

Serial No. \_\_\_\_\_

INSTRUCTION MANUAL  
**MODEL 147**  
**HF SWEEP GENERATOR**

**WAVETEK**  
Box 651, San Diego, Calif., 714-279-2200

1R-10/73

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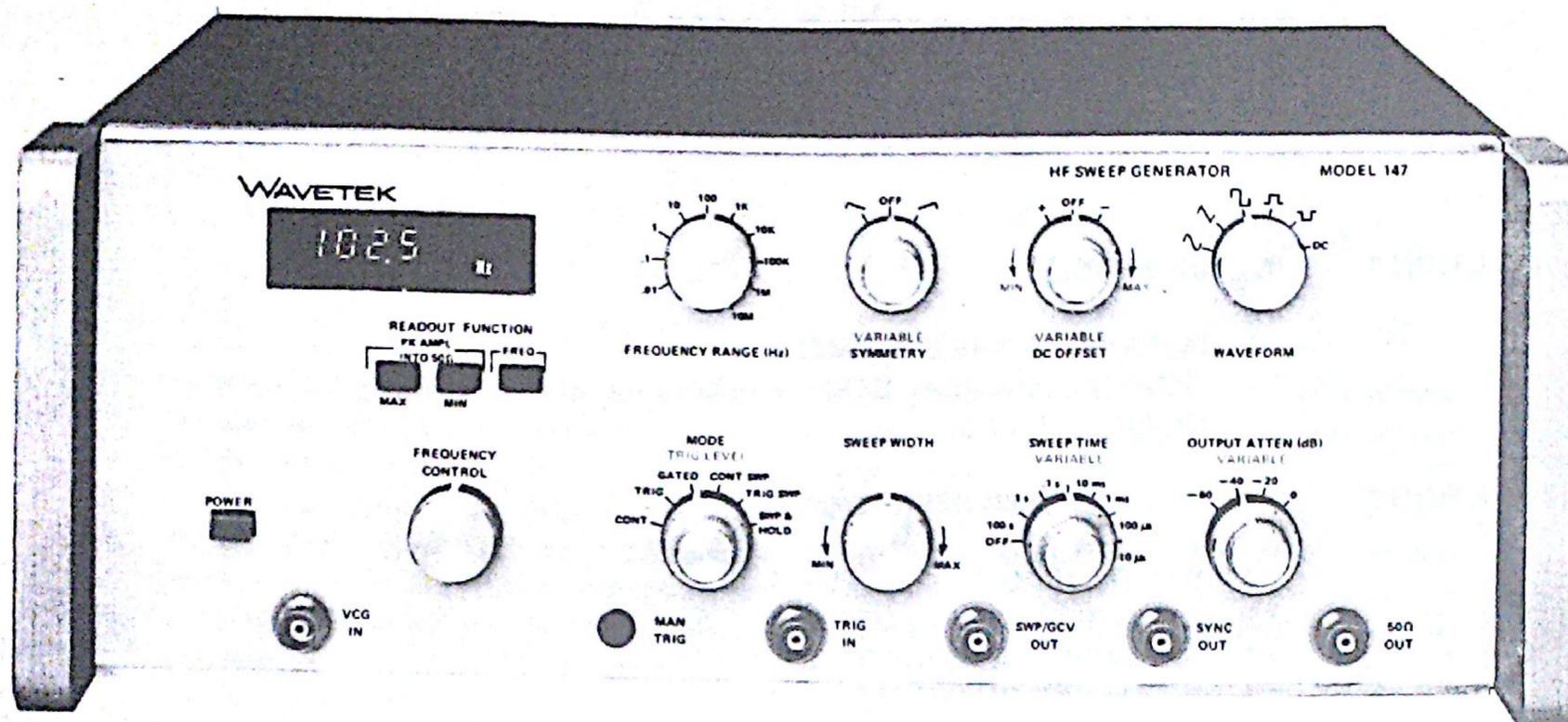


Figure i – Model 147 HF Sweep Generator

### SCOPE OF THIS MANUAL

This manual provides descriptive material and instructions for the installation, operation, maintenance, and repair of this instrument. Wavetek's product improvement program ensures that the latest electronic developments are incorporated in all Wavetek instruments by the addition of circuit and component changes as rapidly as development and testing permit. Due to the time required to document and print instruction manuals, it is not always possible to incorporate the more recent changes in the released manual. In this case, data will be found on engineering change sheets at the rear of the manual. If no change sheets are included, the manual is correct as printed.

# SECTION 1

## INTRODUCTION

### 1.1 PURPOSE OF THE EQUIPMENT

The Model 147 HF Sweep Generator is a precision 0.0005 Hz to 10 MHz source of sine, triangle, square, positive pulse, and negative pulse waveforms, each with variable amplitude, dc offset, and symmetry. Frequency range selection is provided in 10 decades, with a 3½ digit LED readout and vernier control which permits accurate adjustment to the least significant digit of the readout. The 3½ digit readout is 3 digits plus a fourth (the most significant) digit of 0 or 1. DC voltage output is also selectable with an adjustable range of  $\pm 10$  Vdc into an open circuit ( $\pm 5$  Vdc into  $50\Omega$ ) with 150 mA short circuit current.

Maximum output amplitude is 30 V p-p into an open circuit (15 V p-p into  $50\Omega$ ) with a 60 dB calibrated step attenuator and a 20 dB vernier attenuator (80 dB overall) allowing signal levels as low as 1.5 mV p-p. Both the output waveform and the dc offset are attenuated by the 60 dB calibrated step attenuator. Maximum and minimum output peak voltages are displayed on the 3½ digit LED readout and are accurate to the specification when the output has been properly terminated with  $50\Omega$  load.

The Model 147 has six operational modes (continuous, triggered, gated, continuous sweep, triggered sweep, and sweep and hold) plus tone burst capability. The main output can be internally swept over approximately a 1000:1 ratio at sweep times from 10  $\mu$ s to 100 s, or it can be frequency modulated, dc programmed, or externally swept over a greater than 1000:1 ratio by applying an external control signal to the front panel VCG IN connector. A single cycle of output, or one full sweep of the output, can be obtained by manual trigger or an external trigger signal applied to the front panel TRIG IN connector.

In addition to the  $50\Omega$  main output and sync output, the Model 147 also has sweep and generator control voltage (GCV) outputs. When the main output is not internally swept (i.e., operating in continuous, triggered, or gated modes without sweeping), the fixed amplitude sawtooth output of the internal sweep generator appears at the SWP/GCV OUT connector. When the main output is internally swept, an output voltage proportional to the instantaneous frequency of the main generator will appear at the SWP/GCV OUT connector. This GCV output can be used to

drive X-Y recorders or the vertical and horizontal deflection circuits of oscilloscopes, video monitors, etc.

Varying the triangle symmetry produces a sawtooth signal with a rise or fall time as fast as 50 ns at a recurring rate of up to 1 MHz. Pulse outputs as narrow as 50 ns (duty cycles from 19:1 to 1:19) with repetition rates as high as 1 MHz can be generated in either polarity. Even the sine wave symmetry may be varied over this 1:19 to 19:1 range if desired. When the output symmetry is not 1:1, the frequency range setting is divided by approximately 10; however, the actual output frequency is displayed on the LED readout.

With this instrument it is possible to internally or externally sweep the output frequency, select the output symmetry desired, and manually vary the dc offset. The output frequency, positive peak amplitude and negative peak amplitude are displayed on a digital readout. DC offset or dc output voltage can be set by digital readout. These capabilities coupled with the variety of waveforms available and precision output amplitude control make the Model 147 an extremely versatile instrument.

### 1.2 GENERAL PHYSICAL DESCRIPTION

The Model 147 weighs approximately 12 lb (5.45 kg) net and 16 lb (7.26 kg) when shipped. It is 14½ in. (368 mm) wide, 5¼ in. (133 mm) high, and 14¼ in. (362 mm) deep, and is housed in a compact, ruggedized, portable case. The Model 147 is normally shipped with a 10 foot, 3 wire, detachable line cord and one copy of this instruction manual.

### 1.3 SPECIFICATIONS

#### 1.3.1 Waveforms

Waveforms that may be selected are sine , square , triangle , positive pulse  and negative pulse . DC voltage may also be selected. Symmetry of all outputs are continuously adjustable from 1:19 to 19:1. Varying the triangle symmetry produces sawtooth  or  output. The Model 147 has a SWP/GCV OUTput and a SYNC OUTput with variable symmetry as described below. Signal frequency and maximum and minimum peak signal voltages are indicated by a 3½ digit LED readout.

### 1.3.2 Operating Frequency Range

The FREQUENCY RANGE (Hz) switch selects from 0.0005 Hz to 10 MHz in the following ranges:

|      |                      |
|------|----------------------|
| 0.01 | 0.0005 Hz to 0.01 Hz |
| 0.1  | 0.005 Hz to 0.1 Hz   |
| 1    | 0.05 Hz to 1 Hz      |
| 10   | 0.1 Hz to 10 Hz      |
| 100  | 1 Hz to 100 Hz       |
| 1K   | 10 Hz to 1 kHz       |
| 10K  | 100 Hz to 10 kHz     |
| 100K | 1 kHz to 100 kHz     |
| 1M   | 10 kHz to 1 MHz      |
| 10M  | 100 kHz to 10 MHz    |

The FREQUENCY CONTROL adjusts the frequency to the least significant digit of the readout.

### 1.3.3 Main Output

The 50Ω OUT is the output for the selectable waveform and dc voltage output. Maximum output is 30 V p-p into an open circuit; 15 V p-p into 50Ω. There is a precision output attenuator calibrated in 20 dB steps to -60 dB with an overlapping vernier for an overall attenuation of -80 dB. Output impedance is 50Ω. Short circuit current is 150 mA.

### 1.3.4 Sync Output

The SYNC OUT connector provides TTL compatible output level sync signal. Rise and fall times are less than 50 ns. The sync signal is a square waveform for symmetrical outputs and rectangular for asymmetrical outputs. Sync pulse polarity is 180° out of phase with the selectable output square wave and 90° out of phase with the sine and triangle waveforms.

### 1.3.5 DC Offset and DC Output

DC offset and dc output are controlled manually by a front panel control. The adjustable range is ±10 Vdc into an open circuit (±5 Vdc into 50Ω) with peak signal and offset amplitude limited to ±15 Vdc into an open circuit (±7.5 Vdc into 50Ω). Display will flash when peak amplitude plus offset exceeds generator limits. DC offset and output waveform are attenuated proportionately by the 60 dB step output attenuator.

### 1.3.6 Sweep/GCV Output

Sweep output is a 0 to nominal +5 V sawtooth when in continuous, triggered or gated mode, and runs at a frequency determined by the SWEEP TIME control. GCV (Generator Control Voltage) output is a 0 to nominal +5 V signal pro-

portional to the instantaneous frequency output. This GCV signal is present when the Model 147 is in any of the sweep modes.

### 1.3.7 Operational Modes

#### Continuous (CONT)

The Model 147 operates as a standard VCG (Voltage Controlled Generator). Frequency at the 50Ω OUT connector is determined by front panel control settings in conjunction with the VCG input signal. Output of the internal sweep generator appears at the SWP/GCV OUT connector in this mode.

#### Triggered (TRIG)

Only one complete cycle of output appears at the 50Ω OUT connector for each pulse applied to the TRIG IN connector or push of the MAN TRIG control. The cycle begins and ends at zero phase angle, which is zero volt or the offset base line voltage level. At least 1 V peak (and up to 50 V peak) is required for the trigger signal. TRIG IN is 10 kΩ, dc coupled.

#### GATED

Gated mode is the same as triggered mode except that output oscillations continue for the duration of the gating signal applied to the TRIG IN connector or push of the manual trigger. The output will be an integral number of cycles beginning and ending at zero phase angle, which is approximately zero volt.

#### Continuous Sweep (CONT SWP)

In continuous sweep, the main generator is swept by the internal sweep generator so that the signal frequency at the 50Ω OUT connector is swept from a low frequency established by the front panel frequency controls to a high frequency determined by the SWEEP WIDTH control setting. Sweep width can be up to approximately 1000:1. Sweep rate, determined by the SWEEP TIME control, is 10 μs to 100 s. GCV appears at the SWP/GCV connector.

#### Triggered Sweep (TRIG SWP)

Triggered sweep is the same as continuous sweep mode except that the output is swept only once for each pulse applied to the TRIG IN connector. During the time between sweeps, the main generator oscillates at a low frequency determined by the FREQUENCY CONTROL settings.

### Sweep and Hold (SWP & HOLD)

In this mode, a gate signal at the TRIG IN connector causes the Model 147 to begin a frequency sweep. After sweeping to the high frequency (set by the SWEEP WIDTH control), the output holds at the high frequency as long as the gate signal is present. When the gate signal drops, the output returns to the frequency set by the front panel frequency controls.

### Tone Burst

A tone burst can be accomplished in the gated mode by connecting the ramp output of the SWP/GCV OUT to TRIG IN. Tone burst rate, frequency and duration can be independently controlled.

### 1.3.8 Voltage Controlled Generator

#### VCG Control Range

The generator frequency can be controlled by an external voltage; e.g., five volts can vary the frequency 1000:1. Restrictions for linear operation are: frequency range selection is the upper frequency and the lower frequency is 1000 times below the frequency range selection; the required external signal for full voltage control is  $\pm 5$  V. Either restriction may be exceeded for nonlinear operation, but operation is not specified. Input impedance is 5 k $\Omega$ .

#### VCG Input Frequency

VCG Bandwidth . . . . . 100 kHz  
VCG Slew Rate . . . . . 2% of range per  $\mu$ s

#### VCG Linearity

10 Hz to 100 kHz . . . . .  $\pm 0.2\%$   
0.001 Hz to 1 MHz . . . . .  $\pm 0.5\%$

### 1.3.9 Horizontal Precision

#### Frequency Readout Accuracy

0.01 Hz to 10 kHz . . . . .  $\pm(0.3\%$  of range  $\pm 1$  digit)  
10 kHz to 10 MHz . . . . .  $\pm(0.2\%$  of range  $\pm 1$  digit)

#### Time Symmetry

10 Hz to 100 kHz . . . . .  $\pm 0.5\%$   
0.01 Hz to 500 kHz . . . . .  $\pm 1.0\%$

### 1.3.10 Vertical Precision

#### Amplitude Readout Accuracy

1 Hz to 100 kHz . . . . .  $\pm(3\%$  of full output  $\pm 1$  digit)  
100 kHz to 10 MHz . . . . .  $\pm(5\%$  of full output  $\pm 1$  digit)

### Sine Wave Frequency Response

Amplitude change with frequency is less than:

- 0.1 dB to 100 kHz
- 0.2 dB to 1 MHz
- 2.0 dB to 10 MHz

### Step Attenuator Accuracy

$\pm 0.25$  dB per 20 dB step

### Stability

Short Term . . . . .  $\pm 0.05\%$  for 10 minutes  
Long Term . . . . .  $\pm 0.25\%$  for 24 hours  
Percentages apply to amplitude, frequency, and dc offset.

### Amplitude Symmetry

All waveforms (except pulse) are symmetrical about ground within  $\pm 1\%$  of maximum peak to peak amplitude.

### 1.3.11 Purity

#### Sine Wave Distortion

10 Hz to 100 kHz . . . . . Less than 0.5% (typically 0.25%)  
100 kHz to 1 MHz . . . . . Less than 1.0%  
1 MHz to 10 MHz . . . . . All harmonics are at least 28 dB down

#### Triangle Linearity

0.0005 Hz to 100 kHz . . . . . Greater than 99%

#### Square Wave Rise and Fall Time

Less than 30 ns when terminated in 50 $\Omega$  load.

#### Total Aberrations

Less than 5%.

### 1.3.12 Environmental

#### Temperature

All specifications listed, except for stability, are for 25 $^{\circ}$ C  $\pm 5^{\circ}$ C. For operation from 0 $^{\circ}$ C to 55 $^{\circ}$ C, derate all specifications by a factor of 2.

### 1.3.13 Mechanical

#### Dimensions

14 $\frac{1}{2}$  in. (368 mm) wide; 5 $\frac{1}{4}$  in. (133 mm) high; 14 $\frac{1}{4}$  in. (362 mm) deep.

#### Weight

12 lb (5.45 kg) net; 16 lb (7.26 kg) shipping.

#### Power

90 to 110 V, 105 to 125 V, 180 to 220 V or 210 to 250 V;  
50 to 400 Hz switchable; less than 50 watts.

# SECTION 2

## INSTALLATION AND OPERATION

### 2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to knobs, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

### 2.2 ELECTRICAL INSTALLATION

#### 2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit.

#### NOTE

*Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 105 - 125 Vac line supply and with 1/2 amp, 115 V line fuse.*

Conversion for 90 to 110 V, 180 to 220 V or 210 to 250 V operation requires resetting two switches on the inside of the rear panel. To reset the switches, unscrew the four captive screws securing the rear panel, and remove the rear panel. Set the two switches and select the fuse for the ac line voltage according to the following table.

| AC Line Voltage | Switch A | Switch B | Fuse (SB) |
|-----------------|----------|----------|-----------|
| 90 - 110        | 115      | LO       | ½ amp     |
| 105 - 125       | 115      | HI       | ½ amp     |
| 180 - 220       | 230      | LO       | ¼ amp     |
| 210 - 250       | 230      | HI       | ¼ amp     |

#### 2.2.2 Signal Connections

Use 50Ω shielded cables equipped with female BNC connectors to distribute all signals when connecting this instrument to associated equipment.

### 2.3 OPERATING CONTROLS

The operating controls and electrical connections for the Model 147 are shown in Figure 2-1. The listing below discusses each control and its function.

1. **POWER Switch** – Power is on when this push button switch is in, and off when extended.
2. **READOUT FUNCTION FREQ Push Button** – When this push button is depressed, it causes the signal frequency at the 50Ω output to be displayed.
3. **READOUT FUNCTION PK AMPL, MAX/MIN Push Buttons** – MAX push button, when depressed, causes the maximum peak signal voltage to be displayed; MIN causes the minimum peak voltage to be displayed.
4. **Display and Readout Functions** – A fully automatic, direct reading display of the generator frequency and peak voltage outputs. When PK AMPL MAX or MIN push button is depressed, maximum or minimum peak voltage, respectively, is displayed. When the FREQ push button is depressed, the frequency is displayed. This is a 3½ digit display with sign, decimal point, and unit of measure. The decimal point is automatically positioned and the correct unit of measure automatically displayed. The three least significant digits each can be 0 through 9 while a fourth digit, the most significant, can be 0 or 1 only. The display is updated three times a second. The voltmeter is updated once every cycle.

#### NOTE

- A. *Display voltage is output voltage when the 50Ω output connector is properly terminated with a 50Ω load.*
- B. *For operation in the 0.01 Hz or 0.1 Hz range, amplitude display is instantaneous voltage value in a tracking mode rather than peak voltage. To set peak amplitudes, select a higher frequency range, set the peaks, then*

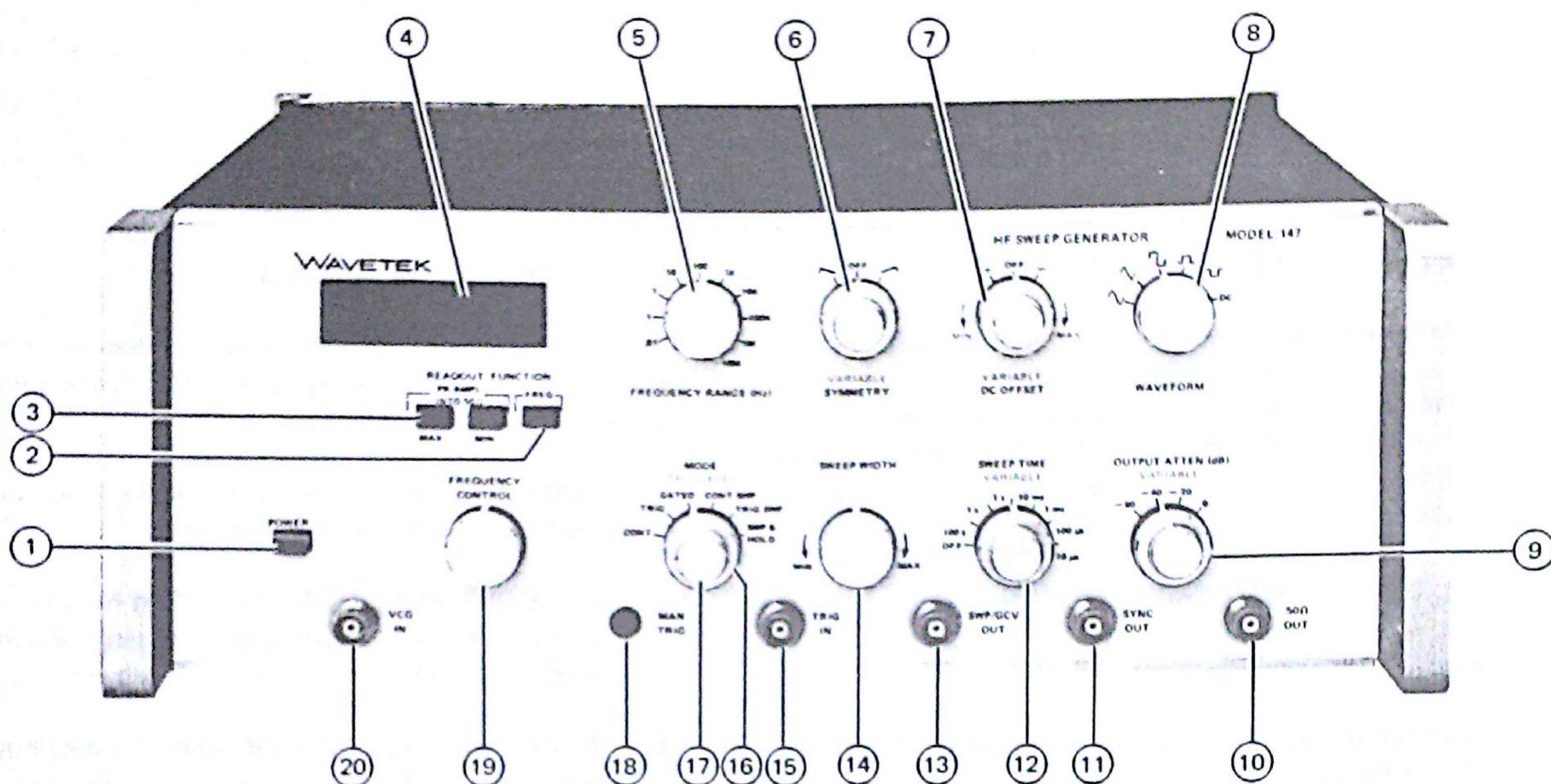


Figure 2-1. Operating Controls

return to the lower frequency range. In the 1 Hz through 10 MHz ranges, the amplitude display is updated once every cycle.

5. **FREQUENCY RANGE (Hz) Switch** – Selects one of the 10 frequency ranges. The range number represents the maximum frequency obtainable for the selected range. Some overranging exists.
6. **SYMMETRY Control** – The large knob selects a right-hand or left-hand waveform time-symmetry. The small VARIABLE knob varies the waveform time-symmetry up to 19:1 or 1:19. When these controls are used, the frequency range is divided by approximately ten; however, the readout shows actual output frequency.
7. **DC OFFSET Control** – Adjusts dc base line offset above (+) or below (–) signal ground; or, when DC is selected on the WAVEFORM switch, adjusts dc voltage at the 50Ω output. The large knob selects polarity, and the small VARIABLE knob adjusts voltage up to

±10 Vdc into an open circuit (±5 Vdc into 50Ω load).

Peak circuit output is limited to ±15 Vdc into an open circuit (±7.5 Vdc into a 50Ω load). (The OUTPUT ATTEN (dB) switch (9) affects dc offset as well as waveform amplitude.)

8. **WAVEFORM Selector** – This selects the waveform that appears at the 50Ω output. The waveforms are sine  $\sim$ , triangle  $\nabla$ , square  $\square$ , positive going pulse  $\text{—} \uparrow \text{—}$ , negative going pulse  $\text{—} \downarrow \text{—}$ , and DC voltage. See Figure 2-2 for phase and polarity relationships.
9. **OUTPUT ATTEN (dB) Control** – The large knob attenuates the 50Ω output from 0 dB (15 V p-p max into 50Ω load) to –60 dB (15 mV p-p into 50Ω) in 20 dB steps. The small VARIABLE knob may be used to continuously change the amplitude between the detented steps up to 40 dB. Maximum attenuation is –80 dB (1.5 mV p-p into 50Ω). The OUTPUT ATTEN (dB) VARIABLE control is inoperative when DC is selected on the WAVEFORM switch.

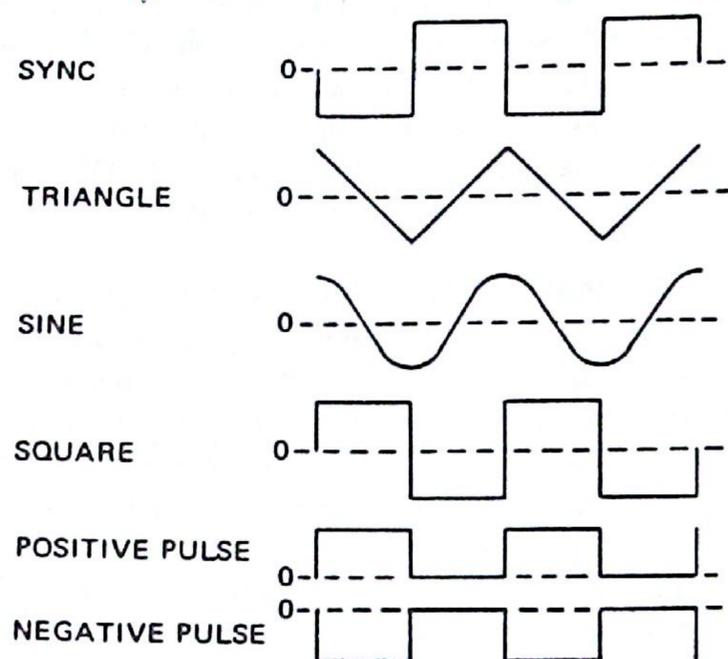


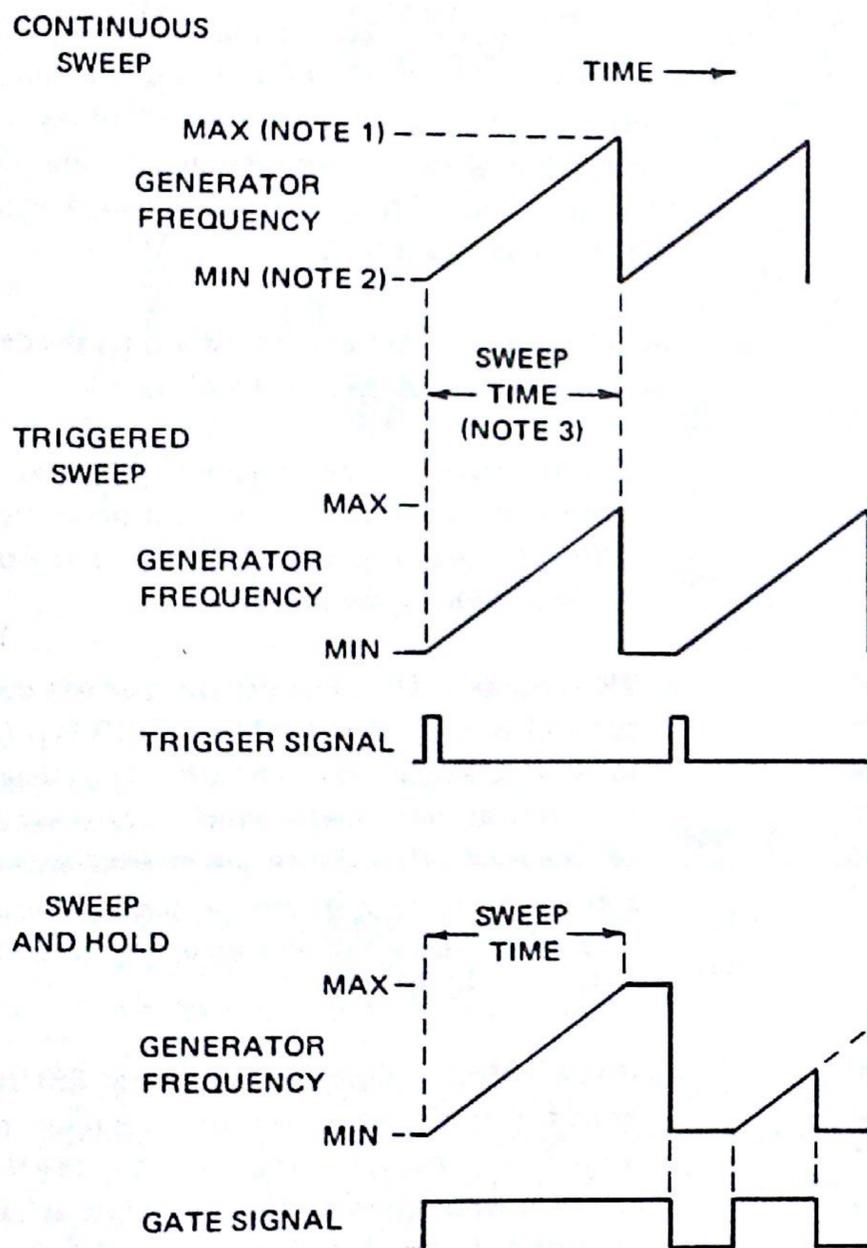
Figure 2-2.

### Selectable and Sync Signal Phase and Polarity Relationships

10. **50Ω OUT** – This is the selected waveform output for the main generator or a dc voltage. The Model 147 operating into an open circuit provides 30 V maximum, or into a 50Ω load provides a 15 V p-p output. The displayed amplitude is correct for the 50Ω termination.
11. **SYNC OUT** – This is a square wave (or rectangular if SYMMETRY control is in use) with the same frequency and opposite polarity of the selectable square wave at the 50Ω output. Amplitude into an open circuit is greater than 4 V p-p (2 V p-p into 50Ω). Rise and fall times are less than 50 ns. See Figure 2-2 for phase and polarity relationships.
12. **SWEEP TIME Control** – When in any of the sweep modes, this control determines the duration of the sweep cycle by controlling the frequency of the sweep generator, which is independent of the frequency of the main generator. The large knob selects the range, which is bounded by the time values printed on the panel on either side of the detent setting. The small VARIABLE knob varies the time throughout the range; when full cw, the sweep time is equal to the time printed to the right of the detent line; rotating the VARIABLE knob ccw increases the sweep time at least by 10:1 and up to 100:1. The full ccw position is not calibrated.
13. **SWP/GCV OUT** – When the generator is in CONT, TRIG, or GATED mode, this output provides a fixed 0 to nominal +5 V sawtooth. The frequency of this sawtooth is controlled by SWEEP TIME. When the generator is in CONT SWP, TRIG SWP, or SWP & HOLD mode, the output becomes the generator control voltage (GCV) that is proportional to main generator frequency. This voltage may be used to drive the X-axis of an oscilloscope in the X-Y mode or the X-axis of an X-Y recorder, thus converting the recording device from the time to the frequency domain.
14. **SWEEP WIDTH Control** – Determines the amount of sweep when in one of the sweep modes by varying the amplitude of the sweep signal.
15. **TRIG IN** – A dc coupled input with 10 kΩ input impedance. The TRIG LEVEL control adjusts the sensitivity of the generator to this input signal. Sensitivity can be varied to accept signals greater than 1 V to greater than 7.5 V, positive or negative voltage. Maximum voltage is 50 V.
16. **MODE Switch** – Selects the operating mode of the main generator (50Ω OUT) as follows:
  - a. **CONT Mode** – The generator operates at the selected frequency and runs continuously. (The SWP/GCV output is a fixed 0 to 5 V ramp in this and the following two modes.)
  - b. **TRIG Mode** – The generator will give one complete cycle of output when the MAN TRIG is pressed or for each pulse applied to TRIG IN. The cycle begins and ends at zero phase, which is zero volts or dc voltage level offset. Since the internal sweep operates independently it can be used to provide a repetitive trigger signal by connecting the SWP/GCV OUT to TRIG IN.
  - c. **GATED Mode** – Operates the same as TRIG MODE except that the generator will continue to have output for the full time that the MAN TRIG switch is held down or the gate signal at TRIG IN exceeds the gating level set by the TRIG LEVEL control.
  - d. **CONT SWP Mode** – The main generator operates continuously and repetitively sweeps from the minimum to maximum frequency as determined by the sweep controls. See Figure 2-3. (In this mode as in the following two sweep modes, SWP/GCV OUT becomes the generator control voltage (GCV) which is proportional to the instantaneous frequency of the generator.)
  - e. **TRIG SWP Mode** – The main generator oscillates at the start or low frequency until a trigger signal

is applied. The frequency then sweeps to the maximum frequency as determined by SWEEP WIDTH and then returns to the low frequency until another trigger is applied. See Figure 2-3.

- f. **SWP & HOLD Mode** – When gated, the generator sweeps to the high frequency and remains at the high frequency for the duration of the gate signal. When the gate falls, the generator returns to the low frequency. See Figure 2-3.



#### NOTES

1. Set by *SWEEP WIDTH* control.
2. Set by *FREQUENCY* control.
3. Set by *SWEEP TIME* control.

Figure 2-3. Sweep Modes

17. **TRIG LEVEL Control** – Adjusts the sensitivity of the TRIG IN circuitry. When full ccw, approximately +7.5 V or greater voltage is required for triggering.

In the full cw position, approximately -7.5 V or greater voltage is required for triggering. By rotating the knob, it is possible to manually trigger the generator. In the GATED mode, the generator will begin to run continuously as the control is rotated cw past the midpoint. When using the MAN TRIG, this control must be ccw of the midpoint.

18. **MAN TRIG** – When in TRIG mode, pressing this switch causes one cycle of the selected waveform to appear at the 50Ω output. When in GATED mode, the waveform is continuous while the switch is pressed. The TRIG LEVEL control must be ccw from midpoint for proper MAN TRIG operation.
19. **FREQUENCY CONTROL** – A combination coarse and fine control used in conjunction with the FREQUENCY RANGE switch and the display to select the desired frequency. The fine or vernier portion of the FREQUENCY CONTROL covers approximately 30 degrees of knob rotation. After the knob has been rotated through the vernier range, further rotation is in the coarse control range. Reversing the direction of rotation immediately places the knob back in the 30 degrees of vernier range again. The usual procedure is to rotate the knob just past the desired frequency, reverse the direction of rotation, and use the fine control range to accurately select the desired frequency.
20. **VCG IN** – This connector allows external control of frequency. With 0 volt in, the generator frequency (50Ω OUT) is determined by the frequency range selected and the FREQUENCY CONTROL setting and is displayed on the LED readout. A positive VCG voltage will increase this frequency, and a negative voltage will decrease the frequency. Input impedance is 5 kΩ. Restrictions for linear operation are (1) FREQUENCY RANGE selection is the upper frequency and the lower frequency is 1000 times below the FREQUENCY RANGE selection and (2) 5 V is the maximum voltage input. Either restriction may be exceeded for nonlinear operation, but operation is not specified.

#### 2.4 INSTALLATION CHECKS

The following procedures are used to determine that the instrument is operating properly. Field calibration and check-out instructions are given in Section 4 to ensure that the instrument complies with the specifications. If the instrument is not operating properly or within specifications, refer to the warranty on the back of the title page.

Use a Tektronix Model 454 oscilloscope or equivalent when performing these installation checks.

