SPECIFICATIONS

RF Carrier Frequency	One of the following, crystal controlled:

27 MHz Band	53 MHz Band	72 MHz Band
26.995	53.100	72.080
27.045	53.200	72.160
27.095	53.300	72.240
27.145	53.400	72.320
27.195	53.500	72.400
		72.960
		75.640

Frequency Stability	Within ±.005% on 27 MHz band. Within ±.002% on 53 and 72 MHz bands.
Temperature Range	0 to 160 degrees F.
RF Output Circuit	Pi network.
RF Input Power	500 mW.
Modulation	ON-OFF carrier keying.
Approximate Current Drain	100 mA on all bands.
Controls	Eight channels; four with trim; ON-OFF switch. Frequency selector switch. Trainer pushbutton.
Power Supply	Internal 9.6 V, 500 mA hour, nickel-cadmium battery. Rechargeable simultaneously with receiver battery at 35 to 40 mA from 120 volt power line.
Dimensions	7" high x 7" wide x 2" deep.
Net Weight with Battery	2-3/4 lbs.

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

THEORY OF OPERATION

The Transmitter produces a crystal-controlled, rf carrier that is modulated by on-off carrier keying. This method of modulation makes 8-channel precision control possible. The following paragraphs will help you to understand the modulation principles used in this Transmitter.

The first waveform in Figure 2-6 shows a frame of nine pulses that is repeated every 17,000 microseconds in a continuous train. After every ninth pulse there is a 5 millisecond pause before the start of the next pulse. Each pulse is 350 micorseconds wide and normally there are 1500

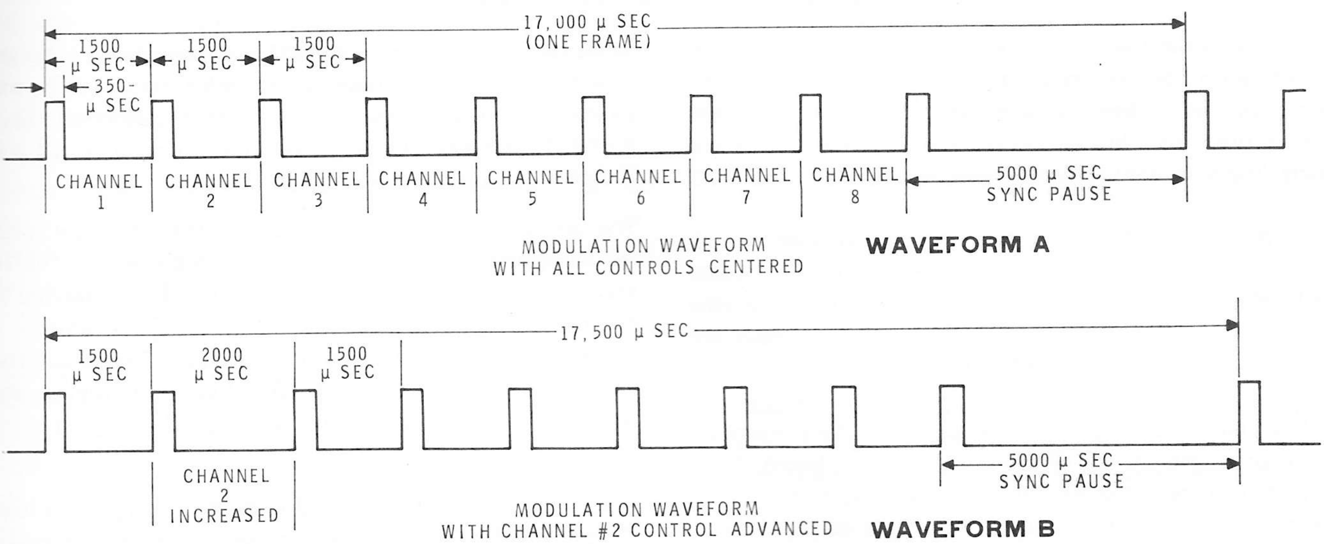


Figure 2-6

microseconds from the start of one pulse to the start of the next pulse.

The second waveform in Figure 2-6 shows that the time difference between two pulses, by moving the transmitter controls, can be increased or decreased as much as 500 microseconds. It is this time difference that determines the position of the Servo. Example: 1500 microseconds is the center position for the Servo. 1000 microseconds is full left and 2000 microseconds is full right.

When a control on the Transmitter is moved, the time interval of that channel is changed. The second waveform in Figure 2-6 illustrates an increase in the time interval of channel #2 when the channel #2 control is moved from its center position. All other channels remain unaffected. The 5 millisecond pause after the ninth pulse in each frame is the sync pause. This pause synchronizes the receiver's decoder circuit with the transmitter's signal.

The modulated rf carrier, as it is transmitted, is shown in Figure 2-7. Here the absence of a carrier represents each pulse shown in Figure 2-6. This form of modulation, as opposed to the carrier being on only during the 350 microsecond pulse, reduces the possibility of erratic operation caused by interference to the Receiver.

The Receiver circuits amplify and detect the rf carrier to produce the pulse modulated waveform. The pulses are then shaped and amplified for proper triggering of the decoder integrated circuit.

