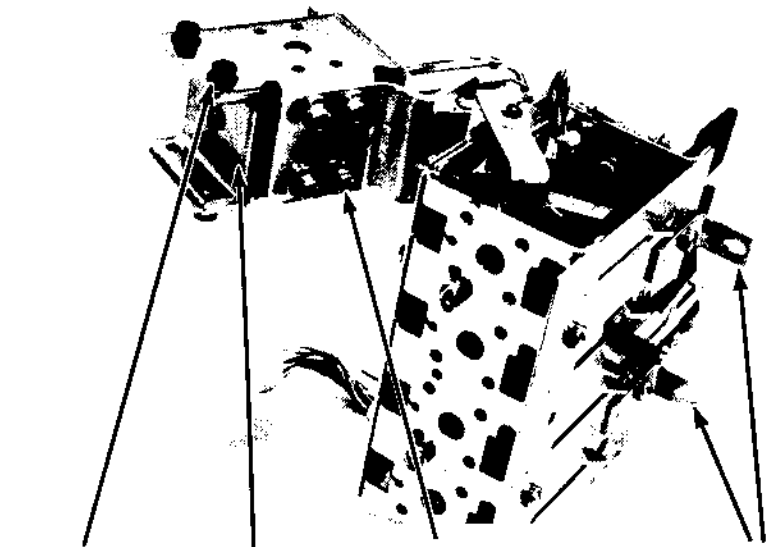
DROP TARGETS

PART III

THE RESET COIL

To remove the bank reset coil, unsolder the wires and unscrew the four slotted hex-head screws. A screwdriver may be used, but a 1/4" socket driver is recommended for better tightened screws. Remove the four allen-headed screws using a 9/64" wrench and work off the coil-stop backpiece. Withdraw the coil and examine the plastic sleeve for signs of melting or cracks and replace if any are found. Be certain the diode on the new coil is positioned correctly. Insert the new coil and push the coil stop tightly against the coil and replace the allen-head screws.

Two adjustments must be made before the coil housing screws are fully tightened. First, the plunger stroke is adjustable by moving the coil. Hold in the plunger against the coil stop. The targets should be slightly past their reset position, but the lip on the lower end of the targets must not touch the frame. Finally, make certain that the plunger moves freely within the coil. Proceed to tighten the four hex screws.



MISCELLANEOUS

Switches pressing too hard against the target arm could prevent the target from dropping smoothly and completely. Adjust the switches for slight overtravel. Keep the target shanks lightly coated with White Lube and add a drop of light oil (10 Wgt.) to the pivot points of the reset bar when necessary. If the pivot rod should ever be removed (such as to replace a target arm), be sure that the wire spring located at one end does not fly free and that it is replaced correctly when the rod is re-inserted.

POP BUMPERS

For dynamic and unpredictable playfield action, nothing can beat the pop bumper. It is the only playfield device providing ball contact about its entire periphery and guaranteeing sharp ball action. A player knows that a ball approaching a pop bumper means wild and exciting action. That is why pop bumpers must be maintained for optimum operation. Dead or dull pop bumpers spell disaster for the entire game.

Figure 1 shows a view of a complete pop bumper assembly. Figure 2 shows an exploded view of the pop bumper components. When a ball on the playfield depresses the bumper skirt, the cup blade configuration permits the bumper skirt stem to close the switch and actuate the circuitry necessary to energize the coil. A voltage pulse is applied to the coil, quickly pulling down the kicker ring that is attached to the coil plunger. The action kicks the ball out onto the playfield and closes the scoring switch contacts.

Replacing the kicking ring, bumper body, or bumper skirt requires the following steps:

1) After removing the playfield glass, lift and secure the playfield with the playfield brace.
2) From the playfield bottom:
   a) Unsolder the wires from the lamp socket terminals.
   b) Unscrew the elastic stop nuts from the kicker ring tie rods. (Use a 5/16" hex nut driver.)
3) From the playfield top:
   a) Remove the pop bumper cap.
   b) Remove the lamp.
   c) Unscrew the two screws in the bumper body.
4) The complete top assembly can now be pulled away from the playfield.
5) Now pull the bumper base from the bumper body. Any component is now capable of being replaced.
6) Assembly is the reverse of the above procedure.

NOTE: To replace a lamp, follow Steps 3a and 3b.

