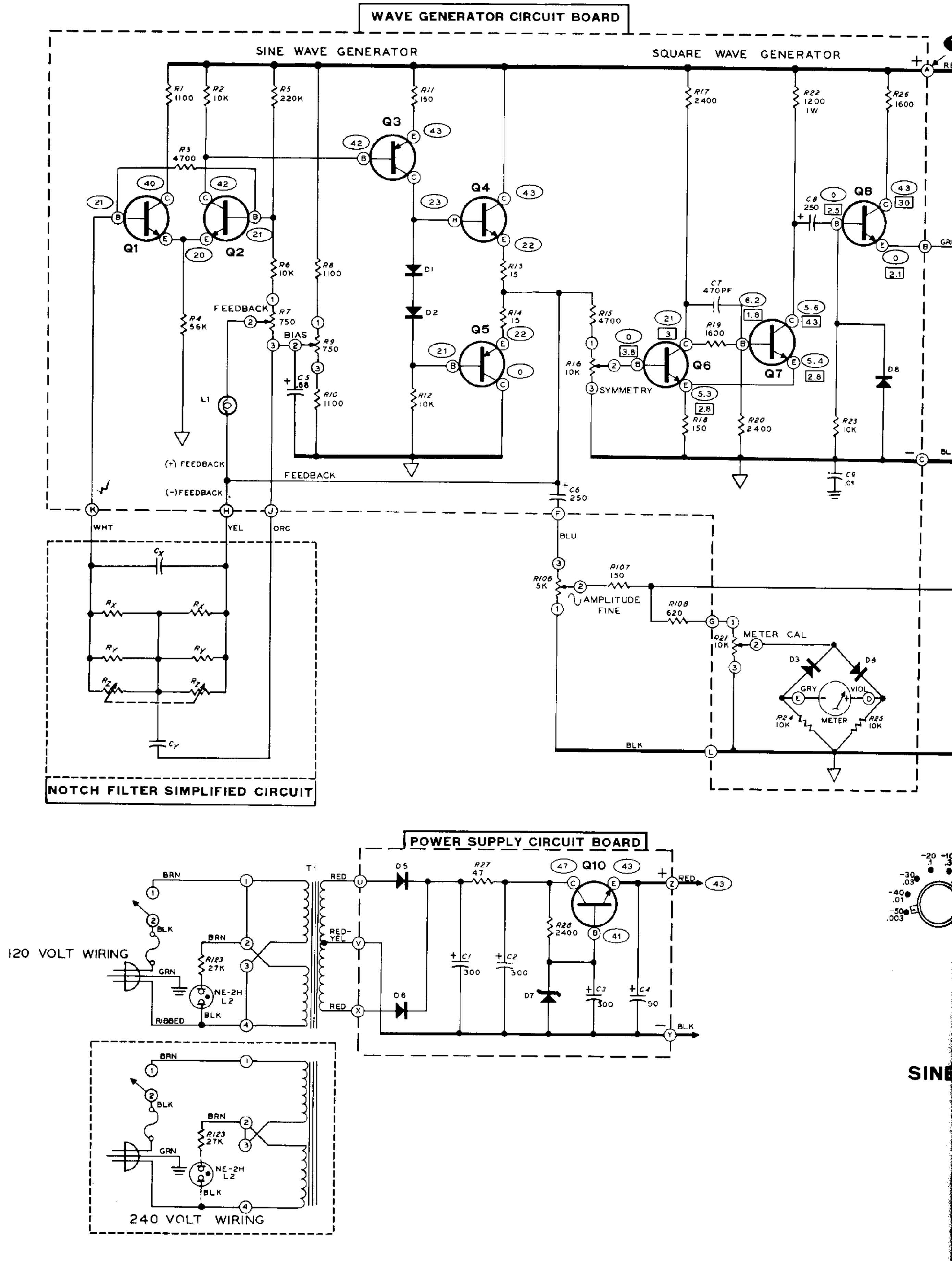
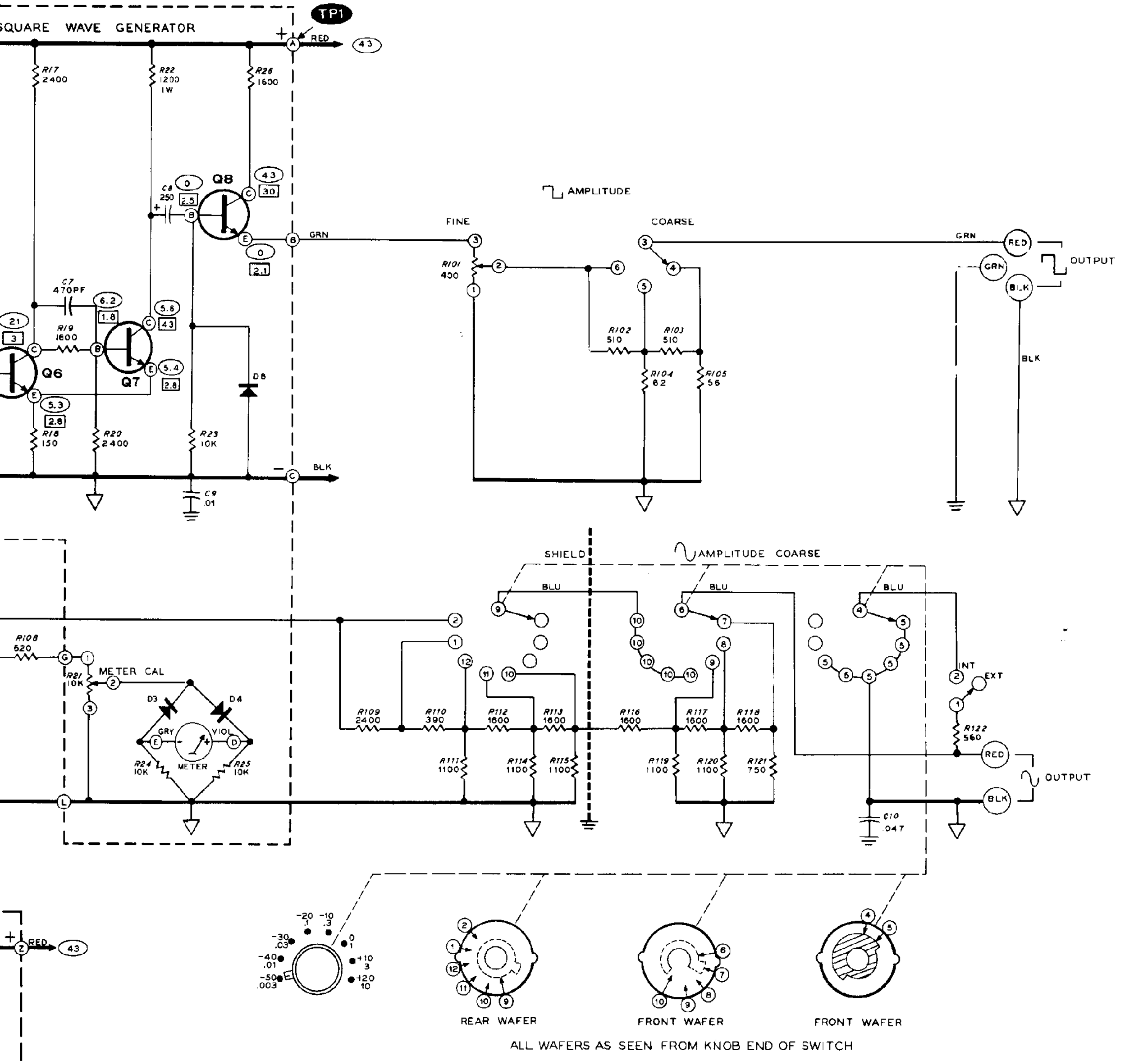