1. After connecting the line cord to the ac line, set the front panel controls and switches as follows:
 

|                            |   |
|----------------------------|---|
| POWER                      | In  |
| FREQUENCY RANGE            | 1K  |
| SYMMETRY                   | OFF   |
| DC OFFSET                  | OFF   |
| WAVEFORM                   |  |
| OUTPUT ATTEN (dB)          | 0   |
| OUTPUT ATTEN (dB) VARIABLE | Fully Clockwise   |
| SWEEP TIME                 | OFF   |
| MODE                       | CONT  |
| READOUT FUNCTION FREQ      | In  |
2. Connect the 50Ω OUT connector with a shielded cable terminated in a 50 ohm load to the oscilloscope and set FREQUENCY CONTROL to obtain a 1 kHz reading on the 147 display.
3. Press the PK AMPL MAX push button. Approximately +7.5 V should be displayed. Press MIN; approximately -7.5 V should be displayed. Observe the oscilloscope and verify the 1 kHz sine wave and peak voltages.
4. Set the OUTPUT ATTEN (dB) VARIABLE control full ccw. Approximately -0.7 V should be displayed. Compare with oscilloscope values.
5. Check minimum and maximum amplitudes of sine  and triangle  waveforms. They should be approximately plus and minus 7.5 V at 0 dB.
6. Check minimum and maximum amplitudes of positive and negative pulse waveforms  and . They should be approximately +7.5 V, 0 V and 0 V, -7.5 V, respectively at 0 dB.
7. Set the OUTPUT ATTEN (dB) VARIABLE control full clockwise and the WAVEFORM switch to  and press the FREQ push button. Adjust the FREQUENCY CONTROL for a 1 kHz readout.
8. Switch the FREQUENCY RANGE control to check range-to-range tracking accuracy. The 147 should read approximately the FREQUENCY RANGE value. Verify the frequencies with the oscilloscope.
9. Select the square waveform and rotate the SYMMETRY switch to  and the VARIABLE control full clockwise. Waveform asymmetry should be approximately 19:1. Rotate the VARIABLE control full ccw; the waveform should be symmetrical. Verify that the other switch position and VARIABLE control give approximately 1:19 waveform asymmetry.
10. Turn the SYMMETRY switch to OFF; press the PK AMPL MAX push button and select DC on the WAVEFORM switch.
11. Set the DC OFFSET switch to + and rotate the VARIABLE control full clockwise. The readout should be approximately +5 V. Verify the reading with the oscilloscope.
12. Set the DC OFFSET switch to -. Readout should be approximately -5 V. Verify the reading with the oscilloscope.
13. Rotate the OUTPUT ATTEN (dB) switch through each position. Verify the attenuation on the oscilloscope. (The VARIABLE control is inoperative for DC.)
14. Turn the DC OFFSET switch to OFF and connect the SWP/GCV OUT to the oscilloscope without a load. With the SWEEP TIME switch set to 10 ms/1 ms and the VARIABLE control set full clockwise (1 ms sweep), verify that the SWP/GCV OUT waveform is approximately a 1 kHz sawtooth. Set the VARIABLE control full ccw. The SWP/GCV OUT waveform should be approximately 100 Hz.
15. Check the SWP/GCV OUT frequency in all positions of the SWEEP TIME switch and at both the cw and ccw ends of the VARIABLE control.
16. Use a shielded cable equipped with BNC connectors to connect SWP/GCV OUT to TRIG IN and connect the oscilloscope to 50Ω OUT. Set the MODE switch to TRIG, the WAVEFORM switch to  and the SWEEP TIME to 1 s/0.1 s. Rotate the TRIG LEVEL control while observing the oscilloscope. One cycle of the waveform should be displayed each time the sweep output triggers the main generator.
17. Set the MODE switch to GATED and rotate the TRIG LEVEL control while observing the oscilloscope. The multiple cycles of the selected output waveform should appear when the TRIG LEVEL control is rotated full cw and disappear when the control is turned full ccw.
18. This step sets low and high frequencies of the sweep range. Disconnect the cable to TRIG IN. Set the MODE switch to SWP & HOLD, the SWEEP WIDTH control full clockwise, the TRIG LEVEL control to 9 o'clock and the FREQUENCY RANGE switch to 10K. Set the SWEEP TIME switch to 100 s/1 s and the SWEEP TIME VARIABLE control full clockwise. Set the output frequency to 0.1 kHz with the FREQUENCY CONTROL. Rotate the TRIG LEVEL control to 3 o'clock and set the SWEEP WIDTH control

for a 10 kHz readout. Repeat the low and high frequency settings because of interaction. Set the MODE switch to CONT SWP. Set the SWEEP TIME VARIABLE control full ccw. The displayed output should sweep from 100 Hz to 10 kHz.

19. Set the MODE switch to TRIG SWP and press the MAN TRIG switch while observing the oscilloscope. Displayed output should sweep once from 100 Hz to 10 kHz.
20. Connect the SWP/GCV OUT connector to the oscilloscope input without a load. Set the MODE switch to CONT, SWEEP TIME switch to 10 ms/1 ms and the SWEEP TIME VARIABLE control full clockwise. The oscilloscope should display approximately a 1 kHz sawtooth waveform.
21. Set the MODE switch to TRIG and then to GATED. The same 1 kHz sawtooth waveform should be present in these modes.
22. Set the MODE switch to CONT SWP, then TRIG SWP, then SWP & HOLD. The SWP/GCV OUT signal should be a GCV signal proportional to the instantaneous frequency of the main generator.

## 2.5 OPERATING PROCEDURE

No preparation for operation is required beyond the completion of the initial installation checks given in Paragraph 2.4. A one-half hour warm-up period should be allowed for the associated equipment to reach a stabilized operating temperature, and for the Model 147 to attain stated accuracies.

### 2.5.1 Operation as a Function Generator

1. Properly terminate the 50Ω OUT connector for accurate voltage readings.
2. Select desired output waveform using the WAVEFORM switch.
3. Set MODE switch to CONT.
4. Press the FREQ push button; set the FREQUENCY RANGE switch to the desired range, and set FREQUENCY CONTROL for the desired frequency. (For frequency readout press the READOUT FUNCTION FREQ push button.)
5. Set the OUTPUT ATTEN (dB) switch for the desired output level and amplitude. (For amplitude readout, press the READOUT FUNCTION AMPL MAX or MIN push button.) For reference, Table 2-1 gives the approximate output amplitude levels at attenuator

settings. The output levels of the positive and negative pulse waveforms are one half of these levels. The maximum amplitude voltage is ±7.5 volts.

Table 2-1

| Attenuator Position | Peak to Peak Output into 50Ω Load |                             |
|---------------------|-----------------------------------|-----------------------------|
|                     | Maximum (variable full cw)        | Minimum (variable full ccw) |
| 0 dB                | 15 V                              | 1.5 V                       |
| -20 dB              | 1.5 V                             | 150 mV                      |
| -40 dB              | 150 mV                            | 15 mV                       |
| -60 dB              | 15 mV                             | 1.5 mV                      |

6. With the DC OFFSET and SYMMETRY controls turned to OFF, the output waveform should be a symmetrical waveform oscillating around a zero dc reference point (except when a positive or negative pulse has been selected).
7. To add dc offset, first set the DC OFFSET control for the polarity of dc offset desired. Next, change the WAVEFORM switch to DC position and, using the readout display, adjust the DC OFFSET VARIABLE control until the desired amount is read on the display. Return the WAVEFORM switch to the selected waveform position. If an excessive amount of dc offset is used, waveform clipping may be observed and the display will flash. The sum of peak waveform voltage and the dc offset cannot exceed the maximum rated output of the generator. For example, on the 0 dB attenuator setting, the maximum output is 15 V peak-to-peak or 7.5 V peak above and below zero volt. Therefore, offset plus the peak voltage cannot exceed 7.5 V peak. See Figure 2-4.

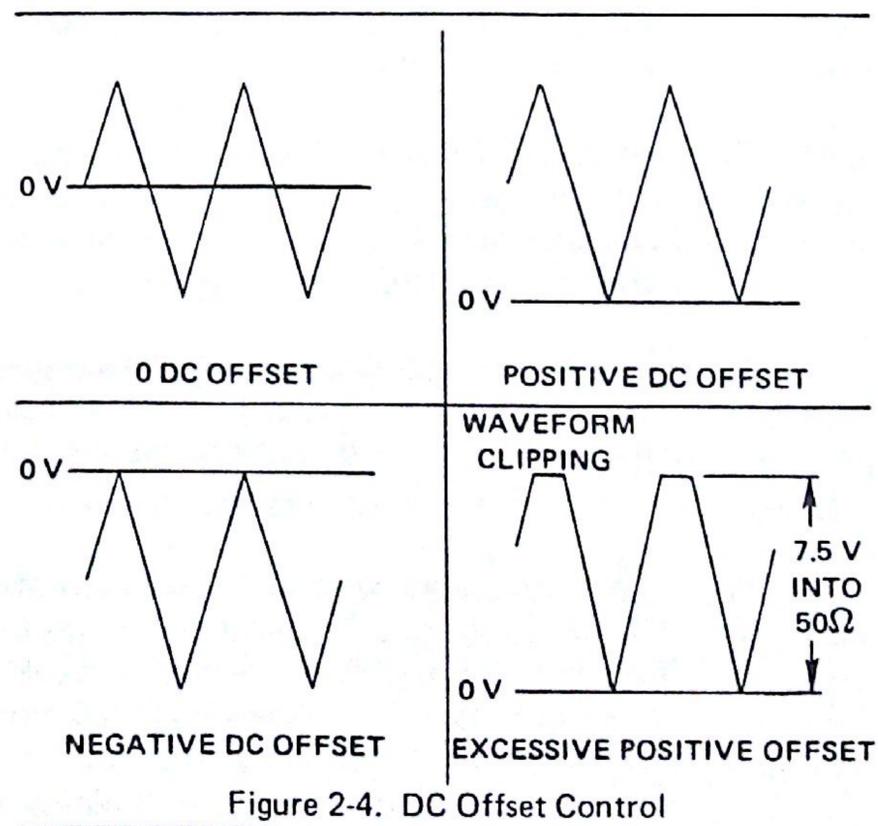


Figure 2-4. DC Offset Control

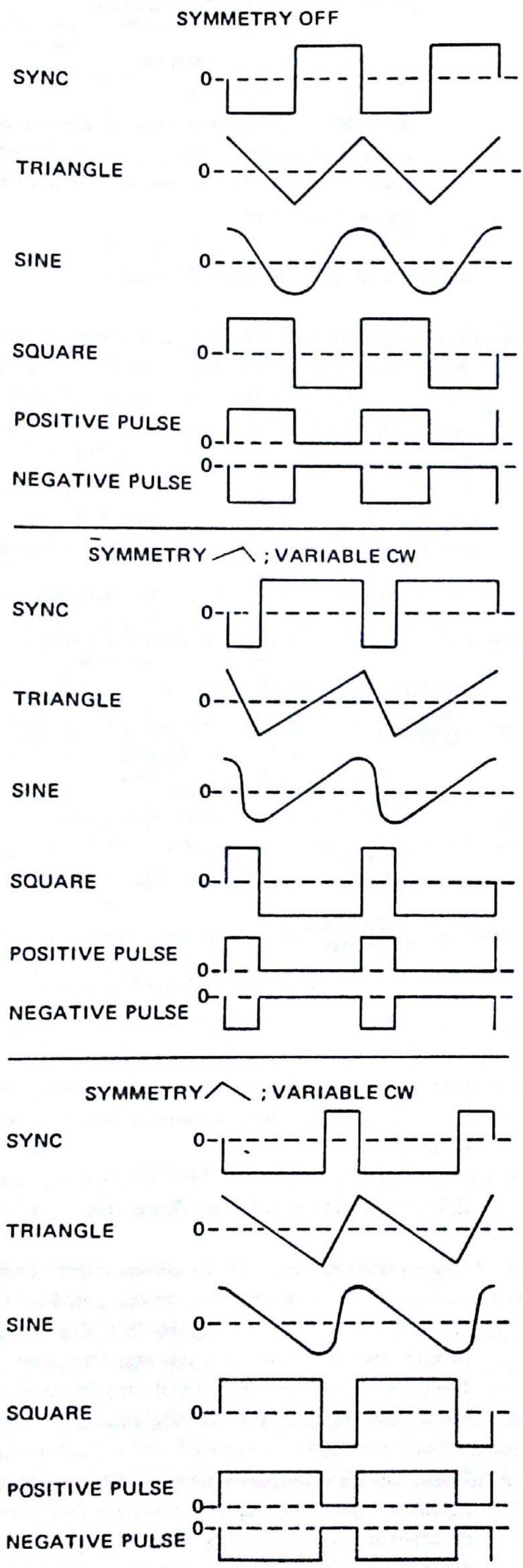


Figure 2-5. Waveform Phasing and Symmetry Control

8. Set SYMMETRY control for desired symmetry or asymmetry. The symmetry control can be used to develop ramp waveforms with variable rise/fall ratios and single or multiple pulses with variable duty cycles. By using the sine wave with asymmetry, controllable sine distortion can be developed. Figure 2-5 shows the effect of this control on output waveforms. The frequency of an asymmetrical waveform will be approximately a factor of 10 lower than the symmetrical waveform frequency output.

2.5.2 Operation as a Voltage Controlled Generator

The VCG input connector can be used to externally control the frequency of the generator. If a positive voltage is applied to the VCG input terminal, the frequency will increase from the FREQUENCY CONTROL setting. A negative voltage will cause the frequency to decrease from the FREQUENCY CONTROL setting.

A 5 V excursion in VCG voltage can vary the frequency up to 1000:1 in each range as follows:

| Range | Limits for Linear Operation |         |
|-------|-----------------------------|---------|
|       | Lower                       | Upper   |
| 0.01  | 0.01 mHz                    | 0.01 Hz |
| 0.1   | 0.1 mHz                     | 0.1 Hz  |
| 1     | 1 mHz                       | 1 Hz    |
| 10    | 10 mHz                      | 10 Hz   |
| 100   | 100 mHz                     | 100 Hz  |
| 1K    | 1 Hz                        | 1 kHz   |
| 10K   | 10 Hz                       | 10 kHz  |
| 100K  | 100 Hz                      | 100 kHz |
| 1M    | 1 kHz                       | 1 MHz   |
| 10M   | 10 kHz                      | 10 MHz  |

As shown, the range setting is the upper limit. This limit may be exceeded as there is a 10 to 20% overranging capability; however, overranging will be nonlinear and the operation is unspecified. Operation below the lower limit of any range setting is not recommended.

The nomograph of Figure 2-6 shows the characteristics of the VCG circuit. Column A gives a factor which is multiplied by the FREQUENCY RANGE to give the frequency shown in the readout. (Example: Column A X FREQUENCY RANGE = Readout Frequency or 0.3 X 100 = 30.0 Hz.) Column B is the voltage applied to the VCG IN. Column C (like A) is the factor which is multiplied by the FREQUENCY RANGE to give the frequency shown in the readout after the VCG voltage has been applied.

## EXAMPLE:

| Freq Range | Readout | Column A | Column B | Column C | Readout |
|------------|---------|----------|----------|----------|---------|
| 100        | 30.0 Hz | 0.3      | +3.5 V   | 1        | 100 Hz  |
| 100        | 30.0 Hz | 0.3      | -1.5 V   | 0.001    | 0.1 Hz  |

## NOTE

A further increase in VCG voltage will cause nonlinear operation as the range value will be exceeded.

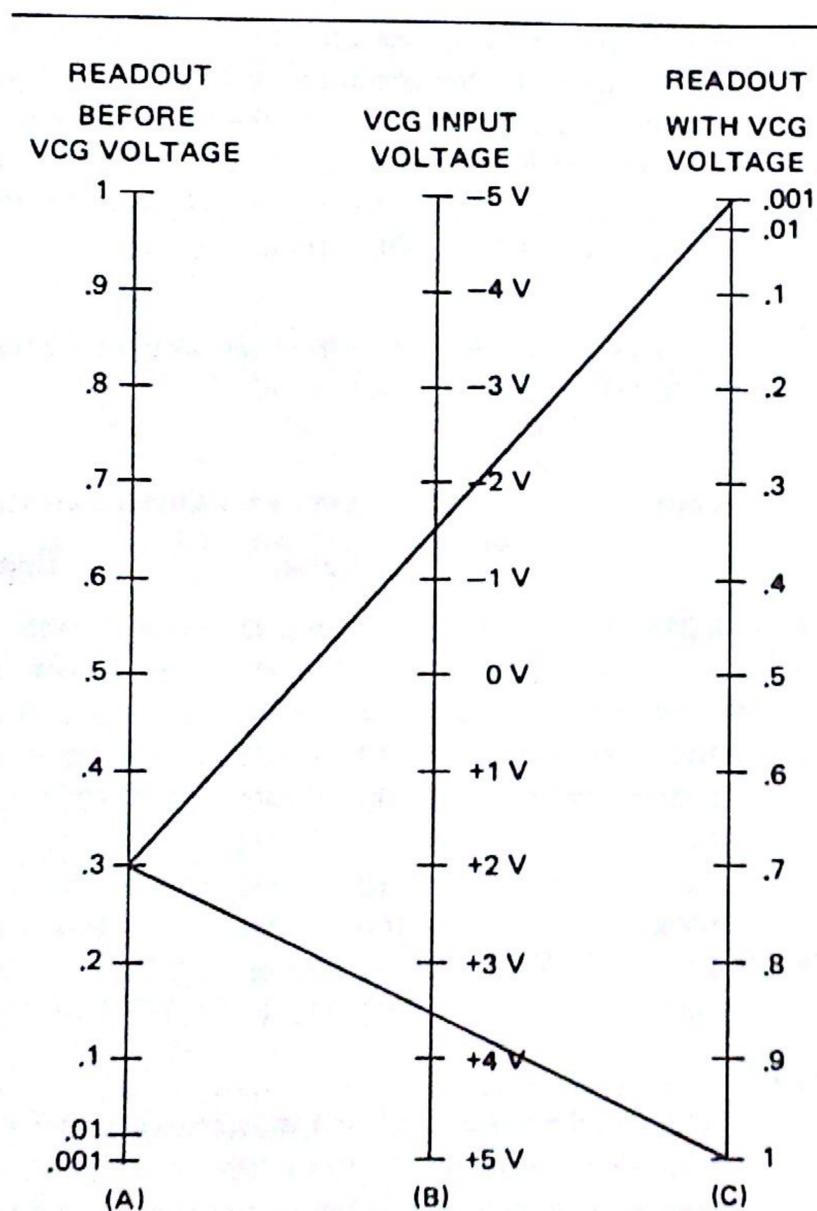


Figure 2-6. VCG Voltage-to-Frequency Nomograph

## 2.5.3 Operation as a Triggered Generator

1. Adjust the generator as for continuous operation (Paragraph 2.5.1); then set the MODE switch to TRIG.
2. If manual triggering is desired, set the TRIG LEVEL control (small knob) to the 11 o'clock position. For external triggering, set the TRIG LEVEL control to exclude undesirable trigger levels.

3. Operate the MAN TRIG switch or apply a 1 to 50 V signal to the TRIG IN connector.

## NOTE

The SWP/GCV output may be used as a repetitive trigger source. In this case, the SWEEP TIME control determines the repetition rate of the triggered output signal.

## 2.5.4 Gated or Tone Burst Operation

With the generator adjusted as in trigger operation, change the MODE control to GATED position. The generator output will then be a burst of cycles. If the trigger is the SWP/GCV OUT sawtooth waveform, the duration of the burst is adjustable by the TRIG LEVEL control (see Figure 2-7). Notice that the last cycle gated is completed even if the gate signal is removed. In manual gating, the tone burst continues as long as the manual switch is pressed.

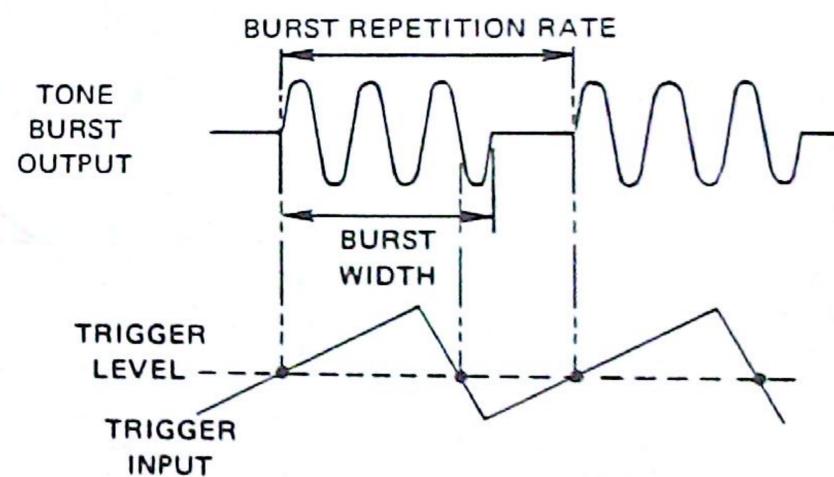


Figure 2-7. Gated Operation

The generator can be made to free run in this mode at certain settings of the trigger level control. By resetting the TRIG LEVEL control, normal gated operation can be re-established.

## 2.5.5 Operation as a Sweep Generator

The operation of the three sweep modes (continuous with sweep, triggered sweep, and sweep and hold) can be visualized by the graphs in Figure 2-3. Operation consists of proper terminations, and setting the low and high end frequencies, sweep time, signal amplitude and sweep mode. All are covered in the following example.

These modes together with the GCV output can be used to perform frequency response tests and drive an X-Y recorder or oscilloscope for display of the frequency response. As an example, Figure 2-8 shows a circuit under test which is to be swept and the frequency response of the circuit displayed

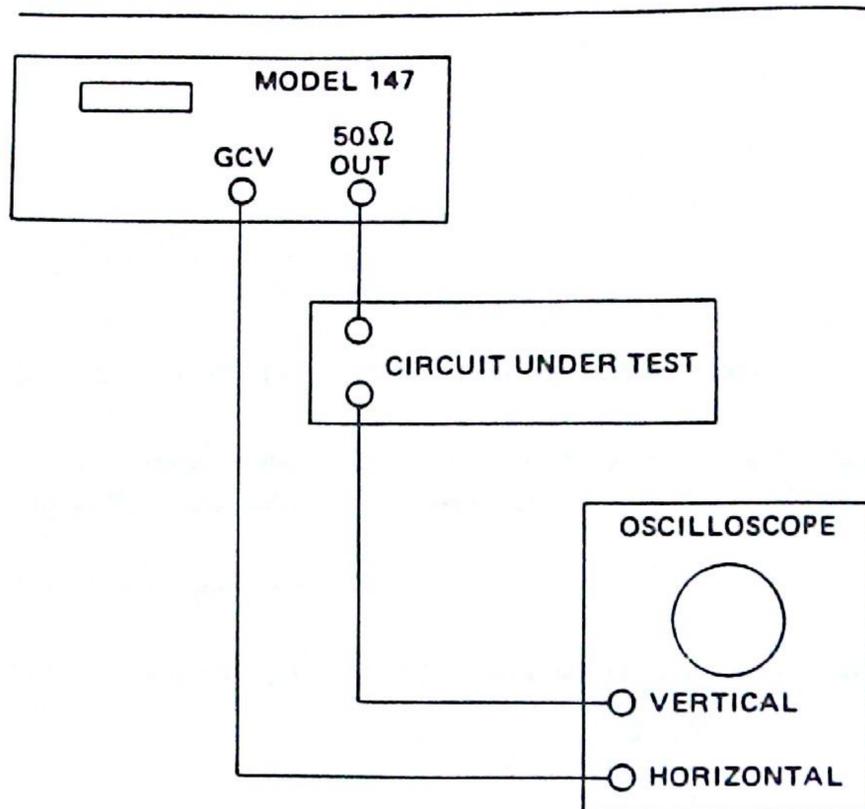


Figure 2-8. Frequency Response Test Using an Oscilloscope in the X-Y Mode

on the oscilloscope. Figure 2-9 shows a similar setup using an X-Y recorder. The following procedure is used to set up the Model 147 as a sweep generator.

1. Terminate the  $50\Omega$  output with  $50\Omega$ . Setup as in Figure 2-8 or 2-9 except bypass the circuit under test for this setup procedure.
2. Set the MODE switch to SWP & HOLD, the SWEEP TIME switch to OFF, and TRIG LEVEL to 9 o'clock.
3. Depress the READOUT FUNCTION FREQ push button and use the FREQUENCY RANGE switch and the FREQUENCY CONTROL switch to obtain the desired low frequency on the display.
4. Set the SWEEP TIME controls for the desired sweep time.
5. Rotate the TRIG LEVEL control to 3 o'clock. The frequency sweeps to the top and holds. Then rotate the SWEEP WIDTH control until the desired top frequency is displayed.
6. Rotate the TRIG LEVEL control back to 9 o'clock and reset the low frequency. Check the top frequency again and return the TRIG LEVEL control back to 9 o'clock.

7. Use the READOUT FUNCTION PK AMPL push buttons and the display and the OUTPUT ATTEN (dB) controls to obtain the desired signal amplitude.
8. With the circuit under test bypassed, and the oscilloscope, if used, in the external horizontal mode, adjust the horizontal position so that the trace is positioned on the left reticle on the screen or chart.
9. Rotate the TRIG LEVEL control to 3 o'clock and adjust the horizontal gain of the oscilloscope or recorder so that the waveform is positioned on the extreme right hand reticle, or any convenient reticle of the screen or chart for proper scaling.
10. Set the SWEEP TIME controls as desired for sweep duration. Sweep fast for the best oscilloscope presentation and sweep slow if the X-Y recorder is used.
11. For continuous sweep, rotate the MODE switch to TRIG. For triggered sweep or sweep and hold operation, adjust the TRIG LEVEL control to 9 o'clock for manual triggering or gating, or adjust as desired for external triggering or gating.
12. Insert the circuit to be tested as in Figures 2-8 or 2-9 and observe the frequency response characteristics shown on the oscilloscope or recorder.

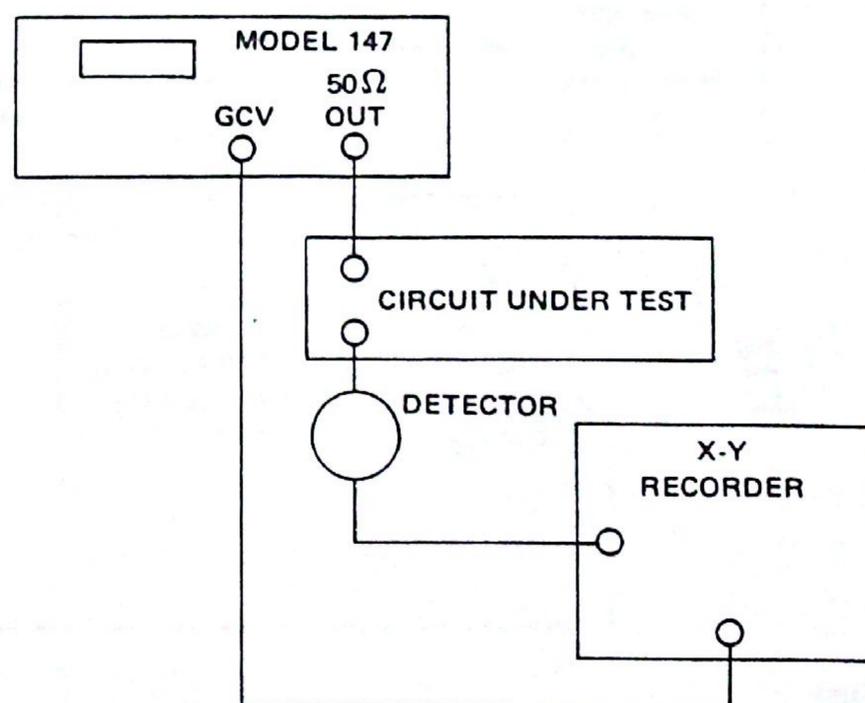


Figure 2-9. Frequency Response Test Using an X-Y Recorder

# SECTION 3

## CIRCUIT DESCRIPTION

### 3.1 SIMPLIFIED BLOCK DIAGRAM ANALYSIS

This paragraph describes, briefly, the major circuit elements and their relationship to one another.

#### 3.1.1 Main Generator

Refer to Figures 3-1 and 3-2 when reading this description.

As shown in Figure 3-1, the VCG summing amplifier sums the currents from the FREQUENCY CONTROL, vernier, and VCG IN connector. The VCG summing amplifier is an inverting amplifier whose output voltage is used to control a positive current source and a negative current source. For symmetrical output waveforms, the currents from the two current sources are equal and directly proportional to the voltage of the VCG summing amplifier output. The diode

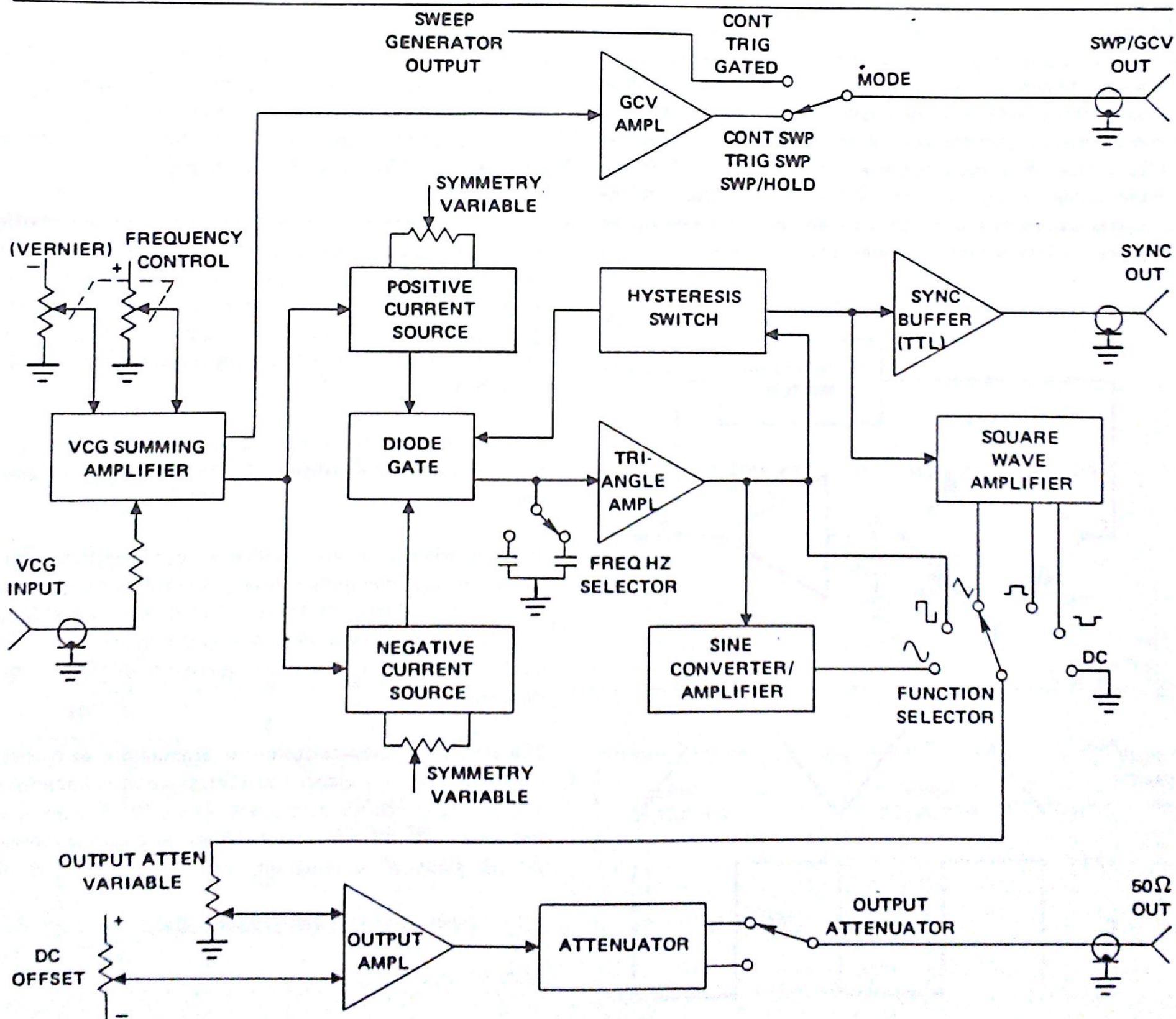


Figure 3-1. Main Generator Block Diagram

gate, which is controlled by the hysteresis switch, is used to switch the positive current or the negative current to the timing capacitor selected by the FREQUENCY RANGE (Hz) selector. If the positive current is switched into the timing capacitor, the voltage across the capacitor will rise linearly to generate the triangle rise transition. If the current is negative, the voltage across the timing capacitor will fall linearly to produce the fall transition.

The triangle amplifier is a unity gain amplifier whose output is fed to the hysteresis switch as well as to the sine converter. The hysteresis switch has two voltage limit points (+1.25 V and -1.25 V).

During the time the output voltage of the triangle amplifier is rising, the output voltage of the hysteresis switch is positive. But when the output voltage of the triangle amplifier reaches +1.25 V, it triggers the hysteresis switch causing the switch output to go negative. Once the control voltage into the diode gate becomes negative, it will switch the positive current out and switch the negative current in to the timing capacitor, so that the voltage across the capacitor will reverse, starting a linear decrease of the waveform. When the decreasing voltage reaches -1.25 V, the output of the hysteresis switch will switch back to positive, reversing the process. This action generates the triangle waveform as

shown in Figure 3-2. Since the output of the hysteresis switch is a square wave, the result is simultaneous generation of a square wave and a triangle wave at the same frequency.

The output frequency is determined by the magnitude of the capacitor selected by the FREQUENCY RANGE (Hz) selector and the magnitude of the positive and negative current sources. Since the current sources are linearly proportional to the control voltage of the VCG circuit, the output frequency will also be linearly proportional to the control voltage.

If the current of the negative current source is decreased by 19 times, the fall time of the triangle will be 19 times longer than the rise time of the triangle, resulting in an unsymmetrical waveform and a division of the frequency by a factor of 10. Gradually increasing the current from the negative current source and decreasing the current from the positive current source in such a way that the period for the triangle to complete one cycle remains constant, the symmetry of the output waveform can be continuously varied while the frequency is held constant.

The output of the hysteresis switch is fed to the sync buffer and also the square wave amplifier. The square wave amplifier consists of a shaping circuit which limits the output swing to  $\pm 1.25$  volts. For positive pulse outputs, it limits the output voltage swing from -1.25 V to 0 V; and for negative pulse outputs, it limits the output swing from 0 V to +1.25 V.

The output signal from the triangle amplifier is applied to the sine converter, consisting of a sine shaping circuit and a sine amplifier.

The sine, triangle, square, positive pulse, or negative pulse is fed to the output amplifier through the WAVEFORM selector switch and the OUTPUT ATTEN (dB) VARIABLE control. The output amplifier is an inverting amplifier whose output is fed into a step attenuator and then to the output BNC connector.

The attenuator consists of three pi attenuators, each having a 50 ohm input impedance and a 50 ohm output impedance. There is one -20 dB attenuator, one -40 dB attenuator, and one -60 dB attenuator. These attenuators provide 20 dB steps of attenuation, from 0 dB to -60 dB.