The decoder circuit passes the first pulse to the channel #1 Servo, the second pulse to the channel #2 Servo, the third pulse to the channel #3 Servo, etc. Therefore, each Servo receives one pulse in each frame. The sync pause resets the decoder circuit to start with channel #1 again.

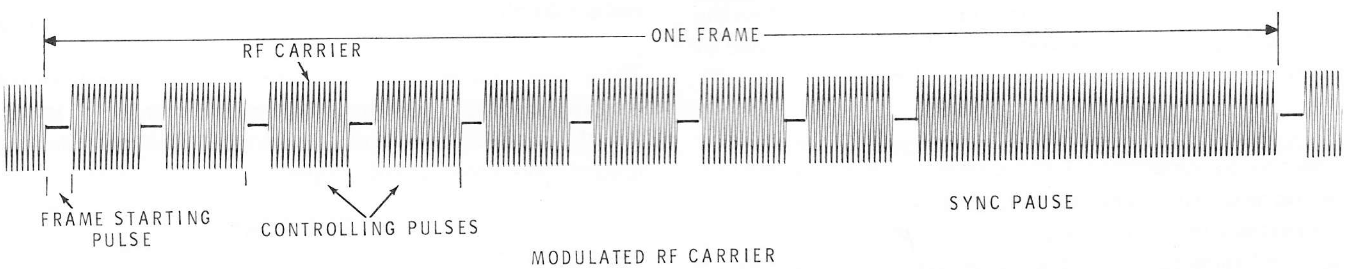


Figure 2-7

CIRCUIT DESCRIPTION

A number series has been assigned to each of the two circuit boards and to the Transmitter case. These number series are used on the Schematic Diagram and in this "Circuit Description" to help you identify and locate circuits and parts. The part numbers are grouped as follows:

1-99	Parts mounted on the encoder circuit board.
101-199	Parts mounted on the RF transmitter circuit board.
201-299	Parts mounted on the case.

Pulses that are used to key the rf carrier of the Transmitter originate in the circuits of the encoder circuit board. These circuits include a free-running multivibrator, a monostable multivibrator, and timer circuits that are enclosed in an integrated circuit. The rf circuit board contains a crystal-controlled oscillator and an rf stage output on the 27 and 53 MHz bands. The 72 MHz rf circuit board contains a crystal-controlled oscillator, a doubler, and an rf output stage. Each circuit of the Transmitter will be described separately in the following paragraphs.

Refer to the Schematic Diagram (fold-out from Page 65) while you read this "Circuit Description." Refer to the "Circuit Board X-Ray Views" on Page 59 to help you locate the parts on the circuit boards.

FREE-RUNNING MULTIVIBRATOR

The free running multivibrator is composed of transistors Q1, Q2, Q3, and Q4, and their associated circuitry. Transistors Q3 and Q4 conduct alternately. The rate at which these transistors conduct is determined by the value of capacitors C1, C2, and the associated controls.

Assume that transistor Q3 conducts first when power is applied to the circuit. The collector voltage of transistor Q3 will be low. This will lower the voltage at the input of counter integrated circuit IC1. The counter circuit, which is enclosed in IC-1, is constructed in such a way that when the input voltage is low, the counter will activate only one of the timing circuits connected to the base of Q4.

This charges capacitor C1 and causes the voltage at the base of transistor Q4 to rise. When the base voltage of Q4 reaches a sufficient level, the transistor turns on and the collector voltage begins to drop. This low voltage is coupled through capacitor C2 to the base of transistor Q3 and turns off Q3. The collector voltage of Q3 rises and the counter is again triggered and activates the next channel in sequence.

Transistor Q3 will remain cut off until capacitor C2 charges to a sufficient level to allow Q3 to conduct again. At the end of the ninth pulse, the larger value of R17, connected to pin 8 of IC1, provides a longer charge time for capacitor C1 and therefore produces the 5 millisecond pause.

The outputs of IC1 are connected to 10 kΩ controls, with the exception of channel #5, the switched channel. The 10 kΩ controls regulate the amount of voltage that is applied to the control sticks and auxiliary controls. This provides a means of adjusting the travel of the Servo. The greater the voltage that is applied to the 10 kΩ controls, the less the Servos travel; the lower the voltage applied, the greater the travel.

Transistors Q1 and Q2 are used to quickly charge capacitors C1 and C2. This is necessary to prevent interaction between adjacent channels. If these capacitors were not completely charged, the time that transistors Q3 and Q4 conduct would be shorter and the time for the channels would be shortened. Diodes D4 through D10 prevent the negative voltage on the base of Q3 or Q4 from discharging to ground during the off time. This would upset the timing. These diodes also provide temperature compensation.