WAVE GENERATOR CIRCUIT BOARD
SINE WAVE GENERATOR
SQUARE WAVE GENERATOR
R1 1100
R2 10K
R5 220K
R11 150
R3 4700
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
R6 10K
R8 1100
R4 56K
FEEDBACK
R7 750
BIAS
R9 750
C5 68
R10 1100
L1
D1
D2
R13 15
R14 15
R12 10K
R17 2400
R22 1200 1W
R26 1600
C8 250
C7 470PF
R19 1600
R15 4700
R16 10K
SYMMETRY
R18 150
R20 2400
R23 10K
D8
C9 .01
(+) FEEDBACK
(-)FEEDBACK
FEEDBACK
C6 250
WHT
YEL
ORG
BLU
R107 150
R106 5K
AMPLITUDE FINE
R108 620
METER CAL
R21 10K
D3
D4
GRY
VIOL
METER
R24 10K
R25 10K
BLK
NOTCH FILTER SIMPLIFIED CIRCUIT
POWER SUPPLY CIRCUIT BOARD
T1
RED
RED-YEL
D5
D6
R27 47
Q10
R28 2400
C1 300
C2 300
C3 300
C4 50
D7
BRN
BLK
GRN
RIBBED
R123 27K
NE-2H L2
120 VOLT WIRING
240 VOLT WIRING
SINE



SCHEMATIC OF THE
HEATHKIT®
SINE-SQUARE AUDIO GENERATOR
MODEL IG-18

TROUBLESHOOTING CHART

DIFFICULTY	POSSIBLE CAUSE AND SUGGESTED CURE
Pilot lamp lights. No sine or square wave output.	1. All controls set at zero. 2. Measure the B+ voltage at point A on the generator circuit board. If the voltage is low or there is no voltage, refer to the next Difficulty on this Chart. 3. Feedback control not set properly. (Refer to Adjustments section on Page 41.) 4. Check transistors Q1, Q2, Q5, Q4, and Q3 in that order. 5. Open filament in lamp L1. 6. Wrong part value, improper connection, or faulty part in notch filter circuits (units and tens switches). (Make checks at other frequency settings to test this possibility.)
B+ voltage low or no B+ voltage.	Measure the resistance of the generator circuit board at TP1 as described in the step under "Tests" on Page 39. If this resistance is less than 1500 Ω, apply the checks on the previous page to the generator circuit board. If the resistance is 1500 Ω or greater, check the following: 1. Transistor Q10. 2. Diodes D5 and D6. 3. Zener diode D7. 4. Capacitors C1, C2, C3, and C4. 5. Transformer primary windings.
No sine wave output. Square wave output ok.	1. Short circuit or excessive load at sine wave output terminals. 2. Check control R106. 3. Check capacitor C6.
No square wave output. Sine wave output ok.	1. Short circuit or excessive load at square wave output terminals. 2. Symmetry trimmer not adjusted properly. 3. Check transistors Q6, Q7, and Q8. 4. Check control R101. 5. Check capacitor C8. 6. Frequency set too low.
Bottom of square wave goes below zero.	1. D8 open.

