outputs are applied to the pin 6 inputs of current-to-voltage converters C12 and A12.

From the current-to-voltage converters, the signal is fed to two sample-and-hold circuits: One is non-inverted and the other is inverted. The non-inverted sample and hold consists of one stage of analog switch D12 and capacitor C98 for the X axis, and B12 and C106 for the Y axis. The inverting sample and hold consists of inverter E12, one stage of analog switch D12, and capacitor C119 for the X axis and B/C12, B12 and C118 for the Y axis.

The sample and hold circuits are controlled by SHCON (sample and hold control). SHCON is derived by gating 3 MHz from the microcomputer clock circuitry and VGCK from the vector generator’s state generator. The result of these inputs insures that the non-inverted and inverted analog signals that are applied to the analog switches have sufficiently stabilized before being applied to the sample and hold capacitors.

The output swing of SHCON is -8 to +8 VDC. When SHCON is high, the voltage charges or discharges the sample-and-hold capacitors to the X and Y analog voltage value. The voltages are then applied to the inputs of the second analog switch. These switches select either the non-inverted or inverted X-axis and Y-axis outputs. The outputs are then amplified by the second stages of C12 and A12 for an impedance-matched output to the X and Y inputs to the monitor. Since the monitor doesn’t have field-adjustable X and Y gains, the gains are adjustable by variable resistors R120 and R126.

Z Output

The Z axis video output receives six inputs. BVLD (beam valid), from the output of the vector generator’s position counters, tells the Z axis to draw the line. BLANK (vector line blank), from the vector generator’s state machine, tells the Z axis to stop drawing a line. SCALE0 thru SCALE3 (grey level shading scale), from the output of the vector generator’s data latch, tells the Z axis the grey level shading of the line that is being drawn on the monitor.

When BVLD and BLANK are both high, a high is clocked through shift register K9 that turns transistor Q3 off. This allows the scale inputs to be passed through transistor Q2. When BLANK goes low, a low is clocked through K9, transistor Q3 turns on, and the signal is grounded at the base of transistor Q2.

The scale inputs at the base of transistor Q1 determine Q1’s emitter voltage, during the line draw period. The SCALE0 thru SCALE3 resistors R36 thru R39, resistor R35, and resistor R40 result in a range of about +1.0 VDC when all are low and +4.0 VDC when all are high. The emitter of Q1 follows at about +1.7 to 4.7 VDC, while the emitter of transistor Q2 follows at about +1.0 to 4.0 VDC. This output is applied to the Z input of the monitor. Since there are brightness and contrast controls in the monitor, there are no adjustments in this circuit.
The EXPLODE generator produces a random noise. This noise is filtered by P11 and produces the random noise when the ship is hit by any object.
The game option switches are read by the MPU when OPTS (option switch enable) is low. Switch toggles to be read are selected by AB0 and AB1 from the MPU. Switch toggles 1, 3, 5, and 7 are read on data line DB0 and toggles 2, 4, 6 and 8 are read on DB1. Toggle inputs are “on” when pulled to ground.

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**VIDEO INVERTER**

The video inverter circuitry is only used in a cocktail game. In an upright game, pin 19 is unconnected and therefore floats. When pin 19 floats, transistor Q16 is turned off and transistor Q17 is turned on. Therefore, INV is $-8.2$ VDC and NONINV is about $+8.2$ VDC. The result is a non-inverted X-axis and Y-axis output.

In a cocktail game, the wiring harness shorts connector J20's output pin 7 input pin 19. When the video of player 1 is being displayed, pins 7 and 19 are $+5$ VDC. This results in a non-inverted video output. When the video for player 2 is being displayed, pins 7 and 19 are grounded. This causes transistor Q16 to be turned on and Q17 to be turned off. Therefore, INV is $+8.2$ VDC and NONINV is $-8.2$ VDC. The result is an inverted X-axis and Y-axis output, causing the monitor's display to be upside down.

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NOTE: FOR COUNTER P3, 9311 IS AN ACCEPTABLE SUBSTITUTE FOR 74LS161.
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R9 and P9 generate random noise. The noise is filtered by P11 and produces a rumble sound heard when thrusting.
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The coin door and some control panel switches are read by the MPU when SINP1 (switch input one enable) is low. Switches to be read are selected by A0 through A2 from the MPU. All inputs are read on data line DB7. Switch inputs are “on” when pulled to ground.
The THUMP sound is heard throughout play, as the 555 is connected as an oscillator, enabled by N7 pin 2. The frequency is determined by the current coming out of Q2. This depends on the base voltage, which is derived from the four-bit code in N7.

The SAUCER sound is heard when an enemy saucer appears. The 556 is a voltage-controlled oscillator. Its modulating voltage is derived from the 555. The 556 is a low frequency oscillator. The effect is a warning sound. SAUCERSeven changes some component values in order to provide for 2 different saucer sounds.

LIFE sound is heard when an enemy saucer is gained. It is merely 3 kHz from the circuitry.

The Fire sounds for the Saucer and the Space Ships are generated by two identical circuits. Each contain a 556 operating as a voltage-controlled oscillator. The Saucer Fire Sound is initiated by SAUCERFIREEN. Each of the 556s is connected in such a way that when they are enabled, they output a signal of a specific frequency and amplitude. This signal begins to decay immediately, both in frequency and amplitude, due to the discharge of the capacitors (C5 & C6).
LAMP, LED, AND COIN COUNTER OUTPUT

This circuit consists of coin counter drivers Q11, Q12, Q13, and data latch N11, clocked by the microcomputer's address decoder. When the input to a decoder is clocked high, its collector goes low, grounding the return of the coin counter output. When START or START 2 is clocked low, it grounds the START LEDs in the control panel.

All sounds are mixed in 1/4 of P11. The signal is then inverted by another phase signal from P11 and becomes Audio 2. These signals provide a push-pull output to the audio section of the Regulator Audio PCB.

VIDEO OUTPUTS
The DAC's converts three binary number inputs to current outputs. The DAC's current outputs are applied to the pin 6 inputs of constant-current voltage converters C12 and A12.

The monitor picture is turned upside down. This is used for a two-player cocktail game. The monitor screen, 512 is at the center and 996 is at the top. When the X axis and Y axes are inverted, the numbers range from 128 to 996. Where 128 is at the bottom of the monitor screen, 512 is at the center and 1023 is at the top right for the non-inverted X axis, the numbers range from 0 to 1023, where 0 is at the bottom of the monitor screen, 512 is at the center and 1023 is at the top right. These numbers represent the location of the beam on the monitor screen. X and Y outputs achieve binary numbers from the vector generator's position.

The video output circuit consists of three individual circuits: X axis, Y axis, and Z axis amplifiers. The Z axis video output circuit consists of a shift register and a summer.