MONOSTABLE MULTIVIBRATOR

The monostable multivibrator is composed of transistors Q5, Q6, and their associated circuitry. This multivibrator produces the 350 microsecond pulse each time transistor Q3 or Q4 starts to conduct. As transistors Q3 and Q4 alternately conduct, they produce pulses at their collectors which are coupled through capacitor C5 to diode D3. Diode D3 allows only the negative half of each pulse to be coupled through to the base of transistor Q5, which causes Q5 to conduct. A positive pulse from the collector of Q5 is then coupled through C8 to the base of Q6. This positive pulse lasts for 350 microseconds and is determined by the combination of capacitor C8 and resistor R14. While transistor Q6 is not conducting, its collector voltage is low. Resistor R12 provides positive dc feedback to the base of transistor Q5 to keep it conducting while transistor Q6 is not conducting.

The rf and doubler circuits also receive their power from the collector of Q6. Therefore when the collector of Q6 is low, the rf and doubler circuits are cut off. This provides the needed modulation of the rf signal.

27 MHz AND 53 MHz BAND RF TRANSMITTER CIRCUITS

The following circuit description applies directly to the 53 MHz circuit. The 27 MHz circuit is similar except for some differences in the resistor, capacitor, and coil numbers.

The crystal-controlled oscillator and rf output amplifier circuits are contained on the small rf transmitter circuit board. These circuits generate and amplify the radio frequency carrier signal that is modulated by the controlling pulses from the multivibrator.

Crystal oscillator transistor Q101 operates as a grounded-base Colpitts oscillator. Coil L102, which is in parallel with capacitor C104, tunes the circuit to the frequency of the crystal.

During the intervals between pulses from the monostable multivibrator circuit, while transistor Q6 conducts, power is applied through the winding of L102 to the collector of Q101 and causes the oscillator to operate. Since the oscillator stops when the power is cut off during a pulse, the oscillator's output signal is negative-modulated by the pulse signals.

Capacitor C106 couples the modulated oscillator signal to coil L103. The signal is then coupled from a tap on coil L103 through capacitor C108, to the base of transistor Q102. Transistor Q102 conducts on the positive peaks of the rf carrier which charges capacitor C108. Resistor R104 provides a return path for the negative voltage on the base of Q102 and provides proper bias. This bias is determined by the time constant of resistor R104 and capacitor C108.

Transistor Q102 operates as a tuned collector amplifier. The pi network of capacitor C110, C112, and coil L104 tunes the amplifier output to the crystal frequency and provides a proper impedance match between transistor Q102 and the antenna. Coil L106 provides antenna loading and capacitor C114 prevents the dc supply voltage from reaching the antenna. Supply voltage is coupled to the circuit through coil L105.

A portion of the rf signal is taken from the pi network through capacitor C113 and rectified by diode D101 to operate the meter, which indicates relative carrier strength. Resistor R106 provides a dc return path for the diode while capacitor C115 filters the diode's rectified output.

72 MHz BAND RF TRANSMITTER CIRCUITS

The 72 MHz band oscillator operates just like the oscillators for the other bands, except that it oscillates at a frequency that is one-half of the final transmitted frequency. The secondary winding of transformer T101 couples the oscillator signal through capacitor C106 to the base of Q102. Transistor Q102 conducts on the positive peaks of the oscillator signals.

The output of transistor Q102, capacitors C108, C109, and coil L102 is tuned to the second harmonic of the oscillator frequency. This appears as a low impedance to ground for the fundamental oscillator frequency and, at the same time, resonates at a high impedance for the second harmonic.

Coil L103 couples DC to the collector of Q102 from multivibrator Q6 and at the same time, isolates Q6 from the rf at transistor Q102. The dc from Q6 causes Q102 to operate normally until a negative pulse arrives at the collector of Q102. Then Q102 cuts off for the duration of the pulse, modulating the rf.

The doubled and modulated signal is then coupled from Q102 to rf amplifier Q103, amplified, and coupled to the antenna in the same manner as the signals of the other two bands.

POWER SUPPLY

Power for the Transmitter circuits is supplied by a self-contained, rechargeable 9.6 volt nickel-cadmium battery. When the Power switch is in the Off position, the Battery is connected to a charging circuit which operates in the following manner.

The Receiver's battery is connected, by means of the charging cable, in series with the pilot lamp (charging indicator), to the negative (–) lead of the Transmitter Battery. Resistor R39 connects to the positive (+) lead of the Transmitter Battery through the ON-OFF switch. When the charging cable is connected between the 4-pin connector and a 120 volt ac outlet, the series circuit charges both the Receiver Battery and the Transmitter Battery at the same time.

Diode D12 rectifies the ac line voltage and resistor R39 limits the charging current to a safe value. The pilot lamp indicates when the battery is being charged. Since the Off position of the power switch removes all connections between the Battery and the Transmitter circuits, the danger of shock from the charging circuit is eliminated.