DIFFICULTY	POSSIBLE CAUSE AND SUGGESTED CURE
Meter inoperative. Sine wave output ok.	1. Check diodes D3 and D4. 2. Check control R21. 3. Meter pointer stuck. 4. Meter coil open. WARNING: When testing the meter for continuity, use only the highest resistance range of the ohmmeter.
Sine wave distorted.	1. Feedback control set too high. 2. Bias control not set correctly. 3. Check Q10. 4. Check Q5, Q4, Q1, Q2, and Q3. 5. Improper ground connections between Generator and associated equipment. 6. Low line voltage.

FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) If you wish, you can deliver your kit to a nearby Heath Authorized Service Center. These centers are listed in your Heathkit catalog.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heath Authorized Service Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heath Authorized Service Center, please ship it to the factory at Benton Harbor, Michigan and follow the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan.

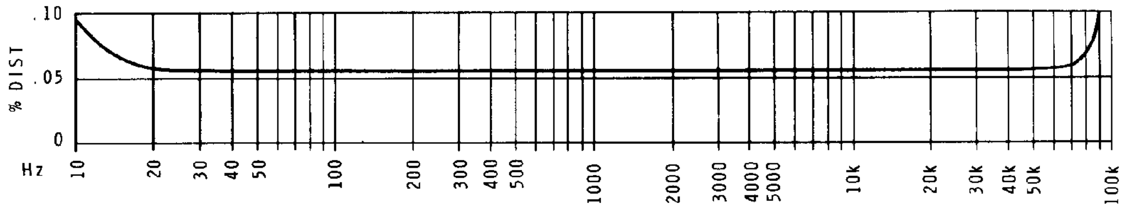
Check the equipment to see that all parts and screws are in place. (Do not include wooden cabinets when shipping receivers, tuners, amplifiers, or TV sets, as these are easily damaged in shipment.) Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

SPECIFICATIONS

SINE WAVE OUTPUT

Frequency Range.	1 Hz to 100 kHz.
Output Voltage Ranges.	0 - .003 0 - .01 0 - .03 0 - .1 0 - .3 0 - 1 0 - 3 0 - 10
Internal Load.	Internal 600 Ω load available on .003, .01, .03, .1, .3, and 1 volt ranges.
dB Ranges.	-62 to +22 dB. -12 to +2 dB on meter; -50 to +20 dB in eight 10 dB switch positions. +2 dB maximum into 600 Ω load.
Output Variation.	±1 dB from 10 Hz to 100 kHz.
Output Indication.	Two voltage scales and one dB scale on front panel meter.
Output Impedance.	10 volt range: 0-1000 Ω. 3 volt range: 800-1000 Ω. 1 volt range and lower: 600 Ω.
Meter Accuracy.	±10% of full scale with proper load termination.



PERCENT DISTORTION-TYPICAL

Distortion. . . . . Less than .1% from 10 Hz to 20 kHz.

Type Of Circuit. . . . . Differential amplifier with complementary pair output. Notch filter frequency determination.

SQUARE WAVE OUTPUT

Frequency Ranges. . . . . 5 Hz to 100 kHz.

Output Voltage Ranges. . . . . 0-.1 V, 0-1 V, and 0-10 V zero-to-peak into 2000 Ω or higher load.

Output Impedance. . . . . 52 Ω on .1 V and 1 V ranges;
Up to 220 Ω on 10 V range.

Rise Time. Less than 50 nanoseconds.

GENERAL

Frequency Selection. . . . . First two significant figures on 0-100 and 0-10 switches each in ten steps.
Third figure on 0-1 control.
Multiplier switch: X1, X10, X100, X1000.

Frequency Error . . . . Within ± 5% of first and second digit.

Power Requirements. . . . . 105-125 VAC or 210-250 VAC, 50/60 Hz, 6 Watts.

Dimensions. 5-1/8" high x 13-1/4" wide x 7" deep.

Net Weight. 7 lbs.

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

CIRCUIT DESCRIPTION

Refer to the Block Diagram on Page 65 and to the Schematic Diagram (fold-out from Page 75) while reading this Circuit Description.

The circuit of the Sine-Square Audio Generator includes three principal sections: The Sine Wave Generator (including the meter and output attenuator circuits), the Square Wave Generator and the Power Supply. Each of these Sections will be described separately.

SINE WAVE GENERATOR

The sine wave oscillator circuits consists of differential amplifier transistors Q1 and Q2; voltage amplifier transistor Q3; power amplifier transistors Q4 and Q5; and the positive and negative feedback loops. Positive (regenerative) feedback comes from the common emitter output of transistors Q4 and Q5, and is coupled to the base of transistor Q2 through the lamp L1, the arm of feedback control R7, and resistor R6. Negative (degenerative) feedback comes through the notch filter and is directly coupled to the base of transistor Q1.