### 3.1.2 Sweep Generator and Trigger Logic

#### CONTINUOUS MODE

In this mode, both the main generator and the sweep generator operate independently. As shown in Figure 3-3,

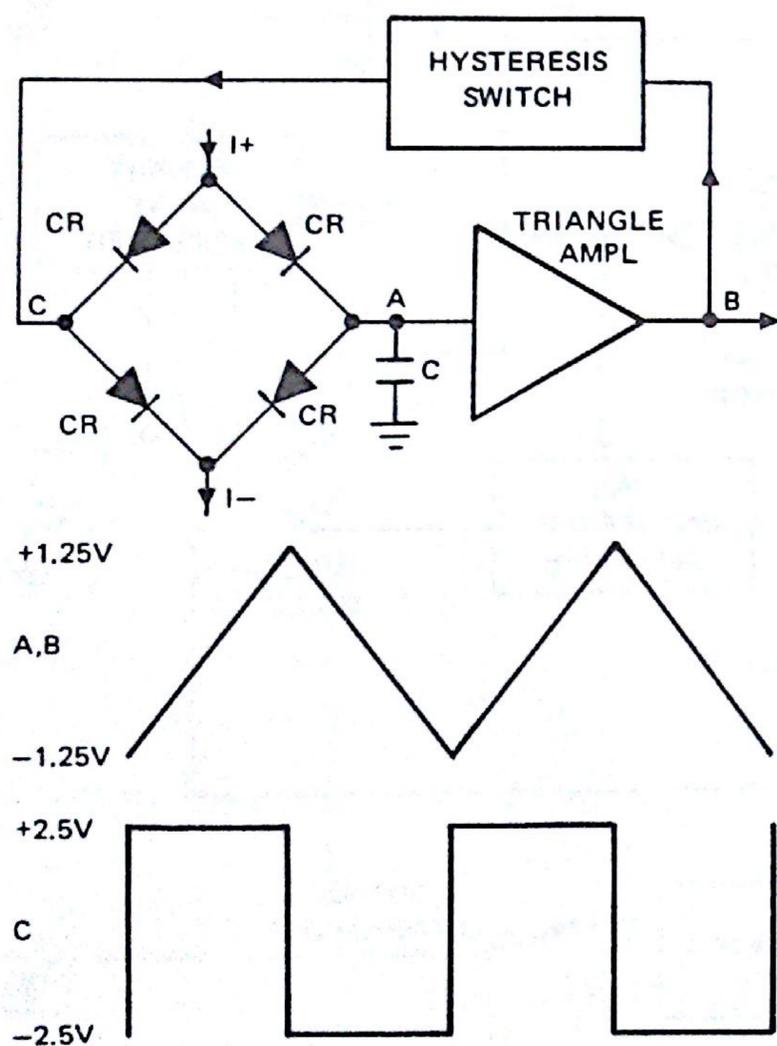


Figure 3-2. Basic Generator Timing Diagram

the sweep generator is a passive integrator with a voltage controlled current source. The output of the sawtooth amplifier changes the states of both the peak and zero detectors when either the peak or the zero limit is reached, thus switching on and off the current source output. The result of this charging and discharging of the timing capacitor is a continuous generation of a sawtooth waveform.

The charging and discharging rate of the timing capacitor, and also the repetition rate of the sawtooth waveform, are proportional to the amount of current fed into the capacitor and the size of the capacitor. The amount of current output is proportional to the controlling voltage and the current programming resistor. Thus, the repetition rate is controlled by the SWEEP TIME VARIABLE control and the SWEEP TIME range selector switch.

The current source switch provides a shunt path to signal ground for the timing capacitor when the sawtooth waveform is in the negative slope region. Switching action is activated by the peak detector and the zero detector outputs. The sawtooth amplifier is a non-inverting, high input impedance, high slew rate amplifier providing low output impedance and complete isolation for the passive integrator.

The peak and zero detectors accomplish detection of both extremes of the sawtooth waveform. The outputs of these two detectors, in conjunction with other transistor switches, cause the current source switch to place a shunt path across the timing capacitor or remove the shunt path. Thus, the operational loop is completed for the continuous mode operation of the sweep generator.

### TRIGGERED OR GATED MODE

Refer to Figure 3-4. In both the triggered and the gated modes, the main generator and the sweep generator operate independently.

When this instrument is in the TRIG mode and ready, the main generator diode gate is switched off by the trigger gate control, and the timing capacitor is discharged through the shunt path. When a trigger signal arrives at the trigger gate control, the control flip-flop changes the state, opening the diode gate. Current flows into the timing capacitor, allowing the passive integrator to generate a triangle waveform. The control flip-flop is reset by the square wave from the sync amplifier when the proper phase triggers the flip-flop. The flip-flop output, in conjunction with the level-

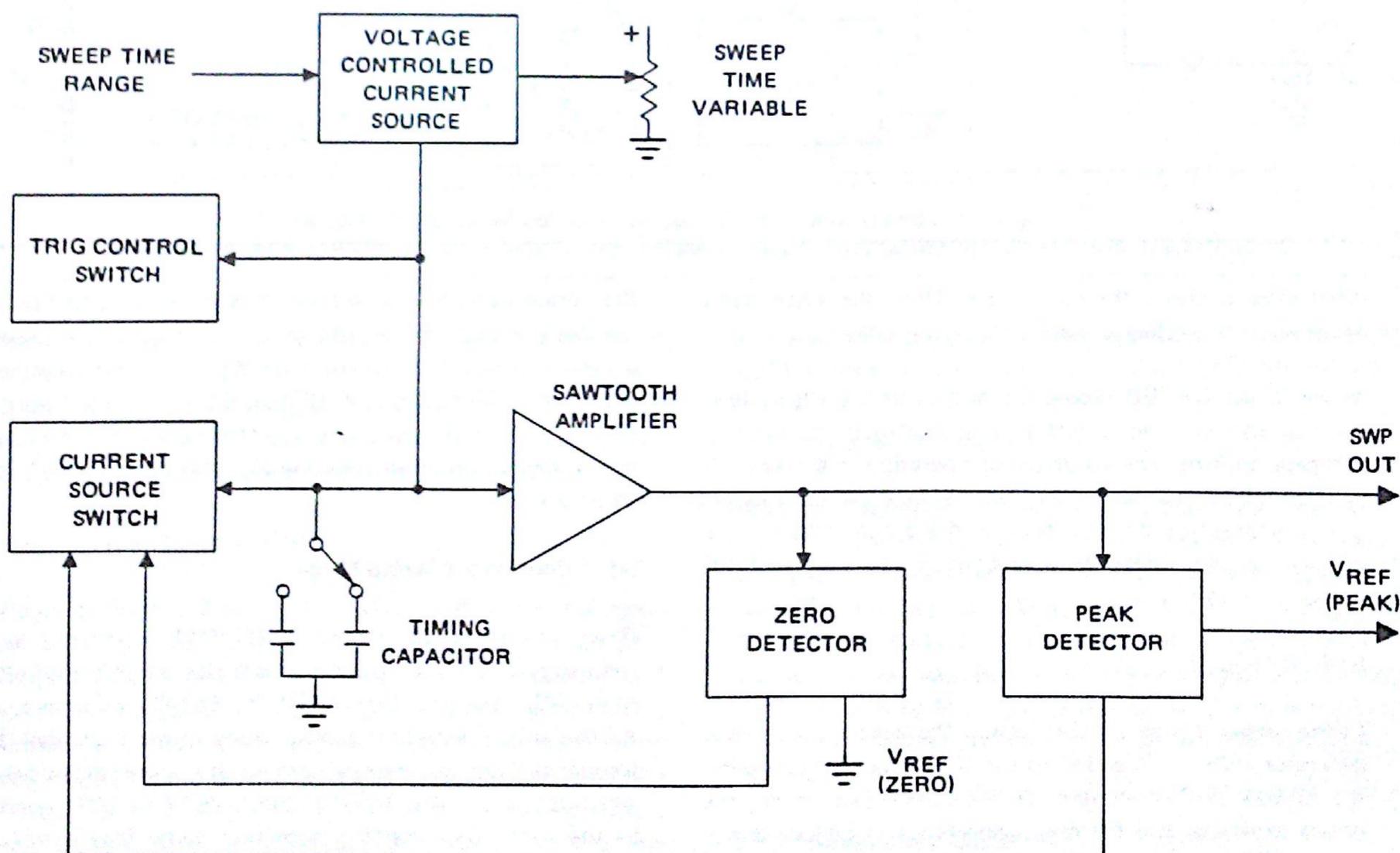


Figure 3-3. Sweep Generator Block Diagram



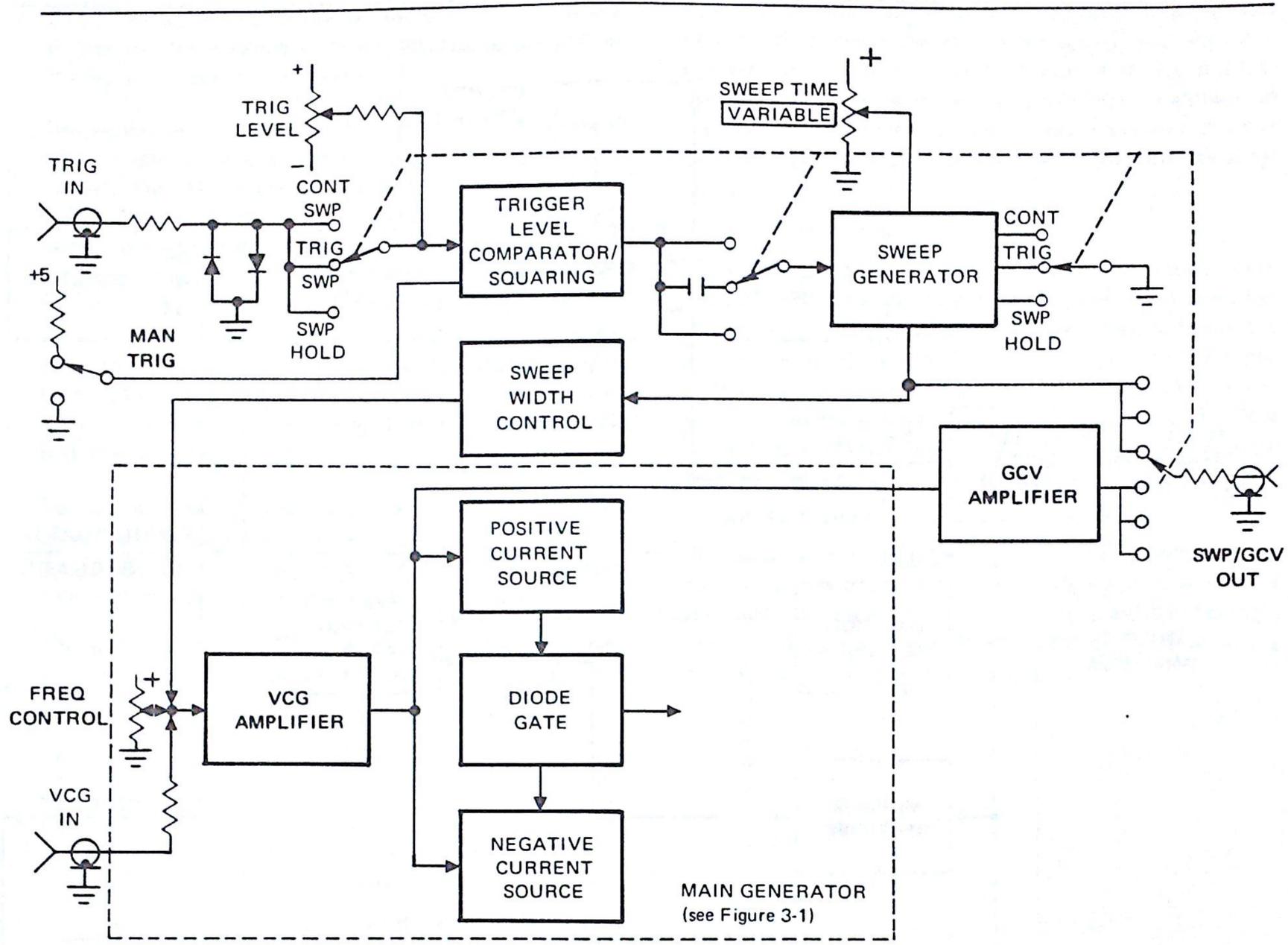


Figure 3-5. Sweep Generator Continuous Sweep, Triggered Sweep, and Sweep and Hold Mode Block Diagram

the basic frequency is set to less than 1/100 of the maximum frequency in the selected range. The swept output waveform repeats for as long as the MODE switch is set to CONT SWP. SWEEP TIME switch and SWEEP TIME VARIABLE control determine the sweep repetition rate.

(b) Triggered Sweep Mode

Refer to Figure 3-5. In the TRIG SWP mode, the main generator runs continuously at the minimum frequency set by the FREQUENCY CONTROL and the FREQUENCY RANGE (Hz) selector. The sweep generator is, initially, in a standby condition. When an input trigger signal is applied at the TRIG IN connector, or the MAN TRIG is depressed, the output of the trigger level comparator/squaring circuit changes the state of the trigger/gate control circuit. The output of the trigger level comparator/squaring circuit is coupled through a capacitor to release the sweep generator clamp for a single cycle. Thus, a single sweep of the main

generator is accomplished. The operation of the SWEEP WIDTH control is the same as in the CONT SWP mode.

(c) Sweep and Hold Mode

Refer to Figure 3-5. In the SWP HOLD mode, the main generator continuously generates the minimum frequency set by the FREQUENCY CONTROL and FREQUENCY RANGE (Hz) selector. When the TRIG IN is gated, or MAN TRIG depressed, the sweep generator will ramp up and hold at its maximum until the gate signal is removed from TRIG IN or MAN TRIG is released. The operation of the SWEEP WIDTH control is the same as in the CONT SWP mode.

3.1.3 Measurement Circuitry

Refer to Figure 3-6. The main board contains the necessary circuit for frequency counting and displays. The frequency

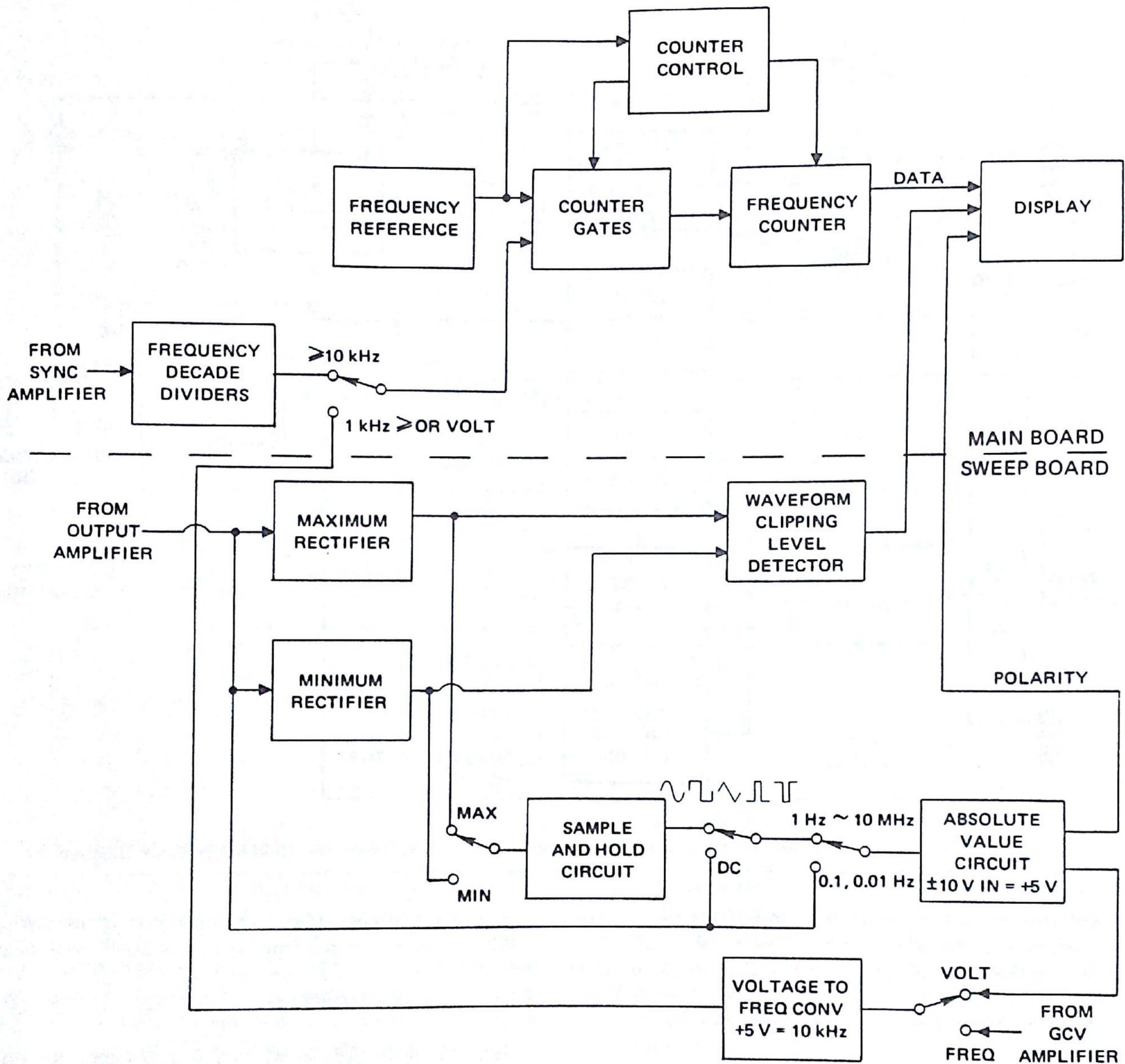


Figure 3-6. Measurement (Voltage and Frequency) Circuit Block Diagram

reference is a stable fixed frequency generator set precisely at 40 Hz.

The counter gate opens precisely for 200 ms and the frequency counter counts the number of pulses which went through the gate during the interval.

In order to normalize the maximum digits ( $3\frac{1}{2}$  digits) displayed, the frequency decade dividers are provided in front of the counter gates. Thus, the counter gates receive

the full scale frequency of 10 kHz, whether 10 MHz or 10 kHz range measurements, by dividing the sync amplifier output by 1000 or none.

The sweep board contains the necessary circuits for peak reading and low frequency measurement (less than 1 kHz range).

The output of the output amplifier is fed to four circuits: the output attenuator network, the dc voltage divider, and two rectifiers.

The dc voltage divider is used in the 0.1 Hz, 0.01 Hz and dc modes. The amplifier voltage is divided in half and fed directly to the absolute value circuit.

The minimum and maximum rectifiers use a trim cap in their divider circuits to compensate for high frequency roll-off. The 741 operational amplifier is a gain of one buffer, compensating for the voltage drop on the rectifying diode. At higher frequencies, the output from the buffer is a flat dc; at lower frequencies, the output tries to follow the input, but the waveform peaks are rectified enabling the sample and hold circuit to sample accurately. For the extreme low frequency, the sampled data is stored in digital form until the next sampling signal occurs. Thus, the inaccuracy caused by the discharging of capacitor in the sample and hold circuit is eliminated.

Pressing the MIN or MAX switch will connect the corresponding rectifier to the sample and hold circuit. The FET gate is pulsed once a cycle at the peak of a selected waveform and the capacitor is charged to the peak value.

The sampling sync pulse is controlled by the sync logic circuitry on the main board.

The WAVEFORM switch and FREQUENCY RANGE (Hz) switch will connect the dc divider output (dc, 0.01 Hz, 0.1 Hz) or the sample and hold output to the absolute value circuit. This circuit will invert a negative voltage, so the output is positive voltage. It also generates the polarity indicator for the display logic circuit on the main board.

When the instrument is in the minimum or maximum position, the output of the absolute value circuit is connected to the voltage to frequency converter. The voltage to frequency circuit gives an output of 10 kHz for an input of +5.00 volts. In the frequency position, the output from the GCV amplifier is fed to the voltage to frequency converter. The GCV is scaled to give an output of +5.00 volts to the maximum frequency of the range, when adjusted.

The waveform clipping detector is a simple voltage limit detector whose input is set to approximately  $\pm 7.6$  volts. If the limit is exceeded, the signal is sent to the display logic and the display will indicate the condition by blinking the data readout (whatever is displayed).

# SECTION 4

## MAINTENANCE

### 4.1 ACCESS INSTRUCTIONS

The Model 147 is packaged so that it can be quickly disassembled to afford access to the majority of components within the unit, while allowing the instrument to be operated.

#### 4.1.1 Removing the Dust Cover

To remove the dust cover (case) from the Model 147, the following procedure should be followed:

1. Unplug the ac line cord and unscrew the four captive screws on the rear panel.
2. Remove the rear panel and power supply.
3. Unplug power supply connector from power supply board. Slide dust cover off slowly.
4. At this time, the power supply can be remounted and the Model 147 may be operated normally.

#### 4.1.2 Disassembly for Troubleshooting or Repair

1. Complete Steps 1 through 3 of Paragraph 4.1.1.
2. Remove the six screws which hold the main board in place.
3. Remove the top row of knobs off the front panel by pulling on them slowly.
4. To remove the main board, have the front panel facing you. Place your finger between the two boards at the connectors and lift the top connectors up until they come free of the pins. With the back of the board slightly raised, carefully slide the control shafts out of the front panel.

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#### CAUTION

THE SWEEP BOARD (BOTTOM BOARD) MUST BE SUPPORTED WHILE PUSHING THE CONNECTOR ONTO THE PINS.

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#### CAUTION

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5. To put the main board in the maintenance position (see Figure 4-1), stand the main board up and slowly lower it onto the pin.

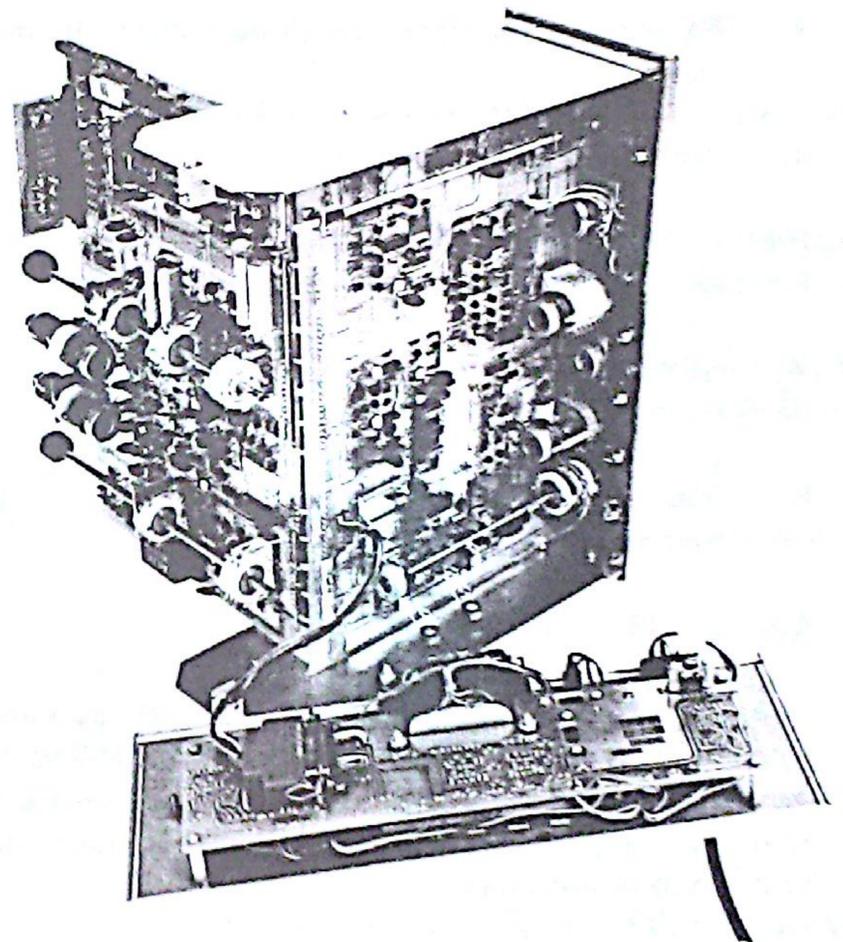


Figure 4-1. Model 147 in the Maintenance Position

6. Plug the power supply connector into the power supply board and plug in the ac line cord.
7. The power switch located on the power supply board will control the power to the instrument while in this configuration.

#### 4.1.3 Reassembly Procedure

1. Turn off power switch on power supply board; unplug the ac line cord; and disconnect power connector from power supply.
2. Lift main board off connector pins.

3. With the back end of the main board slightly raised, guide the control shafts just into the front panel. Then lower the back and slide forward checking the three READOUT FUNCTION buttons. When they are through the front panel, raise the back and mate the pins and connector.

---

**CAUTION**

---

**THE SWEEP BOARD (BOTTOM BOARD) MUST BE SUPPORTED WHILE PUSHING THE CONNECTOR ONTO THE PINS.**

---



---

**CAUTION**

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4. Replace the six screws which hold down the main board.
5. Replace knobs on front panel.
6. Slide the dust cover on slowly, making sure it is seated into the groove on the front panel.
7. Reconnect the power supply connector to the power supply board.
8. Replace the rear panel and power supply; tighten the four captive screws.

### 4.2 CALIBRATION INSTRUCTIONS

This paragraph provides complete sequential calibration instructions for this instrument. The instructions are concise and are written for the experienced electronics technician or field engineer having a working knowledge of this type of instrument.

WAVETEK maintains a factory repair department for those customers not possessing the necessary test equipment or personnel to maintain this type of instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached. This will hasten turnaround time.

#### 4.2.1 Preliminary Procedures

1. Complete precalibration checkout procedure as necessary.
2. Perform the following front panel settings:

|                                |          |
|--------------------------------|----------|
| FREQUENCY CONTROL . . . . .    | fully cw |
| READOUT FUNCTION . . . . .     | FREQ     |
| FREQUENCY RANGE (Hz) . . . . . | 1K       |
| SYMMETRY . . . . .             | OFF      |

|                                      |                |
|--------------------------------------|----------------|
| SYMMETRY VARIABLE . . . . .          | fully ccw      |
| DC OFFSET . . . . .                  | OFF            |
| DC OFFSET VARIABLE . . . . .         | fully ccw      |
| WAVEFORM . . . . .                   | ∧              |
| MODE . . . . .                       | CONT           |
| TRIG LEVEL . . . . .                 | fully ccw      |
| SWEEP WIDTH . . . . .                | fully ccw      |
| SWEEP TIME . . . . .                 | OFF            |
| SWEEP TIME VARIABLE . . . . .        | fully ccw      |
| OUTPUT ATTEN (dB) . . . . .          | 0              |
| OUTPUT ATTEN (dB) VARIABLE . . . . . | fully cw       |
| POWER . . . . .                      | depressed (ON) |

3. Install the unit in the cover and allow 30 minutes warm-up time.

#### 4.2.2 Power Supply Board

##### POWER SUPPLY REGULATION

1. Connect ac power to the instrument and connect the voltmeter leads to TP1 (common) and TP2 (+15 V) on the main board.
2. Adjust R10 (power supply board) for a reading of +15 Vdc ±20 mV on the voltmeter.
3. Check the voltage at TP3 for -15 Vdc ±50 mV, at TP4 for +24 Vdc ±400 mV, at TP5 for -24 Vdc ±400 mV, and at TP6 for +5 Vdc ±200 mV.

#### 4.2.3 Main Board

##### TRIANGLE AMPLITUDE ADJUSTMENT

*NOTE*

*Fold out Page 4-7 for calibration adjustment and test point locations.*

1. Connect the oscilloscope probe (a peak reading plug-in module should be used with the scope) to ( ∧ ) TP7 (WAVEFORM selector wafer, yellow wire).
2. Adjust the triangle amplitude to ±1.25 V ±5 mV using R90 and R100.  
*R89*

##### FREQUENCY AND TIME SYMMETRY CALIBRATION

1. Set FREQUENCY RANGE (Hz) to 100K, WAVEFORM selector to □, FREQUENCY CONTROL fully ccw; and adjust R10 for approximately 1/1250 of full scale (80 Hz) and R22 for time symmetry within 1%.

- Turn FREQUENCY CONTROL to 1/100 of full scale (1 kHz) and adjust R12 for minimum frequency shift while opening and shorting the VCG IN.

## NOTE

If Step 2 cannot be accomplished, center R12 and repeat Step 1.

- Turn FREQUENCY CONTROL fully cw, and adjust time symmetry within 0.1% with R23.
- Repeat Steps 1 and 3 as necessary for accurate time symmetry at full scale to 1/1000 of full scale.
- Turn FREQUENCY CONTROL fully cw, FREQUENCY RANGE (Hz) to 100K, and adjust R4 to obtain 105.0 kHz.
- Set FREQUENCY RANGE (Hz) to 10M and adjust C17 to obtain an output frequency of 10.50 MHz.
- Set FREQUENCY RANGE (Hz) to 1M and adjust C26 to obtain 1.050 MHz at the output.
- Set FREQUENCY RANGE (Hz) to 10K and adjust R5 to obtain 10.50 kHz.

## NOTE

1.050 in frequency equals 0.952381 in time.

- Set FREQUENCY RANGE (Hz) to 1K and adjust R6 to obtain 1.050 kHz.
- Set FREQUENCY RANGE (Hz) to 100 and adjust R7 to obtain 105.0 Hz.
- Set FREQUENCY RANGE (Hz) to 10 and adjust R39 to obtain 10.50 Hz. (95.0ms)
- Adjust R66 for 0.1% time symmetry.
- Readjust R39 for optimum frequency on 10, 1, 0.1, and 0.01 of FREQUENCY RANGE (Hz) selector.
- Set FREQUENCY RANGE (Hz) to 10K, FREQUENCY CONTROL fully cw; and connect counter to SYNC OUT.
- Adjust R235 to read same frequency on the readout as the counter (10.50 kHz). Note: R11 Adjusts lower Range Readout
- Connect DVM to pin 12; set FREQUENCY RANGE (Hz) to 1K; adjust FREQUENCY CONTROL for

Adjust For Nominal 5V and 1000 on Readout  
1.000 on counter; adjust R47 for 5.00 V on DVM; adjust FREQUENCY CONTROL for 50 Hz on counter; adjust R45 for 0.25 V on DVM; and recheck for 5.00 V at 1.000 kHz. R43

## SINE DISTORTION AND AMPLIFIER ADJUSTMENTS

- Set FREQUENCY RANGE (Hz) to 1K, FREQUENCY CONTROL fully cw, and WAVEFORM selector to  $\sim$ .
- Connect oscilloscope probes to (  $\sim$  ) TP7 (WAVEFORM selector wafer).
- Adjust R149 so that the dc offset of the sine amplifier is zero.
- Adjust R143, R139 and R140 for minimum sine wave distortion.
- Set FREQUENCY RANGE (Hz) to 10K and readjust R143, R139 and R140 for optimum sine distortion.
- Alternately perform Steps 4 and 5 until the least amount of sine wave distortion is obtained on both ranges (typically 0.14%).
- Adjust R167 for a 2.5 V p-p  $\pm 5$  mV sine wave.
- Readjust R149 so that the dc offset of the sine wave amplifier is 0 V  $\pm 5$  mV.

## SQUARE WAVE AMPLITUDE ADJUSTMENT

- Set WAVEFORM selector to  $\square$ .
- Adjust the square wave amplitude to  $\pm 1.25$  V  $\pm 5$  mV using R184 and R175.

## 4.2.4 Sweep Board

## OUTPUT AMPLIFIER ADJUSTMENT

## NOTE

Fold out Page 4-9 for calibration adjustment and test point locations.

- With the 50 $\Omega$  OUT connected to the oscilloscope using a 50 $\Omega$   $\pm 1\%$  termination, set FREQUENCY RANGE (Hz) to 1K, FREQUENCY CONTROL fully cw, WAVEFORM selector to  $\sim$ , OUTPUT ATTEN (dB) to 0, and OUTPUT ATTEN (dB) VARIABLE fully ccw.

2. Adjust R132 for amplitude symmetry about ground.
3. Set OUTPUT ATTEN (dB) VARIABLE fully cw and adjust R134 for 15 V p-p  $\pm 25$  mV output amplitude.

### HIGH FREQUENCY RESPONSE ADJUSTMENT

1. Set FREQUENCY RANGE (Hz) to 10M, FREQUENCY CONTROL to read 1 MHz and WAVEFORM selector to  $\square$ .
2. Adjust C81 for best square wave, without peaking, at full amplitude with 50 $\Omega$  load.
3. Set WAVEFORM selector to  $\sim$  and FREQUENCY CONTROL fully cw.
4. Adjust C53 (main board) to obtain approximately 15 V p-p output amplitude at full amplitude with 50 $\Omega$  load.
5. If clipping occurs as waveforms are varied from 1M to 10M, readjust C53 to correct this occurrence.

### VOLTAGE TO FREQUENCY CONVERTER ADJUSTMENTS

1. Connect counter to SYNC OUT; set FREQUENCY RANGE (Hz) to 1K; set FREQUENCY CONTROL fully cw.
2. Adjust R111 to match counter on 147 readout.

### SAMPLE AND HOLD CIRCUIT ZERO

1. Set READOUT FUNCTION to PK AMPL MAX.
2. Ground the input (pin 27); connect a DVM to sample and hold output (pin 28).
3. Set R191 for 0.000 volt. *Bottom Board*

### ABSOLUTE VALUE CIRCUIT

1. Adjust R237 for 0.00 volt at summing node of absolute value circuit (TP1).
2. Adjust R230 for 0.00 volt at output of absolute value circuit (pin 6).
3. Remove ground jumper on pin 27; set WAVEFORM selector to DC.
4. Connect 50 $\Omega$  OUT to a 50 $\Omega$  load and a DVM.

5. Use - DC OFFSET control to set 5.50 V to 6.00 V on the DVM; set the readout to match the DVM with R227.
6. Switch to + DC OFFSET; set the readout to match the DVM with R224.
7. Repeat Steps 5 and 6 until both + and - readings match the DVM.

### RECTIFIER CALIBRATION

1. Set WAVEFORM selector to  $\sim$ , DC OFFSET to OFF, FREQUENCY RANGE (Hz) to 100K.
2. Connect 50 $\Omega$  OUT (loaded with 50 $\Omega$ ) to scope.
3. Use OUTPUT ATTEN (dB) VARIABLE to set a 14.00 V peak-to-peak waveform.
4. Select PK AMPL MAX; set the + peak waveform to exactly +7.00 V on the scope using a peak comparator; and set the readout to +7.00 V with R217.
5. Select PK AMPL MIN; set the - peak waveform to exactly -7.00 V on the scope using a peak comparator; and set the readout to -7.00 V with R206.
6. Set FREQUENCY RANGE (Hz) to 10M.
7. Set the - peak waveform to exactly -7.00 V on the scope; and set the readout to -7.00 V with C70.
8. Select PK AMPL MAX; set the + peak waveform to exactly +7.00 V on the scope; set the readout to +7.00 V with C74.
9. Repeat Steps 4 through 8 if necessary.

### NOTE

*The peak comparator should not be used to check voltmeter settings above 100 kHz.*

### SWEEP/GCV ADJUSTMENTS

1. Set FREQUENCY RANGE (Hz) to 1K and connect oscilloscope to the sweep output (TP13).
2. Adjust R21 to set the output to 0  $\pm$  5 mV.
3. Set SWEEP TIME selector to 0.1 s/10 ms and the SWEEP TIME VARIABLE fully cw.

4. Adjust R46 to set the lower peak of the sawtooth wave for 0 V (+0, -5 mV) and R238 to set the upper peak of the sawtooth wave for +5 V  $\pm$ 20 mV at the SWP/GCV OUT connector (unloaded).
5. Reset R46 to assure at least 1000:1 operation in the SWP/HOLD MODE.

#### TRIGGER BASELINE ADJUSTMENT

1. Set MODE selector to TRIG, FREQUENCY RANGE (Hz) to 10K, FREQUENCY CONTROL fully cw, DC OFFSET to OFF, WAVEFORM selector to  $\wedge \vee$ , OUTPUT ATTEN (dB) to 0, and OUTPUT ATTEN (dB) VARIABLE fully cw.
2. Adjust R84 for 0 V  $\pm$ 20 mV and 50 $\Omega$  OUT (loaded with 50 $\Omega$ ).
3. Set FREQUENCY CONTROL fully ccw and adjust R60 to set baseline to 0 V  $\pm$ 20 mV.
4. Check that the baseline remains within  $\pm$ 50 mV at all frequency settings.