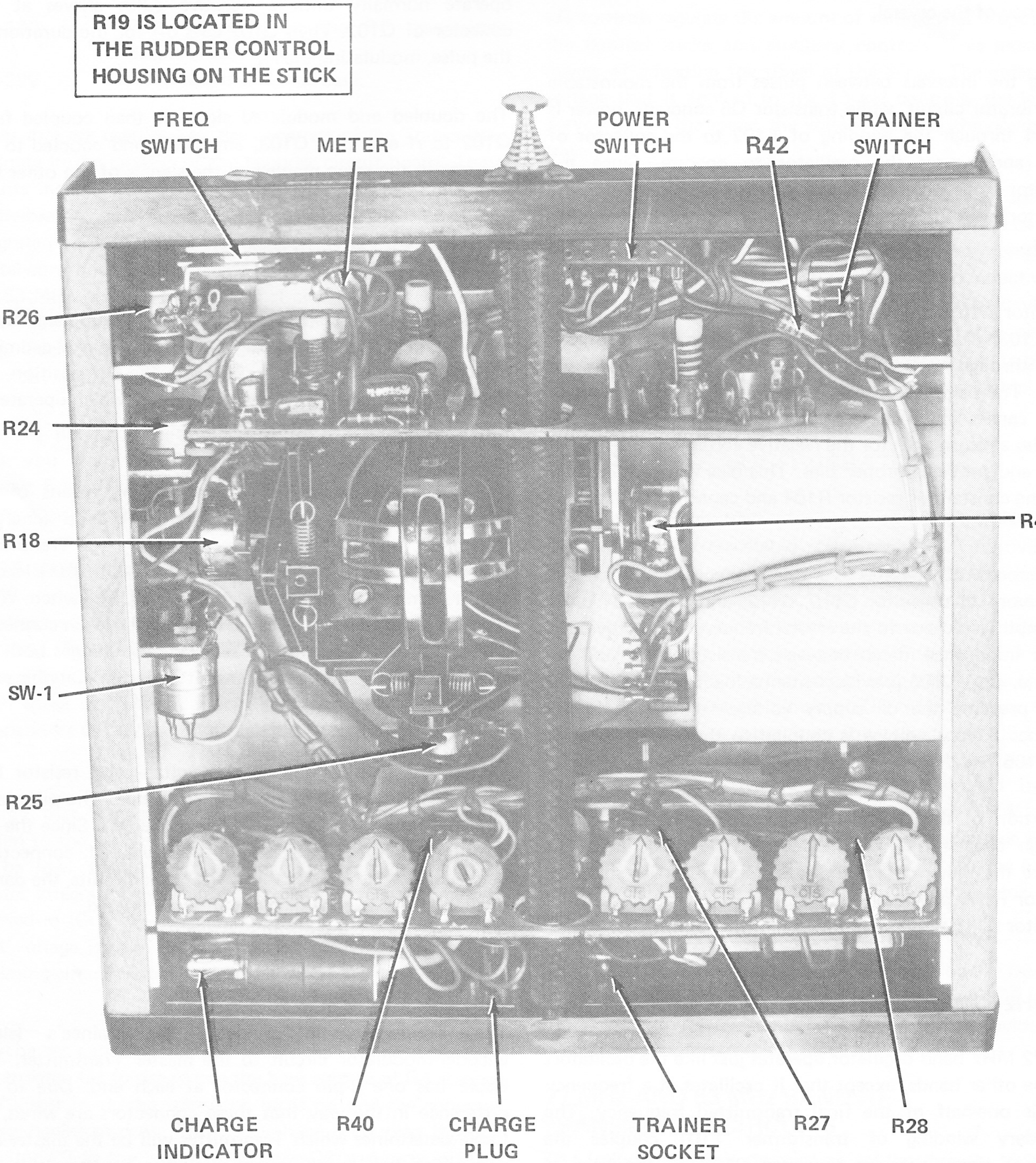
TRAINER CABLE

The Trainer Cable connects the trainee's (slave) encoder-modulator circuit to the master Transmitter. This Cable has one 3-pin connector at each end. Due to the difference in the way that these connectors are wired, the Cable determines which Transmitter will be the master unit and which will be the slave. By reversing the Cable, the former slave Transmitter becomes the master Transmitter and the master Transmitter becomes the slave.

When the Trainer Cable is connected, the slave Transmitter's oscillator is disabled. On the 27 MHz and 53 MHz circuits this is done by grounding the base of oscillator transistor Q101 through coil L101. On the 72 MHz circuit it is done by the supply voltage through resistor R104. The modulator output of the slave Transmitter is coupled through the Trainer Cable to pin 1 on the master Transmitter.

When the trainer wants to switch control to the slave Transmitter, he pushes down his trainer pushbutton which disconnects his modulator and connects the slave modulator to the rf circuit.