Oscillation occurs due to the positive feedback. Without negative feedback, the circuit would oscillate at some indeterminate frequency; however, the notch filter, which passes all frequencies except the one to which it is tuned, provides the negative feedback to the base of transistor Q1. This negative feedback prevents oscillation at all frequencies except the one that is not passed, permitting the system to oscillate at only the selected frequency.

The tuned frequency of the RC notch filter circuit may be calculated by the general formula:

$$F = \frac{1}{2 \pi RC}$$

where F is frequency in hertz, R is resistance in ohms, and C is capacitance in farads. However, since this notch filter is a specialized RC network in which there are two resistances and two capacitances, the formula for this network then becomes:

$$F = \frac{1}{2\pi \sqrt{R_1 R_2} \sqrt{C_1 C_2}} .$$

Since R_1 and R_2 will always be equal, the formula simplifies to:

$$F = \frac{1}{2\pi R \sqrt{C_1 C_2}} .$$

In the notch filter in the Sine-Square Audio Generator R may consist of one or several resistors in parallel; or

$$R = \frac{1}{\frac{1}{R_x} + \frac{1}{R_y} + \frac{1}{R_z}}; \quad C_1 = C_x; \quad \text{and } C_2 = C_y.$$

R_x represents the resistance value selected by the Tens Frequency switch for a particular frequency. This resistance may consist of one resistor, or a parallel combination of several resistors. For example; for 20 Hz the two 5000 Ω resistors are selected and R_x = 5000 Ω, for 40 Hz the two 2500 Ω resistors are selected and R_x = 2500 Ω, for 60 Hz both the 5000 Ω and the 2500 Ω resistors are selected in parallel and R_x = 1670 Ω.

R_y represents the resistance value selected by the Units Frequency switch for a particular frequency. The operation of this switch is identical to that of the Tens Frequency switch, except that the resistance values are ten times those of the Tens Frequency switch.

R_z represents the resistance value of the Frequency Control when adjusted for a particular frequency.

C_x and C_y represent the capacitors on the Multiplier switch. The value of C_y will always be 10 times larger than the value of C_x for all positions of the Multiplier switch.

As shown in the general formula $F = \frac{1}{2\pi RC}$, the tuned frequency of a notch filter is inversely proportional to the value of its resistances and capacitances. Therefore, to achieve an increase in frequency the resistance must decrease. Likewise, for a tenfold increase in frequency, by using the Multiplier switch, the capacitance must decrease tenfold.

Any tendency of the oscillator to produce signals of increasing amplitude is controlled by lamp L1. If the oscillator output increases, more current is fed through the feedback circuit and through lamp L1. This increased current causes the filament of the lamp to heat slightly, which causes its resistance to increase. This increase in resistance attenuates the feedback signal to the base of transistor Q2. The result is a regulated output from transistor Q2.

DC base bias is provided to Q1 and Q2 through a voltage divider that consists of resistors R5 and R6, and control R7. (Resistor R3 decreases the gain of the differential amplifier to make it more stable.) The voltage at the lower end of this divider, and therefore at the bases of Q1 and Q2, is made adjustable by being connected to the arm of Bias control R9, which is connected in a DC voltage divider with R8 and R10.

The signal from the differential amplifier is direct coupled from the collector of Q2 to the base of voltage amplifier transistor Q3. From the collector of Q3, the signal is direct coupled to the base of Q4, and through diodes D1 and D2 to the base of Q5. These diodes maintain a 1.2 volt difference between the bases of transistors Q4 and Q5.

Q4 and Q5 form an emitter follower complementary-pair amplifier with no voltage gain and a low impedance output. The output signal from this stage is coupled to the square wave circuits as a trigger signal and to the sine wave output attenuator.

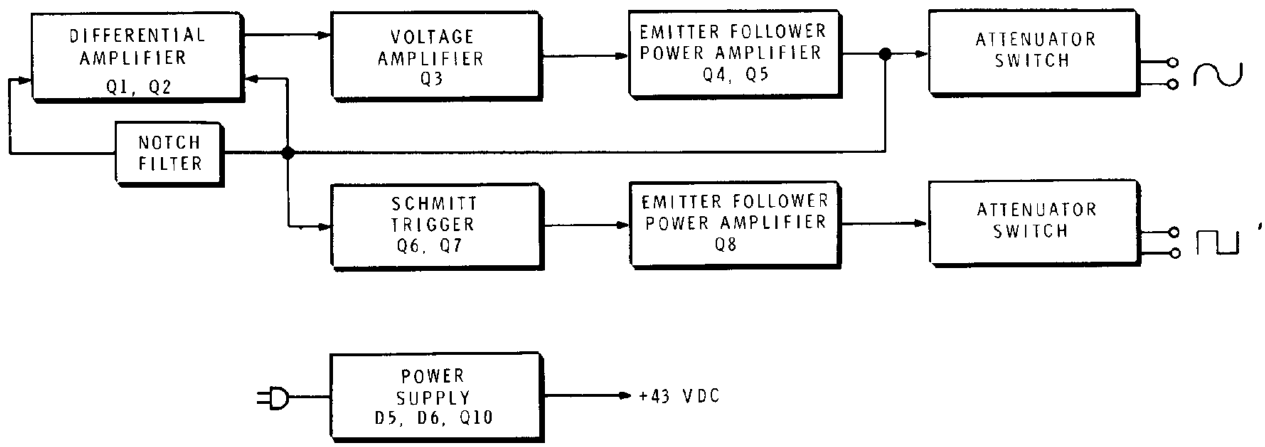
SINE WAVE OUTPUT ATTENUATOR

The sine wave signal from Q4 and Q5 is coupled through capacitor C6 to Sine Wave Amplitude control R106. From R106, the signal is coupled through isolating resistor R107 to the meter circuit and to the Sine Wave Amplitude switch.