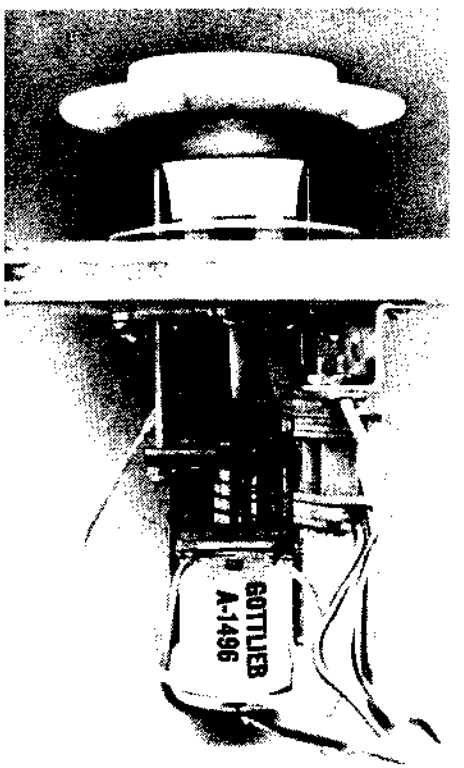


FIG. 1

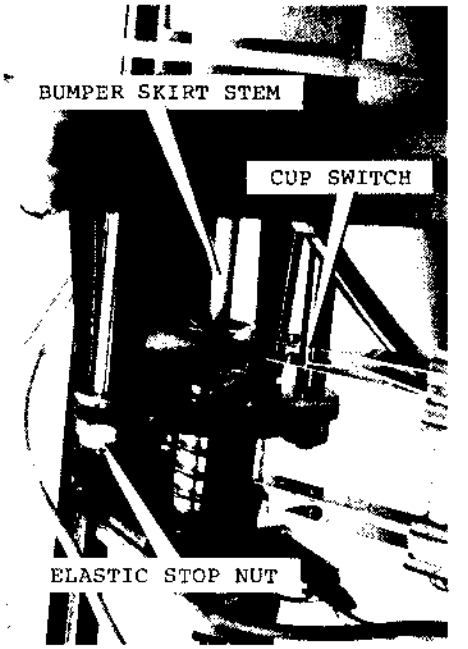


FIG. 1A,

POP BUMPERS

REPLACING THE COIL

1) Lift and secure the playfield with the playfield brace.
2) Remove the elastic stop nuts from the kicker ring tie rods.
3) Unscrew and remove the coil mounting bracket from the pop bumper pad and the kicker ring tie rods.
4) Unscrew the stop bracket from the coil mounting bracket.
5) Pull the whole assembly, consisting of the stop bracket, plunger, kicker return spring and yokes away from the coil. Keep this assembly intact.
6) The coil can now be removed from the coil mounting bracket.
7) Unsolder the wires from the bad coil, carefully noting how they are connected with respect to the diode. The band on the diode indicates the cathode terminal.
8) Unsolder the diode.
9) Solder the diode, then the wires, to the new coil.
10) Assembly is the reverse of the above procedure.

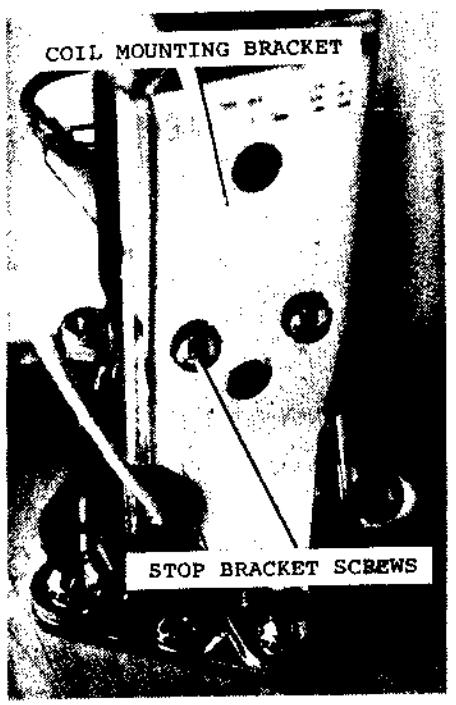


FIG. 1B,

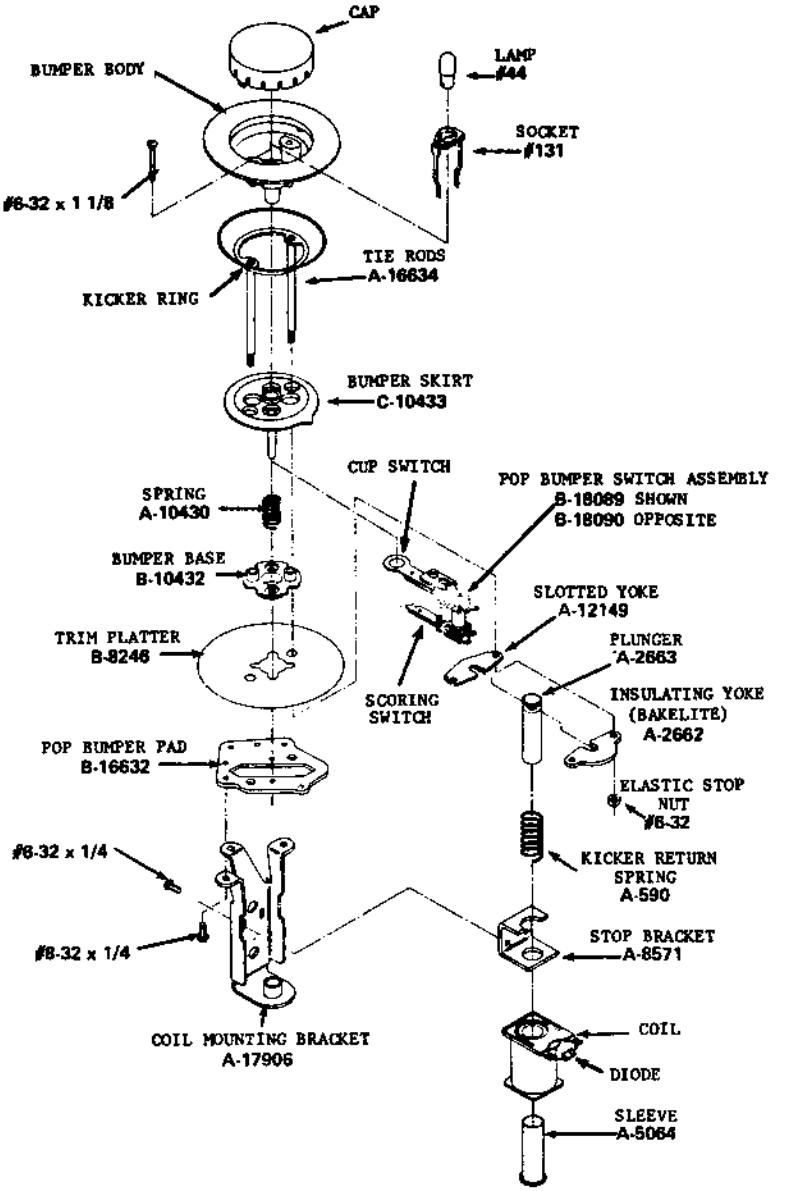


FIG. 2

SWITCH ADJUSTMENT

Proper cup switch alignment with the bumper skirt stem is necessary for consistent action around the pop bumper. The bumper skirt stem should sit exactly in the cup switch center, lightly resting on the bottom of the cup.

To make this adjustment, loosen the switch mounting bracket screws. Adjust, then hold the switch mounting bracket firmly in place while retightening the screws.