CHASSIS PHOTOGRAPH

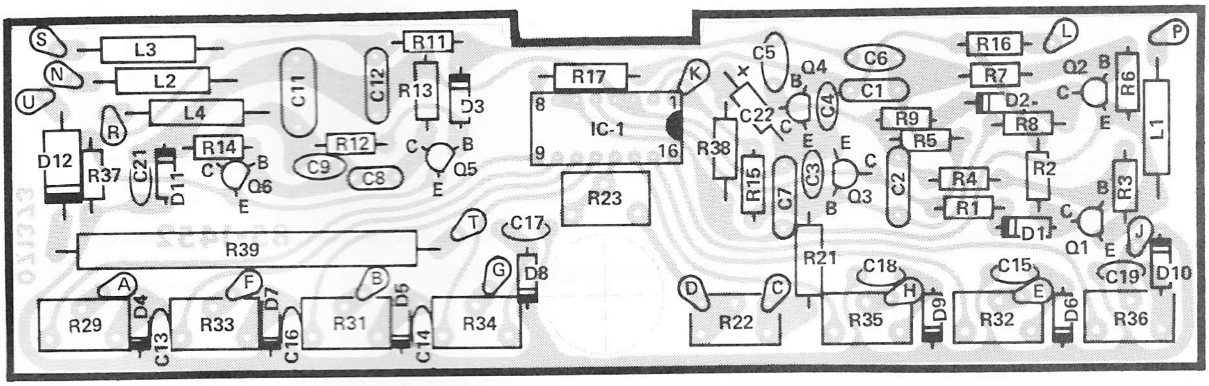


CIRCUIT BOARD X-RAY VIEWS

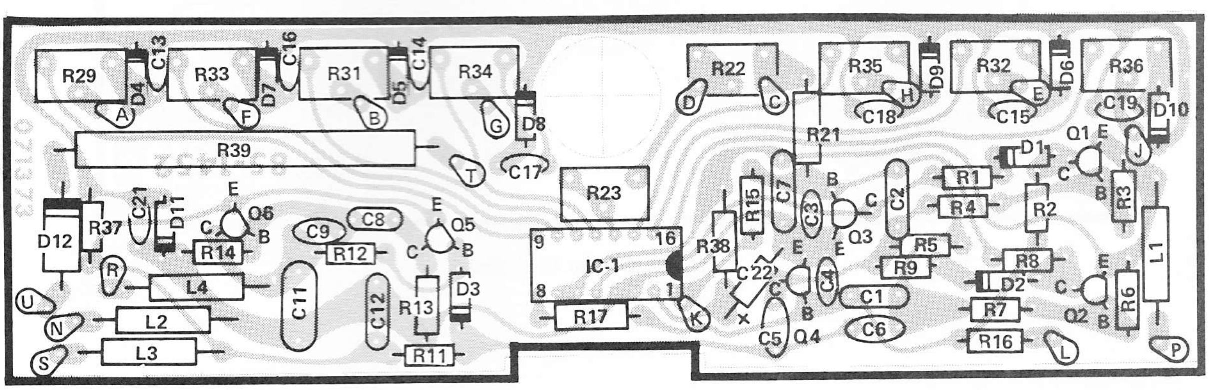
NOTE: To identify a part shown in one of these Views, so you can order a replacement, proceed as follows:

1. Note the identification number of the part (R-number, C-number, etc.).
2. Locate the same identification number (next to the part) on the Schematic. The "Description" of the part (for example: 22 kΩ, .05 μF, or 2N2712) will also appear near the part.
3. Look up this Description in the Parts List.

ENCODER CIRCUIT BOARD

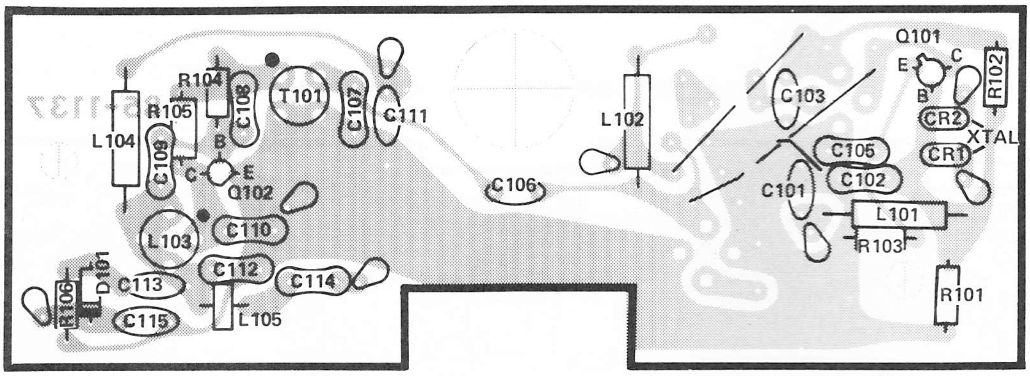


(VIEWED FROM COMPONENT SIDE)



(viewed from foil side)

27 MHz RF CIRCUIT BOARD



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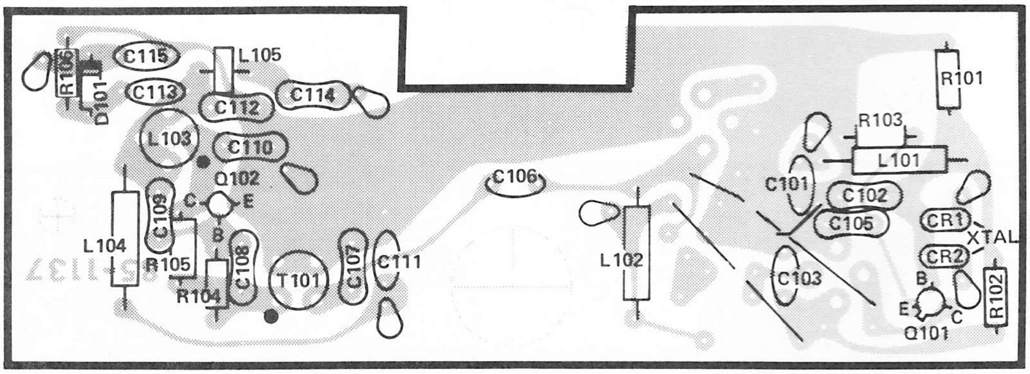