The resistor network on two sections of this switch comprise an eight-step voltage divider (R109 to R121) which proportionately divides the signal into steps of 10 dB each. The selected voltage level is applied to the sine wave output terminals. The remaining section of the switch permits internal load resistor R122 to be connected across the output terminals in the six lowest output ranges.

METER CIRCUIT

Resistor R108 and meter calibration control R21 comprise a voltage divider through which some of the signal from resistor R107 is bypassed for monitoring by the panel meter. Diodes D3 and D4, and load resistors R24 and R25 form a half-wave bridge rectifier circuit for the output meter.



BLOCK DIAGRAM

SQUARE WAVE GENERATOR

The square wave section consists of a Schmitt trigger circuit Q6 and Q7, a power amplifier Q8, and the square wave attenuator. The square wave is produced by the Schmitt trigger circuit, which is triggered by a sine wave signal that is coupled through resistor R15 and Symmetry control R16 to the base of Q6.

The Schmitt trigger circuit has two stable states: one in which Q7 is conducting and Q6 is cut off, and the other in which Q6 is conducting and Q7 is cut off. The switching time between these two states is extremely short, which permits the circuit to produce a square wave with a very fast rise time.

The switching is controlled by the voltage on the base of Q6. This voltage varies with the rising and falling voltage of the sine wave input. Symmetry control R16 is adjusted to produce time intervals between switching on and switching off that are of equal length; therefore, producing a symmetrical square wave.

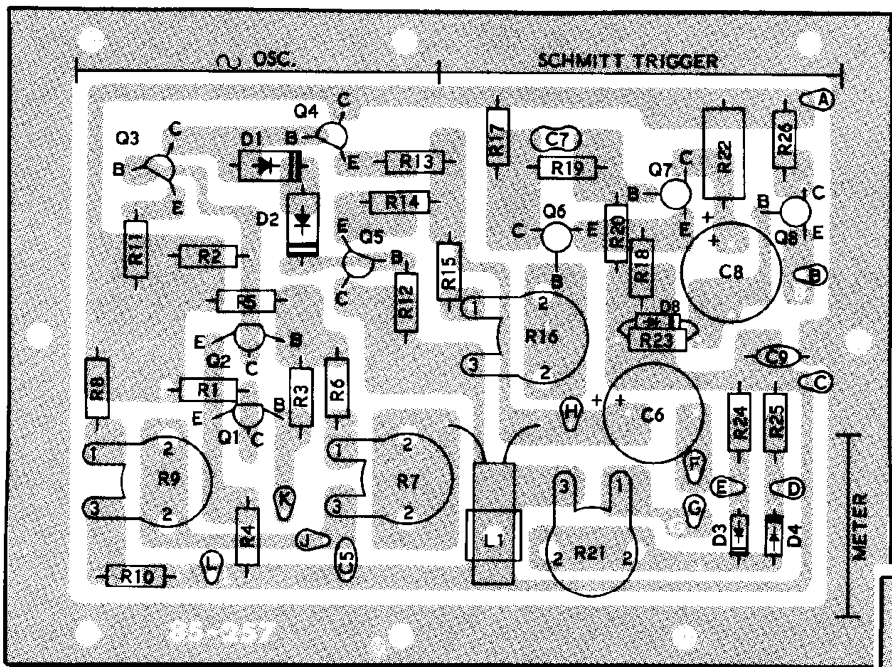
The Schmitt trigger output from the collector of transistor Q7 is coupled through capacitor C8 to the base of emitter follower transistor Q8, which provides a low impedance output with no voltage gain. D8 protects the base of Q8 from excessive negative voltage. The output from Q8 passes directly to Square Wave Amplitude control R101. From R101, the square wave is applied through the attenuator network on the Square Wave Amplitude switch to the square wave output terminals.

POWER SUPPLY

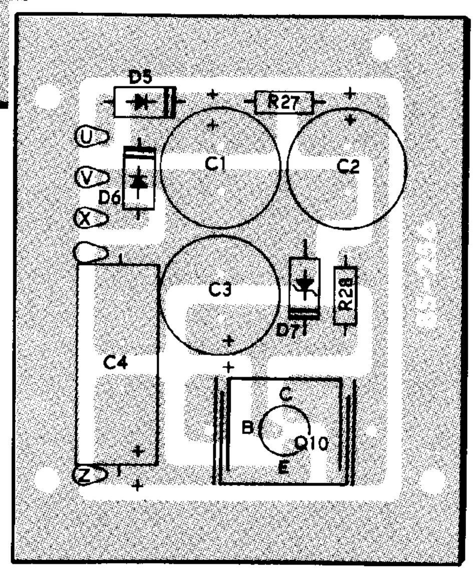
Dual-primary power transformer T1 can be wired to operate from either 120 VAC or 240 VAC. The output from the secondary of T1 is rectified by diodes D5 and D6 in a full wave rectifier circuit, and filtered by the pi filter consisting of capacitors C1 and C2 and resistor R27.