The cup switch contact gap should be approximately 1/32". The score switch contact gap should be a 1/32" to 1/16" clearance with a 1/32" overtravel when closed.

FLIPPERS

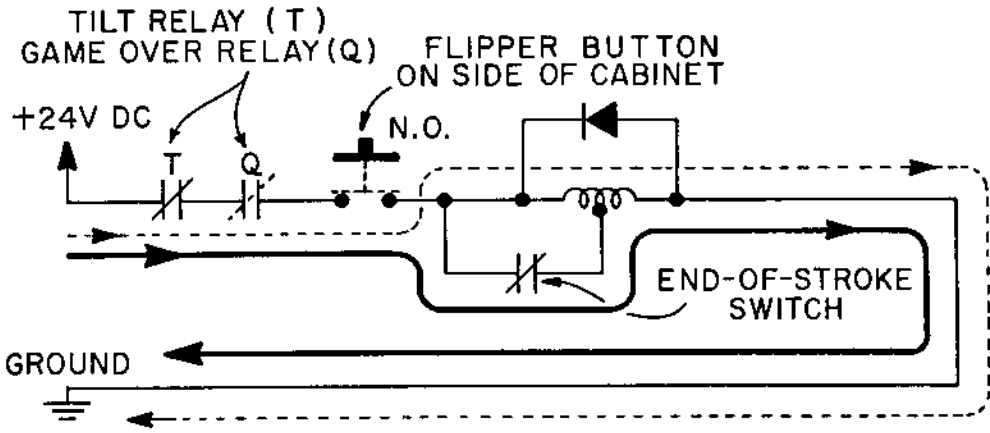


FIGURE I.

Electrical flipper operation is shown in Figure I. All contacts are shown in attract mode positions. During game play, the Game Over Relay (Q)* energizes and closes the Q contact (dashed lines). When a player presses the flipper button, the 24 VDC voltage generates a current that passes through the end-of-stroke switch and the low resistance windings of the flipper coil (direction indicated by dark line). The plunger is pulled into the coil core with the end-of-stroke switch contacts opening approximately 1/16" before full plunger stroke. The 24 VDC is now applied to the full winding, increasing the current (direction indicated by dashed line). This protects the coil from burn-out when the flippers stay energized. Poor flipper power or a high burn-out rate for coils may result if the end-of-stroke switch is not adjusted as mentioned above.

When a tilt condition occurs, the Tilt relay* is energized. Subsequently, the T contact opens, deactivating the flippers.

Flipper coils and their ratings are listed on page 4. The 1N4004 diode across the flipper coil suppresses any transient voltage spikes developed when the flipper button switch opens.

* Game Over and Tilt relays controlled by system control board. See game manual.

FLIPPER REPLACEMENT

(Refer to Figure II)

1. Lift playfield and secure with bracket.
2. Loosen both socket head cap screws with a 5/32" allen wrench.
3. Slowly pull flipper shaft assembly away from flipper unit and playboard.
4. Unscrew pan head screw holding flipper to flipper shaft.
5. Pull flipper from shaft.
6. Remove rubber ring from defective flipper and install on a new flipper.
7. Align and press new flipper down on the flipper shaft pin.
8. Screw and tighten pan head screw to flipper.
9. From the playfield top, insert the flipper shaft assembly through the flipper unit.
10. Align and hold flipper on playfield for proper position.
11. Tighten both cap screws.