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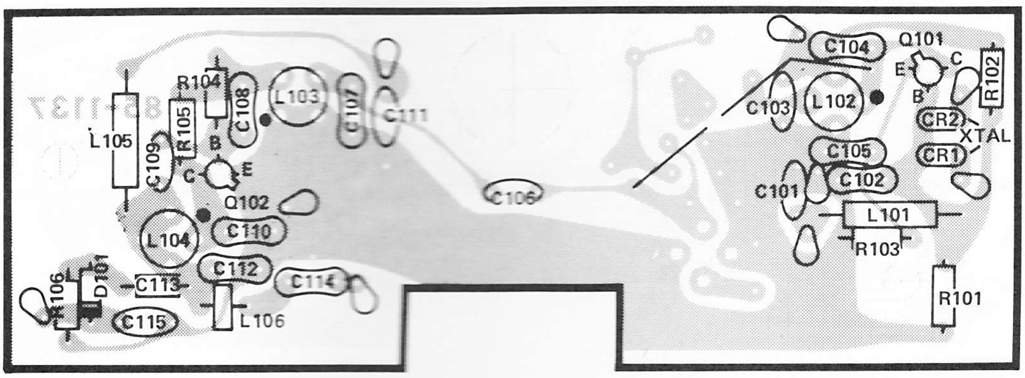
53 MHz RF CIRCUIT BOARD



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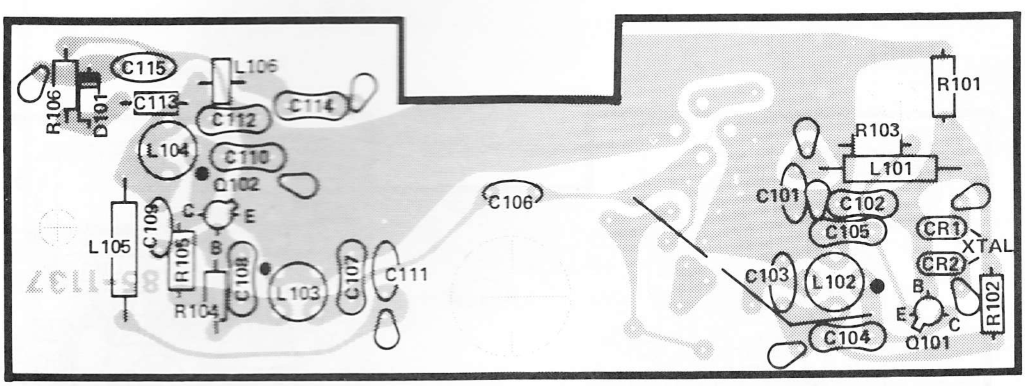

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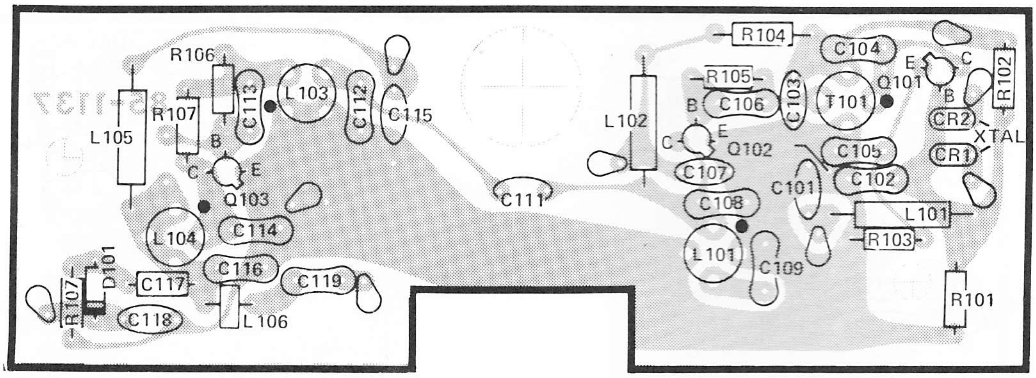
72 MHz RF CIRCUIT BOARD