#### SYMMETRY ADJUSTMENT

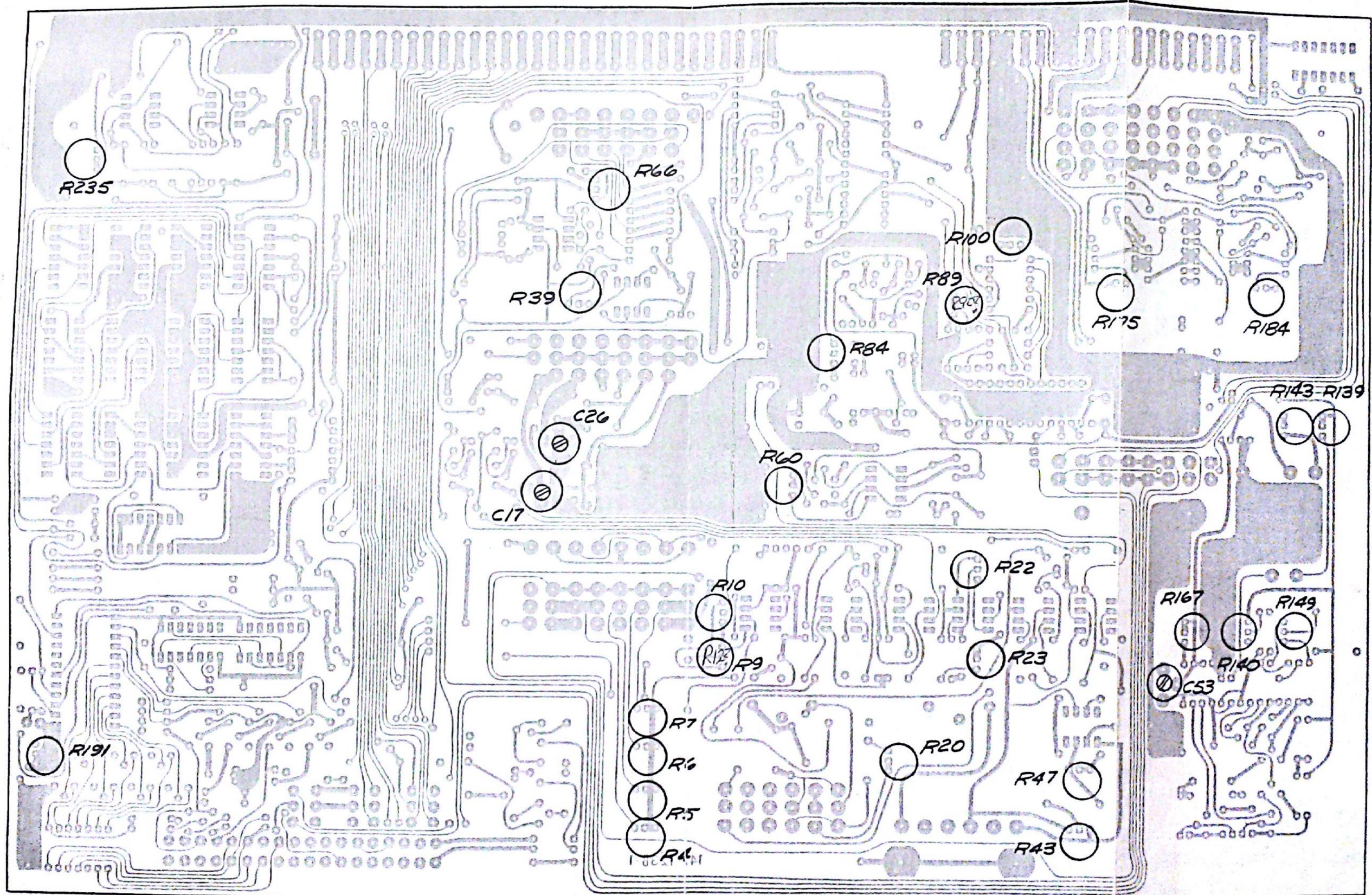
1. Set FREQUENCY RANGE (Hz) to 1K, MODE to CONT, FREQUENCY CONTROL fully cw.
2. Adjust R20 for 1/10 of reading from SYMMETRY switch OFF to SYMMETRY switch  $\wedge$  or  $\wedge$ .

#### READOUT ZERO FLICKER ADJUSTMENT

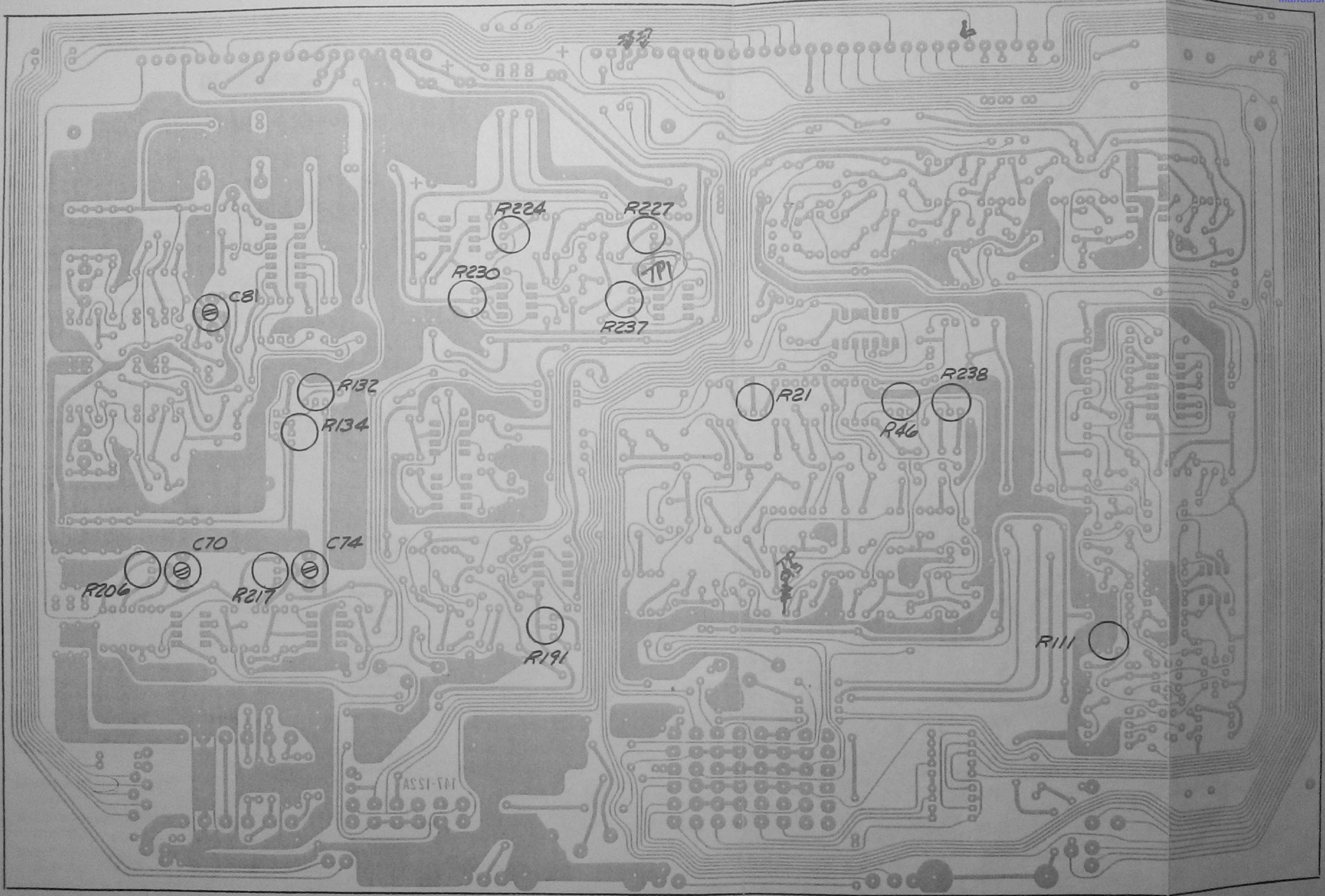
1. Set SYMMETRY switch to OFF, FREQUENCY CONTROL fully ccw.
2. Adjust R191 until no flicker is seen in the blanked out decimal points and zeros. *TOP BOARD*

#### 4.2.5 Post Operational Checkout

1. Check the MODE switch, SYMMETRY switch and SYMMETRY VARIABLE, WAVEFORM switch, SWEEP WIDTH potentiometer, SWEEP TIME switch and SWEEP TIME VARIABLE, and OUTPUT ATTEN (dB) switch and OUTPUT ATTEN (dB) VARIABLE for proper operation.
2. Verify that the readout functions properly in all functions of the READOUT FUNCTION controls at all frequency ranges.



147-010 MAIN BOARD CALIBRATION POINTS.



147-011 SWEEP BOARD CALIBRATION POINTS.

# SECTION 5

## DIAGRAMS ADDENDUMS AND PARTS LISTS

### 5.1 DIAGRAMS

The schematic diagrams within this manual are, wherever possible, arranged in the sequence followed in the circuit description. Whenever assembly drawings are included, they are positioned adjacent to the schematics for maximum information presentation and minimum page flipping. Additional voltage or waveform information, beyond that given in the circuit description, may be shown on the schematic diagrams, at test points and key locations throughout the instrument.

### 5.2 ADDENDUMS

Under WAVETEK's product improvement program, the latest electronic designs and circuits are incorporated into each WAVETEK instrument as quickly as development and

testing permit. Because of the time needed to compose and print instruction manuals, it is not always possible to include the most recent changes in the initial printing. Whenever this occurs, addendum pages are prepared to summarize the changes made under a WAVETEK Engineering Change Notice (ECN) and these ECN pages are inserted immediately inside the rear cover. If no such pages exist, the manual should be correct as printed.

### 5.3 PARTS LISTS

Whenever possible, an assembly drawing and the associated parts list are kept to one piece of paper or are positioned for maximum information presentation. When ordering spare parts, please specify part number, circuit reference, board, serial number of unit, and if applicable, the function performed.

### DRAWINGS

The following assembly drawings (with parts lists) and schematics will be included at the rear of this manual, in the arrangement shown below:

| LEFT PAGE                                      | RIGHT PAGE                                     |
|--|--|
| CHASSIS ASSEMBLY<br>D147-000 1 of 2            | CHASSIS ASSEMBLY<br>D147-000 2 of 2            |
| CHASSIS SCHEMATIC<br>D147-200                  | REAR PANEL ASSEMBLY<br>D147-001                |
| MAIN BOARD ASSEMBLY<br>D147-023 1 of 4         | MAIN BOARD ASSEMBLY<br>D147-023 2 of 4         |
| MAIN BOARD ASSEMBLY<br>D147-023 3 of 4         | MAIN BOARD ASSEMBLY<br>D147-023 4 of 4         |
| MAIN BOARD SCHEMATIC<br>D147-223 1 of 4        | MAIN BOARD SCHEMATIC<br>D147-223 2 of 4        |
| MAIN BOARD SCHEMATIC<br>D147-223 3 of 4        | MAIN BOARD SCHEMATIC<br>D147-223 4 of 4        |
| READOUT BOARD ASSEMBLY<br>D147-021             | READOUT BOARD SCHEMATIC<br>D147-221            |
| SWEEP BOARD ASSEMBLY<br>D147-022 1 of 4        | SWEEP BOARD ASSEMBLY<br>D147-022 2 of 4        |
| SWEEP BOARD ASSEMBLY<br>D147-022 3 of 4        | SWEEP BOARD ASSEMBLY<br>D147-022 4 of 4        |
| SWEEP BOARD SCHEMATIC<br>D147-222 1 of 2       | SWEEP BOARD SCHEMATIC<br>D147-222 2 of 2       |
| POWER SUPPLY BOARD ASSEMBLY<br>D147-020 1 of 2 | POWER SUPPLY BOARD ASSEMBLY<br>D147-020 2 of 2 |
| POWER SUPPLY BOARD SCHEMATIC<br>D147-220       |  |

### 5.4 RECOMMENDED SPARE PARTS LIST

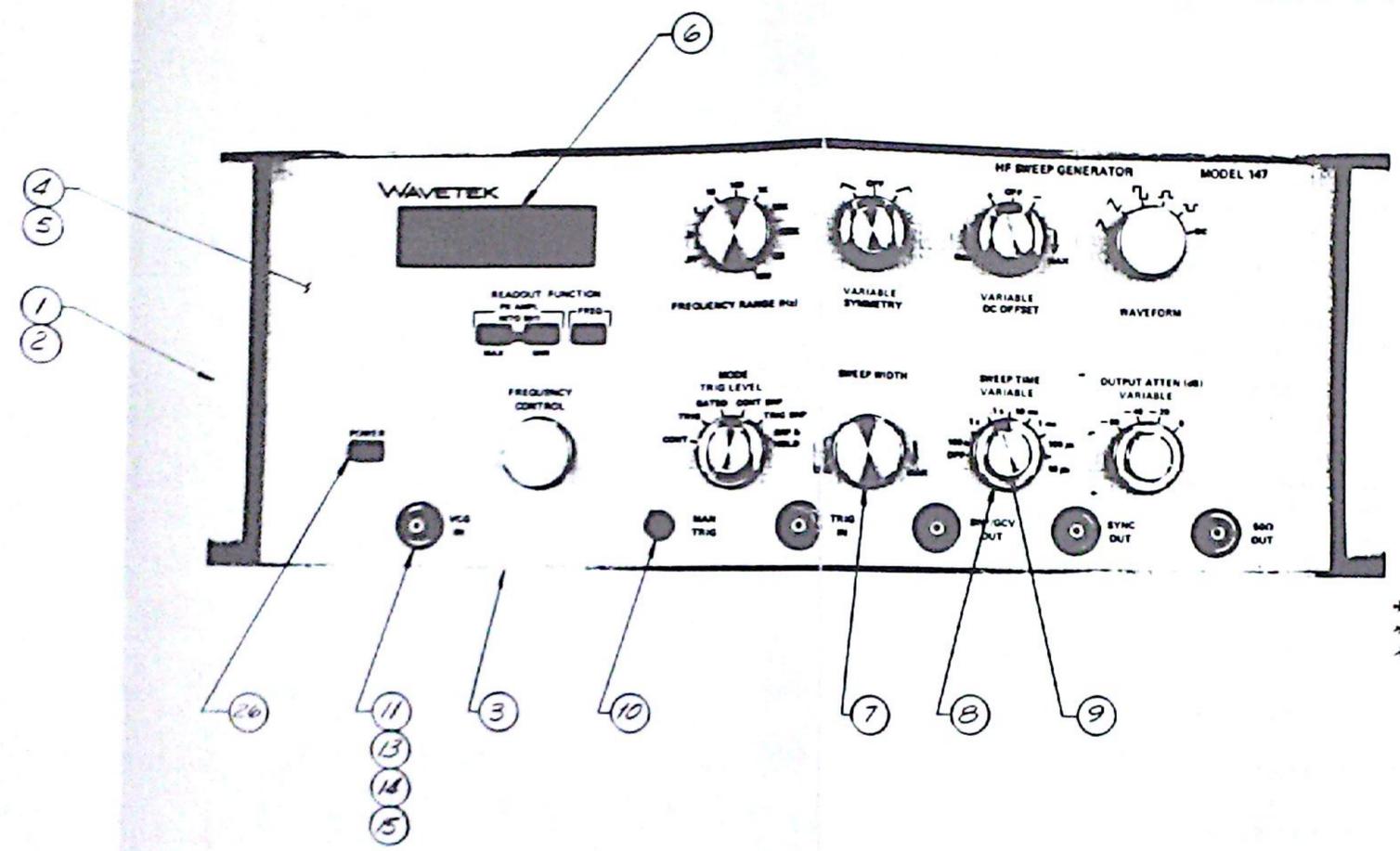
Information is provided to maintain the instrument on a board or component level. Price and delivery information should be obtained from the Wavetek representative in your area or directly from the factory.

| DESCRIPTION                  | MFG                | PART NO.   | QTY |
|------------------------------|--------------------|------------|-----|
| <b>BOARD LEVEL</b>           |                    |            |     |
| COMPLETE REAR PANEL ASSEMBLY | WAVETEK            | 147-001    | 1   |
| READOUT BOARD                | WAVETEK            | 147-021    | 1   |
| SWEEP BOARD                  | WAVETEK            | 147-022    | 1   |
| MAIN BOARD                   | WAVETEK            | 147-023    | 1   |
| <b>COMPONENT LEVEL</b>       |                    |            |     |
| DIODE TUNNEL                 | GE                 | 1N3716     | 1   |
| DIODE                        | SEMTECH            | SCE-1      | 2   |
| DIODE                        | FAIRCHILD          | FD777      | 5   |
| *DIODE SET                   | WAVETEK            | 142-501-58 | 1   |
| DIODE                        | HEWLETT-PACKARD    | HP-2811    | 3   |
| DIODE                        | FAIRCHILD          | FD666      | 5   |
| DIODE ZENER                  | WAVETEK            | 130-506    | 2   |
| FUSE 1/2A 115 V              | LITTELFUSE         | 313-500    | 2   |
| FUSE 1/2A 230 V              | LITTELFUSE         | 313-250    | 2   |
| INTEGRATED CIRCUIT           | FAIRCHILD          | 7805       | 1   |
| INTEGRATED CIRCUIT           | FAIRCHILD          | μM741C     | 5   |
| INTEGRATED CIRCUIT           | NAT SEMI-CONDUCTOR | LM-301     | 1   |
| INTEGRATED CIRCUIT           | RCA                | CA3028A    | 1   |
| INTEGRATED CIRCUIT           | RCA                | CA3030     | 1   |
| INTEGRATED CIRCUIT           | RCA                | CA3049     | 1   |
| INTEGRATED CIRCUIT           | MOTOROLA           | MC-3050    | 1   |
| INTEGRATED CIRCUIT           | RCA                | CA3054     | 1   |
| INTEGRATED CIRCUIT           | RCA                | CA3080     | 2   |
| INTEGRATED CIRCUIT           | MOSTEK             | 5005 P     | 1   |
| LED                          | OPCOA              | OSL-6L-1   | 2   |
| LED READOUT                  | FAIRCHILD          | FND 70     | 1   |
| LED READOUT                  | FAIRCHILD          | FND 71     | 1   |
| *TRANSISTOR SET              | WAVETEK            | 142-501-52 | 1   |
| *TRANSISTOR SET              | WAVETEK            | 142-501-53 | 1   |
| *TRANSISTOR SELECTED         | WAVETEK            | 142-501-55 | 2   |
| TRANSISTOR                   | MOTOROLA           | 2N2219A    | 2   |
| TRANSISTOR                   | FAIRCHILD          | 2N2905A    | 2   |
| TRANSISTOR                   | FAIRCHILD          | 2N3563     | 1   |
| TRANSISTOR                   | FAIRCHILD          | 2N3565     | 5   |
| TRANSISTOR                   | FAIRCHILD          | 2N3638     | 1   |
| TRANSISTOR                   | FAIRCHILD          | 2N3638A    | 5   |
| TRANSISTOR                   | FAIRCHILD          | 2N3640     | 5   |
| TRANSISTOR                   | FAIRCHILD          | 2N3642     | 1   |
| TRANSISTOR                   | FAIRCHILD          | 2N3646     | 10  |
| TRANSISTOR                   | FAIRCHILD          | 2N4248     | 1   |
| TRANSISTOR                   | FAIRCHILD          | 2N5139     | 5   |
| TRANSISTOR                   | MOTOROLA           | 2N5485     | 1   |
| TRANSISTOR                   | FAIRCHILD          | 2N4047     | 1   |
| TRANSISTOR                   | FAIRCHILD          | 2N5160     | 1   |
| TRANSISTOR                   | MOTOROLA           | MPS L08    | 2   |
| TRANSISTOR                   | TECH PROD          | TD308      | 1   |
| TRANSISTOR                   | TECH PROD          | TD401      | 1   |
| TRANSISTOR                   | SILICONIX          | U233       | 1   |
| TRANSISTOR                   | NATIONAL           | NF-510     | 1   |
| TRANSISTOR                   | TEXAS INST         | TIP 29     | 2   |
| TRANSISTOR                   | TEXAS INST         | TIP 30     | 2   |

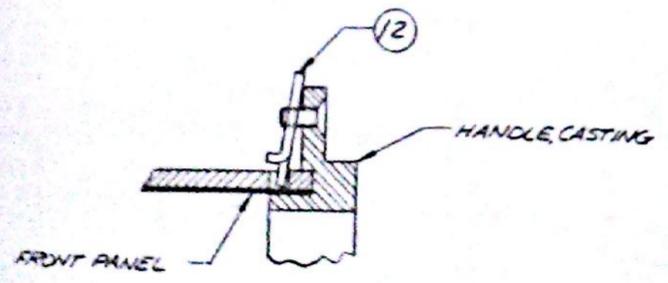
\*Denotes special selected parts and should be ordered from Wavetek.

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| REV | ECN | BY | DATE    | APP |
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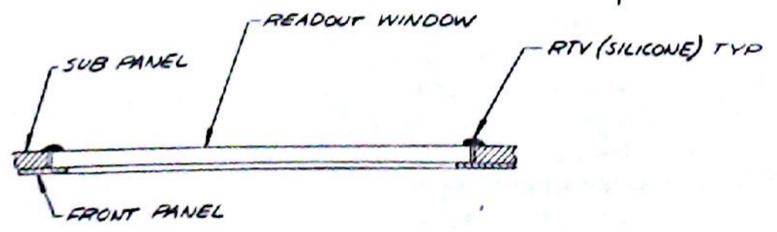


| PARTS LIST |                                   |           |       |             |     |
|------------|-----------------------------------|-----------|-------|-------------|-----|
| LINE NO    | DESCRIPTION                       | MFR       | FSCM  | MFR PIN     | QTY |
| 1          | HANDLE TRIM (MAKE FROM 847-333)   | WAVETEK   | 23338 | 8147-345    | 2   |
| 2          | HANDLE (MAKE FROM C147-315)       | WAVETEK   | 23338 | C147-342    | 2   |
| 3          | TRIM (MAKE FROM 847-313)          | WAVETEK   | 23338 | 8147-317    | 2   |
| 4          | SUB PANEL                         | WAVETEK   | 23338 | C147-301    | 1   |
| 5          | FRONT PANEL                       | WAVETEK   | 23338 | C147-300    | 1   |
| 6          | READOUT WINDOW                    | WAVETEK   | 23338 | 8147-350    | 1   |
| 7          | KNOB                              | WAVETEK   | 23338 | 8130-314    | 4   |
| 8          | KNOB, COAX                        | WAVETEK   | 23338 | 8130-309    | 5   |
| 9          | KNOB, SMALL                       | WAVETEK   | 23338 | 8130-354    | 5   |
| 10         | SWITCH (MOMENTARY)                | C + K     | 09353 | 7108 PDCN   | 1   |
| 11         | BNC CONNECTOR                     | KING      | 98336 | KC7946      | 5   |
| 12         | CLAMP (MAKE FROM 141-914)         | WAVETEK   | 23338 | A147-354    | 4   |
| 13         | SHOULDER WASHER                   | H H SMITH | 83330 | 2668        | 5   |
| 14         | FLAT WASHER                       | H H SMITH | 83330 | 2264        | 5   |
| 15         | SOLDER LUG                        | H H SMITH | 83330 | 1497        | 5   |
| 16         | SWEEP BD                          | WAVETEK   | 23338 | D147-022    | 1   |
| 17         | MAIN BD                           | WAVETEK   | 23338 | D147-023    | 1   |
| 18         | READOUT BD                        | WAVETEK   | 23338 | D147-021    | 1   |
| 19         | SIDE PLATE                        | WAVETEK   | 23338 | D147-355    | 2   |
| 20         | SUPPORT BAR                       | WAVETEK   | 23338 | 8147-347    | 1   |
| 21         | SWAGE NUTS                        | SOUTHCO   | 94222 | 78-11-20-13 | 4   |
| 22         | REAR PANEL (POWER SUPPLY)         | WAVETEK   | 23338 | D147-001    | 1   |
| * 23       | COVER                             | WAVETEK   | 23338 | C147-307    | 1   |
| * 24       | BAIL KIT (WITH FEET)              | WAVETEK   | 23338 | 8147-505    | 1   |
| * 25       | COVER SUPPORT (MAKE FROM 141-914) | WAVETEK   | 23338 | 8147-365    | 1   |
| 26         | PUSH BUTTON (RED)                 | CRL       | 71590 | J52305 RED  | 1   |
| 27         | CHASSIS BLOCKS                    | USECO     | 88245 | 15918-11    | 4   |
| 28         | MYLAR                             | H H SMITH | 83330 | 4L2FF       | 9   |
| 29         | SHOULDER WASHER                   | H H SMITH | 83330 | 2661        | 2   |
| 30         |                                   |           |       |             |     |
| 31         |                                   |           |       |             |     |
| 32         |                                   |           |       |             |     |
| 33         |                                   |           |       |             |     |
| 34         |                                   |           |       |             |     |
| 35         |                                   |           |       |             |     |



NOTE: BEFORE CLAMPING HANDLE CASTING (2) IN PLACE THE TRIM (TOP & BOTTOM) & PANELS MUST BE IN PLACE

**HANDLE DETAILS**



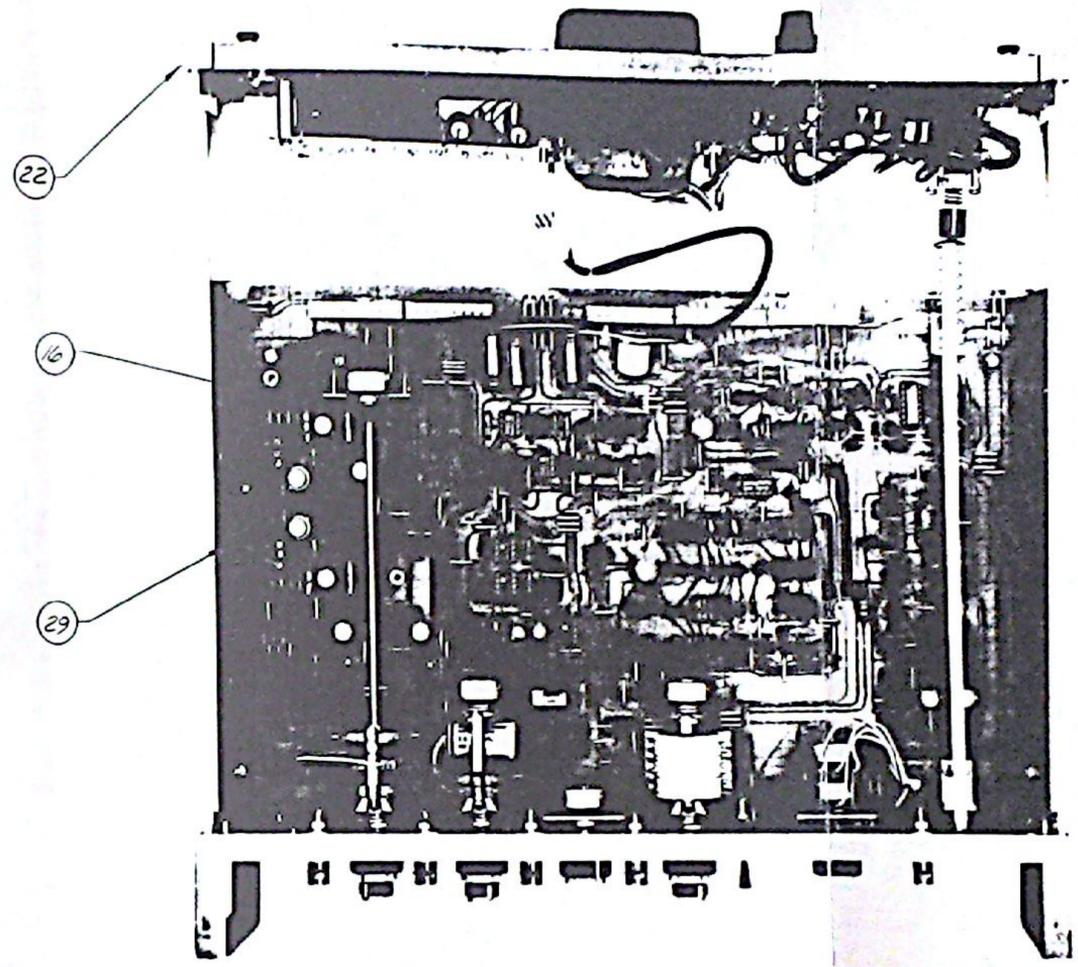
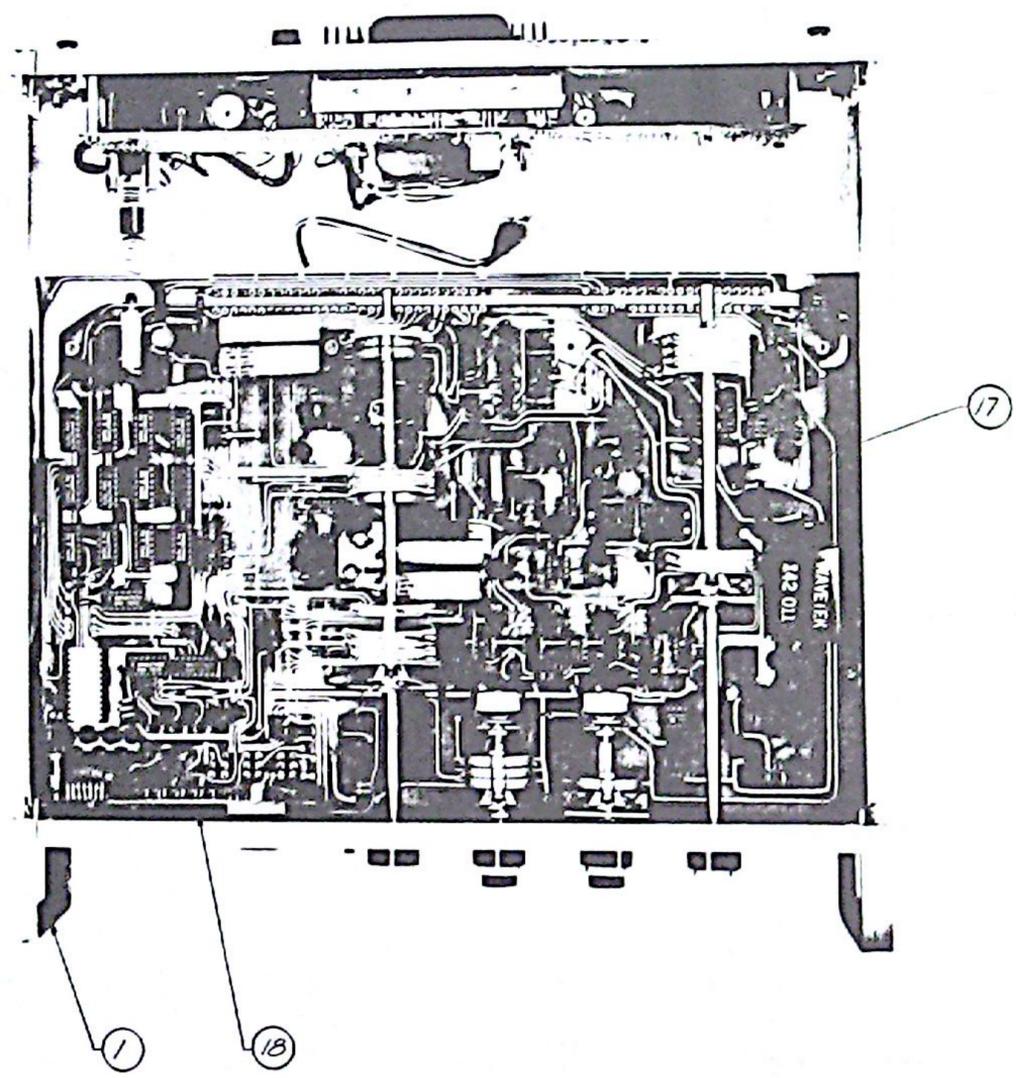
**READOUT WINDOW DETAIL**