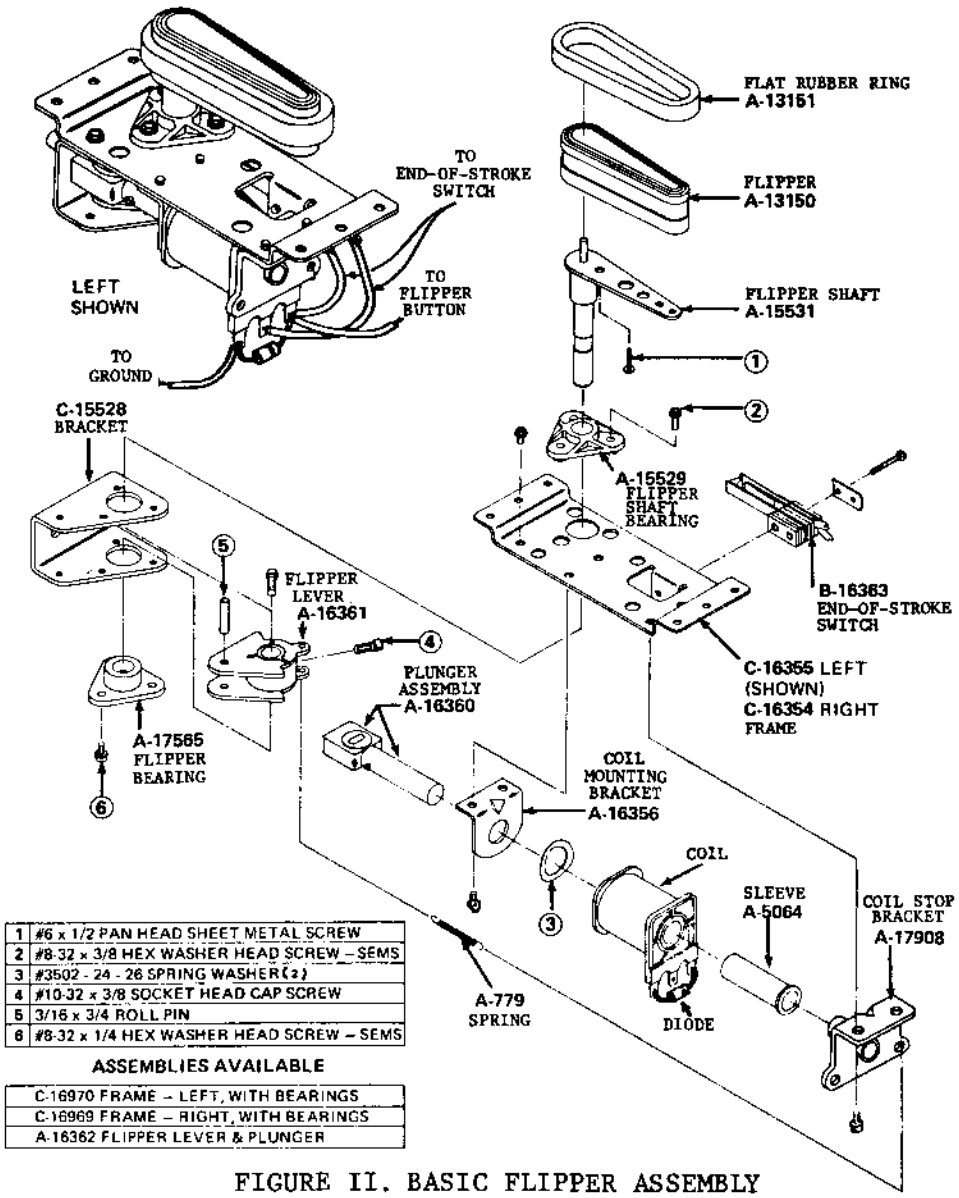
FLIPPER COIL REPLACEMENT

1. Lift playfield and secure with bracket.
2. Unsolder the wires from the three coil terminals. Note the wire-to-terminal connections of the end-of-stroke switch, the diode, the ground wire (GRN/YEL 54), and the wire leading to the flipper button. See Figure II illustration.

FLIPPERS

3. Remove the coil stop bracket by unscrewing the two hex screws with a 1/4" hex nut driver or a regular screwdriver.
4. Pull the coil away from the plunger assembly.
5. Pull the plastic sleeve out of the bad coil and insert it into the new coil.
6. Slide the new coil onto the plunger assembly, insuring that the spring washers slide over the plastic sleeve.
7. Replace and screw the coil stop bracket into place.
8. Solder the wires and diode to their proper terminals.

Figure III is a flipper assembly occasionally used when flippers are positioned in the upper portion of the playfield where lack of space does not permit the flipper assembly of Figure II. The end-of-stroke switch is screwed to the playboard and positioned so that the flipper lever arm opens its contacts during flipper activation.



1	#6 x 1/2 PAN HEAD SHEET METAL SCREW
2	#8-32 x 3/8 HEX WASHER HEAD SCREW – SEMS
3	#3502 - 24 - 26 SPRING WASHER(2)
4	#10-32 x 3/8 SOCKET HEAD CAP SCREW
5	3/16 x 3/4 ROLL PIN
6	#8-32 x 1/4 HEX WASHER HEAD SCREW – SEMS

ASSEMBLIES AVAILABLE

C-16970 FRAME – LEFT, WITH BEARINGS
C-16969 FRAME – RIGHT, WITH BEARINGS
A-16362 FLIPPER LEVER & PLUNGER

FIGURE II. BASIC FLIPPER ASSEMBLY

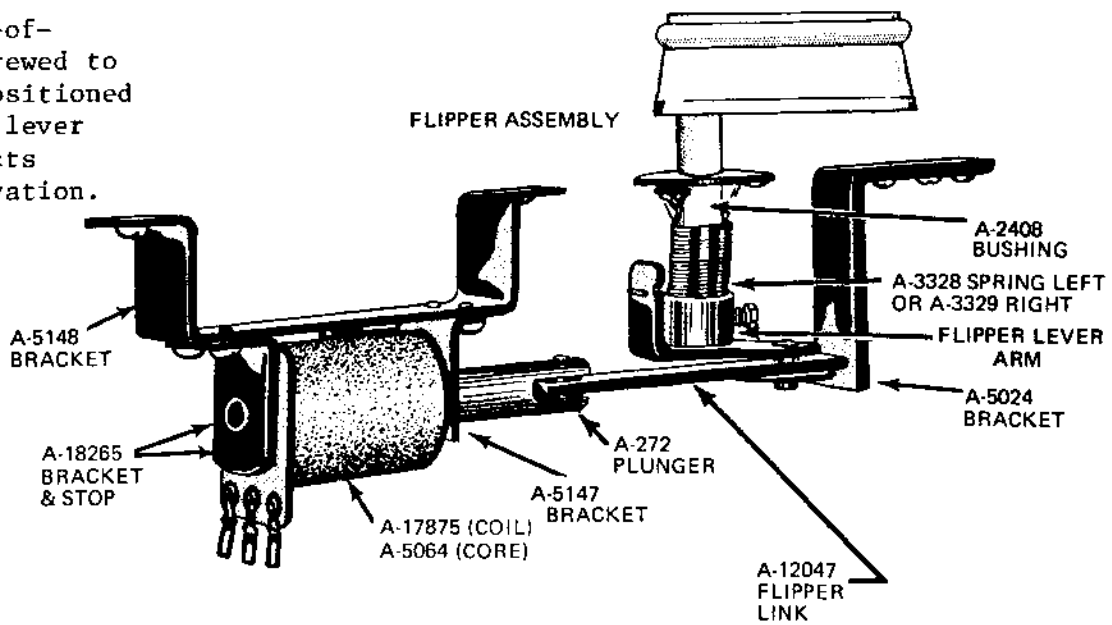


FIGURE III. ALTERNATE FLIPPER ASSEMBLY

COIL CHART

SOLENOID COILS

PART NUMBER	GENERAL USAGE	RESISTANCE (OHMS)	NUMBER OF TURNS	WIRE GAUGE	WRAPPER COLOR
A-1496	KICKING TARGET KICKING RUBBERS POP BUMPERS	2.95	635	#23	Yellow
A-4893	UP KICKER POP BUMPERS BALL KICKER	2.1	535	#22	Red
A-5194	UP KICKER GONG KICKING TARGETS	4.5	780	#24	Blue
A-5195	CONTACT KICKER KNOCKER HOLE KICKER	12.3	1305	#26	White
A-16570	HOLE KICKER, OUTHOLE	15.5	1450	#27	Green
A-17875	FLIPPERS	2.8/40.0	560/1100	#24/31	Yellow
A-17891	5 BANK RESET	3.35	850	#22	White
A-18102	3 BANK RESET, 7 BANK RESET USES 2	9.0	1430	#24	Red
A-18318	4 BANK RESET	6.7	1130	#24	Orange
A-19300	BALL KICKER	7.8	1075	#25	Orange
A-20095	SUPER FLIPPER	1.55/35.5	450/900	#22/31	Red
A-21741	UP KICKER	2.5	575	#23	Orange