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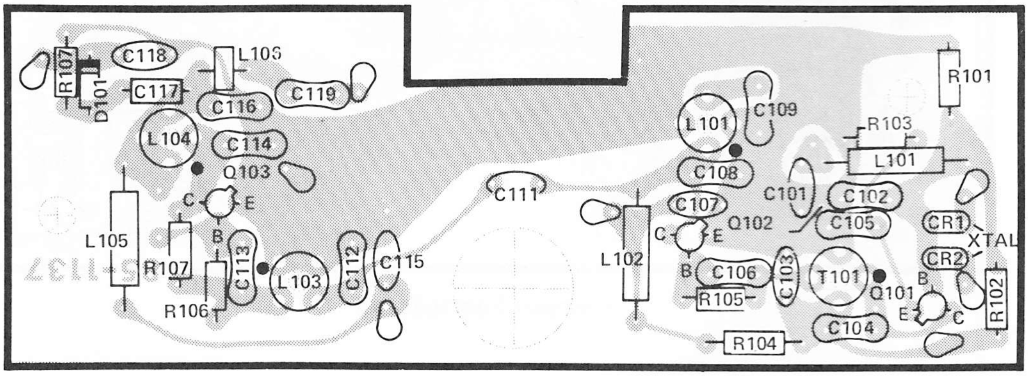
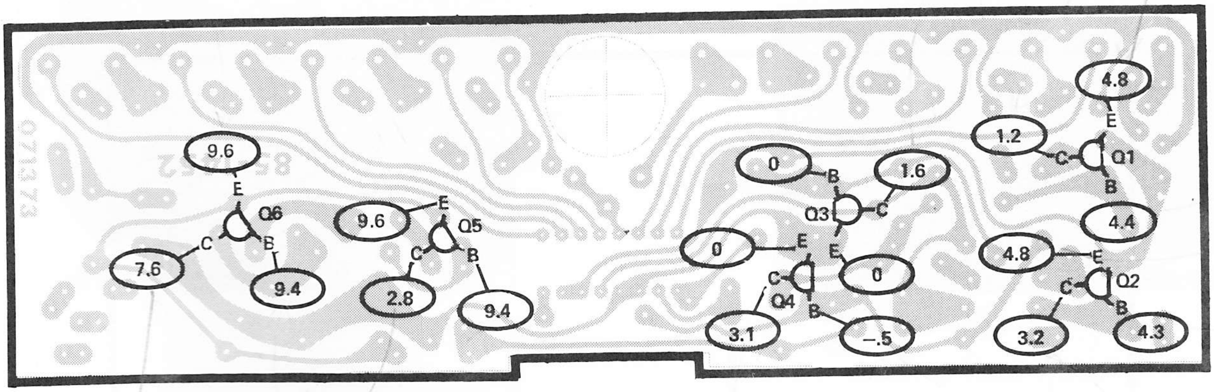
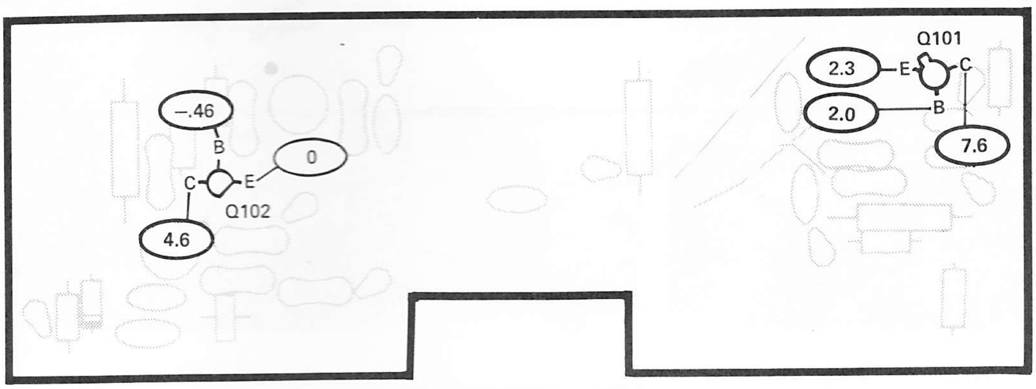


(viewed from foil side)

VOLTAGE CHARTS



ENCODER CIRCUIT BOARD
(viewed from foil side)