\* # INDICATES ITEMS NOT SHOWN  
 NOTE: UNLESS OTHERWISE SPECIFIED

|  |                                 |   |
|--|---------------------------------|---|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE 9/2/73                     | <b>WAVETEK</b> SAN DIEGO • CALIFORNIA<br>TITLE<br><b>ASSEMBLY CHASSIS</b> |
| MATERIAL                               | DESIGNED BY BOCHICCHIO          |   |
| FINISH WAVETEK PROCESS                 | RELEASED BY [Signature] 8-18-74 | MODEL NO 147<br>DWG NO D147-000<br>SCALE<br>CODE 23338 SHEET 1 OF 2       |

|     |     |    |      |     |
|-----|-----|----|------|-----|
| REV | ECN | BY | DATE | APP |
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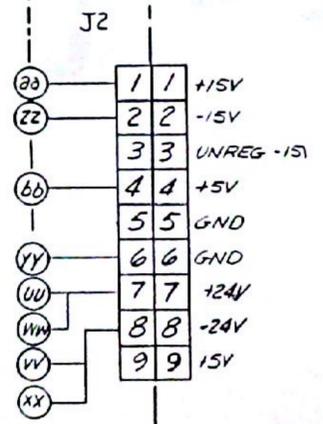
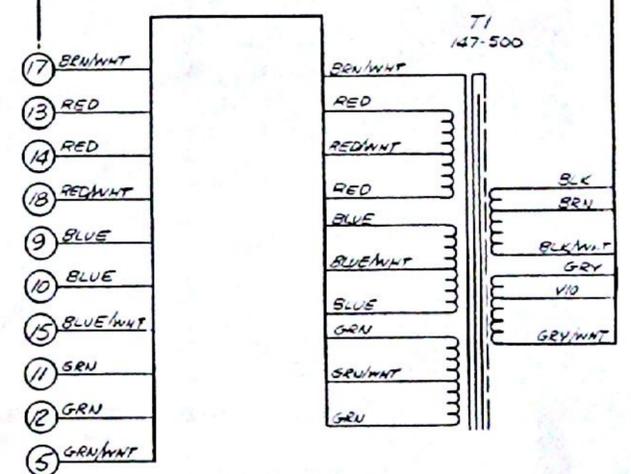
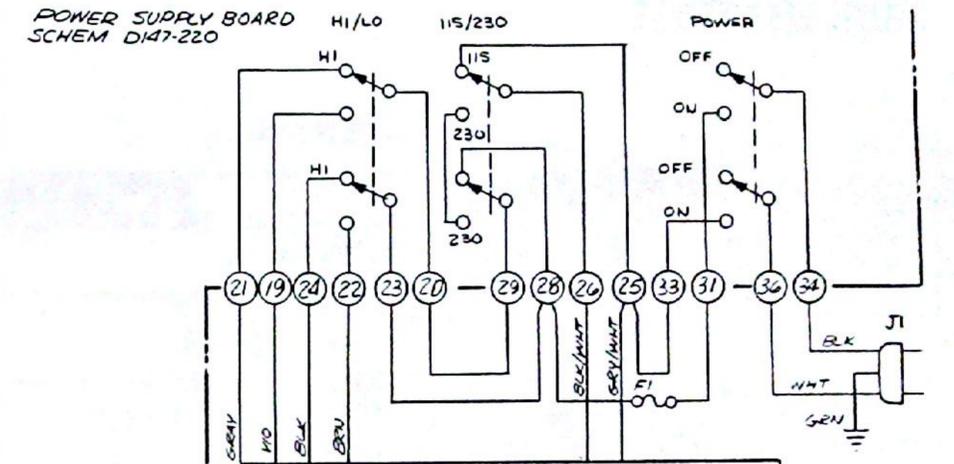
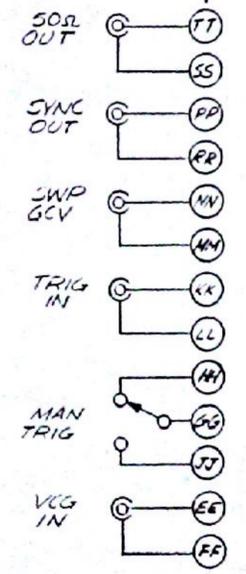
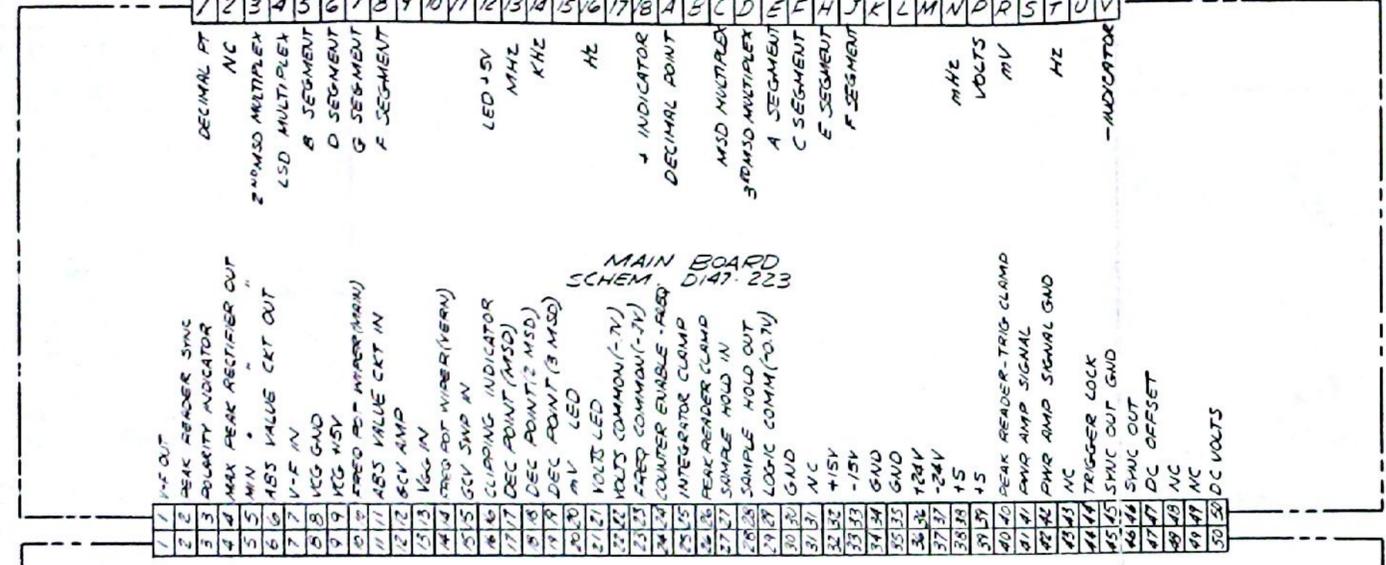
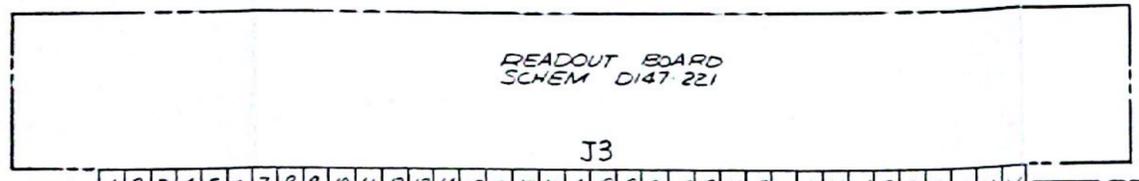


NOTE: UNLESS OTHERWISE SPECIFIED

|  |  |        |                               |  |
|--|--|--------|-------------------------------|--|
| REMOVE ALL BURRS AND BREAK SHARP EDGES |  | DATE   | WAVETEK SAN DIEGO, CALIFORNIA |  |
| DRAWN                                  |  | 9/2/79 | TITLE                         |  |
| BOONK/MO                               |  |        | ASSEMBLY CHASSIS              |  |
| MATERIAL                               |  |        | MODEL NO                      |  |
| 303 STAINLESS STEEL                    |  |        | 147                           |  |
| TOLERANCE UNLESS OTHERWISE SPECIFIED   |  |        | REV                           |  |
| XX .010 ANGLES .5                      |  |        | D147-000 A                    |  |
| FINISH WAVETEK PROCESS                 |  |        | SCALE                         |  |
| DO NOT SCALE DWG                       |  |        | 23330 SHEET 2 OF 2            |  |

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| REV | ECN | BY | DATE | APP |
|-----|-----|----|------|-----|
| A   | 764 | S  | 9/73 |     |



NOTE: UNLESS OTHERWISE SPECIFIED

|  |                             |  |                                       |
|--|-----------------------------|--|---------------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DRAWN: COGNICH/D            | DATE: 9/73   | <b>WAVETEK</b> SAN DIEGO • CALIFORNIA |
| MATERIAL:                              | PROJ: 147-220               | TITLE: SCHEMATIC CHASSIS   |                                       |
| FINISH: WAVETEK PROCESS                | RELEASE APPROV: [Signature] | TOLERANCES UNLESS OTHERWISE SPECIFIED: .25 .10 .03 ANGLES: 1:2:1 | MODEL NO: 147                         |
|  | DO NOT SCALE DWG            | SCALE:   | DWG NO: D147-200                      |
|  |                             |  | REV: A                                |
|  |                             |  | 23338                                 |
|  |                             |  | SHEET 1 OF 1                          |

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|     |     |    |      |     |
|-----|-----|----|------|-----|
| REV | ECN | BY | DATE | APP |
|-----|-----|----|------|-----|

| PARTS LIST |                          |             |       |                |     |
|------------|--------------------------|-------------|-------|----------------|-----|
| LINE NO    | DESCRIPTION              | MFR         | FSCM  | MFR P/N        | QTY |
| 1          | CAPACITORS               |             |       |                |     |
| 2          | CERAMIC DISC 50V .01uF   | CRL         | 71590 | CK103          | 4   |
| 3          | CERAMIC DISC 20V .1uF    | CRL         | 71590 | UK20-104       | 7   |
| 4          | CERAMIC DISC 50V .1uF    | CRL         | 71590 | CK104          | 2   |
| 5          | ELECTROLYTIC 50V 50uF    | SPRAGUE     | 56289 | 500506G0500D7  | 2   |
| 6          | ELECTROLYTIC 16V 250uF   | SPRAGUE     | 56289 | 500257G0160F7  | 3   |
| 7          | ELECTROLYTIC 50V 500uF   | SPRAGUE     | 56289 | 590507G0500GL4 | 2   |
| 8          | ELECTROLYTIC 35V 1000uF  | SPRAGUE     | 56289 | 390108G035GL4  | 2   |
| 9          | ELECTROLYTIC 15V 1900uF  | SPRAGUE     | 56289 | 390198G015GL4  | 1   |
| 10         | CERAMIC DISC 33PF        | CRL         | 71590 | CD-330         | 1   |
| 11         |                          |             |       |                |     |
| 12         | DIODES SCE-1             | SEMTECH     | 14099 | SCE-1          | 10  |
| 13         | ZENER                    | WAVETEK     | 23338 | A130-506       | 1   |
| 14         |                          |             |       |                |     |
| 15         |                          |             |       |                |     |
| 16         |                          |             |       |                |     |
| 17         | INTEGRATED CIRCUITS 741  | FAIRCHILD   | 33888 | uM741C         | 4   |
| 18         | INTEGRATED CIRCUITS 7805 | FAIRCHILD   | 33888 | 7805393        | 1   |
| 19         |                          |             |       |                |     |
| 20         |                          |             |       |                |     |
| 21         | TRANSISTORS 2N3642       | FAIRCHILD   | 33888 | 2N3642         | 6   |
| 22         | TRANSISTORS 2N4248       | FAIRCHILD   | 33888 | 2N4248         | 6   |
| 23         | TRANSISTORS TIP-29       | TEXAS INST. | 01295 | TIP-29         | 2   |
| 24         | TRANSISTORS TIP-30       | TEXAS INST. | 01295 | TIP-30         | 2   |
| 25         |                          |             |       |                |     |
| 26         |                          |             |       |                |     |
| 27         |                          |             |       |                |     |
| 28         |                          |             |       |                |     |
| 29         |                          |             |       |                |     |
| 30         |                          |             |       |                |     |
| 31         |                          |             |       |                |     |
| 32         |                          |             |       |                |     |

| PARTS LIST |                             |             |       |             |     |
|------------|-----------------------------|-------------|-------|-------------|-----|
| LINE NO    | DESCRIPTION                 | MFR         | FSCM  | MFR P/N     | QTY |
| 33         | RESISTORS                   |             |       |             |     |
| 34         | CARBON 1/2W 5% 3.9Q         | STACKPOLE   | 29604 | RC20GF3R9J  | 2   |
| 35         | CARBON 1/2W 5% 4.7Q         | STACKPOLE   | 29604 | RC20GF4R7J  | 2   |
| 36         | METALFILM 1/8W 1% 464Q      | CORNING     | 16299 | RN550       | 2   |
| 37         | METALFILM 1/8W 1% 681Q      | CORNING     | 16299 | RN550       | 2   |
| 38         | METALFILM 1/8W 1% 825Q      | CORNING     | 16299 | RN550       | 2   |
| 39         | METALFILM 1/8W 1% 2.21K     | CORNING     | 16299 | RN550       | 4   |
| 40         | METALFILM 1/8W 1% 2.74K     | CORNING     | 16299 | RN550       | 2   |
| 41         | METALFILM 1/8W 1% 2.87K     | CORNING     | 16299 | RN550       | 1   |
| 42         | METALFILM 1/8W 1% 3.92K     | CORNING     | 16299 | RN550       | 1   |
| 43         | METALFILM 1/8W 1% 4.75K     | CORNING     | 16299 | RN550       | 7   |
| 44         | METALFILM 1/8W 1% 5.76K     | CORNING     | 16299 | RN550       | 2   |
| 45         | METALFILM 1/8W 1% 6.19K     | CORNING     | 16299 | RN550       | 1   |
| 46         | METALFILM 1/8W 1% 8.25K     | CORNING     | 16299 | RN550       | 1   |
| 47         | METALFILM 1/8W 1% 9.09K     | CORNING     | 16299 | RN550       | 2   |
| 48         | METALFILM 1/8W 1% 9.53K     | CORNING     | 16299 | RN550       | 2   |
| 49         | METALFILM 1/8W 1% 10K (-64) | CORNING     | 16299 | RN550       | 2   |
| 50         | METALFILM 1/8W 1% 18.2K     | CORNING     | 16299 | RN550       | 2   |
| 51         | METALFILM 1/8W 1% 38.3K     | CORNING     | 16299 | RN550       | 2   |
| 52         | POTENTIOMETER 1K            | BECKMAN     | 80740 | 91AR1K      | 1   |
| 53         |                             |             |       |             |     |
| 54         | PUSH BUTTON (RED)           | CRL         | 71590 | J52315(RED) | 1   |
| 55         | STANDOFFS                   | WAVETEK     | 23338 | 013-005-1   | 2   |
| 56         | POWER SWITCH                | WAVETEK     | 23338 | 157-422     | 1   |
| 57         | CONNECTOR BLOCK             | MOLEX       |       | 03-06-1091  | 1   |
| 58         | CONNECTOR PINS              | MOLEX       |       | 02-06-1152  | 9   |
| 59         | SWITCH (115-230)            | SWITCHCRAFT | 82389 | 46256LF     | 1   |
| 60         | SWITCH (HI - LO)            | SWITCHCRAFT | 82389 | 5M422-FT-HK | 1   |
| 61         | TRANSISTORS                 | MILTON ROSS | 07047 | 10123N      | 8   |
| 62         | BOARD                       | WAVETEK     | 23338 | 147-120     | 1   |
| 63         | SOLDER GUARD                | SWITCHCRAFT | 82389 | 46256LF-50  | 2   |
| 64         |                             |             |       |             |     |

LINE ITEM REFERENCE LIST

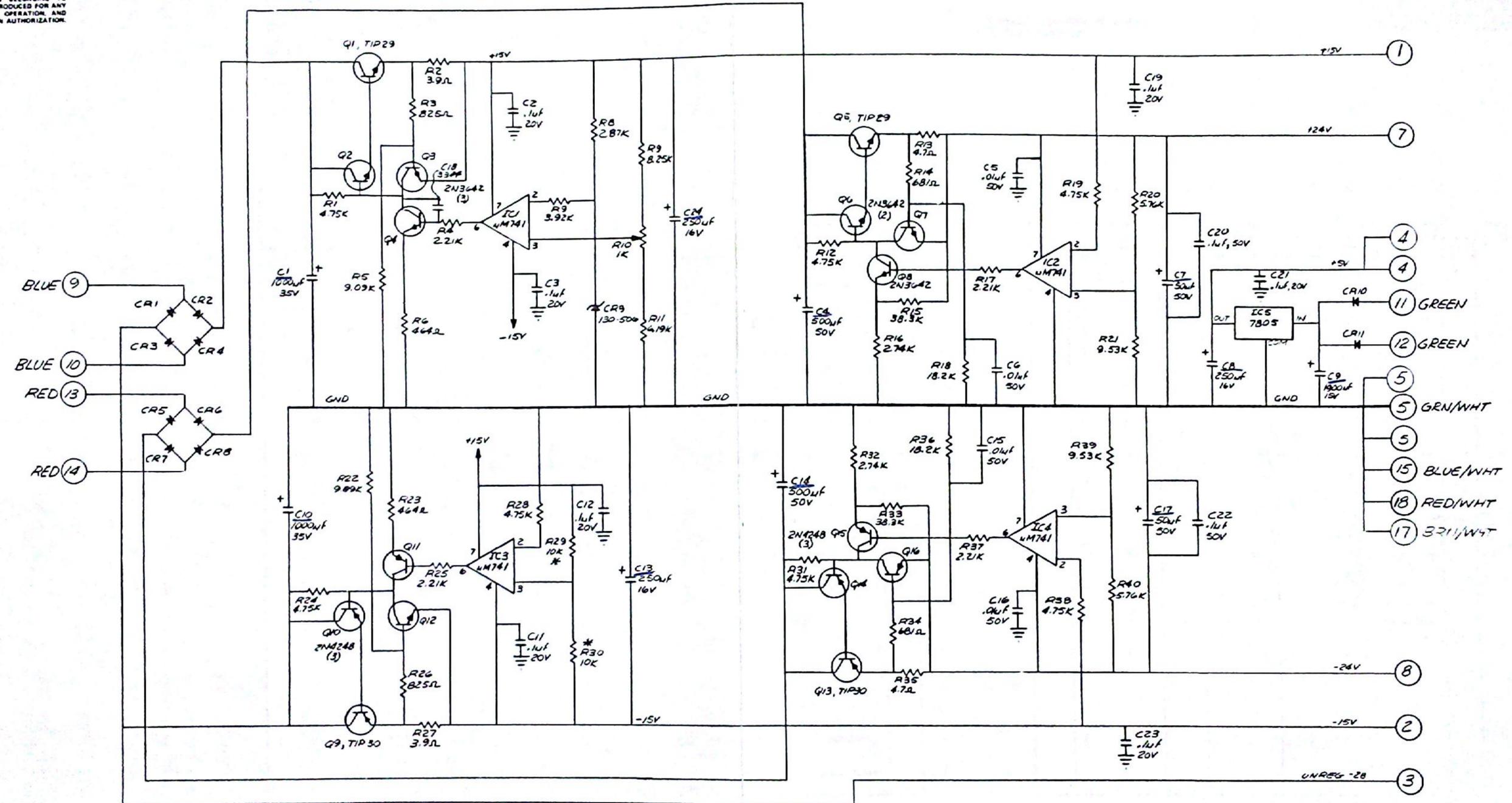
| Ref. Desig | F/L Line | Ref. Desig | F/L Line | Ref. Desig | F/L Line |
|------------|----------|------------|----------|------------|----------|
| C1         | 8        | IC1        | 17       | R12        | 43       |
| C2         | 3        | IC2        | 17       | R13        | 35       |
| C3         | 3        | IC3        | 17       | R14        | 37       |
| C4         | 7        | IC4        | 17       | R15        | 51       |
| C5         | 2        | IC5        | 18       | R16        | 40       |
| C6         | 2        |            |          | R17        | 39       |
| C7         | 5        |            |          | R18        | 50       |
| C8         | 5        |            |          | R19        | 43       |
| C9         | 9        | Q1         | 23       | R20        | 44       |
| C10        | 8        | Q2         | 21       | R21        | 48       |
| C11        | 5        | Q3         | 21       | R22        | 47       |
| C12        | 5        | Q4         | 21       | R23        | 36       |
| C13        | 6        | Q5         | 23       | R24        | 43       |
| C14        | 7        | Q6         | 21       | R25        | 39       |
| C15        | 2        | Q7         | 21       | R26        | 38       |
| C16        | 2        | Q8         | 21       | R27        | 34       |
| C17        | 5        | Q9         | 24       | R28        | 43       |
| C18        | 10       | Q10        | 22       | R29        | 49       |
| C19        | 3        | Q11        | 22       | R30        | 49       |
| C20        | 4        | Q12        | 22       | R31        | 43       |
| C21        | 3        | Q13        | 24       | R32        | 40       |
| C22        | 4        | Q14        | 22       | R33        | 51       |
| C23        | 3        | Q15        | 22       | R34        | 37       |
| C24        | 6        | Q16        | 22       | R35        | 35       |
|            |          |            |          | R36        | 50       |
|            |          |            |          | R37        | 39       |
|            |          |            |          | R38        | 43       |
|            |          |            |          | R39        | 48       |
|            |          |            |          | R40        | 44       |
| CR1        | 12       |            |          |            |          |
| CR2        | 12       |            |          |            |          |
| CR3        |          |            |          |            |          |
| CR4        | 12       | R1         | 43       |            |          |
| CR5        | 12       | R2         | 34       |            |          |
| CR6        | 12       | R3         | 38       |            |          |
| CR7        | 12       | R4         | 39       |            |          |
| CR8        | 12       | R5         | 47       |            |          |
| CR9        | 15       | R6         | 36       |            |          |
| CR10       | 12       | R7         | 42       |            |          |
| CR11       | 12       | R8         | 41       |            |          |
|            |          | R9         | 46       |            |          |
|            |          | R10        | 52       |            |          |
|            |          | R11        | 45       |            |          |

NOTE UNLESS OTHERWISE SPECIFIED

|  |  |                                |
|--|--|--------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE<br>10/19/99   | WAVETEK SAN DIEGO, CALIFORNIA  |
| MATERIAL                               | PROJ. NO.<br>23338   | TITLE<br>ASSEMBLY POWER SUPPLY |
| FINISH<br>WAVETEK PROCESS              | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XX.X - .010<br>XX.X - .020 | DO NOT SCALE DIMS              |
| SCALE                                  | 147  | DI47-020 D                     |
|  | 23338  | SHEET 2 OF 2                   |

| REV | ECN | BY | DATE | APP |
|-----|-----|----|------|-----|
| B   | 761 |    | 9/79 |     |

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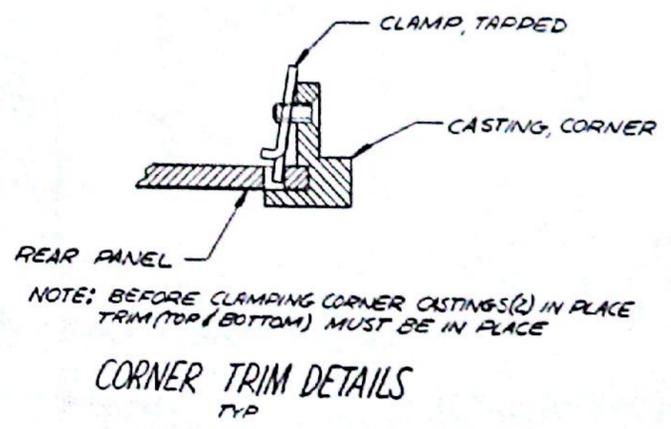
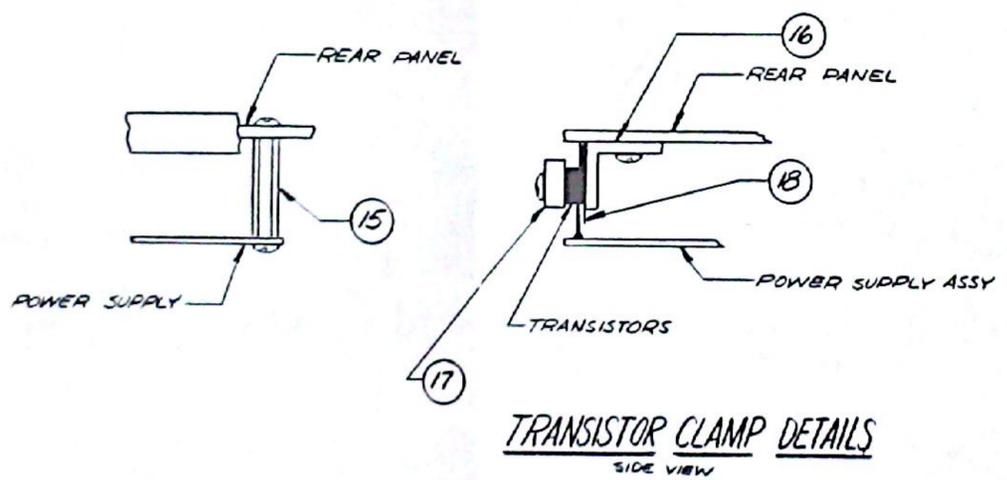
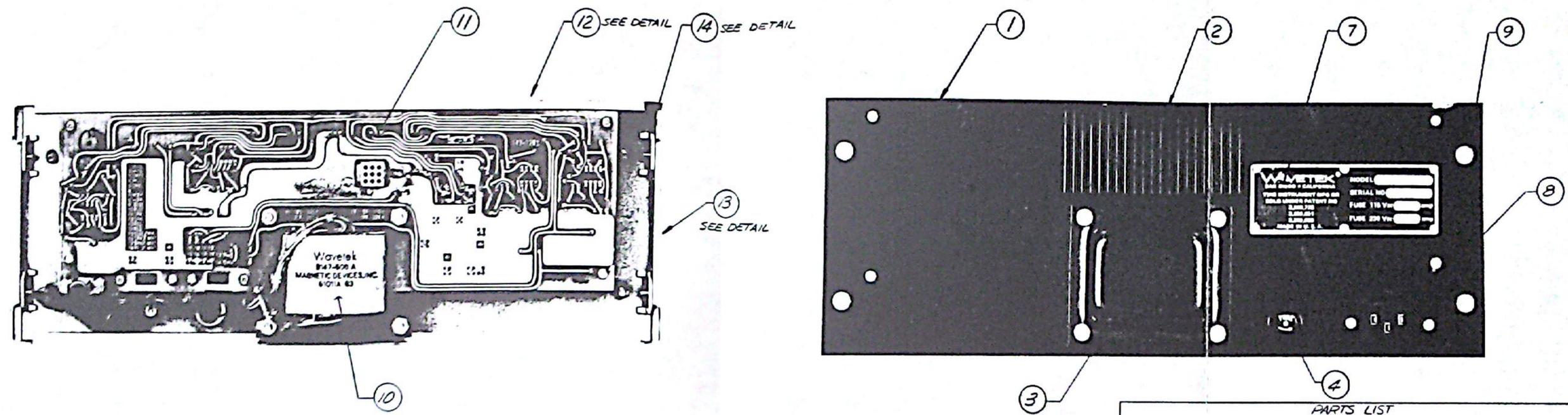
1) COLORED CALLOUTS INDICATE TRANSFORMER LEADS  
 2) SEE CHASSIS SCHEMATIC D147-200 FOR INTERWIRING  
 3) DIODES ARE SCE-11  
 4) \* INDICATES MATCHED PAIR (R29, R30)  
 NOTE UNLESS OTHERWISE SPECIFIED

| LAST DESIGNATORS USED  | NOT USED |
|------------------------|----------|
| CAPACITOR C24          |          |
| DIODE CR11             |          |
| INTEGRATED CIRCUIT IC5 |          |
| TRANSISTOR Q10         |          |
| RESISTOR R40           |          |

|  |                         |  |                                       |
|--|-------------------------|--|---------------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DESIGNER BOLEMANO       | DATE 9/79  | <b>WAVETEK</b> SAN DIEGO - CALIFORNIA |
| MATERIAL                               | PROJECT                 | TITLE  |                                       |
| FINISH WAVETEK PROCESS                 | RELEASE APPROVAL 9.5.79 | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XXX - 010 ANGLES - 1<br>XX - 030 | SCHEMATIC POWER SUPPLY BOARD          |
| SCALE                                  | DO NOT SCALE DWG        | MODEL NO 147   |                                       |
|  |                         | REV B  |                                       |
|  | 2338                    |  | SHEET 1 OF 1                          |

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| REV | ECN     | BY | DATE | APP |
|-----|---------|----|------|-----|
| A   | ECN 765 | Bo | 7/74 |     |



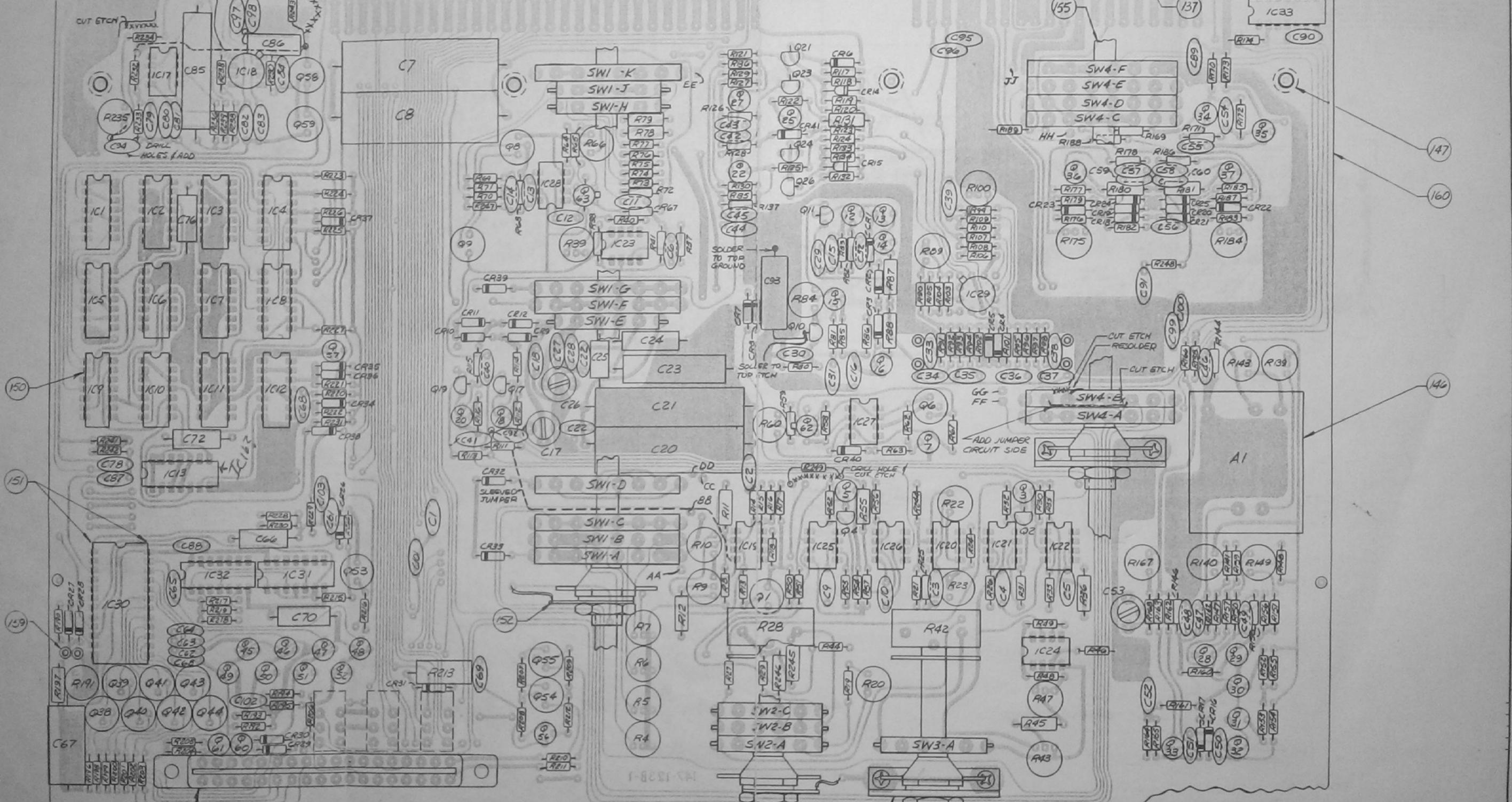
PARTS LIST

| LINE NO | DESCRIPTION                        | MFGR       | FSCM  | MFGR PIN       | QTY |
|---------|------------------------------------|------------|-------|----------------|-----|
| 1       | REAR PANEL                         | WAVETEK    | 23338 | C147-302       | 1   |
| 2       | HEATSINK                           | WAVETEK    | 23338 | B147-312       | 1   |
| 3       | TRANSFORMER END BELL               | WAVETEK    | 23338 | A147-352       | 1   |
| 4       | FUSE HOLDER                        | LITTELFUSE | 75915 | 342012         | 1   |
| 5       | FUSE 1/2 AMP (115V)                | LITTELFUSE | 75915 | 313.500        | 1   |
| 6       | FUSE 1/4 AMP (230V)                | LITTELFUSE | 75915 | 313.250        | 1   |
| 7       | NAMETAG (SERIAL NO)                | WAVETEK    | 23338 | B147-334       | 1   |
| 8       | POWER CONNECTOR                    | SMITHCRAFT | 82389 | EAC-301        | 1   |
| 9       | CAPTIVE SCREWS                     | DEUTSCH    | -     | DKN7900-10-C-2 | 4   |
| 10      | TRANSFORMER                        | WAVETEK    | 23338 | B147-500       | 1   |
| 11      | POWER SUPPLY BO ASSY               | WAVETEK    | 23338 | D147-020       | 1   |
| 12      | TRIM (MADE FROM 807-513)           | WAVETEK    | 23338 | B147-317       | 2   |
| 13      | CORNER CASTING (MADE FROM CM7-340) | WAVETEK    | 23338 | C147-341       | 2   |
| 14      | CLAMPS TAPPED (MADE FROM AM7-810)  | WAVETEK    | 23338 | A147-354       | 4   |
| 15      | STANDOFFS                          | WAVETEK    | 23338 | A201-333       | 4   |
| 16      | BRACKET, POWER TRANS.              | WAVETEK    | 23338 | B147-351       | 1   |
| 17      | CLAMPING BAR                       | WAVETEK    | 23338 | B147-303       | 1   |
| 18      | INSULATOR (TRANSISTOR)             | WAVETEK    | 23338 | B154-314       | 1   |
| 19      |                                    |            |       |                |     |
| 20      |                                    |            |       |                |     |
| 21      |                                    |            |       |                |     |
| 22      |                                    |            |       |                |     |
| 23      |                                    |            |       |                |     |
| 24      |                                    |            |       |                |     |
| 25      |                                    |            |       |                |     |
| 26      |                                    |            |       |                |     |
| 27      |                                    |            |       |                |     |
| 28      |                                    |            |       |                |     |

1) FOR CHASSIS WIRING SEE CHASSIS SCHEMATIC D147-200  
NOTE: UNLESS OTHERWISE SPECIFIED

|  |                         |               |  |        |
|--|-------------------------|---------------|--|--------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DESIGN: BOCHKENIG, M    | DATE: 7-26-73 | <b>WAVETEK</b> SAN DIEGO, CALIFORNIA       |        |
| MATERIAL:                              | PAINTING:               |               | TITLE: ASSEMBLY, REAR PANEL (POWER SUPPLY) |        |
| FINISH: WAVETEK PROCESS                | SCALE: DO NOT SCALE DWG | MODEL NO: 147 | DWG NO: D147-001                           | REV: A |
|  |                         | CODE: 23338   | SHEET 1 OF 1                               |        |

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NOTE: UNLESS OTHERWISE SPECIFIED:

|  |                                      |                       |                                       |
|--|--------------------------------------|-----------------------|---------------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE                                 | 3/18/73               | <b>WAVETEK</b> SAN DIEGO - CALIFORNIA |
| MATERIAL                               | PROJECT                              |                       |                                       |
| FINISH WAVETEK PROCESS                 | RELEASE APPROV                       | J. M. [Signature]     | TITLE                                 |
|  | TOLERANCE UNLESS OTHERWISE SPECIFIED | XXX ± 0.10 ANGLES 11° | <b>ASSEMBLY MAIN BOARD</b>            |
| DO NOT SCALE DWG                       | MODEL NO                             | 147                   | REV                                   |
| SCALE                                  | DOC NO                               | D147-023              | B                                     |
|  | WORK CENTER                          | 23338                 | SHEET 1 OF 4                          |