RELAY COILS

A-16890	Q, T, AND COIN LOCKOUT RELAYS	231.0	4000	#35	Orange
A-20558	GATE RELAY	156.0	3400	#34	White
A-18642	MEMORY/ DROP TARGETS	58.0	1590	#33	White

* Coils may vary from game to game. Check game manual for exact coil usage

TRANSISTOR AND DIODE SUBSTITUTION GUIDE

PART NUMBER	GOTTLIEB XO NO.	SYLVANIA SUBS. ECG	RCA SUBS. SK	GEN. ELEC. SUBS. GE	INT. RECT. SUBS. IR/WEP	MOTOROLA SUBS. HEP	RADIO SHACK SUBS. MISC.	POLARITY (TYPE)	RATED I_C (A)	RATED V_{CEO} (V)	RATED V_{CBO} (V)	RATED P_T TOTAL POWER DISSIPATION (W)	RATED h_{FE} MIN. MAX.	
PMD 10K40	XO 315					2N6057		NPN	12	40	40	150	1K-20K	
PMD 10K60	XO 311					2N6057		NPN	12	60	60	150	1K-20K	
PMD 12K40	XO 308							NPN	8.0	40	40	100	1K-20K	
T1P 31B	XO 641	184				S5000		NPN	3	80	80	16	10-50	
T1P 31C	XO 307					S5004		NPN	3	100	100	16	10-50	
T1P 105	XO 319							PNP	8	60	60	32	1K-20K	
T1P 115	XO 312							PNP	2	60	60	20	1000-	
T1P 640	XO 322	245						NPN	10	60	60	100	1000-	
2SC 945	XO 316	199	3124	20		S0015		NPN	100M	50	60		200	
2SA 1015	XO 317							NPN	5.0	50	50		70	
MPS A13	XO 304	172		64	TR69/S9100	S9100		NPN	100M	30	30	625M	10K-	
MPS A43	XO 305					S0005		NPN	30M	200	200	625M	50-200	
MPS U45	XO 306	272						NPN	2.0	40	50	10	4K-12K	
MPS A70	XO 309	159	3114	65	TR20/717	S0019		PNP	5M	40	30	350M	40-400	
MPS 6534	XO 318	159	3114	21	TR20/717	S0019		PNP	100M	40	40	350M	90-270	
2N 2222A	XO 320			20		S3001		NPN	150M	40	75	0.5	100-300	
2N 2907A	XO 321	159	3114	67	TR20/717	S0013		PNP	150M	60	60	0.4	100-300	
2N 3055	XO 301	130	3027	14	TR59/247	S7004		NPN	15	70	100	65	20-70	
2N 3416	XO 302	123A	3124	210	TR21/735	S0015		NPN	500M	50	50	360M	75	
2N 4400	XO 313	123A	3122	20	TR21/735	S0015		NPN	600M	40	60	350M	20	
2N 5550	XO 314	194	3045		TR78/	S0005		NPN	10M	140	160	625M	60-250	
2N 5875	XO 310						2N6229	PNP	10	60	60	86	20-100	
2N 6043	XO 303	261	3180			S9102		NPN	8.0	60	60	2.2	1K-20K	

Z = ZENER
* = GERMANIUM

DIODES AND ZENERS

PART NO.	XO NO.	PIV (V)	I_o (A)	(W)	TOLERANCE
1N 270	XO 265	100V	200M		*
1N 703	XO 251	3.5V	250M	0.5 W	13%
1N 3445	XO 266	8.2V	2M	1.0 W	10% Z
1N 4002	XO 253	100V	1.0		
1N 4004	XO 254	400V	1.0		
1N 4148	XO 261	75V	10M		
1N 4720	XO 260	100V	3.0		
1N 4734A	XO 255	5.6V	45M	1.0 W	5% Z
1N 4738A	XO 256	8.2V	31M	1.0 W	5% Z
1N 4742A	XO 257	12V	21M	1.0 W	5% Z

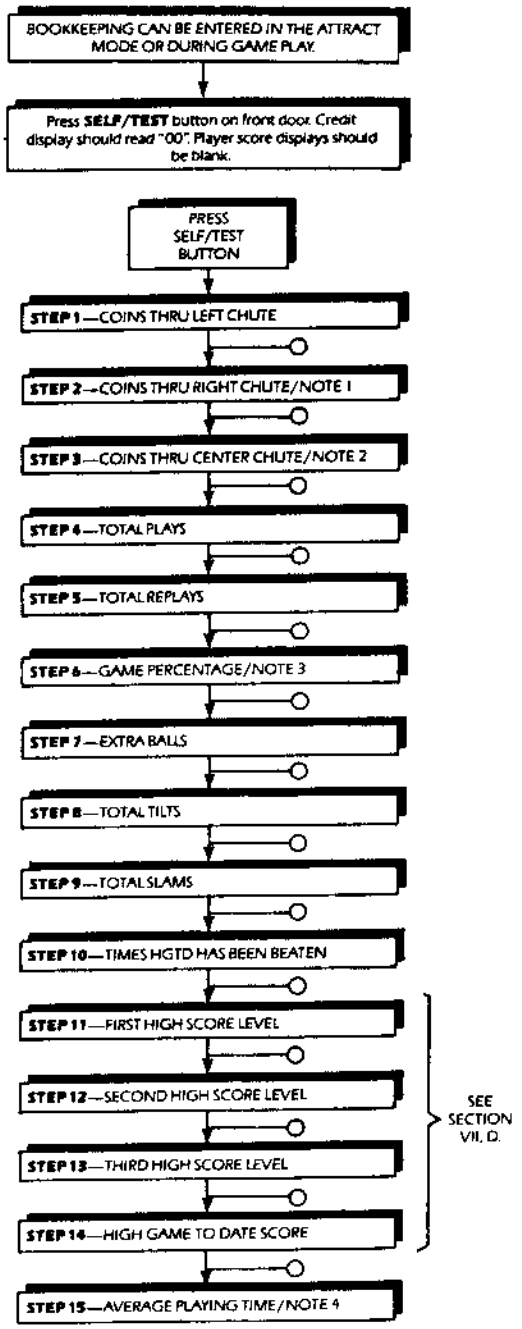
PART NO.	XO NO.	PIV (V)	I_o (A)	(W)	TOLERANCE
1N 4743A	XO 262	13V	19M	1.0 W	5% Z
1N 4746A	XO 258	18V	14M	1.0 W	5% Z
1N 4751A	XO 271	30V	8.5M	1.0 W	5% Z
1N 4753	XO 259	36V	7M	1.0 W	10% Z
1N 4759A	XO 267	62V	4M	1.0 W	5% Z
1N 5225B	XO 269	3V	20M	0.5 W	5% Z
1N 5401	XO 263	100V	3.0		