Zener diode D7 provides a regulated reference voltage for the base of voltage regulator transistor Q10, which regulates the DC output at 43 volts. Capacitor C4 grounds AC feedback from the sine wave generator at high frequencies.

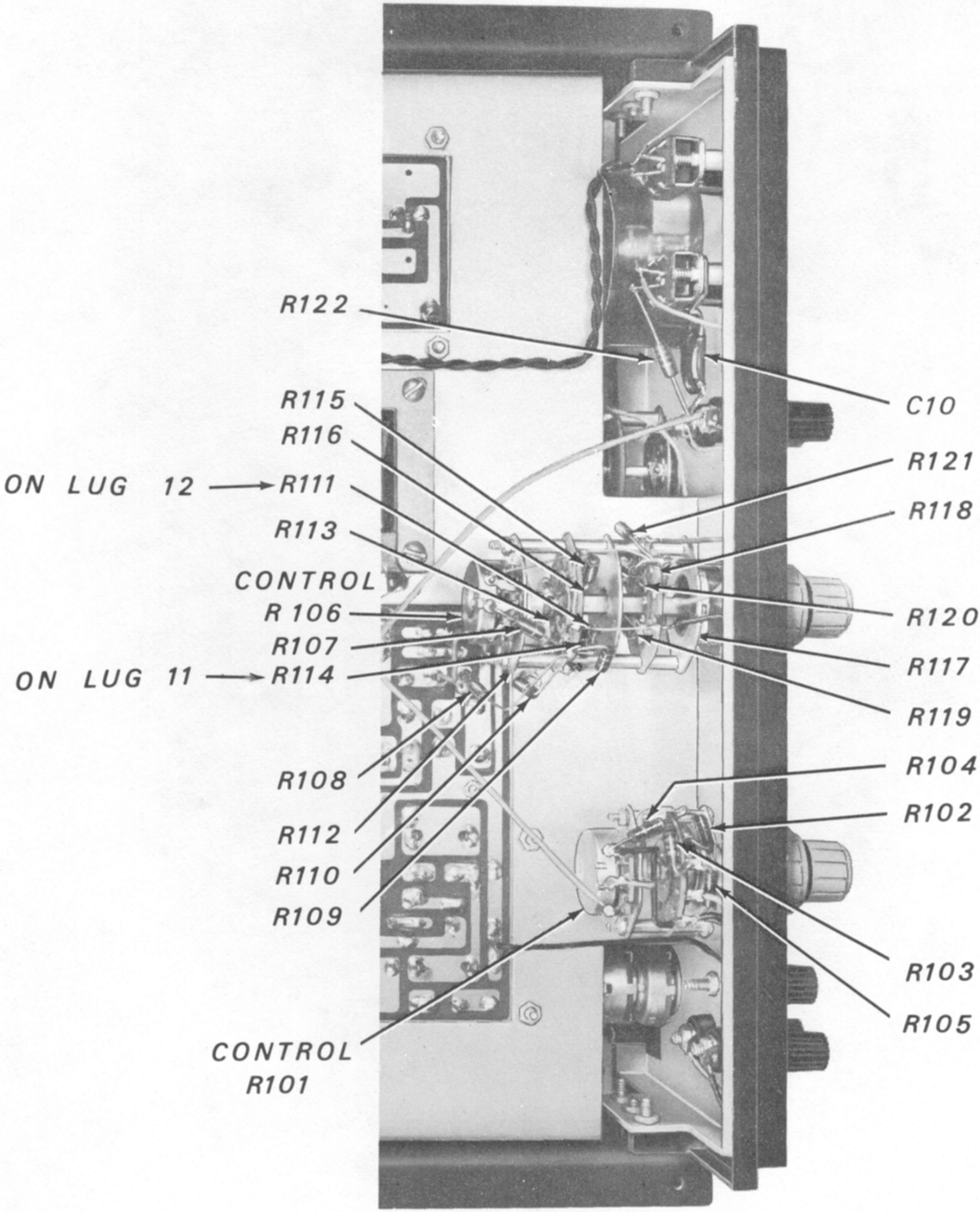
CIRCUIT BOARD X-RAY VIEWS



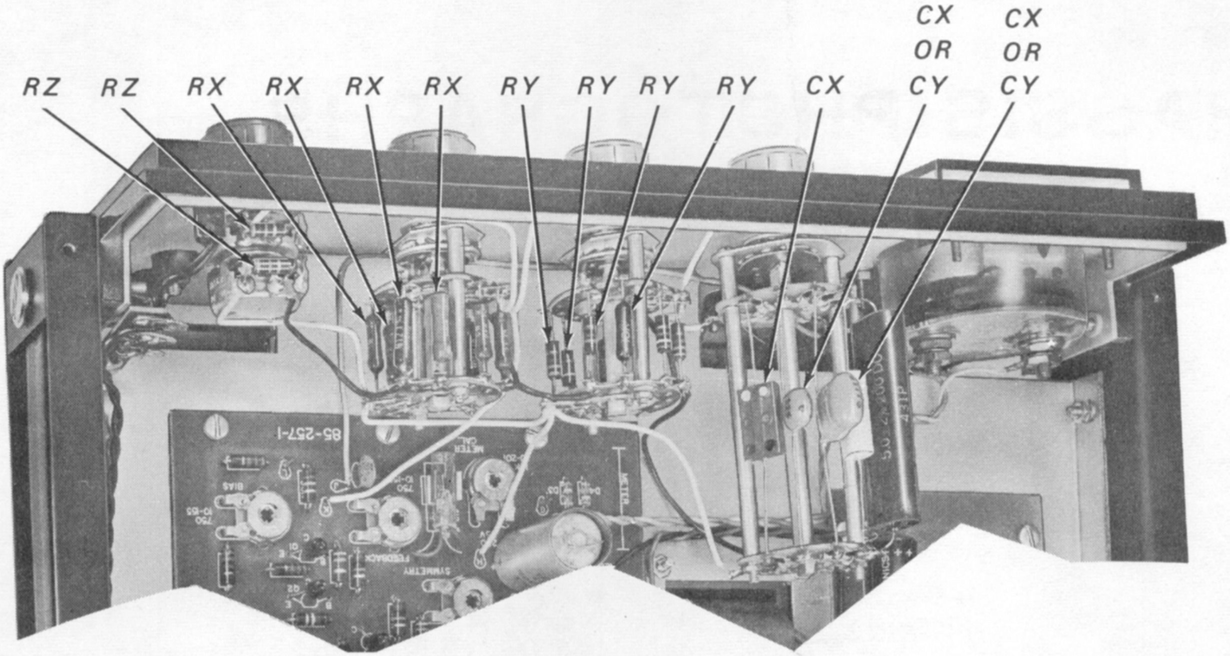
WAVE GENERATOR CIRCUIT BOARD
(VIEWED FROM FOIL SIDE)

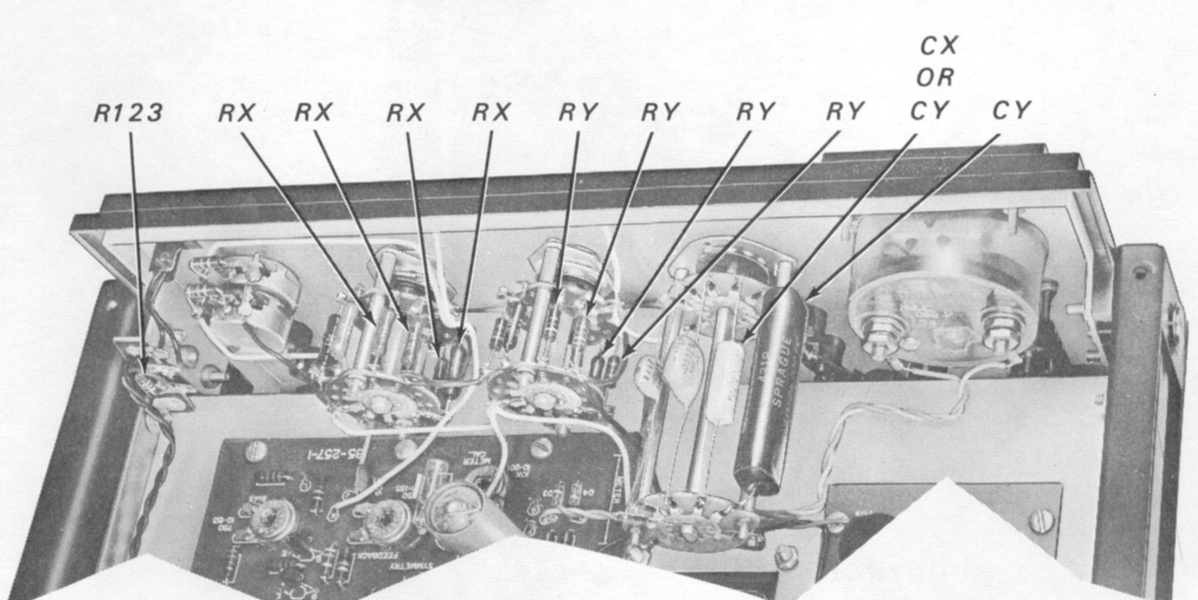


POWER SUPPLY
CIRCUIT BOARD
(VIEWED FROM FOIL SIDE)



R122
C10
R115
R116
ON LUG 12 R111
R121
R118
R113
CONTROL
R 106
R120
R107
R117
ON LUG 11 R114
R119
R108
R104
R102
R112
R110
R109
R103
R105
CONTROL
R101


RZ
RZ
RX
RX
RX
RX
RY
RY
RY
RY
CX
CX OR CY
CX OR CY
85-257-1


R123
RX
RX
RX
RX
RY
RY
RY
RY
CX OR CY
CY
85-257-1
SPRAGUE

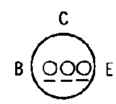
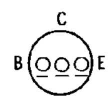
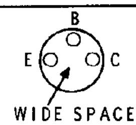
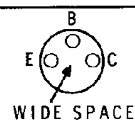
CHASSIS PARTS