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| PARTS LIST |                           |             |       |                 |      |
|------------|---------------------------|-------------|-------|-----------------|------|
| LINE NO    | DESCRIPTION               | MFR         | FSCM  | MFR P/N         | QTY  |
| 1          | CAPACITOR                 |             |       |                 |      |
| 2          | CERAMIC DISC 1000V 15PF   | CRL         | 71590 | 00150           | 1    |
| 3          | CERAMIC DISC 1000V 22PF   | CRL         | 71590 | 00220           | 1    |
| 4          | SILVER MICA 500V 5A 30PF  | ELMENCO     | 72136 | DM15-300J       | 3    |
| 5          | CERAMIC DISC 1000V 47PF   | CRL         | 71590 | 00470           | 1    |
| 6          | SILVER MICA 500V 68PF     | ELMENCO     | 72136 | DM15-680J       | 2    |
| 7          | CERAMIC DISC 500V 91PF    | CRL         | 71590 | DM-15-910       | 2    |
| 8          | SILVER MICA 500V 100PF    | ELMENCO     | 72136 | DM15-101J       | 2    |
| 9          | SILVER MICA 500V 150PF    | ELMENCO     | 72136 | DM15-151J       | 4    |
| 10         | CERAMIC DISC 1000V 220PF  | CRL         | 71590 | 00221           | 1    |
| 11         | CERAMIC DISC 1000V 330PF  | CRL         | 71590 | 00331           | 2    |
| 12         | SILVER MICA 470PF         | ELMENCO     | 72136 | DM15-471J       | 1    |
| 13         | SILVER MICA 820PF         | ELMENCO     | 72136 | DM15-821J       | 1    |
| 14         | CERAMIC DISC 50V .005uE   | CRL         | 71590 | CK502           | 5    |
| 15         | CERAMIC DISC 1000V .001uE | CRL         | 71590 | DD102           | 3    |
| 16         | CERAMIC DISC 50V .01uE    | CRL         | 71590 | CK105           | 20   |
| 17         | CERAMIC DISC 20V .1uE     | CRL         | 71590 | UK20-104        | 28   |
| 18         | POLYSTYRENE 200V 1A 1uE   | ELECTROCUBE |       | 21001C105F      | 1    |
| 19         | MYLAR 100V 5uE            | WAVETEK     | 23338 | B146-505        | 1SET |
| 20         | TANTALIUM 10V 33uE        | SPRAGUE     | 56289 | 1500356X901002  | 5    |
| 21         | ELECTROLYTIC 50V 50uE     | SPRAGUE     | 56289 | 5000506G0500D7  | 1    |
| 22         | ELECTROLYTIC 16V 100uE    | SPRAGUE     | 56289 | 5000107G0180C7  | 1    |
| 23         | MATCHED SET 5uE           | WAVETEK     | 23338 | B146-504        | 1SET |
| 24         | MATCHED SET 1uE           |             |       |                 | REF  |
| 25         | MATCHED SET 2uE           |             |       |                 | REF  |
| 26         | MATCHED SET 0.1uE         |             |       |                 | REF  |
| 27         | VARIABLE 7/35PF           | STETNER     |       | 75-TRIKO-02-77E | 3    |
| 28         | Ceramic Disc 1000V 470PF  | CRL         | 71590 | 00471           | 3    |
| 29         |                           |             |       |                 |      |
| 30         |                           |             |       |                 |      |
| 31         |                           |             |       |                 |      |

| PARTS LIST |                              |  |       |            |     |
|------------|------------------------------|--|-------|------------|-----|
| LINE NO    | DESCRIPTION                  | MFR                                    | FSCM  | MFR P/N    | QTY |
| 32         |                              |  |       |            |     |
| 33         | DIODE FD777                  | FAIRCHILD                              | 33888 | FD777      | 8   |
| 34         | DIODE MATCHED FD777          | WAVETEK                                | 23338 | 142-501-58 | 1PR |
| 35         | DIODE MATCHED FD6666         | FAIRCHILD                              | 33888 | FD6666     | 23  |
| 36         | DIODE MATCHED 1N3716         |  |       | 1N3716     | 2   |
| 37         | DIODE MATCHED HP2811         | GENERAL ELECTRIC<br>HEWLETT<br>PACKARD |       | HP-2811    | 2   |
| 38         | DIODE MATCHED ZENER          | WAVETEK                                | 23338 | A130-506   | 3   |
| 39         |                              |  |       |            |     |
| 40         |                              |  |       |            |     |
| 41         |                              |  |       |            |     |
| 42         | INTEGRATED CIRCUIT uA709     | WAVETEK                                | 23338 | 130-501-14 | 1   |
| 43         | INTEGRATED CIRCUIT uM741     | FAIRCHILD                              | 33888 | uM741C     | 11  |
| 44         | INTEGRATED CIRCUIT CA3049    | RCA                                    | 86684 | CA3049     | 1   |
| 45         | INTEGRATED CIRCUIT MK5005P   | FAIRCHILD                              | 33888 | MK5005P    | 1   |
| 46         | INTEGRATED CIRCUIT 7400      | FAIRCHILD                              | 33888 | 7400       | 2   |
| 47         | INTEGRATED CIRCUIT 7402      | FAIRCHILD                              | 33888 | 7402       | 3   |
| 48         | INTEGRATED CIRCUIT 7403      | FAIRCHILD                              | 33888 | 7403       | 1   |
| 49         | INTEGRATED CIRCUIT 7404      | FAIRCHILD                              | 33888 | 7404       | 2   |
| 50         | INTEGRATED CIRCUIT 7405      | FAIRCHILD                              | 33888 | 7405       | 1   |
| 51         | INTEGRATED CIRCUIT 7474      | FAIRCHILD                              | 33888 | 7474       | 3   |
| 52         | INTEGRATED CIRCUIT 7490      | FAIRCHILD                              | 33888 | 7490       | 4   |
| 53         |                              |  |       |            |     |
| 54         |                              |  |       |            |     |
| 55         |                              |  |       |            |     |
| 56         |                              |  |       |            |     |
| 57         | TRANSISTORS LDB              | MOTOROLA                               | 04713 | MPSL08     | 4   |
| 58         | TRANSISTORS TP308            | TECHNICAL PRODUCTS                     |       | TP308      | 2   |
| 59         | TRANSISTORS 2N3563           | FAIRCHILD                              | 33888 | 2N3563     | 1   |
| 60         | TRANSISTORS (MATCHED) 2N3563 | WAVETEK                                | 23338 | 142-501-52 | 1PR |
| 61         | TRANSISTORS 2N3565           | FAIRCHILD                              | 33888 | 2N3565     | 9   |
| 62         | TRANSISTORS 2N3638           | FAIRCHILD                              | 33888 | 2N3638     | 3   |

| PARTS LIST |                              |           |       |            |     |
|------------|------------------------------|-----------|-------|------------|-----|
| LINE NO    | DESCRIPTION                  | MFR       | FSCM  | MFR P/N    | QTY |
| 63         | TRANSISTORS 2N3638A          | FAIRCHILD | 33888 | 2N3638A    | 10  |
| 64         | TRANSISTORS 2N3642           | FAIRCHILD | 33888 | 2N3642     | 3   |
| 65         | TRANSISTORS 2N3646           | FAIRCHILD | 33888 | 2N3646     | 10  |
| 66         | TRANSISTORS 2N4248           | FAIRCHILD | 33888 | 2N4248     | 1   |
| 67         | TRANSISTORS 2N5139           | FAIRCHILD | 33888 | 2N5139     | 12  |
| 68         | TRANSISTORS 2N5462           | WAVETEK   | 23338 | 142-501-55 | 2   |
| 69         | TRANSISTORS 2N5485           | MOTOROLA  | 04713 | 2N5485     | 2   |
| 70         | TRANSISTORS (MATCHED) 2N5485 | WAVETEK   | 23338 | 142-501-55 | 1PR |
| 71         |                              |           |       |            |     |
| 72         |                              |           |       |            |     |
| 73         |                              |           |       |            |     |
| 74         |                              |           |       |            |     |
| 75         | RESISTORS                    |           |       |            |     |
| 76         | CARBON 1/2W 5% 4.7k          | STACKPOLE | 29604 | RC20GF4R7J | 2   |
| 77         | CARBON 1/2W 5% 8.2k          | STACKPOLE | 29604 | RC20GF8R2J | 4   |
| 78         | METALFILM 1/8W 1% 100        | CORNING   | 16299 | RN550      | 4   |
| 79         | METALFILM 1/8W 1% 21.50      | CORNING   | 16299 | RN550      | 6   |
| 80         | METALFILM 1/8W 1% 33.20      | CORNING   | 16299 | RN550      | 5   |
| 81         | METALFILM 1/8W 1% 46.40      | CORNING   | 16299 | RN550      | 6   |
| 82         | METALFILM 1/8W 1% 56.20      | CORNING   | 16299 | RN550      | 3   |
| 83         | METALFILM 1/8W 1% 82.50      | CORNING   | 16299 | RN550      | 2   |
| 84         | METALFILM 1/8W 1% 90.90      | CORNING   | 16299 | RN550      | 2   |
| 85         | METALFILM 1/8W 1% 1000       | CORNING   | 16299 | RN550      | 8   |
| 86         | METALFILM 1/8W 1% 1240       | CORNING   | 16299 | RN550      | 11  |
| 87         | METALFILM 1/8W 1% 1500       | CORNING   | 16299 | RN550      | 1   |
| 88         | METALFILM 1/8W 1% 1960       | CORNING   | 16299 | RN600      | 1   |
| 89         | METALFILM 1/8W 1% 1490       | CORNING   | 16299 | RN550      | 4   |
| 90         | METALFILM 1/8W 1% 2740       | CORNING   | 16299 | RN550      | 2   |
| 91         | METALFILM 1/8W 1% 1160       | CORNING   | 16299 | RN550      | 5   |
| 92         | METALFILM 1/8W 1% 1320       | CORNING   | 16299 | RN550      | 1   |
| 93         | METALFILM 1/8W 1% 1640       | CORNING   | 16299 | RN550      | 1   |

NOTE: UNLESS OTHERWISE SPECIFIED

|  |                    |  |                          |
|--|--------------------|--|--------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE: 7/20/64      | <b>WAVETEK</b> SAN DIEGO - CALIFORNIA                                      |                          |
| MATERIAL:                              | DESIGNER: BOCHICHO | TITLE: ASSEMBLY MAIN BOARD   |                          |
| FINISH: WAVETEK PROCESS                | RELEASE APPROV:    | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XXX - .010 ANGLES 1:1<br>XX - .020 |                          |
| SCALE:                                 | DO NOT SCALE DWG   | WORKING NO: 147  | TRNG NO: D147-023 REV: B |
|  |                    | 23338  | SHEET 2 OF 4             |

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| PARTS LIST |                         |           |       |         |     |
|------------|-------------------------|-----------|-------|---------|-----|
| LINE NO    | DESCRIPTION             | MFG#      | FSC#  | MFG P/N | QTY |
| 94         | CARBON 1W 5K 4700       | STACKPOLE | 29604 | RC32GF  | 1   |
| 95         | METALFILM 1/8W 1K 4990  | CORNING   | 16299 | RN55D   | 4   |
| 96         | METALFILM 1/8W 1K 5110  | CORNING   | 16299 | RN55D   | 4   |
| 97         | METALFILM 1/8W 1K 7500  | CORNING   | 16299 | RN55D   | 1   |
| 98         | METALFILM 1/8W 1K 8250  | CORNING   | 16299 | RN55D   | 2   |
| 99         | METALFILM 1/8W 1K 1K    | CORNING   | 16299 | RN55D   | 19  |
| 100        | METALFILM 1/8W 1K 1.1K  | CORNING   | 16299 | RN55D   | 3   |
| 101        | METALFILM 1/8W 1K 1.21K | CORNING   | 16299 | RN55D   | 4   |
| 102        | METALFILM 1/8W 1K 1.5K  | CORNING   | 16299 | RN55D   | 9   |
| 103        | METALFILM 1/8W 1K 1.62K | CORNING   | 16299 | RN55D   | 3   |
| 104        | METALFILM 1/8W 1K 1.78K | CORNING   | 16299 | RN55D   | 2   |
| 105        | METALFILM 1/8W 1K 2.21K | CORNING   | 16299 | RN55D   | 1   |
| 106        | METALFILM 1/8W 1K 2.37K | CORNING   | 16299 | RN55D   | 3   |
| 107        | METALFILM 1/8W 1K 2.49K | CORNING   | 16299 | RN55D   | 8   |
| 108        | METALFILM 1/8W 1K 3.32K | CORNING   | 16299 | RN55D   | 3   |
| 109        | METALFILM 1/8W 1K 3.65K | CORNING   | 16299 | RN55D   | 2   |
| 110        | METALFILM 1/8W 1K 3.92K | CORNING   | 16299 | RN55D   | 1   |
| 111        | METALFILM 1/8W 1K 4.32K | CORNING   | 16299 | RN55D   | 1   |
| 112        | METALFILM 1/8W 1K 4.75K | CORNING   | 16299 | RN55D   | 4   |
| 113        | METALFILM 1/8W 1K 4.99K | CORNING   | 16299 | RN55D   | 15  |
| 114        | METALFILM 1/8W 1K 6.19K | CORNING   | 16299 | RN55D   | 2   |
| 115        | METALFILM 1/8W 1K 7.5K  | CORNING   | 16299 | RN55D   | 2   |
| 116        | METALFILM 1/8W 1K 8.25K | CORNING   | 16299 | RN55D   | 2   |
| 117        | METALFILM 1/8W 1K 9.09K | CORNING   | 16299 | RN55D   | 2   |
| 118        | METALFILM 1/8W 1K 10K   | CORNING   | 16299 | RN55D   | 21  |
| 119        | METALFILM 1/8W 1K 12.1K | CORNING   | 16299 | RN55D   | 1   |
| 120        | METALFILM 1/8W 1K 15K   | CORNING   | 16299 | RN55D   | 2   |
| 121        | METALFILM 1/8W 1K 16.5K | CORNING   | 16299 | RN55D   | 1   |
| 122        | METALFILM 1/8W 1K 18.2K | CORNING   | 16299 | RN55D   | 3   |
| 123        | METALFILM 1/8W 1K 19.1K | CORNING   | 16299 | RN55D   | 2   |
| 124        | METALFILM 1/8W 1K 27.4K | CORNING   | 16299 | RN55D   | 1   |

| PARTS LIST |                         |             |       |               |      |
|------------|-------------------------|-------------|-------|---------------|------|
| LINE NO    | DESCRIPTION             | MFG#        | FSC#  | MFG P/N       | QTY  |
| 125        | METALFILM 1/8W 1K 69.8K | CORNING     | 16299 | RN55D         | 1    |
| 126        | METALFILM 1/8W 1K 100K  | CORNING     | 16299 | RN55D         | 1    |
| 127        | METALFILM 1/4W 1K 464K  | CORNING     | 16299 | RN60D         | 1    |
| 128        | METALFILM 1/4W 1K 1M    | CORNING     | 16299 | RN60D         | 2    |
| 129        | CARBON 1/2W 5K 4.7M     | STACKPOLE   | 29604 | RC20GF475K    | 1    |
| 130        | CARBON 1/2W 5K 6.8M     | STACKPOLE   | 29604 | RC20GF685K    | 2    |
| 131        | MATCHED SET 1M          | WAVETEK     | 23338 | 142-501-50    | 1SET |
| 132        | MATCHED SET 100K        |             |       |               | REF  |
| 133        | MATCHED SET 10K         |             |       |               | REF  |
| 134        | MATCHED SET 1K          |             |       |               | REF  |
| 135        |                         |             |       |               |      |
| 136        |                         |             |       |               |      |
| 137        | CONNECTOR               | MCLEX       |       | 09523101      | 5    |
| 138        | POTENTIOMETER 1000      | BECKMAN     | 80740 | 91AR100       | 2    |
| 139        | POTENTIOMETER 2000      | BECKMAN     | 80740 | 91AR200       | 1    |
| 140        | POTENTIOMETER 5000      | BECKMAN     | 80740 | 91AR500       | 8    |
| 141        | POTENTIOMETER 1K        | BECKMAN     | 80740 | 91AR1K        | 4    |
| 142        | POTENTIOMETER 2K        | BECKMAN     | 80740 | 91AR2K        | 5    |
| 143        | POTENTIOMETER 10K       | BECKMAN     | 80740 | 91AR10K       | 2    |
| 144        | POTENTIOMETER 100K      | BECKMAN     | 80740 | 91AR100K      | 4    |
| 145        | POTENTIOMETER 10K       | WAVETEK     | 23338 | 146-R1        | 2    |
| 146        | SINE MODULE             | WAVETEK     | 23338 | 142-011       | 1    |
| 147        | STANDOFFS (SWAGE)       | LYNTRON     |       | 6311-4-2-C    | 4    |
| 148        | CONNECTOR               | MCLEX       |       | 09-52-3101    | 5    |
| 149        | CONNECTOR (CARD EDGE)   | CINCH JONES | 71785 | 252-18-30-160 | 1    |
| 150        | SOCKET (14 PIN)         | CINCH JONES | 71785 | 14-D1P        | 15   |
| 151        | SOCKET (12 PIN)         | CINCH JONES | 71785 | CSA-2300-12   | 2    |
| 152        | SWITCH ASSY SW1         | WAVETEK     | 23338 | 0147-005      | 1    |
| 153        | SWITCH ASSY SW2         | WAVETEK     | 23338 | 0147-008      | 1    |
| 154        | SWITCH ASSY SW3         | WAVETEK     | 23338 | 0147-014      | 1    |
| 155        | SWITCH ASSY SW4         | WAVETEK     | 23338 | 0147-015      | 1    |

| PARTS LIST |                     |             |       |         |     |
|------------|---------------------|-------------|-------|---------|-----|
| LINE NO    | DESCRIPTION         | MFG#        | FSC#  | MFG P/N | QTY |
| 156        | SWITCH ASSY SWS-SW7 | WAVETEK     | 23338 | 132-401 | 1   |
| 157        | TRANSIPADS          | MILTON ROSS | 07047 | 10123N  | 16  |
| 158        | SWITCH BRACKET      | WAVETEK     | 23338 | 133-305 | 7   |
| 159        | TERMINALS           | USECO       | 88245 | 20108-1 | 2   |
| 160        | CIRCUIT BOARD       | WAVETEK     | 23338 | 147-123 | 1   |

NOTE UNLESS OTHERWISE SPECIFIED

|  |  |                                |
|--|--|--------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE<br>9/25/81  | WAVETEK SAN DIEGO - CALIFORNIA |
| MATERIAL                               | ENGINEER<br>S. J. WILSON   | TITLE<br>ASSEMBLY MAIN BOARD   |
| FINISH<br>WAVETEK PROCESS              | RELEASE APPROV   | DO NOT SCALE DWG               |
|  | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XXX - 010 ANGLES - 1<br>XX - 020 | MODEL NO<br>147                |
|  | SCALE  | DWG NO<br>0147-023             |
|  |  | REV<br>B                       |
|  |  | CODE<br>23338                  |
|  |  | SHEET 3 OF 4                   |

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LINE ITEM REFERENCE LIST

| Ref. Desig. | F/L Line | Ref. Desig. | F/L Line | Ref. Desig. | F/L Line |
|-------------|----------|-------------|----------|-------------|----------|
| C1          | 17       | C92         | 17       | Q1          | 62       |
| C2          | 17       | C93         | 21       | Q2          | 69       |
| C3          | 17       | C94         | 12       | Q3          | 65       |
| C4          | 17       | C95         | 21       | Q4          | 68       |
| C5          | 16       | C96         | 17       | Q5          | 67       |
| C6          | 10       | C97         | 17       | Q6          | 64       |
| C7          | 19       | C98         | 17       | Q7          | 66       |
| C8          | 19       | C99         | 17       | Q8          | 64       |
| C9          | 17       | C100        | 17       | Q9          | 62       |
| C10         | 16       | C101        | 17       | Q10         | 70       |
| C11         | 16       | C102        | 16       | Q11         | 70       |
| C12         | 12       | C103        | 16       | Q12         | 67       |
| C13         | 28       |             |          | Q13         | 59       |
| C14         | 16       |             |          | Q14         | 65       |
| C15         | 17       |             |          | Q15         | 65       |
| C16         | 17       |             |          | Q16         | 67       |
| C17         | 27       |             |          | Q17         | 68       |
| C18         | 2        | CR1         | 38       | Q18         | 67       |
| C19         |          | CR2         | 35       | Q19         | 69       |
| C20         | 23       | CR3         | 35       | Q20         | 65       |
| C21         | 23       | CR4         | 35       | Q21         | 57       |
| C22         | 16       | CR5         | 35       | Q22         | 67       |
| C23         | 24       | CR6         | 38       | Q23         | 57       |
| C24         | 25       | CR7         | 34       | Q24         | 57       |
| C25         | 26       | CR8         | 34       | Q25         | 67       |
| C26         | 27       | CR9         | 33       | Q26         | 57       |
| C27         | 13       | CR10        | 33       | Q27         | 67       |
| C28         | 6        | CR11        | 33       | Q28         | 60       |
| C29         | 16       | CP12        | 33       | Q29         | 60       |
| C30         | 4        | CP13        |          | Q30         | 67       |
| C31         | 16       | CP14        | 36       | Q31         | 67       |
| C32         | 16       | CR15        | 36       | Q32         | 65       |
| C33         | 7        | CR16        | 35       | Q33         | 67       |
| C34         | 15       | CR17        | 35       | Q34         | 67       |
| C35         | 9        | CR18        | 33       | Q35         | 65       |
| C36         | 9        | CR19        | 33       | Q36         | 65       |
| C37         | 15       | CR20        | 33       | Q37         | 67       |
| C38         | 7        | CR21        | 33       | Q38         | 63       |
| C39         | 17       | CR22        | 37       | Q39         | 63       |
| C40         | 11       | CR23        | 37       | Q40         | 63       |
| C41         | 11       | CR24        | 35       | Q41         | 63       |
| C42         | 16       | CR25        | 35       | Q42         | 63       |
| C43         | 16       | CR26        | 38       | Q43         | 63       |
| C44         | 17       | CR27        | 35       | Q44         | 63       |
| C45         | 17       | CR28        | 35       | Q45         | 61       |
| C46         | 8        | CR29        | 35       | Q46         | 61       |
| C47         | 8        | CR30        | 35       | Q47         | 61       |
| C48         | 9        | CR31        | 35       | Q48         | 61       |
| C49         | 4        | CR32        | 35       | Q49         | 61       |
| C50         | 16       | CR33        | 35       | Q50         | 61       |
| C51         | 16       | CR34        | 35       | Q51         | 61       |
| C52         | 17       | CR35        | 35       | Q52         | 61       |
| C53         | 27       | CR36        | 35       | Q53         | 63       |
| C54         | 5        | CR37        | 35       | Q54         | 63       |
| C55         | 17       | CR38        | 35       | Q55         | 63       |
| C56         | 3        | CR39        | 35       | Q56         | 61       |
| C57         | 16       | CR40        | 35       | Q57         | 65       |
| C58         | 16       | CR41        | 35       | Q58         | 64       |
| C59         | 16       | IC1         | 51       | Q59         | 62       |
| C60         | 16       | IC2         | 52       | Q60         | 65       |
| C61         | 17       | IC3         | 52       | Q61         | 65       |
| C62         | 14       | IC4         | 39       | Q62         | 58       |
| C63         | 14       | IC5         | 46       | Q63         | 58       |
| C64         | 14       | IC6         | 51       |             |          |
| C65         | 14       | IC7         | 52       |             |          |
| C66         | 20       | IC8         | 48       |             |          |
| C67         | 22       | IC9         | 46       |             |          |
| C68         | 28       | IC10        | 47       |             |          |
| C69         | 16       | IC11        | 52       |             |          |
| C70         | 20       | IC12        | 47       |             |          |
| C71         |          | IC13        | 51       |             |          |
| C72         | 20       | IC14        |          |             |          |
| C73         | 6        | IC15        |          |             |          |
| C74         |          | IC16        |          |             |          |
| C75         |          | IC17        | 43       | R1          |          |
| C76         | 20       | IC18        | 42       | R2          |          |
| C77         |          | IC19        | 43       | R3          |          |
| C78         | 16       | IC20        | 43       | P4          | 142      |
| C79         | 17       | IC21        | 43       | R5          | 142      |
| C80         | 17       | IC22        | 43       | R6          | 142      |
| C81         | 17       | IC23        | 43       | R7          | 142      |
| C82         | 17       | IC24        | 43       | R8          | 121      |
| C83         | 17       | IC25        | 43       | R9          | 144      |
| C84         | 9        | IC26        | 43       | R10         | 144      |
| C85         | 18       | IC27        | 43       | R11         | 127      |
| C86         | 20       | IC28        | 43       | R12         | 128      |
| C87         | 28       | IC29        | 44       | R13         | 113      |
| C88         | 14       | IC30        | 45       | R14         | 125      |
| C89         | 17       | IC31        | 50       | R15         | 112      |
| C90         | 17       | IC32        | 47       | R16         | 112      |
| C91         | 4        | IC33        | 49       | R17         | 113      |
|             |          |             |          | R18         | 97       |
|             |          |             |          | R19         | 124      |

LINE ITEM REFERENCE LIST

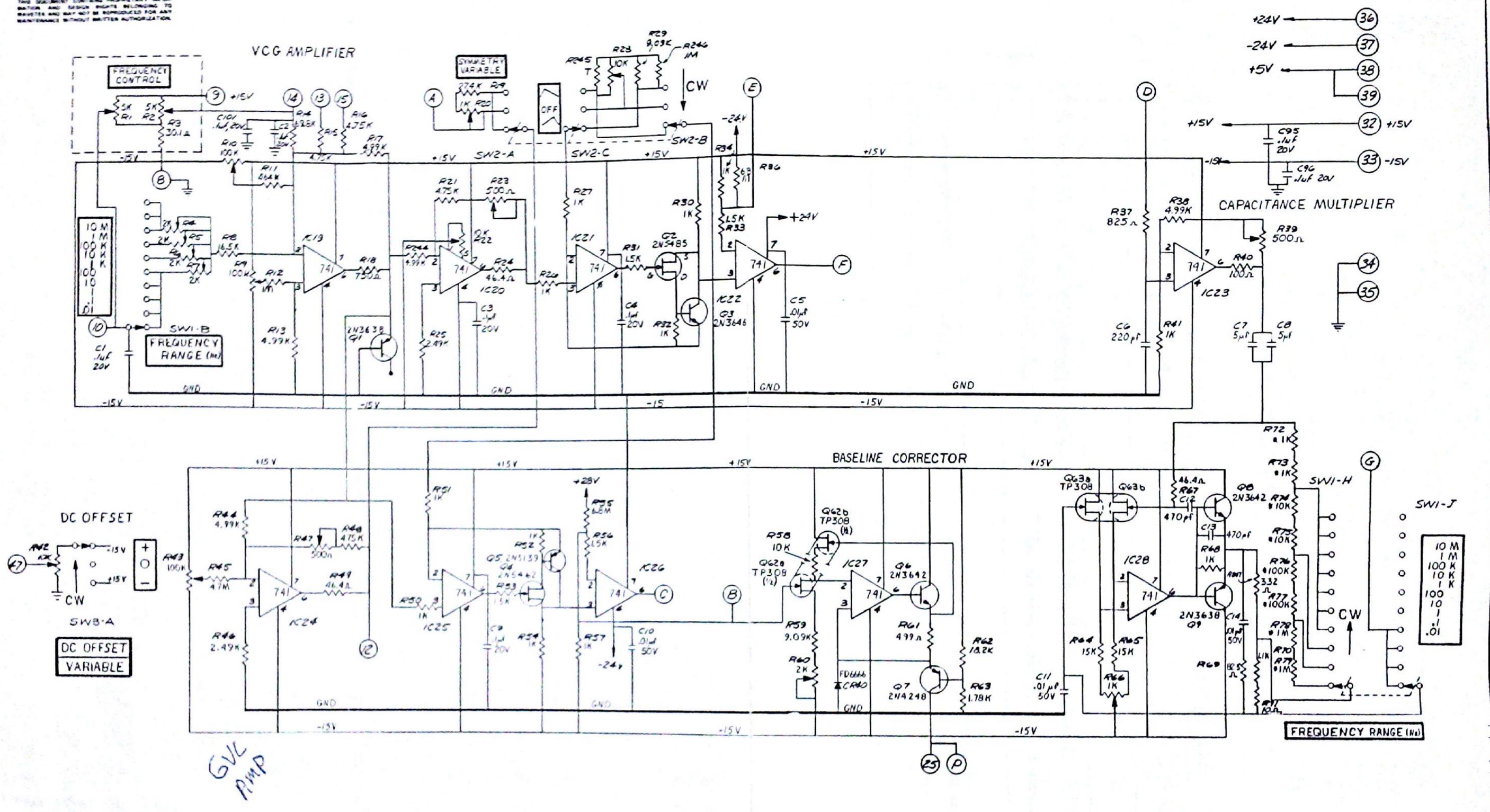
| Ref. Desig. | F/L Line | Ref. Desig. | F/L Line | Ref. Desig. | F/L Line |
|-------------|----------|-------------|----------|-------------|----------|
| R20         | 141      | R111        | 102      | R202        | 86       |
| R21         | 112      | R112        | 99       | R203        | 86       |
| R22         | 143      | R113        | 102      | R204        | 99       |
| R23         | 140      | R114        | 85       | R205        | 99       |
| R24         | 81       | R115        | 85       | R206        | 99       |
| R25         | 107      | R116        | 99       | R207        | 113      |
| R26         | 99       | R117        | 84       | R208        | 113      |
| R27         | 99       | R118        | 89       | R209        | 113      |
| R28         | 145      | R119        | 85       | R210        | 86       |
| R29         | 117      | R120        | 89       | R211        | 86       |
| R30         | 99       | R121        | 100      | R212        | 113      |
| R31         | 102      | R122        | 95       | R213        | 94       |
| R32         | 99       | R123        | 106      | R214        | 113      |
| R33         | 102      | R124        | 89       | R215        | 107      |
| R34         | 99       | R125        | 100      | R216        | 86       |
| R35         |          | R126        | 96       | R217        | 118      |
| R36         | 130      | R127        | 96       | R218        | 118      |
| R37         | 98       | R128        | 111      | R219        | 118      |
| R38         | 113      | R129        | 101      | R220        | 113      |
| R39         | 140      | R130        | 90       | R221        | 118      |
| R40         | 85       | R131        | 88       | R222        | 118      |
| R41         | 99       | R132        | 84       | R223        | 118      |
| R42         | 145      | R133        | 85       | R224        | 118      |
| R43         | 144      | R134        | 89       | R225        | 118      |
| R44         | 113      | R135        | 107      | R226        | 118      |
| R45         | 129      | R136        | 103      | R227        | 105      |
| R46         | 107      | R137        | 107      | R228        | 118      |
| R47         | 140      | R138        | 83       | R229        | 118      |
| R48         | 112      | R139        | 140      | R230        | 113      |
| R49         | 81       | R140        | 143      | R231        | 118      |
| R50         | 99       | R141        | 126      | R232        | 123      |
| R51         | 99       | R142        | 80       | R233        | 123      |
| R52         | 99       | R143        | 140      | R234        | 119      |
| R53         | 102      | R144        | 87       | R235        | 140      |
| R54         | 99       | R145        | 1        | R236        | 81       |
| R55         | 130      | R146        | 82       | R237        | 113      |
| R56         | 102      | R147        | 80       | R238        | 118      |
| R57         | 99       | R148        | 98       | R239        | 108      |
| R58         | 118      | R149        | 138      | R240        | 108      |
| R59         | 117      | R150        | 96       | R241        | 113      |
| R60         | 142      | R151        | 96       | R242        | 118      |
| R61         | 95       | R152        | 82       | R243        | 76       |
| R62         | 122      | R153        | 82       | R244        | 113      |
| R63         | 104      | R154        | 80       | R245        |          |
| R64         | 120      | R155        | 93       | R246        | 128      |
| R65         | 120      | R156        | 90       | R247        | 92       |
| R66         | 141      | R157        | 81       | R248        | 92       |
| R67         | 81       | R158        | 81       | R249        | 102      |
| R68         | 99       | R159        | 106      |             |          |
| R69         | 83       | R160        | 80       |             |          |
| R70         | 100      | R161        | 108      |             |          |
| R71         | 78       | R162        | 78       |             |          |
| R72         | 134      | R163        | 78       |             |          |
| R73         | 134      | R164        | 106      |             |          |
| R74         | 133      | R165        | 80       |             |          |
| R75         | 133      | R166        | 79       |             |          |
| R76         | 132      | R167        | 138      |             |          |
| R77         | 132      | R168        | 95       |             |          |
| R78         | 131      | R169        | 85       |             |          |
| R79         | 131      | R170        | 104      |             |          |
| R80         | 79       | R171        | 113      |             |          |
| R81         | 101      | R172        | 99       |             |          |
| R82         | 85       | R173        | 95       |             |          |
| R83         | 99       | R174        | 99       |             |          |
| R84         | 119      | R175        | 141      |             |          |
| R85         | 85       | R176        | 107      |             |          |
| R86         | 110      | R177        | 116      |             |          |
| R87         | 77       | R178        | 102      |             |          |
| R88         | 77       | R179        | 122      |             |          |
| R89         | 140      | R180        | 77       |             |          |
| R90         | 109      | R181        | 77       |             |          |
| R91         | 79       | R182        | 91       |             |          |
| R92         | 118      | R183        | 107      |             |          |
| R93         | 115      | R184        | 141      |             |          |
| R94         | 91       | R185        | 116      |             |          |
| R95         | 91       | R186        | 102      |             |          |
| R96         | 115      | R187        | 122      |             |          |
| R97         | 118      | R188        | 78       |             |          |
| R98         | 79       | R189        | 92       |             |          |
| R99         | 109      | R190        | 107      |             |          |
| R100        | 140      | R191        | 144      |             |          |
| R101        | 91       | R192        | 118      |             |          |
| R102        | 91       | R193        | 118      |             |          |
| R103        | 101      | R194        | 118      |             |          |
| R104        | 114      | R195        | 118      |             |          |
| R105        | 103      | R196        | 86       |             |          |
| R106        | 79       | R197        | 76       |             |          |
| R107        | 114      | R198        | 86       |             |          |
| R108        | 101      | R199        | 86       |             |          |
| R109        | 79       | R200        | 86       |             |          |
| R110        | 103      | R201        | 86       |             |          |

NOTE: UNLESS OTHERWISE SPECIFIED

|  |                   |  |                                |
|--|-------------------|--|--------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DRAWN<br>ROCKWELL | DATE<br>1/18/83  | WAVETEK SAN DIEGO - CALIFORNIA |
| MATERIAL                               | PROJENGR          | TITLE<br>ASSEMBLY MAIN BOARD   |                                |
| FINISH<br>WAVETER PROCESS              | RELEASE APPROV    | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XXX - 0.10 ANGLES - 1<br>XX - 0.20 | SCALE<br>DO NOT SCALE DWG      |
|  | MODEL NO<br>147   | DWG NO<br>D147-023   | SHEET 4 OF 2                   |
|  | 23338             |  |                                |

| REV | ECN     | BY | DATE | APP |
|-----|---------|----|------|-----|
| A   | ECN 764 |    | 7/76 |     |

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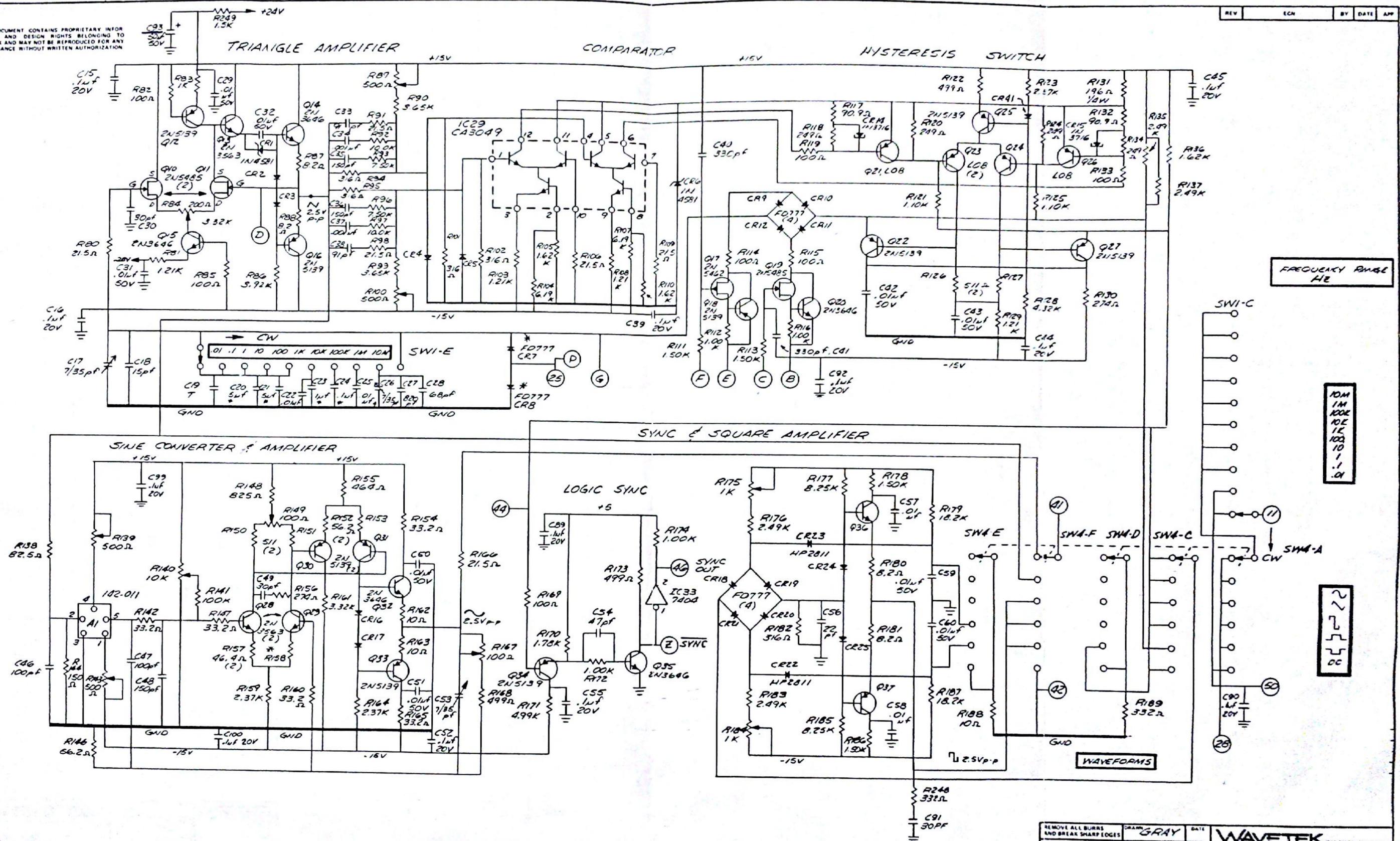
NOTE: UNLESS OTHERWISE SPECIFIED