PROM IDENTIFICATION

GAME NAME	GAME PROM NUMBER	CHECKSUM GAME PROM	PROM # SOUND 1	CHECKSUM SOUND 1	PROM # SOUND 2	CHECKSUM SOUND 2
MARS	666	1720	666/S1	0DC5	666/S2	13CB
VOLCANO	667/1B	6DD6	667/S1	0D32	667/S2	B271
BLACK HOLE	668/2	4F52	668/S1	272F	668/S2	316A
HAUNTED HOUSE	669/2	1424	669/S1	26E7	669/S2	9AA4
CAVEMAN	P810/1	376E	P810/S1	1CB4	P810/S2	0FF4
DEVIL'S DARE	670/2	0782	670/S1	4CB2	670/S2	464F
ECLIPSE	671	627E	671/S1	N/A	671/S2	N/A
ROCKY	672/2	C125	672/S1	4336	672/S2	11C9
SPIRIT	673/2	9A81	673/S1	506B	673/S2	61B7
PUNK	674	E7F4	674/S1	63A6	674/S2	4902
STRIKER	675/2	B6D3	675/S1	87DF	675/S2	23FD
Q*BERT'S QUEST	677	1677	677/S1	A4C9	677/S2	11EE
SUPER ORBIT	680	18EB	680/S1	69A1	680/S2	CD6D

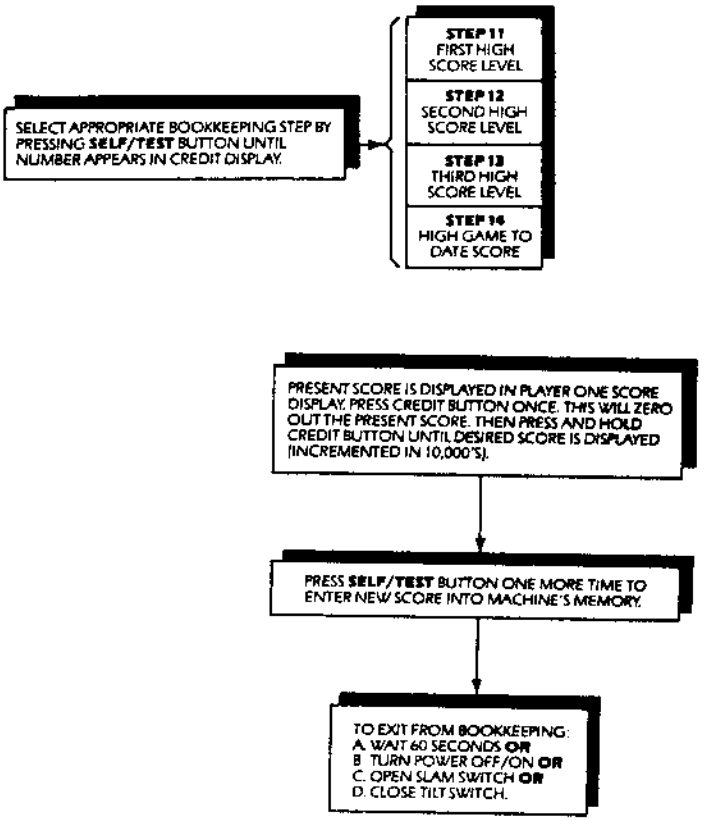
BOOKKEEPING

- Pressing the SELF-TEST button inside the front door begins the bookkeeping which are steps 01 through 15.
- The data in any of these steps may be reset to zero while it is displayed by pressing the replay button on the front door.
- THE SELF-TEST BUTTON MUST THEN BE PRESSED TO ENTER ZERO INTO MEMORY.



1. If control board switch #14 is on, Steps 01 and 02 are added together and displayed in Step 01.
2. IN GERMAN GAMES ONLY, Step 02 displays total coins thru center chute, and Step 03 displays total coins thru right chute.
3. If Step 06 is reset, Steps 04 and 05 must also be reset.
4. If Step 15 is reset, Step 04 must also be reset.

HOW TO RESET HIGH SCORE LEVELS OR HIGH GAME TO DATE SCORES



NOTES:

1. Step 11 must be a lower score than Step 12. Step 12 must have a lower score than Step 13.
2. If Step 12 or Step 13 is not desired, set those scores to 0.
3. If Step 11 is set to 0, no replays will be awarded, no matter what the settings are for Step 12 and Step 13.

- All bookkeeping information is checked against itself to insure that it is correct. If any data is invalid or bad, that information will flash while it is displayed.
- If the SELF-TEST button is not pressed within 60 seconds of each step, the game will return to the attract mode.