27 MHz RF CIRCUIT BOARD
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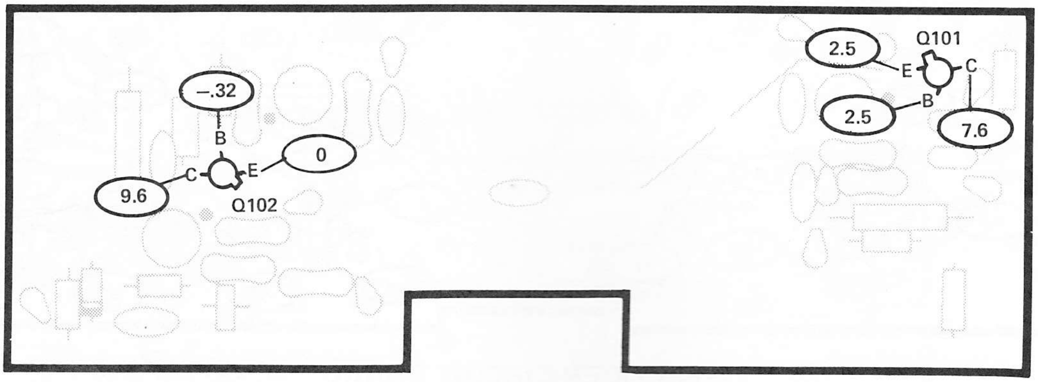

53 MHz RF CIRCUIT BOARD
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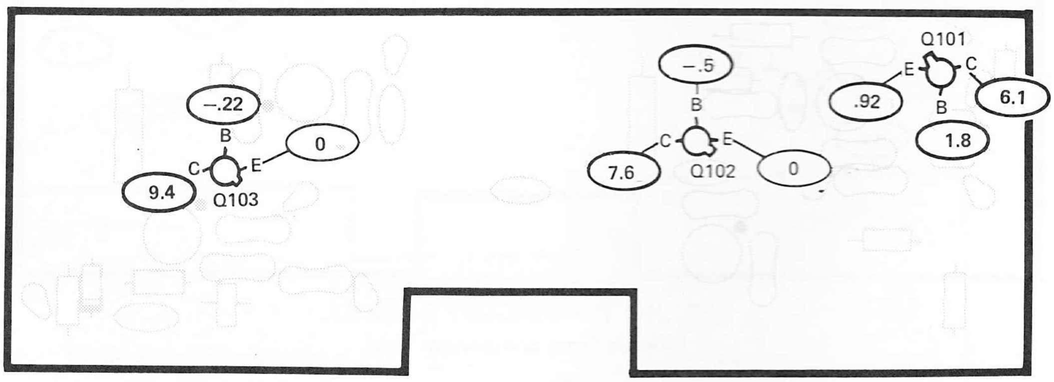
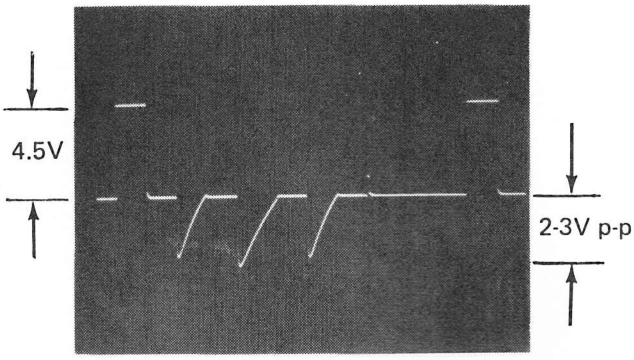


72 MHz RF CIRCUIT BOARD
(viewed from component side)



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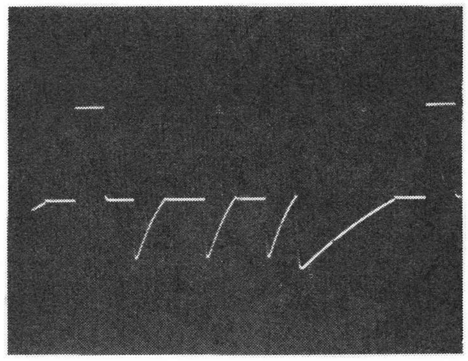
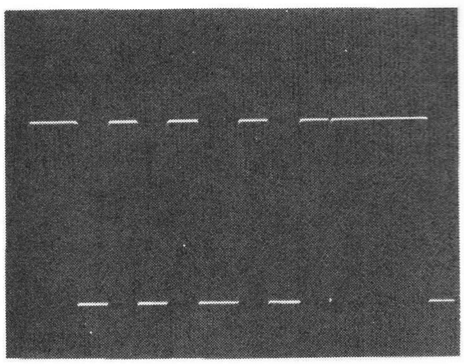
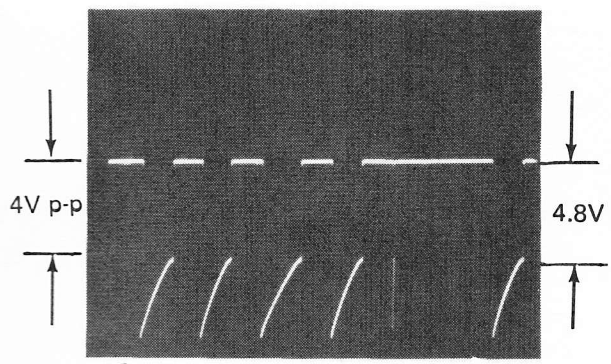


2 2-3V P-P



3 4.5V P-P



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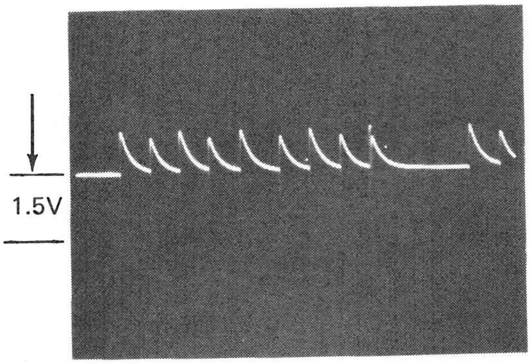

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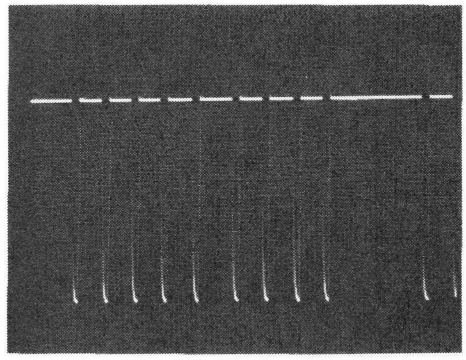

6 9V P-P