LAST DESIGNATOR USED  
 R250  
 C102  
 Q63  
 CR39  
 IC53

|  |                             |   |                                       |
|--|-----------------------------|---|---------------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DRAWN<br>COSHOW             | DATE<br>5/30/73   | <b>WAVETEK</b> SAN DIEGO • CALIFORNIA |
| MATERIAL                               | PROFESSOR                   | TITLE<br>SCHEMATIC MAIN BOARD                               |                                       |
| FINISH<br>WAVETEK PROCESS              | RELEASE APPROVAL<br>7/16/73 | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>RES ± 1% ANGLES 45° | MODEL NO.<br>147                      |
| SCALE                                  | DO NOT SCALE DWG            | DO NOT SCALE DWG  | DWG NO.<br>D147-223                   |
|  |                             |   | REV.<br>A                             |
|  |                             |   | LOG#<br>23338                         |
|  |                             |   | SHEET 1 OF 4                          |

|     |     |    |      |     |
|-----|-----|----|------|-----|
| REV | ECN | BY | DATE | APP |
|-----|-----|----|------|-----|

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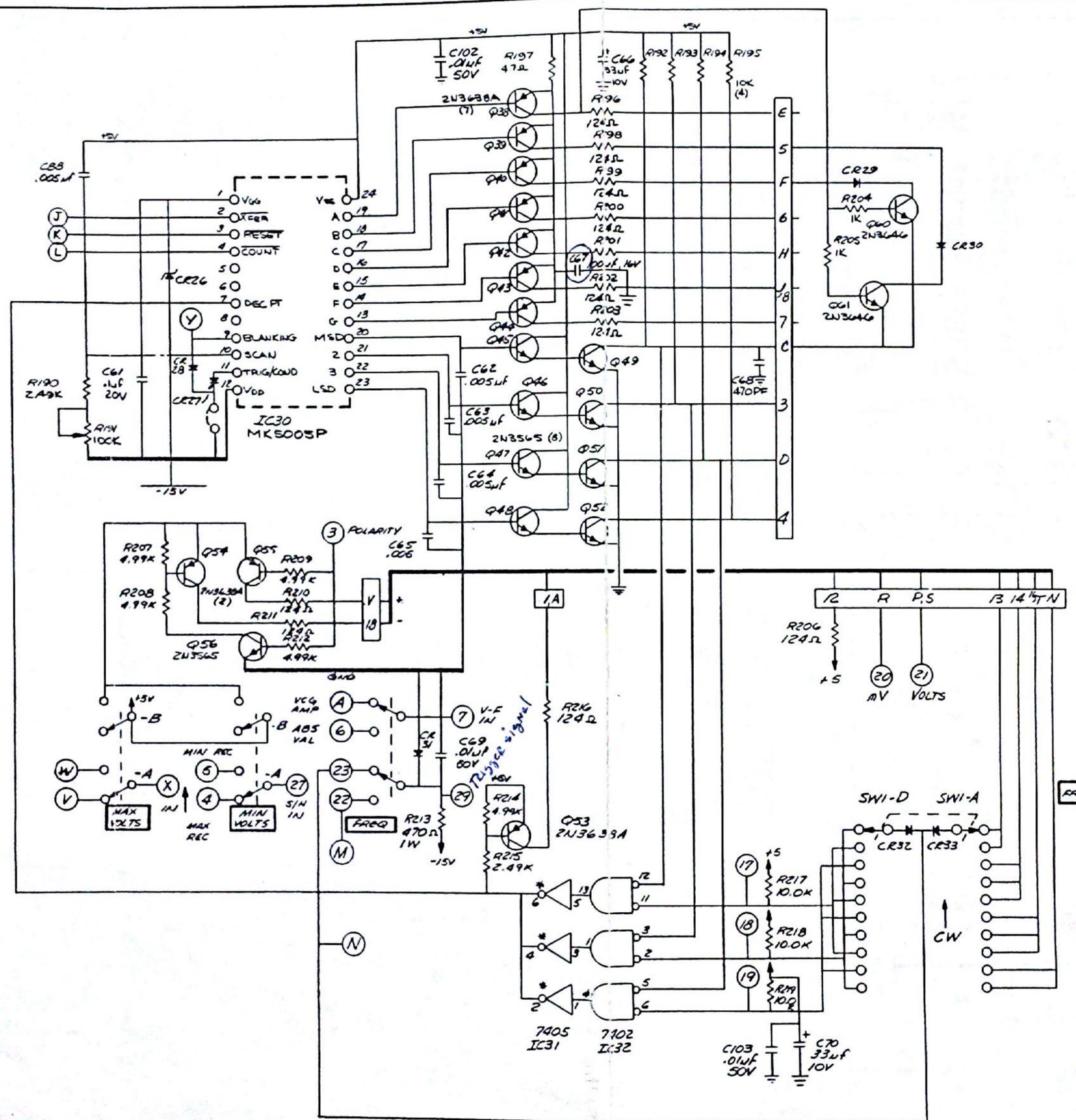
DC  
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WAVEFORMS

NOTE UNLESS OTHERWISE SPECIFIED

|  |                 |                     |
|--|-----------------|---------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE            | WAVETEK             |
| MATERIAL                               | DESIGNER        | TITLE               |
| FINISH                                 | WAVETEK PROCESS | SCHMATIC MAIN BOARD |
| SCALE                                  | MODEL NO        | 147                 |
|  | REV NO          | 047-223             |
|  | REV             | A                   |
|  | DATE            | 23338               |
|  | SHEET           | 2 of 4              |

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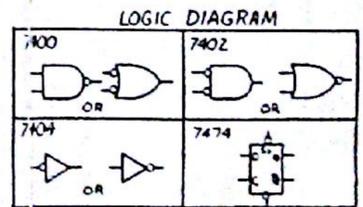
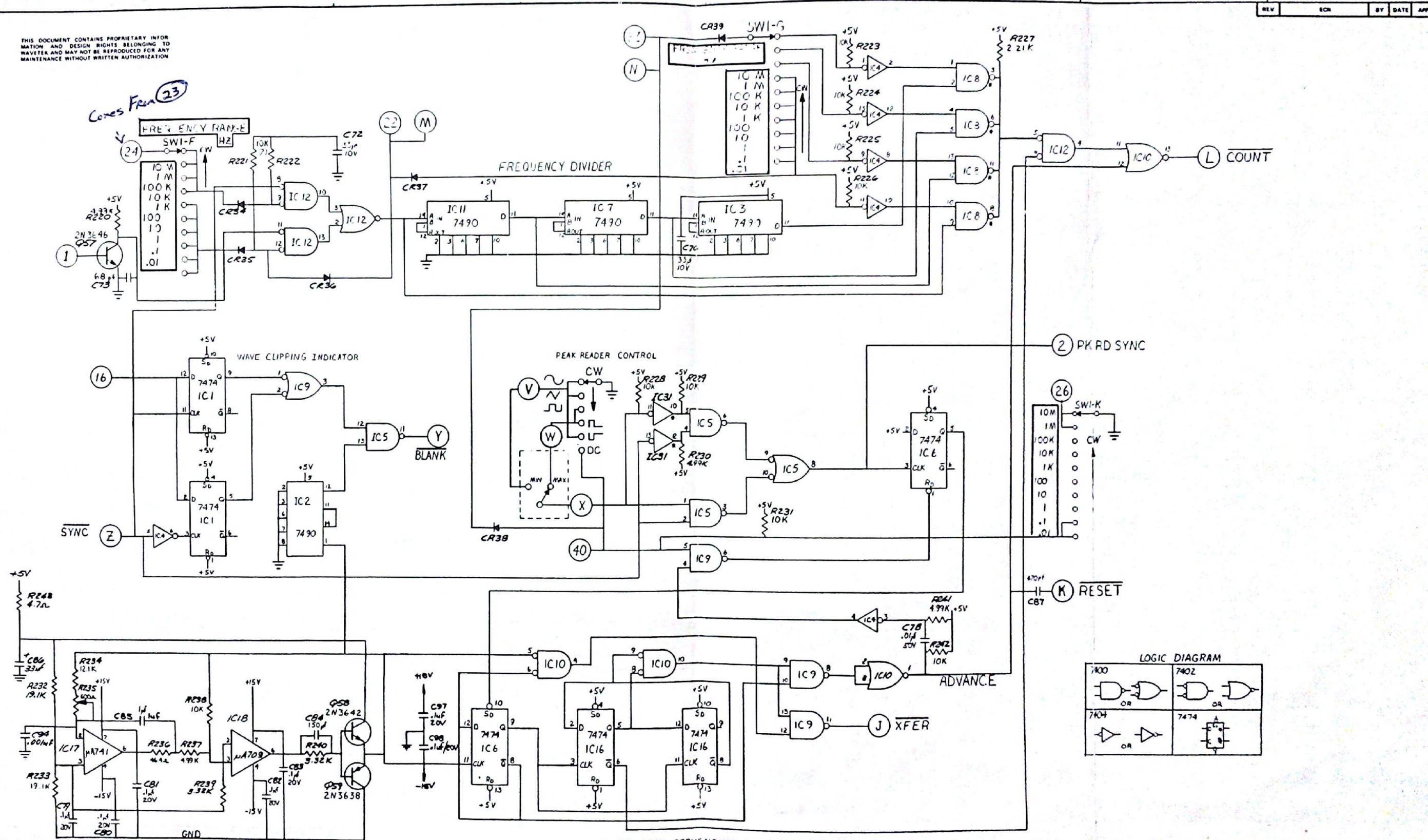
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NOTE: UNLESS OTHERWISE SPECIFIED

|  |  |                                |                         |
|--|--|--------------------------------|-------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE   | WAVETEK SAN DIEGO - CALIFORNIA |                         |
| MATERIAL                               | PROJ. NO.  | TITLE                          |                         |
|  | RELEASE APPROV. <i>[Signature]</i>                           | SCHEMATIC MAIN BOARD           |                         |
| FINISH WAVETEK PROCESS                 | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XX ± 0.10 ANGLES 11° | MODEL NO.                      | DWG NO. <b>D147-223</b> |
|  | DO NOT SCALE DWG   | SCALE                          | REV <b>A</b>            |
|  |  | COGN. ONLY 23338               | SHEET 3 OF 4            |

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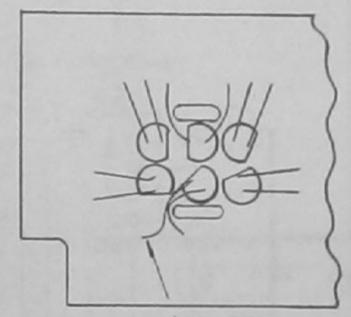
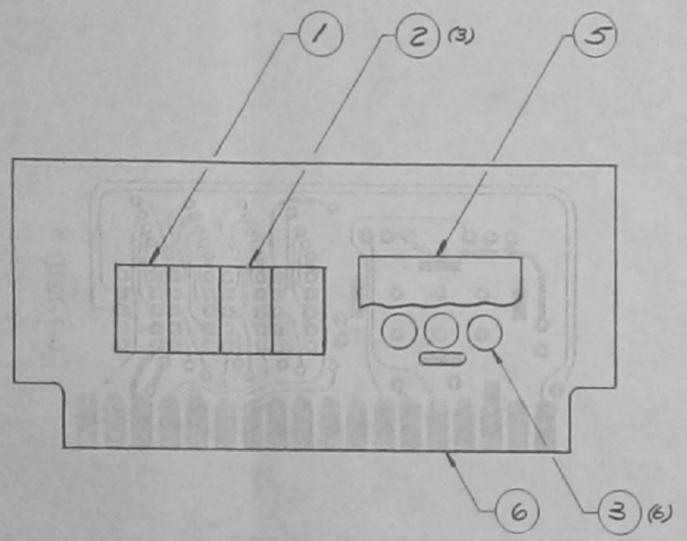


1. ALL DIODES ARE FD666 UNLESS OTHERWISE SPECIFIED

NOTE UNLESS OTHERWISE SPECIFIED

|  |                   |   |                                       |
|--|-------------------|---|---------------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DESIGNER COSHOW   | DATE 10-73  | <b>WAVETEK</b> SAN DIEGO • CALIFORNIA |
| MATERIAL                               | REV. ENG          |   |                                       |
| FINISH WAVETEK PROCESS                 | REL. ENG. 10-73   | TOLERANCES UNLESS OTHERWISE SPECIFIED: XXX ± .01 ANGLES 45° EX. ± .02 | TITLE SCHEMATIC MAIN BOARD            |
| SCALE                                  | DO NOT SCALE DIMS | INCHES 147  | REV. NO. D147-223                     |
|  |                   | DATE 23338  | SHEET 4 OF 4                          |

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PARTS LIST

| ITEM | DESCRIPTION   | MEGR      | FSCM  | MFGR P/N | QTY |
|------|---------------|-----------|-------|----------|-----|
| 1    | READOUT +/-   | FAIRCHILD | 33888 | FND-71   | 1   |
| 2    | DIGIT         | FAIRCHILD | 33888 | FND-70   | 3   |
| 3    | LED           | OPCOA     |       | OSL-6L-1 | 6   |
| 4    |               |           |       |          |     |
| 5    | DISPLAY CAP   | WAVETEK   | 23338 | B147-507 | 1   |
| 6    | CIRCUIT BOARD | WAVETEK   | 23338 | 147-121  | 1   |
| 7    |               |           |       |          |     |
| 8    |               |           |       |          |     |

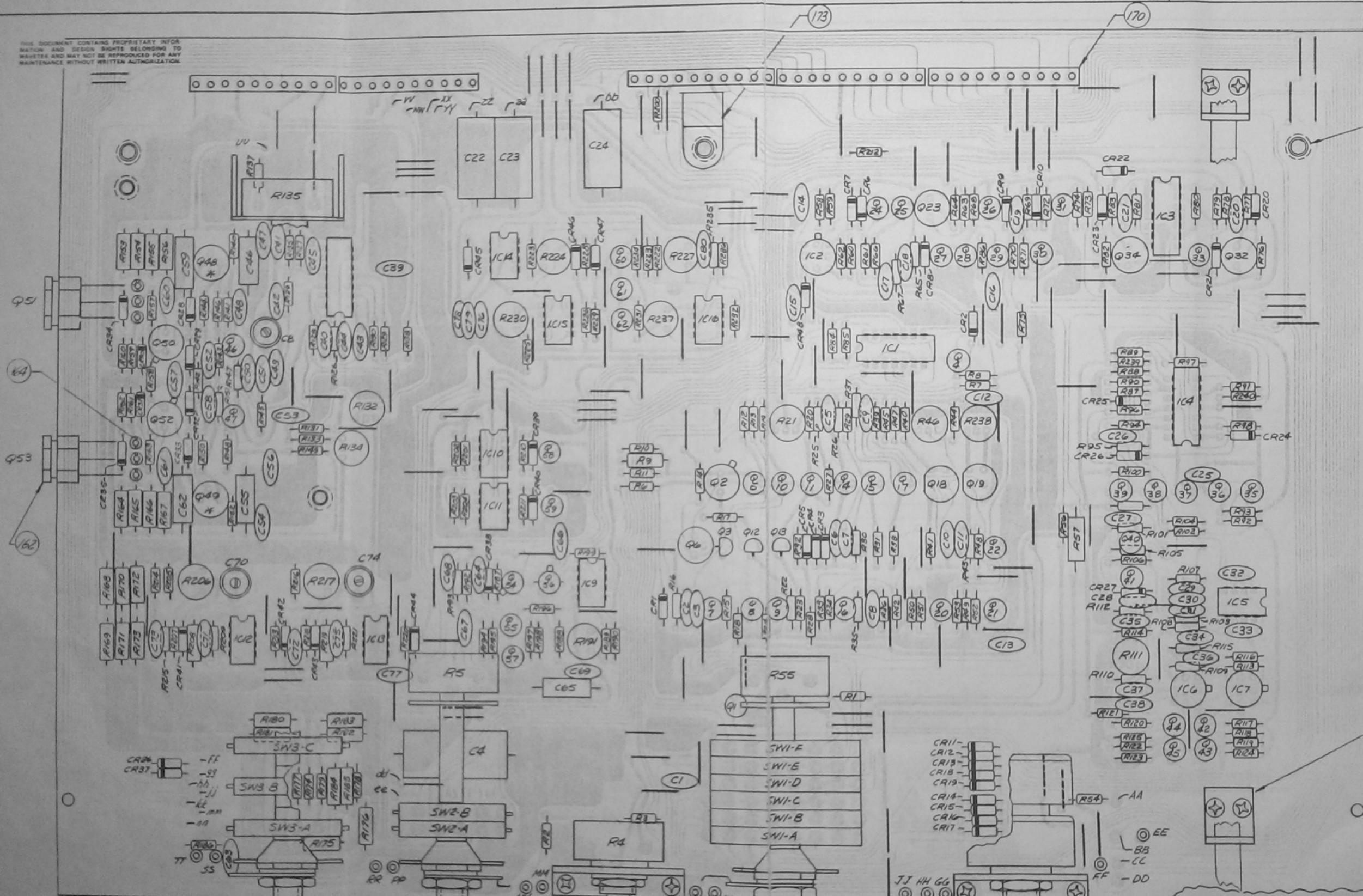
NOTE: UNLESS OTHERWISE SPECIFIED

|  |                         |  |   |                     |
|--|-------------------------|--|---|---------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DRAWN<br>WAVES          | DATE<br>8-28-73  | <b>WAVETEK</b> SAN DIEGO • CALIFORNIA   |                     |
| MATERIAL                               | PROJ ENGR               |  |   |                     |
| FINISH<br>WAVETEK PROCESS              | RELEASE AUTH<br>9-28-73 | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XXX ± .010 ANGLES 1:1<br>XX ± .030 | TITLE<br><b>ASSEMBLY<br/>READOUT BD</b> |                     |
|  | DO NOT SCALE DWG        | SCALE  | MODEL NO.<br>147                        | DWG NO.<br>D147-021 |
|  |                         |  | CODE<br>(IDENT)                         | 23338               |
|  |                         |  | SHEET                                   | 1 OF 1              |



| REV | ECN | BY | DATE   | APP |
|-----|-----|----|--------|-----|
| C   | 764 | Bo | 7/4/78 |     |

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1- INSTALL HEAT-SINK ITEM 163

NOTE: UNLESS OTHERWISE SPECIFIED

|  |  |  |                                 |                                       |
|--|--|--|---------------------------------|---------------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES |  | DRAWN: <i>Bochichio</i>  | DATE: 8/1/78                    | <b>WAVETEK</b> SAN DIEGO - CALIFORNIA |
| MATERIAL:                              |  | PROJ. ENGR.  | TITLE: <b>ASSEMBLY SWEEP BD</b> |                                       |
| FINISH: WAVETEK PROCESS                |  | RELEASE APPROV: <i>[Signature]</i>                                     | DATE: 9/18/78                   | MODEL NO: <b>147</b>                  |
| DO NOT SCALE DWG                       |  | TOLERANCES UNLESS OTHERWISE SPECIFIED: XXX ± 0.10 ANGLES 1:1 XX ± 0.30 |                                 | DWG NO: <b>DI47-022 C</b>             |
| SCALE:                                 |  | CODE: 23338  |                                 | SHEET 1 OF 4                          |

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LINE ITEM REFERENCE LIST

| Ref. Desig. | F/L Line | Ref. Desig. | F/L Line | Ref. Desig. | F/L Line |
|-------------|----------|-------------|----------|-------------|----------|
| C1          | 14       | C46         | 20       | CR1         | 31       |
| C2          | 4        | C47         | 15       | CR2         | 30       |
| C3          | 4        | C48         | 15       | CR3         | 31       |
| C4          | 19       | C49         | 15       | CR4         | 30       |
| C5          | 9        | C50         | 10       | CR5         | 30       |
| C6          | 15       | C51         | 13       | CR6         | 30       |
| C7          | 15       | C52         | 17       | CR7         | 30       |
| C8          | 18       | C53         | 15       | CR8         | 30       |
| C9          | 9        | C54         | 15       | CR9         | 30       |
| C10         | 10       | C55         | 20       | CR10        | 30       |
| C11         | 6        | C56         | 15       | CR11        | 30       |
| C12         | 18       | C57         | 15       | CR12        | 30       |
| C13         | 18       | C58         | 17       | CR13        | 30       |
| C14         | 18       | C59         | 20       | CR14        | 30       |
| C15         | 18       | C60         | 15       | CR15        | 30       |
| C16         | 18       | C61         | 15       | CR16        | 30       |
| C17         | 15       | C62         | 20       | CR17        | 30       |
| C18         | 11       | C63         | 7        | CR18        | 30       |
| C19         | 8        | C64         | 12       | CR19        | 30       |
| C20         | 11       | C65         | 16       | CR20        | 30       |
| C21         | 11       | C66         | 18       | CR21        | 30       |
| C22         | 21       | C67         | 18       | CR22        | 28       |
| C23         | 21       | C68         | 3        | CR23        | 28       |
| C24         | 21       | C69         | 18       | CR24        | 31       |
| C25         | 11       | C70         | 24       | CR25        | 31       |
| C26         | 18       | C71         | 2        | CR26        | 31       |
| C27         | 13       | C72         | 15       | CR27        | 30       |
| C28         | 13       | C73         | 18       | CR28        | 30       |
| C29         | 18       | C74         | 24       | CR29        | 30       |
| C30         | 18       | C75         | 2        | CR30        | 30       |
| C31         | 18       | C76         | 18       | CR31        | 30       |
| C32         | 7        | C77         | 15       | CR32        | 30       |
| C33         | 4        | C78         | 18       | CR33        | 30       |
| C34         | 5        | C79         | 18       | CR34        | 30       |
| C35         | 18       | C80         | 15       | CR35        | 30       |
| C36         | 18       | C81         | 24       | CR36        | 30       |
| C37         | 18       |             |          | CR37        | 30       |
| C38         | 18       |             |          | CR38        | 30       |
| C39         | 18       |             |          | CR39        | 30       |
| C40         | 18       |             |          | CR40        | 30       |
| C41         | 12       |             |          | CR41        | 29       |
| C42         | 12       |             |          | CR42        | 29       |
| C43         | 12       |             |          | CR43        | 29       |
| C44         | 18       |             |          | CR44        | 29       |
| C45         | 12       |             |          | CR45        | 30       |

LINE ITEM REFERENCE LIST

| Ref. Desig. | F/L Line | Ref. Desig. | F/L Line | Ref. Desig. | F/L Line |
|-------------|----------|-------------|----------|-------------|----------|
| CR46        | 30       | Q13         | 56       | Q58         | 53       |
| CR47        | 30       | Q14         | 53       | Q59         | 53       |
| CR48        | 31       | Q15         | 57       | Q60         | 53       |
|             |          | Q16         | 51       | Q61         | 51       |
|             |          | Q17         | 53       | Q62         | 53       |
|             |          | Q18         | 59       |             |          |
|             |          | Q19         | 59       |             |          |
|             |          | Q20         | 53       |             |          |
|             |          | Q21         | 53       |             |          |
|             |          | Q22         | 53       |             |          |
| IC1         | 36       | Q23         | 50       | R1          | 96       |
| IC2         | 37       | Q24         | 51       | R2          | 85       |
| IC3         | 39       | Q25         | 51       | R3          | 85       |
| IC4         | 40       | Q26         | 53       | R4          | 149      |
| IC5         | 35       | Q27         | 53       | R5          | 144      |
| IC6         | 41       | Q28         | 53       | R6          | 87       |
| IC7         | 41       | Q29         | 53       | R7          | 109      |
| IC8         | 38       | Q30         | 53       | R8          | 109      |
| IC9         | 34       | Q31         | 53       | R9          | 130      |
| IC10        | 34       | Q32         | 50       | R10         | 126      |
| IC11        | 34       | Q33         | 53       | R11         | 112      |
| IC12        | 34       | Q34         | 50       | R12         | 119      |
| IC13        | 34       | Q35         | 51       | R13         | 126      |
| IC14        | 34       | Q36         | 51       | R14         | 91       |
| IC15        | 34       | Q37         | 51       | R15         | 76       |
| IC16        | 34       | Q38         | 53       | R16         | 68       |
|             |          | Q39         | 53       | R17         | 94       |
|             |          | Q40         | 54       | R18         | 92       |
|             |          | Q41         | 54       | R19         | 84       |
|             |          | Q42         | 54       | R20         | 84       |
|             |          | Q43         | 54       | R21         | 135      |
|             |          | Q44         | 53       | R22         | 81       |
|             |          | Q45         | 53       | R23         | 81       |
| Q1          | 53       | Q46         | 49       | R24         | 101      |
| Q2          | 47       | Q47         | 51       | R25         | 66       |
| Q3          | 55       | Q48         | 48       | R26         | 76       |
| Q4          | 53       | Q49         | 46       | R27         | 76       |
| Q5          | 51       | Q50         | 46       | R28         | 106      |
| Q6          | 52       | Q51         | 57       | R29         | 76       |
| Q7          | 53       | Q52         | 48       | R30         | 94       |
| Q8          | 53       | Q53         | 58       | R31         | 66       |
| Q9          | 53       | Q54         | 61       | R32         | 94       |
| Q10         | 51       | Q55         | 54       | R33         | 66       |
| Q11         | 51       | Q56         | 60       | R34         | 94       |
| Q12         | 56       | Q57         | 53       | R35         | 76       |
|             |          |             |          | R36         | 104      |

LINE ITEM REFERENCE LIST

| Ref. Desig. | F/L Line | Ref. Desig. | F/L Line | Ref. Desig. | F/L Line |
|-------------|----------|-------------|----------|-------------|----------|
| R37         | 108      | R83         | 116      | R128        | 104      |
| R38         | 119      | R84         | 109      | R129        | 100      |
| R39         | 110      | R85         | 109      | R130        | 100      |
| R40         | 104      | R86         | 109      | R131        | 125      |
| R41         | 94       | R87         | 99       | R132        | 140      |
| R42         | 81       | R88         | 99       | R133        | 104      |
| R43         | 94       | R89         | 120      | R134        | 138      |
| R44         | 113      | R90         | 90       | R135        | 148      |
| R45         | 106      | R91         | 102      | R136        | 90       |
| R46         | 135      | R92         | 99       | R137        | 76       |
| R47         | 98       | R93         | 99       | R138        | 109      |
| R48         | 94       | R94         | 116      | R139        | 86       |
| R49         | 94       | R95         | 109      | R140        | 76       |
| R50         | 94       | R96         | 94       | R141        | 103      |
| R51         | 119      | R97         | 94       | R142        | 116      |
| R52         | 119      | R98         | 104      | R143        | 101      |
| R53         | 100      | R99         | 113      | R144        | 66       |
| R54         | 69       | R100        | 108      | R145        | 76       |
| R55         | 143      | R101        | 94       | R146        | 82       |
| R56         | 116      | R102        | 94       | R147        | 123      |
| R57         | 117      | R103        | 111      | R148        | 103      |
| R58         | 93       | R104        | 118      | R149        | 76       |
| R59         | 93       | R105        | 79       | R150        | 66       |
| R60         | 107      | R106        | 106      | R151        | 103      |
| R61         | 93       | R107        | 95       | R152        | 82       |
| R62         | 76       | R108        | 99       | R153        | 71       |
| R63         | 96       | R109        | 88       | R154        | 71       |
| R64         | 76       | R110        | 97       | R155        | 71       |
| R65         | 124      | R111        | 137      | R156        | 71       |
| R66         | 93       | R112        | 99       | R157        | 72       |
| R67         | 101      | R113        | 88       | R158        | 89       |
| R68         | 100      | R114        | 116      | R159        | 66       |
| R69         | 116      | R115        | 99       | R160        | 67       |
| R70         | 116      | R116        | 116      | R161        | 66       |
| R71         | 129      | R117        | 128      | R162        | 67       |
| R72         | 96       | R118        | 108      | R163        | 72       |
| R73         | 116      | R119        | 108      | R164        | 71       |
| R74         | 116      | R120        | 75       | R165        | 71       |
| R75         | 116      | R121        | 111      | R166        | 71       |
| R76         | 119      | R122        | 75       | R167        | 71       |
| R77         | 110      | R123        | 94       | R168        | 74       |
| R78         | 100      | R124        | 118      | R169        | 74       |
| R79         | 96       | R125        | 94       | R170        | 74       |
| R80         | 96       | R126        | 96       | R171        | 74       |
| R81         | 105      | R127        | 96       | R172        | 74       |
| R82         | 119      |             |          |             |          |

LINE ITEM REFERENCE LIST

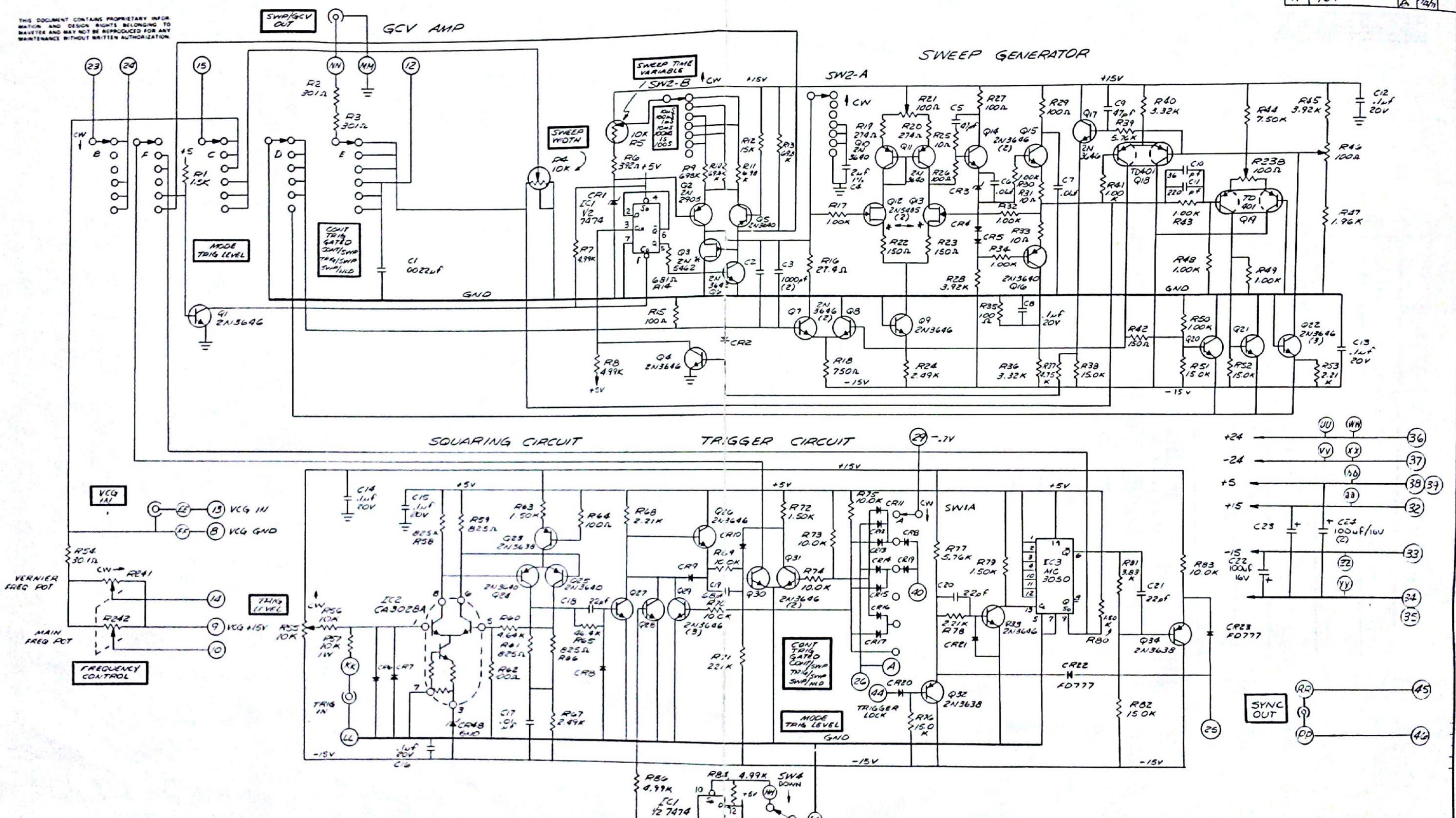
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|-------------|----------|-------------|----------|-------------|----------|
| R173        | 74       | R218        | 94       |             |          |
| R174        | 71       | R219        | 131      |             |          |
| R175        | 71       | R220        | 70       |             |          |
| R176        | 71       | R221        | 128      |             |          |
| R177        | 85       | R222        | 115      |             |          |
| R178        | 172      | R223        | 116      |             |          |
| R179        | 101      | R224        | 137      |             |          |
| R180        | 76       | R225        | 102      |             |          |
| R181        | 80       | R226        | 110      |             |          |
| R182        | 77       | R227        | 138      |             |          |
| R183        | 77       | R228        | 109      |             |          |
| R184        | 77       | R229        | 94       |             |          |
| R185        | 77       | R230        | 139      |             |          |
| R186        | 67       | R231        | 109      |             |          |
| R187        | 127      | R232        | 95       |             |          |
| R188        | 64       | R233        | 101      |             |          |
| R189        | 123      | R234        | 116      |             |          |
| R190        | 121      | R235        | 109      |             |          |
| R191        | 135      | R236        | 94       |             |          |
| R192        | 94       | R237        | 139      |             |          |
| R193        | 115      | R238        | 135      |             |          |
| R194        | 115      | R239        | 106      |             |          |
| R195        | 115      | R240        | 106      |             |          |
| R196        | 116      | R241        | 150      |             |          |
| R197        | 94       | R242        | 150      |             |          |
| R198        | 115      |             |          |             |          |
| R199        | 76       |             |          |             |          |
| R200        | 76       |             |          |             |          |
| R201        | 113      |             |          |             |          |
| R202        | 114      |             |          |             |          |
| R203        | 114      |             |          |             |          |
| R204        | 114      |             |          |             |          |
| R205        | 94       |             |          |             |          |
| R206        | 133      |             |          |             |          |
| R207        | 94       |             |          |             |          |
| R208        | 131      |             |          |             |          |
| R209        | 121      |             |          |             |          |
| R210        | 114      |             |          |             |          |
| R211        | 114      |             |          |             |          |
| R212        | 101      |             |          |             |          |
| R213        | 70       |             |          |             |          |
| R214        | 114      |             |          |             |          |
| R215        | 114      |             |          |             |          |
| R216        | 94       |             |          |             |          |
| R217        | 134      |             |          |             |          |