VII. GENERAL INFORMATION

PINBALL GLOSSARY

Arcing ..... The electrical spark created by electricity jumping across an air gap.

Armature ..... The movable metal part of a relay attracted by the magnetic field of the coil.

Backglass ..... The front part of the lightbox or head on which the game illustration and name is painted. It contains the scoreboard, ball counter and tilt indicator.

Backing blade ..... Auxiliary switch blade used to stop vibrations of operating switch blade.

Bagatelle ..... The ancient parlor game that was the forerunner of pinball.

Ball trough ..... Metal track below the playfield which guides the balls from the out hole to the ball lift mechanism.

Bleed ..... A ball that goes down the drain scoring a minimum amount of points.

Body English ..... The gyrations that accompany the nudges a player uses to control the ball.

Bonus ..... An accumulated score stored in memory added later to the total score.

Bottom board ..... The mounting board used to mount the transformer, relays, etc.

Captive ball ..... A feature used on pinball games that involves one ball being held captive in a kicker hole until another ball performs a certain function to release the captive ball or balls. This is a holdover feature.

Coil ..... Many turns of insulated wire wound on a spool. Used to create a magnetic field that is harnessed to do mechanical work.

Coin chute ..... Mechanism that determines whether a coin is accepted to activate the machine or rejected and returned to the player. Also called Coin acceptor and Coin rejector.

Contact ..... Contact points - silver contact part of a switch.

Credit unit ..... The reel on the backglass that indicates the number of games remaining. It is advanced by coins passing through the coin chute or by the earning of free games.

Distributor ..... Middle man between the manufacturer and the operator.

Drop target ..... A target that is knocked down when hit by the ball. A favorite feature of Gottlieb. Also called Knock-down target.

Extra ball ..... An award for completing a special feature. Also a return through a free-ball gate of the ball to the plunger for another shot. Also the award for high score in those jurisdictions where the replay is not permitted. Also called Free ball or Add-a-ball.

PINBALL GLOSSARY (CONT.)

Flipper .....Electrically driven bat-type lever on the playboard operated by push buttons on each side of the cabinet allowing the player to skillfully manipulate the ball on the playfield. It is driven by a solenoid coil.

Fuse .....A circuit breaking component that prevents damage in the event of excess current flow.

Gap .....The distance between contact points.

Gate .....A one-way device that allows the ball to enter the playfield and act as a rebound in the opposite direction. Free gate is an electrically operated device that will allow the ball to enter the ball runway and be shot again without being counted.

Holdover .....A feature of the game that is not reset at the beginning of each new game but carried over until the feature award is collected. Also applies to a feature that is carried from ball to ball.

Kicker .....An electromagnetic component mounted on the playboard that propels or kicks the ball away when contacted.

Kick-out hole .....A hole on the playfield equipped with a kicker. When the ball lands in the kick-out hole, there is some scoring and then the ball is propelled away. The ball-hole kicker is usually aimed at some particular spot on the playfield.

Knocker .....Coil used to indicate free game.

Lazarus ball .....A ball that passes between the flippers, seemingly out of play, but that then bounces off the backboard and back into play. It is a ball that has come back from the dead.

Lightbox .....The wooden box mounted at the rear of the cabinet. It contains the backglass, lights and the scoring mechanisms. Also called Back-box or head.

Line cord .....Electrical wiring from machine to wall outlet or other source of electricity.

Location .....The bar, drugstore, variety store, or arcade where the machine is located.

Matched number .....A feature that awards a free game for matching a random number that shows up on the backglass to the last number of the final score. This feature is illegal in certain jurisdictions.

Monster .....The white wood prototype of a game under development. It is wired like a true pinball machine but left unpainted.

Nudge .....The slight pushing motion that the player uses to try to control the progress of the ball. Usually a back and forth movement accompanied by Body English. Also called Gunching.
An effort to manipulate ball action by pushing, wobbling, bumping, or shaking the cabinet to deflect the course of the ball.

Operator .....The owner of the pinball machine in the location. Supplies and services the machine for the location and splits the take, usually fifty-fifty.

PINBALL GLOSSARY (CONT.)

Out-Hole ..... The hole or cup at the bottom section of the playfield located under the bottom arch. During the play of the game, the ball is kicked out of the out-hole, over the ball trough to the runway. Also called the Gutter or the Drain or the Death Chute.

Outlane ..... The lanes at each side of the playfield that allow the ball to enter the out-hole without going through the center of the flippers.

Percentage ..... The amount of replays in relation to total plays.

Philadelphia shaker ... A player adept at the art of nudging.

Pla-More-Post ..... A solenoid-driven device that rises up and blocks the gap between the flippers.

Playfield ..... The decorated playboard with bumpers and posts that constitutes the surface area on which the ball is played.

Plunger ..... A spring-operated rod used by the player to propel the ball onto the playfield. Also called Shooter.

Pop bumper ..... A bumper with a metal or plastic skirt rather than a rubber ring around the body. Operates as a bumper and kicker, electrically propelling the ball with greater force than the natural rebound of a regular bumper. Also called Jet bumper or Thumper Bumper.

Posts ..... Rubber-ringed plastic pieces screwed to the playfield on which the ball bounces. These are the modern form of the original pins.

Relay ..... An electromechanical component which operates one or more switches with an electrical impulse.

Replay ..... The opportunity to play a game without any additional cost. It is the reward for attaining a specified score or hitting a special feature. Also called a Free play or Free game.

Replay button ..... Button on the front door used by the player to start a new game without the use of a coin.

Return lane ..... Lanes guiding ball to flippers.

Rollover ..... Wire form protruding from the playfield that scores when it is actuated by the ball. Usually centered in a metal-shaped slot.

Rollover button ..... A plastic button that is fastened directly to a switch below the playboard and that scores in the same way as a rollover.

Roto target ..... Targets that the ball contacts on units which rotate offering different value at random.

Schematic ..... A drawing showing the complete wiring of all the components by means of a shorthand system of symbols and lines.