PART No.	PRICE Each	DESCRIPTION
RESISTORS		
1-95	.10	560 Ω
1-23	.10	27 kΩ
1-102	.10	82 kΩ
ELECTROLYTIC CAPACITORS		
25-193	.60	250 μF
25-205	1.30	300 μF
27-110	.20	.047 μF Mylar
CONTROL-SWITCHES		
12-96	1.15	1 MΩ dual control
60-24	.50	Rocker switch
PLASTIC PARTS		
70-5	.10	Black test lead insulator
70-6	.10	Red test lead insulator
75-17	.10	Binding post base insulator
75-30	.10	Line cord strain relief, round cord
75-71	.10	Line cord strain relief, flat cord
100-16-2	.10	Binding post cap, black
100-16-18	.10	Binding post cap, red
100-699	.15	Binding post cap, green
207-3	.10	Cable clamp
261-28	.05	Plastic foot
413-10	.10	Red pilot lamp lens
261-30	.10	Line cord retainer
HARDWARE		
#6 Hardware		
250-227	.05	6-32 x 7/8" phillips head screw
250-26	.05	6-32 x 5/8" screw
250-304	.15	6-32 x 7/16" spacer stud
250-89	.05	6-32 x 3/8" screw
250-229	.05	6-32 x 1/4" phillips head screw
250-303	.15	6-32 x 1/4" decorative head screw
250-365	.05	#6 x 1/4" sheet metal screw
254-1	.05	#6 lockwasher
254-27	.05	#6 external-internal lockwasher
255-15	.05	#6 x 1/2" spacer
259-1	.05	#6 solder lug
252-3	.05	6-32 nut

PART No.	PRICE Each	DESCRIPTION
Other Hardware		
252-7	.05	Control nut
253-10	.05	Control flat washer
254-4	.05	Control lockwasher
252-32	.05	Speednut
427-3	.10	Binding post base
METAL PARTS		
90-401-2	2.60	Cabinet half shell
100-769	1.55	Front panel
100-770	1.50	Rear panel
100-771	.85	Side rail
204-759-1	.15	End cap
210-35	2.90	Bezel
211-32	.35	Handle
WIRE		
Hookup Wire		
344-50	.05/ft	Black
344-51	.05/ft	Brown
344-54	.05/ft	Yellow
344-55	.05/ft	Green
344-57	.05/ft	Violet
344-58	.05/ft	Gray
Other Wire		
89-23	.75	Line cord
341-1	.10/ft	Black test lead
341-2	.10/ft	Red test lead
KNOBS AND BUSHINGS		
455-50	.10	Single knob bushing
455-51	.10	Inner shaft knob bushing
455-52	.10	Outer shaft knob bushing
462-245	.25	Single knob
462-247	.35	Outer shaft knob
462-276	.25	Inner shaft knob
MISCELLANEOUS		
253-85	.05	Felt washer
260-16	.10	Alligator clip
407-131	10.60	Meter
412-15	.20	Neon lamp
431-41	.10	2-lug terminal strip
431-35	.10	7-lug terminal strip
432-27	.40	Line cord adapter
438-13	.15	Banana plug
259-20	.05	Solder pin
421-22	.35	3/4 ampere slow-blow fuse

NOTES:

1. RESISTORS AND CAPACITORS, EXCEPT THOSE IN THE NOTCH FILTER CIRCUIT, ARE NUMBERED IN THE FOLLOWING GROUPS:
   - 0-99 PARTS MOUNTED ON CIRCUIT BOARDS.
   - 100-199 PARTS MOUNTED ON CHASSIS.
2. ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (k=1000).
3. ALL CAPACITORS ARE IN μF UNLESS MARKED OTHERWISE (pF=PICOFARAD).
4. ALL SWITCHES SHOWN IN FULL COUNTERCLOCKWISE POSITION WHEN VIEWED FROM THE KNOB END.
5. ▽ INDICATES COMMON CIRCUIT GROUND.
6. ⏚ INDICATES CHASSIS GROUND.
7. REFER TO THE CHASSIS PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.
8. ⬭ +DC VOLTAGES TO EITHER COMMON OUTPUT TERMINAL. ALL CIRCUIT BOARD CONTROLS FULLY CCW, ALL FREQUENCY SWITCHES AND CONTROL CCW, ALL AMPLITUDE SWITCHES AND CONTROLS FULLY CW. VOLTAGES ±10%.
9. ▭ +DC VOLTAGES, THE SAME AS ABOVE, EXCEPT SYMMETRY CONTROL FULLY CW.

TRANSISTOR, DIODE	PART NUMBER	MAY BE REPLACED WITH	BASING DIAGRAM
Q1, Q2, Q4	417-94	2N3416	
Q3, Q5	417-201	2N2306	
Q6, Q7, Q8	417-154	2N2369	
Q10	417-178	40389	
D1, D2, D5, D6	57-65	SILICON 100 PIV, 100 mA	
D3, D4	56-26	1N191	
D7	56-66	ZENER VR43 1 WATT	
D8	56-56	1N4149	

NOTCH FILTER — COMPLETE CIRCUIT