NOTE UNLESS OTHERWISE SPECIFIED

|  |                  |   |                                |          |
|--|------------------|---|--------------------------------|----------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DRAWN<br>BOGNER  | DATE<br>7/27/77   | WAVETEK SAN DIEGO - CALIFORNIA |          |
| MATERIAL                               | PROCESSOR        | TITLE   | ASSEMBLY SWEEP BOARD           |          |
|  | WILLIAM APPROV   |   |                                |          |
|  |                  | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>X.X - 0.00 ANGLES - 1 |                                |          |
| FINISH<br>WAVETEK PROCESS              | DO NOT SCALE DWG | MODEL NO<br>147   | DWG NO<br>D147-022             | REV<br>C |
|  | SCALE            | PLATE NO<br>23338   | SHEET 2 OF 2                   |          |

|     |     |    |         |     |
|-----|-----|----|---------|-----|
| REV | ECN | BY | DATE    | APP |
| A   | 764 |    | 1/14/73 |     |

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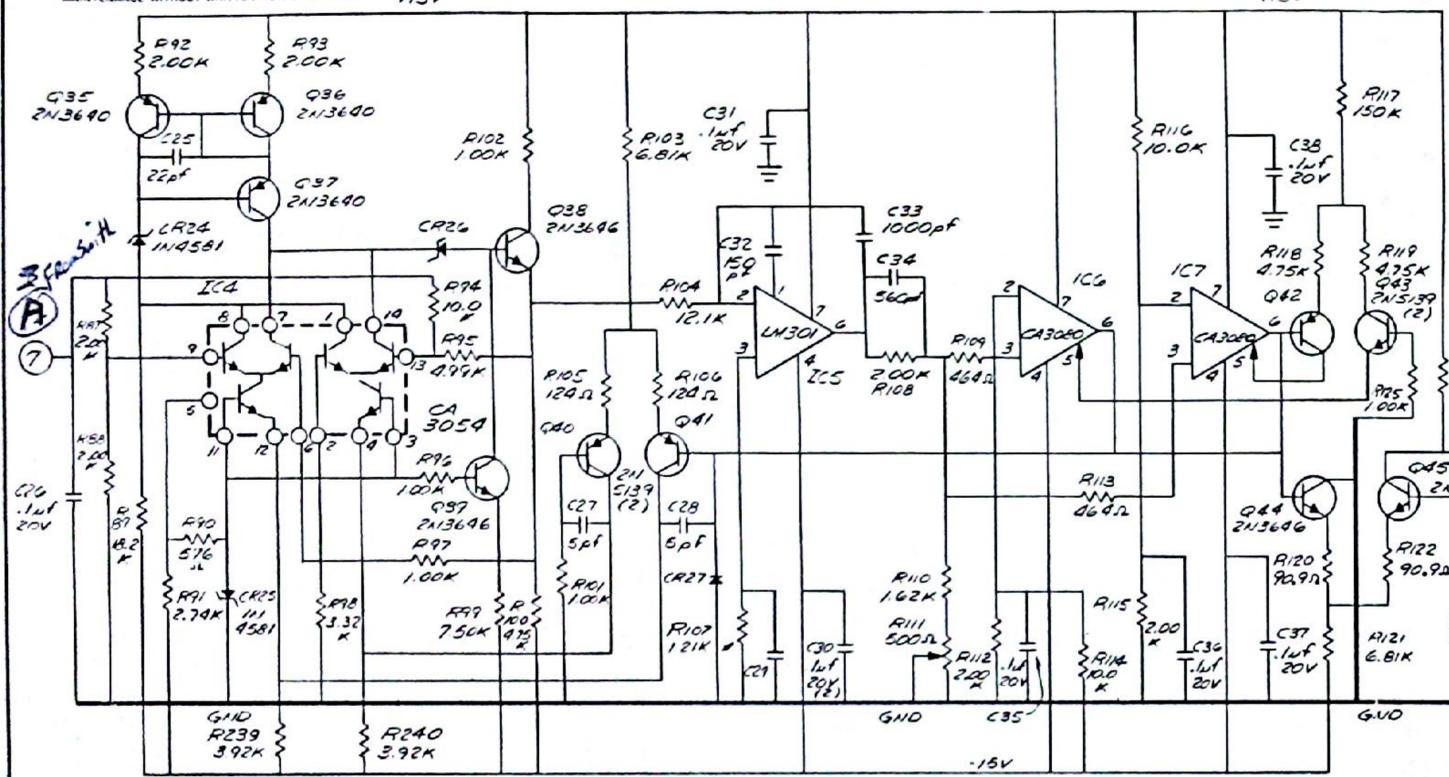
- 5) RESISTORS ARE 1/8W, 1%, METAL FILM
  - 6) DIODES ARE 1N4001
  - 3) LETTERS IN ○ DENOTE INTERCONNECTIONS BETWEEN SHEETS OF THIS SCHEMATIC
  - 2) NUMBERS IN ○ DENOTE PIN NOS ON REAR CONNECTOR (BETWEEN BOARDS)
  - 1) DESCRIPTIONS IN □ DENOTE FRONT PANEL NOMENCLATURE
- NOTE: UNLESS OTHERWISE SPECIFIED

LAST DESIGNATOR USED  
 R242  
 Q62  
 C81  
 CR4B  
 IC1G

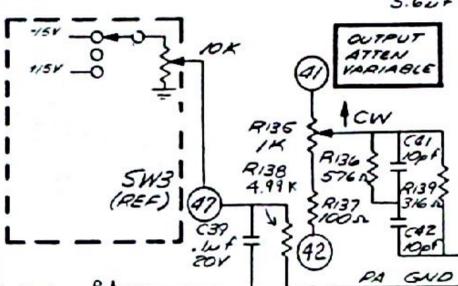
|  |                           |                                    |                                      |
|--|---------------------------|------------------------------------|--------------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DRAWN<br>GRAY             | DATE                               | <b>WAVETEK</b> 648 BRIDGE CALIFORNIA |
| MATERIAL                               | PROJECTOR                 |                                    |                                      |
| FINISH<br>WAVETEK PROCESS              | RELEASE APPROV<br>9-28-72 | TITLE<br>SCHEMATIC,<br>SWEEP BOARD |                                      |
| SCALE                                  | DO NOT SCALE DWG          | MODEL NO<br>147                    | REV<br>A                             |
|  |                           | CODE IDENT<br>23338                | SHEET 1 OF 2                         |

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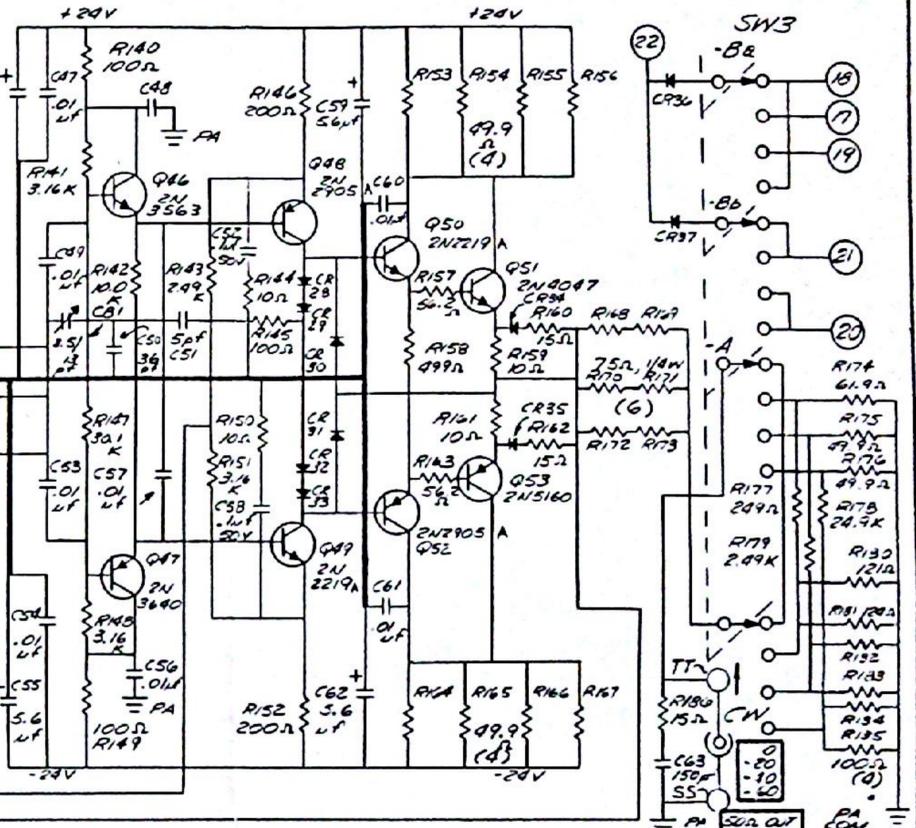
### VOLTAGE TO FREQUENCY CONVERTER



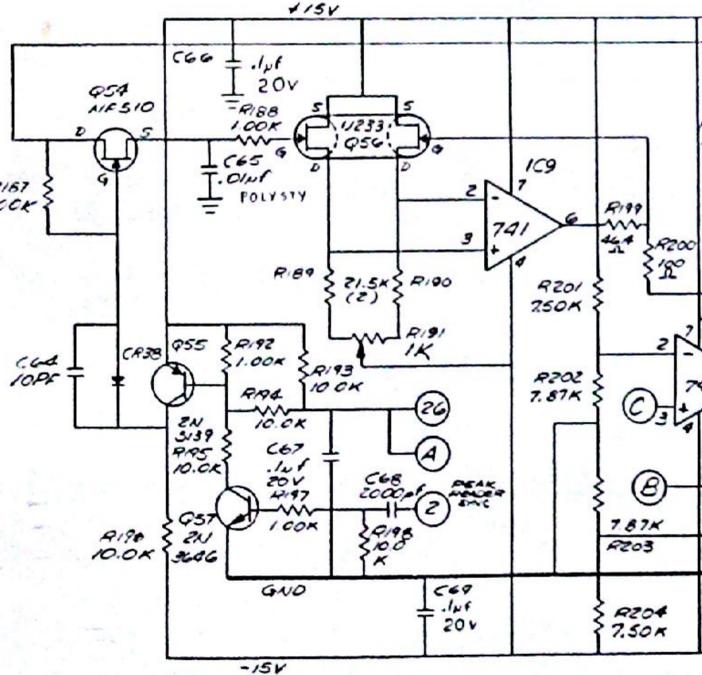
### DC OFFSET



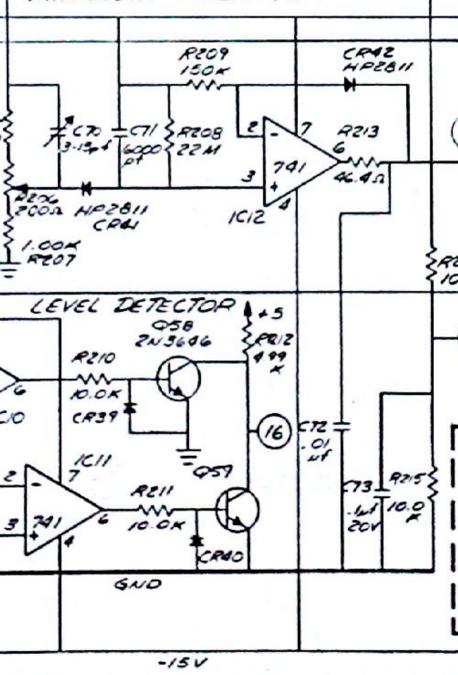
### OUTPUT AMPLIFIER



### SAMPLE & HOLD CIRCUIT

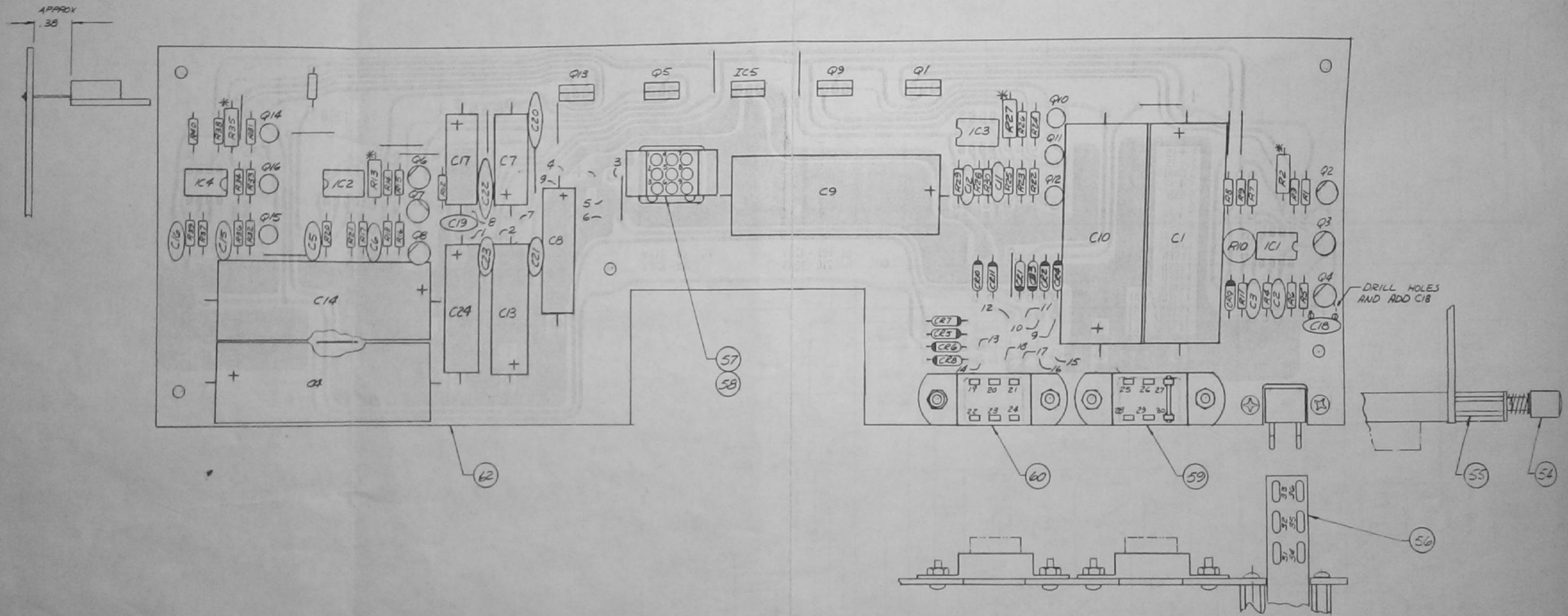


### MINIMUM RECTIFIER



| REV | ECN | BY | DATE | APP |
|-----|-----|----|------|-----|
| D   | 764 | B  | 1/19 |     |

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3 \* INDICATES RESISTORS MOUNTED OFFBOARD  
 2 NUMBERS INDICATE CHASSIS WIRING SEE CHASSIS SCHEMATIC D147-200  
 1

NOTE: UNLESS OTHERWISE SPECIFIED

|  |                                |   |                      |
|--|--------------------------------|---|----------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE<br>1/19/70                | WAVETEK SAN DIEGO - CALIFORNIA  |                      |
| MATERIAL                               | PROJ ENGR                      | TITLE<br>ASSEMBLY POWER SUPPLY  |                      |
| FINISH<br>WAVETEK PROCESS              | RELEASE APPR<br>7/1/70 P-38-23 | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XXX: 010 ANGLES 1:1<br>XX: 1:50 |                      |
|  | DO NOT SCALE DWG               | MODEL NO<br>147   | DWG NO<br>D147-020 D |
|  | SCALE                          | CDD<br>23338  | SHEET 1 OF 2         |

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| PARTS LIST |                             |                    |       |                |     |
|------------|-----------------------------|--------------------|-------|----------------|-----|
| LINE NO    | DESCRIPTION                 | MFR                | FSCM  | MFR P/N        | QTY |
| 1          | CAPACITOR                   |                    |       |                |     |
| 2          | SILVER MICA 500V 5% 6000 pf | ELMENCO            | 72136 | DM19-622J      | 2   |
| 3          | SILVER MICA 500V 5% 2000 pf | ELMENCO            | 72136 | DM19-202J      | 1   |
| 4          | SILVER MICA 500V 1% 1000 pf | ELMENCO            | 72136 | DM19-102F      | 3   |
| 5          | SILVER MICA 500V 5% 560 pf  | ELMENCO            | 72136 | DM15-561J      | 1   |
| 6          | SILVER MICA 500V 5% 220pf   | ELMENCO            | 72136 | DM15-221J      | 1   |
| 7          | CERAMIC DISC 1000V 150 pf   | CRL                | 71590 | DD151          | 2   |
| 8          | CERAMIC DISC 1000V 68 pf    | CRL                | 71590 | DD680          | 1   |
| 9          | CERAMIC DISC 1000V 47 pf    | CRL                | 71590 | DD470          | 2   |
| 10         | SILVER MICA 500V 5% 36pf    | ELMENCO            | 72136 | DM15-360J      | 2   |
| 11         | CERAMIC DISC 1000V27pf      | CRL                | 71590 | DD220          | 4   |
| 12         | CERAMIC DISC 1000V10pf      | CRL                | 71590 | DD100          | 5   |
| 13         | CERAMIC DISC 1000V5pf       | CRL                | 71590 | DD050          | 3   |
| 14         | CERAMIC DISC 1000V .0022uF  | CRL                | 71590 | DD222          | 1   |
| 15         | CERAMIC DISC 50V .01uF      | CRL                | 71590 | CK101          | 15  |
| 16         | POLYSTYRENE 100V .01uF      | IMB                | 30874 | PA28101F       | 1   |
| 17         | CERAMIC DISC 50V .1uF       | CRL                | 71590 | CK104          | 2   |
| 18         | CERAMIC DISC 20V .1uF       | CRL                | 71590 | UK20-104       | 24  |
| 19         | MYLAR 10% 200V 2uF          | AMERICAN RADIONICS | 07994 | 2MF2205K       | 1   |
| 20         | TANT 35V 5 uF               | SPRAGUE            | 56289 | 1500565X9035R2 | 4   |
| 21         | ELECTROLYTIC 16V 100uF      | SPRAGUE            | 56289 | 500D107G016DC7 | 3   |
| 22         |                             |                    |       |                |     |
| 23         |                             |                    |       |                |     |
| 24         | VARIABLE 3.5 -15pf          | STETNER            |       | 75-TRIK0-02    | 3   |
| 25         |                             |                    |       |                |     |
| 26         |                             |                    |       |                |     |
| 27         |                             |                    |       |                |     |
| 28         | DIODE FD777                 | FAIRCHILD          | 33888 | FD777          | 2   |
| 29         | DIODE HP2811                | HEWLETT PACKARD    |       | HP-2811        | 4   |
| 30         | DIODE FD6666                | FAIRCHILD          | 33888 | FD6666         | 36  |
| 31         | DIODE ZENER                 | WAVETEK            | 23338 | A130-506       | 6   |
| 32         |                             |                    |       |                |     |

| PARTS LIST |                            |              |       |         |     |
|------------|----------------------------|--------------|-------|---------|-----|
| LINE NO    | DESCRIPTION                | MFR          | FSCM  | MFR P/N | QTY |
| 33         | INTEGRATED CIRCUIT         |              |       |         |     |
| 34         | INTEGRATED CIRCUIT LM741   | FAIRCHILD    | 33888 | LM741C  | 8   |
| 35         | INTEGRATED CIRCUIT LM301   | NATIONAL     | 27014 | LM301AN | 1   |
| 36         | INTEGRATED CIRCUIT 7474    | MOTOROLA     | 04713 | 7474    | 1   |
| 37         | INTEGRATED CIRCUIT CA3028A | RCA          | 86684 | CA3028A | 1   |
| 38         | INTEGRATED CIRCUIT CA3030  | RCA          | 86684 | CA3030  | 1   |
| 39         | INTEGRATED CIRCUIT MC1050  | MOTOROLA     | 04713 | MC-3050 | 1   |
| 40         | INTEGRATED CIRCUIT CA3054  | RCA          | 86684 | CA3054  | 1   |
| 41         | INTEGRATED CIRCUIT CA3080  | RCA          | 86684 | CA3080  | 2   |
| 42         |                            |              |       |         |     |
| 43         |                            |              |       |         |     |
| 44         |                            |              |       |         |     |
| 45         |                            |              |       |         |     |
| 46         | TRANSISTOR 2N2219A         | MOTOROLA     | 04713 | 2N2219A | 2   |
| 47         | TRANSISTOR 2N2905          | FAIRCHILD    | 33888 | 2N2905  | 1   |
| 48         | TRANSISTOR 2N2905A         | FAIRCHILD    | 33888 | 2N2905A | 2   |
| 49         | TRANSISTOR 2N3563          | FAIRCHILD    | 33888 | 2N3563  | 1   |
| 50         | TRANSISTOR 2N3638          | FAIRCHILD    | 33888 | 2N3638  | 3   |
| 51         | TRANSISTOR 2N3640          | FAIRCHILD    | 33888 | 2N3640  | 11  |
| 52         | TRANSISTOR 2N3642          | FAIRCHILD    | 33888 | 2N3642  | 1   |
| 53         | TRANSISTOR 2N3646          | FAIRCHILD    | 33888 | 2N3646  | 27  |
| 54         | TRANSISTOR 2N5139          | FAIRCHILD    | 33888 | 2N5139  | 5   |
| 55         | TRANSISTOR (-55) 2N5462    | MOTOROLA     | 04713 | 2N5462  | 1   |
| 56         | TRANSISTOR (-55) 2N5485    | MOTOROLA     | 04713 | 2N5485  | 2   |
| 57         | TRANSISTOR 2N4047          | FAIRCHILD    | 33888 | 2N4047  | 1   |
| 58         | TRANSISTOR 2N5160          | FAIRCHILD    | 33888 | 2N5160  | 1   |
| 59         | TRANSISTOR TD401           | TECH PRODUCT |       | TD401   | 2   |
| 60         | TRANSISTOR U255            | SILICONIX    |       | U255    | 1   |
| 61         | TRANSISTOR NF-510          | NATIONAL     | 27014 | NF-510  | 1   |
| 62         |                            |              |       |         |     |
| 63         |                            |              |       |         |     |
| 64         |                            |              |       |         |     |

| PARTS LIST |                         |         |       |         |     |
|------------|-------------------------|---------|-------|---------|-----|
| LINE NO    | DESCRIPTION             | MFR     | FSCM  | MFR P/N | QTY |
| 65         | RESISTORS               |         |       |         |     |
| 66         | METALFILM 1/8W 1% 100   | CORNING | 16299 | RN550   | 7   |
| 67         | METALFILM 1/8W 1% 150   | CORNING | 16299 | RN550   | 3   |
| 68         | METALFILM 1/8W 1% 27.40 | CORNING | 16299 | RN550   | 1   |
| 69         | METALFILM 1/8W 1% 30.10 | CORNING | 16299 | RN550   | 1   |
| 70         | METALFILM 1/8W 1% 46.40 | CORNING | 16299 | RN550   | 3   |
| 71         | METALFILM 1/4W 1% 49.90 | CORNING | 16299 | RN600   | 10  |
| 72         | METALFILM 1/8W 1% 56.20 | CORNING | 16299 | RN550   | 2   |
| 73         | METALFILM 1/8W 1% 61.90 | CORNING | 16299 | RN550   | 1   |
| 74         | METALFILM 1/4W 1% 750   | CORNING | 16299 | RN600   | 6   |
| 75         | METALFILM 1/8W 1% 90.90 | CORNING | 16299 | RN550   | 2   |
| 76         | METALFILM 1/8W 1% 100   | CORNING | 16299 | RN550   | 12  |
| 77         | METALFILM 1/4W 1% 100   | CORNING | 16299 | RN600   | 4   |
| 78         | METALFILM 1/4W 1% 1210  | CORNING | 16299 | RN600   | 1   |
| 79         | METALFILM 1/8W 1% 1240  | CORNING | 16299 | RN550   | 2   |
| 80         | METALFILM 1/4W 1% 1240  | CORNING | 16299 | RN600   | 1   |
| 81         | METALFILM 1/8W 1% 1500  | CORNING | 16299 | RN550   | 3   |
| 82         | METALFILM 1/8W 1% 2000  | CORNING | 16299 | RN550   | 2   |
| 83         | METALFILM 1/8W 1% 2450  | CORNING | 16299 | RN550   | 1   |
| 84         | METALFILM 1/8W 1% 2740  | CORNING | 16299 | RN550   | 2   |
| 85         | METALFILM 1/8W 1% 3010  | CORNING | 16299 | RN550   | 2   |
| 86         | METALFILM 1/8W 1% 3160  | CORNING | 16299 | RN550   | 1   |
| 87         | METALFILM 1/8W 1% 3900  | CORNING | 16299 | RN550   | 1   |
| 88         | METALFILM 1/8W 1% 4640  | CORNING | 16299 | RN550   | 2   |
| 89         | METALFILM 1/8W 1% 4990  | CORNING | 16299 | RN550   | 1   |
| 90         | METALFILM 1/8W 1% 5760  | CORNING | 16299 | RN550   | 2   |
| 91         | METALFILM 1/8W 1% 6810  | CORNING | 16299 | RN550   | 1   |
| 92         | METALFILM 1/8W 1% 7500  | CORNING | 16299 | RN550   | 1   |
| 93         | METALFILM 1/8W 1% 8250  | CORNING | 16299 | RN550   | 4   |
| 94         | METALFILM 1/8W 1% 1K    | CORNING | 16299 | RN550   | 24  |
| 95         | METALFILM 1/8W 1% 1.21K | CORNING | 16299 | RN550   | 2   |
| 96         | METALFILM 1/8W 1% 1.5K  | CORNING | 16299 | RN550   | 7   |

NOTE: UNLESS OTHERWISE SPECIFIED

|  |  |                                |
|--|--|--------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE<br>8/27/77  | WAVETEK SAN DIEGO - CALIFORNIA |
| MATERIAL                               | RELEASE APPROVAL   | TITLE<br>ASSEMBLY SWEEP BOARD  |
| FINISH<br>WAVETEK PROCESS              | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XXX - .010 ANGLES - 1<br>XX - .030 | MODEL NO<br>147                |
| SCALE                                  | DO NOT SCALE DWG   | REV NO<br>0147-022C            |
|  | DATE   | 23338 SHEET 2 OF 4             |

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|     |     |    |      |     |
|-----|-----|----|------|-----|
| REV | ECN | BY | DATE | APP |
|-----|-----|----|------|-----|

| PARTS LIST |                         |           |       |         |     |
|------------|-------------------------|-----------|-------|---------|-----|
| LINE NO    | DESCRIPTION             | MFR       | FSCM  | MFR P/N | QTY |
| 97         | METALFILM 1/8W 1% 1.62K | CORNING   | 16299 | RN55D   | 1   |
| 98         | METALFILM 1/8W 1% 1.96K | CORNING   | 16299 | RN55D   | 1   |
| 99         | METALFILM 1/8W 1% 2K    | CORNING   | 16299 | RN55D   | 7   |
| 100        | METALFILM 1/8W 1% 2.21K | CORNING   | 16299 | RN55D   | 5   |
| 101        | METALFILM 1/8W 1% 2.49K | CORNING   | 16299 | RN55D   | 5   |
| 102        | METALFILM 1/8W 1% 2.74K | CORNING   | 16299 | RN55D   | 2   |
| 103        | METALFILM 1/8W 1% 3.16K | CORNING   | 16299 | RN55D   | 3   |
| 104        | METALFILM 1/8W 1% 3.32K | CORNING   | 16299 | RN55D   | 5   |
| 105        | METALFILM 1/8W 1% 3.83K | CORNING   | 16299 | RN55D   | 1   |
| 106        | METALFILM 1/8W 1% 3.92K | CORNING   | 16299 | RN55D   | 4   |
| 107        | METALFILM 1/8W 1% 4.64K | CORNING   | 16299 | RN55D   | 1   |
| 108        | METALFILM 1/8W 1% 4.75K | CORNING   | 16299 | RN55D   | 4   |
| 109        | METALFILM 1/8W 1% 4.99K | CORNING   | 16299 | RN55D   | 11  |
| 110        | METALFILM 1/8W 1% 5.76K | CORNING   | 16299 | RN55D   | 3   |
| 111        | METALFILM 1/8W 1% 6.81K | CORNING   | 16299 | RN55D   | 2   |
| 112        | METALFILM 1/8W 1% 6.98K | CORNING   | 16299 | RN55D   | 1   |
| 113        | METALFILM 1/8W 1% 7.5K  | CORNING   | 16299 | RN55D   | 4   |
| 114        | METALFILM 1/8W 1% 7.87K | CORNING   | 16299 | RN55D   | 2   |
| 115        | METALFILM 1/8W 1% 9.53K | CORNING   | 16299 | RN55D   | 1   |
| 116        | METALFILM 1/8W 1% 10K   | CORNING   | 16299 | RN55D   | 22  |
| 117        | CARBON 1W 5% 10K        | STACKPOLE | 29604 | RC32GF  | 1   |
| 118        | METALFILM 1/8W 1% 12.1K | CORNING   | 16299 | RN55D   | 2   |
| 119        | METALFILM 1/8W 1% 15K   | CORNING   | 16299 | RN55D   | 6   |
| 120        | METALFILM 1/8W 1% 18.2K | CORNING   | 16299 | RN55D   | 1   |
| 121        | METALFILM 1/8W 1% 21.5K | CORNING   | 16299 | RN55D   | 2   |
| 122        | METALFILM 1/8W 1% 24.9K | CORNING   | 16299 | RN55D   | 1   |
| 123        | METALFILM 1/8W 1% 30.1K | CORNING   | 16299 | RN55D   | 1   |
| 124        | METALFILM 1/8W 1% 46.4K | CORNING   | 16299 | RN55D   | 1   |
| 125        | METALFILM 1/8W 1% 56.2K | CORNING   | 16299 | RN55D   | 1   |
| 126        | METALFILM 1/8W 1% 69.8K | CORNING   | 16299 | RN55D   | 2   |
| 127        | METALFILM 1/8W 1% 100K  | CORNING   | 16299 | RN55D   | 1   |

| PARTS LIST |                              |           |       |            |     |
|------------|------------------------------|-----------|-------|------------|-----|
| LINE NO    | DESCRIPTION                  | MFR       | FSCM  | MFR P/N    | QTY |
| 128        | METALFILM 1/8W 1% 150K       | CORNING   | 16299 | RN55D      | 3   |
| 129        | METALFILM 1/8W 1% 221K       | CORNING   | 16299 | RN55D      | 1   |
| 130        | METALFILM 1/4W 1% 698K       | CORNING   | 16299 | RN60D      | 1   |
| 131        | CARBON 1/2W 5% 22M           | STACKPOLE | 29604 | RC20GF225J | 2   |
| 132        |                              |           |       |            |     |
| 133        |                              |           |       |            |     |
| 134        |                              |           |       |            |     |
| 135        | POTENTIOMETER 100Ω           | BECKMAN   | 80740 | 91AR100    | 3   |
| 136        | POTENTIOMETER 200Ω           | BECKMAN   | 80740 | 91AR200    | 2   |
| 137        | POTENTIOMETER 500Ω           | BECKMAN   | 80740 | 91AR500    | 2   |
| 138        | POTENTIOMETER 1K             | BECKMAN   | 80740 | 91AR1K     | 3   |
| 139        | POTENTIOMETER 10K            | BECKMAN   | 80740 | 91AR10K    | 2   |
| 140        | POTENTIOMETER 100K           | BECKMAN   | 80740 | 91AR100K   | 1   |
| 141        |                              |           |       |            |     |
| 142        |                              |           |       |            |     |
| 143        | SWITCH ASSEMBLY (ATTN)       | WAVETEK   | 23338 | D147-004   | 1   |
| 144        | SWITCH ASSEMBLY (SWEEP TIME) | WAVETEK   | 23338 | D147-007   | 1   |
| 145        | SWITCH ASSEMBLY (MODE)       | WAVETEK   | 23338 | D147-006   | 1   |
| 146        |                              |           |       |            |     |
| 147        |                              |           |       |            |     |
| 148        | POTENTIOMETER                | WAVETEK   | 23338 | A147-401   | 1   |
| 149        | POTENTIOMETER                | WAVETEK   | 23338 | 136-R1A    | 1   |
| 150        | POTENTIOMETER DUAL           | WAVETEK   | 23338 | A147-501   | 1   |
| 151        |                              |           |       |            |     |
| 152        | POWER ROD ASSY               | WAVETEK   | 23338 | D147-003   | 1   |
| 153        |                              |           |       |            |     |
| 154        | D-WASHER (RETAINER)          | WAVESSR   | -     | D-191      | 1   |
| 155        |                              |           |       |            |     |
| 156        |                              |           |       |            |     |
| 157        |                              |           |       |            |     |
| 158        |                              |           |       |            |     |

| PARTS LIST |                       |             |       |            |     |
|------------|-----------------------|-------------|-------|------------|-----|
| LINE NO    | DESCRIPTION           | MFR         | FSCM  | MFR P/N    | QTY |
| 159        |                       |             |       |            |     |
| 160        |                       |             |       |            |     |
| 161        | SWITCH BRACKET        | WAVETEK     | 23338 | B133-305   | 2   |
| 162        | HEATSINK              | THERMOLLY   | 13103 | 1103A      | 2   |
| 163        | HEATSINK              | WAKEFIELD   | 05820 | NF-207     | 2   |
| 164        | THERMinals (TALL BIF) | USECO       | 88245 | 2005B-1    | 6   |
| 165        | TRANSIDADS            | MILTON ROSS | 07047 | 10123W     | 7   |
| 166        | TRANSIDADS (TALL)     | MILTON ROSS | 07047 | 10160      | 2   |
| 167        | AMP PINS              | AMP         | 00779 | 61182-2    | 13  |
| 168        | STANDOFFS (SWAGE)     | LYNTRON     |       | 6311-4-2   | 5   |
| 169        | SHIELD                | WAVETEK     | 23338 | B147-357   | 1   |
| 170        | CONNECTOR PINS        | MOLEX       |       | 09-64-2101 | 5   |
| 171        | CONNECTOR PINS        | MOLEX       |       | 02-06-2132 | 9   |
| 172        | CONNECTOR RECEPTACLE  | MOLEX       |       | 03-06-2091 | 1   |
| 173        | CABLE CLAMP           | H.H. SMITH  | 83330 | 832        | 1   |
| 174        | CIRCUIT BOARD         | WAVETEK     | 23338 | 147-122    | 1   |
| 175        |                       |             |       |            |     |
| 176        |                       |             |       |            |     |
| 177        |                       |             |       |            |     |
| 178        |                       |             |       |            |     |
| 179        |                       |             |       |            |     |
| 180        |                       |             |       |            |     |
| 181        |                       |             |       |            |     |
| 182        |                       |             |       |            |     |
| 183        |                       |             |       |            |     |
| 184        |                       |             |       |            |     |
| 185        |                       |             |       |            |     |
| 186        |                       |             |       |            |     |
| 187        |                       |             |       |            |     |
| 188        |                       |             |       |            |     |
| 189        |                       |             |       |            |     |

NOTE: UNLESS OTHERWISE SPECIFIED

|  |   |                               |
|--|---|-------------------------------|
| REMOVE ALL BURRS AND BREAK SHARP EDGES | DATE<br>7/24/79   |                               |
| MATERIAL                               | DESIGNER<br>BENJAMIN  |                               |
| FINISH<br>WAVETEK PROCESS              | RELEASE APPROV  | TITLE<br>ASSEMBLY SWEEP BOARD |
|  | TOLERANCE UNLESS OTHERWISE SPECIFIED<br>XX - 0.10 ANGLES - 1<br>XX - 0.30 | MODEL NO<br>147               |
|  | DO NOT SCALE DWG<br>SCALE   | DWG NO<br>D147-022            |
|  | CODE IDENT<br>23338   | SHEET 3 OF 8                  |