Slighshot kicker ..... A rubber ring stretched around two posts and a solenoid-powered kicker, located at the lower end of the field in between the side gutters and the flippers.

Slo-blo-fuse ..... A circuit breaking component that permits a temporary surge of high current but breaks on continuous excess current flow.

PINBALL GLOSSARY (CONT.)

Solenoid .....Coil of copper wire with a hollow core that allows a metal rod to slide through its center under the influence of the magnetic field created when the coil is energized. The basic form of power for the pinball machine.

Special feature .....A feature that becomes worth a free game or extra ball when an accompanying series of requirements are completed.

Steel rail .....Those machines subsequent to 1959. Characterized by metal trim, metal legs, and a metal ball runway.

Switch .....A devise that opens and closes electrical circuits.

Target .....A metal or plastic piece projecting above the surface of the playboard that, when hit by the ball, closes a switch to effect scoring or other purpose of the target.

Tilt .....Anticheat devices that prevent physical abuse of the machine. There are three types of tilt mechanisms. The tilt switch located under the playfield closes if the machine is pushed or hit too violently from the side. This is called a Slam tilt. The Ball-roll tilt and Mercury tilt are switches that are closed by the switch being contacted by the ball, or mercury. If the machine is lifted,the mercury or ball rolls down a slightly inclined groove and closes the circuit. The Plumb tilt is a free-swinging pendulum surrounded by the striker plate. The pendulum is centered in the hole of the striker plate when the machine is in normal operating attitude. The jarring of the machine in any direction will cause a contact between the pendulum and the striker plate. On the older machines a tilt turned off the whole game. In the more modern machines you lose only the ball in play.

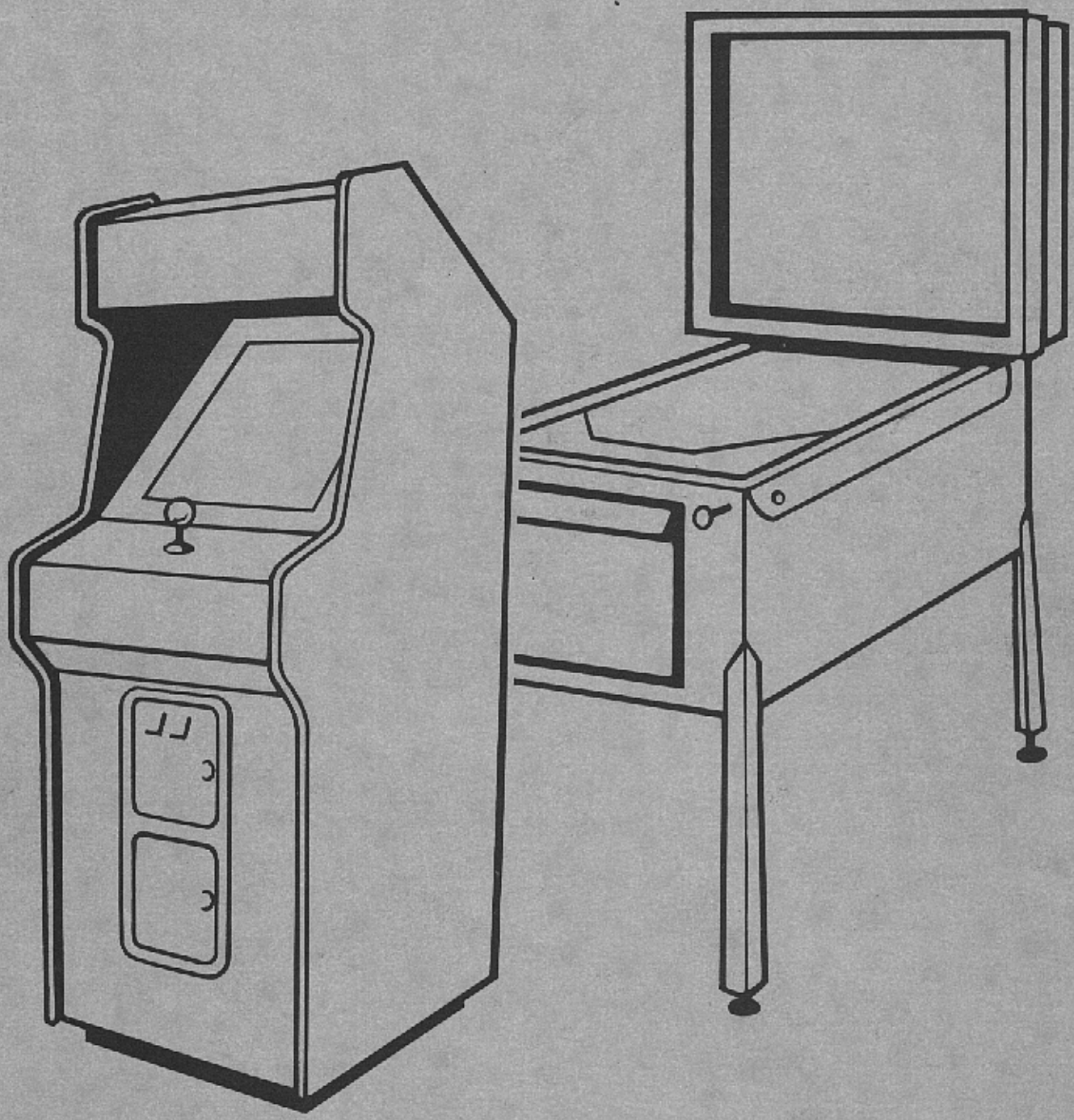
Transformer .....Electric component normally used for changing the high voltage down to the lower voltages used for lighting and relays etc.

Wiper .....The rotating part that makes contact with the disc.

Wiring diagram .....A drawing showing actual placement of wires. (Schematic circuit does not show actual wire location.)

Wizard .....A superior pinball player. One who seems to be able to control the ball as if by magic.

Wood rails .....Those machines between 1946 and 1959. Characterized by wooden trim, wooden legs, and a wooden ball runway.



Gottlieb™

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