OPERATING AND SERVICE MANUAL

MODEL 103AR

SERIALS PREFIXED: 135 -

QUARTZ OSCILLATOR

01037-2

Printed: JAN 1962

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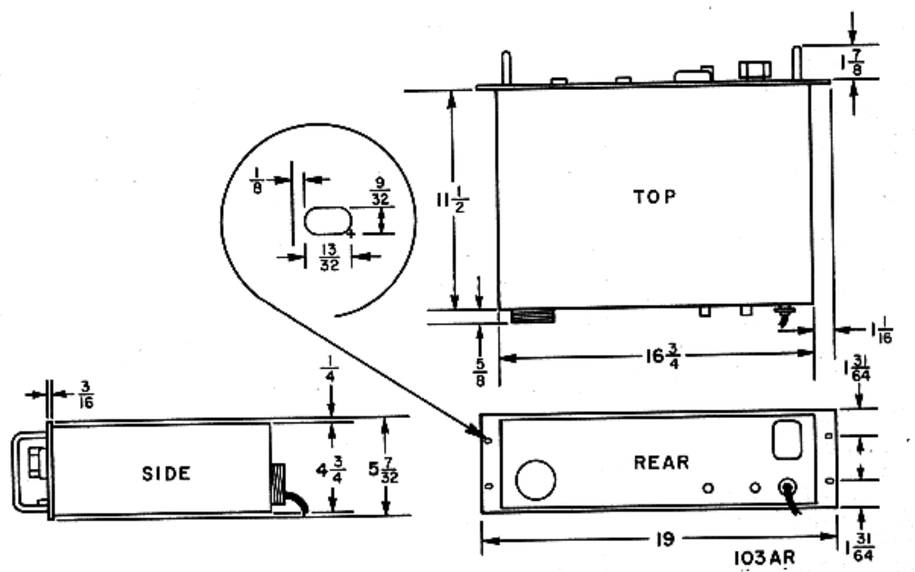
Table 1-1. Specifications

AGING RATE: (after 21 days of operation)	$< \pm 5$ parts in 10^{10} per 24 hours*
STABILITY:	As a function of input voltage: $< \pm 1$ part in 10^{10} for changes of ± 4 volts from 26 volts dc As a function of load: $< \pm 1$ part in 10^{10} for changes from 50 ohms to open or short circuit As a function of ambient temperature: $< \pm 3$ part in 10^{10} for changes of $\pm 25^{\circ}C$ from $25^{\circ}C$
OUTPUT FREQUENCIES:	1) 1 mc sine waves, 1 volt rms into 50 ohms 2) 100 kc sine waves, 1 volt rms into 50 ohms 3) 100 kc output for driving hp 113 Frequency Divider and Clock
HARMONIC DISTORTION:	At least 40 db below rated output
NON-HARMONICALLY RELATED OUTPUT:	At least 80 db below rated output
OUTPUT TERMINALS:	Outputs 1 and 2: BNC connectors on front panel and at rear Output 3: BNC connector at rear
FREQUENCY ADJUSTMENTS:	Coarse: Screwdriver adjustment with range of approximately 1 part in 10^6. Accessible through front panel by removing threaded plug. Fine: Front-panel control with range of approximately 600 parts in 10^{10}. Accessible through front panel by removing threaded plug. Digital indicator calibrated directly in parts in 10^{10}.
MONITOR METER:	Ruggedized front-panel meter and associated selector switch monitors: 1) SUPPLY voltage 2) OSC voltage 3) INNER OVEN current 4) OUTER OVEN current 5) 1 MC output 6) 100 KC output
TEMPERATURE RANGE:	0-50°C
SIZE:	Rack Mount: 
WEIGHT:	Net approximately 17 lbs
POWER REQUIREMENT:	22 to 30 volts dc positive ground, approximately 5 watts after warmup at room temperature. Approximately 10 watts maximum during warmup. hp 724BR/725AR Standby Power Supply with standby battery recommended.
ACCESSORY FURNISHED:	Cable for connecting hp 103AR Frequency Standard to hp Standby Power Supply
COMPLEMENTARY EQUIPMENT:	hp Model 724BR Standby Power Supply, with battery, 16 ampere-hour standby capacity hp Model 725AR Standby Power Supply with battery, 2 ampere-hour capacity hp Model 113BR Frequency Divider and Clock hp Model 120AR Oscilloscope

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual provides instructions on installation, operation, and maintenance of the hp Model 103AR Quartz Oscillator, and applies directly to all instruments whose serial number is prefixed as indicated on the title page. The serial number is stamped on the tag at the rear of the chassis.

1-3. DESCRIPTION.

1-4. The hp 103AR Quartz Oscillator has a stability of 5 parts in 10^{10} per day or better. High stability is achieved by housing the high-quality crystal and all critical elements in a double oven having proportional control. Short-term stability is 5 parts in 10^{10} averaged over one-second intervals. Under reasonably constant conditions, short-term stability is typically one part in 10^{10} averaged over one second intervals.

1-5. The oscillator is well isolated from external circuit influences. Each output signal is isolated in such a way that short-circuiting the 1-mc output will not affect the 100-kc output and vice versa.

1-6. Two output signals, 1 mc and 100 kc are supplied from a low impedance source at a power level well suited for distribution over 50-ohm systems. A separate 100-kc output signal is furnished for driving the 113AR/BR Frequency Divider and Clock or equivalent. Fail-safe operation is provided by using a non-selfstarting regenerative frequency divider. The 100-kc output will cease if any interruptions of power or signal occur.

1-7. The 103AR Quartz Oscillator is used in primary frequency and time standards. The hp 103AR Quartz Oscillator, hp 724BR Standby Power Supply, and hp 113AR/BR Frequency Divider and Clock are the basic elements of a primary frequency and time standard system of small size, and capable of high resolution accuracy. For high frequency (hf) time comparisons, a receiver and triggered oscilloscope such as the hp Model 120AR complete the system. Very low frequency (vlf) comparisons may be made by using a time interval counter such as the hp Model 523 or 524 series electronic counters. Power for the Model 103AR can be obtained from the Model 724BR. Power interruptions have no effect on performance. For use as a secondary standard, only the 103AR and 724BR are required.

1-8. Throughout this manual, the AR Quartz Oscillator will be referred to as the "oscillator", and the 113AR/BR Frequency Divider and Clock will be referred to as the "clock".

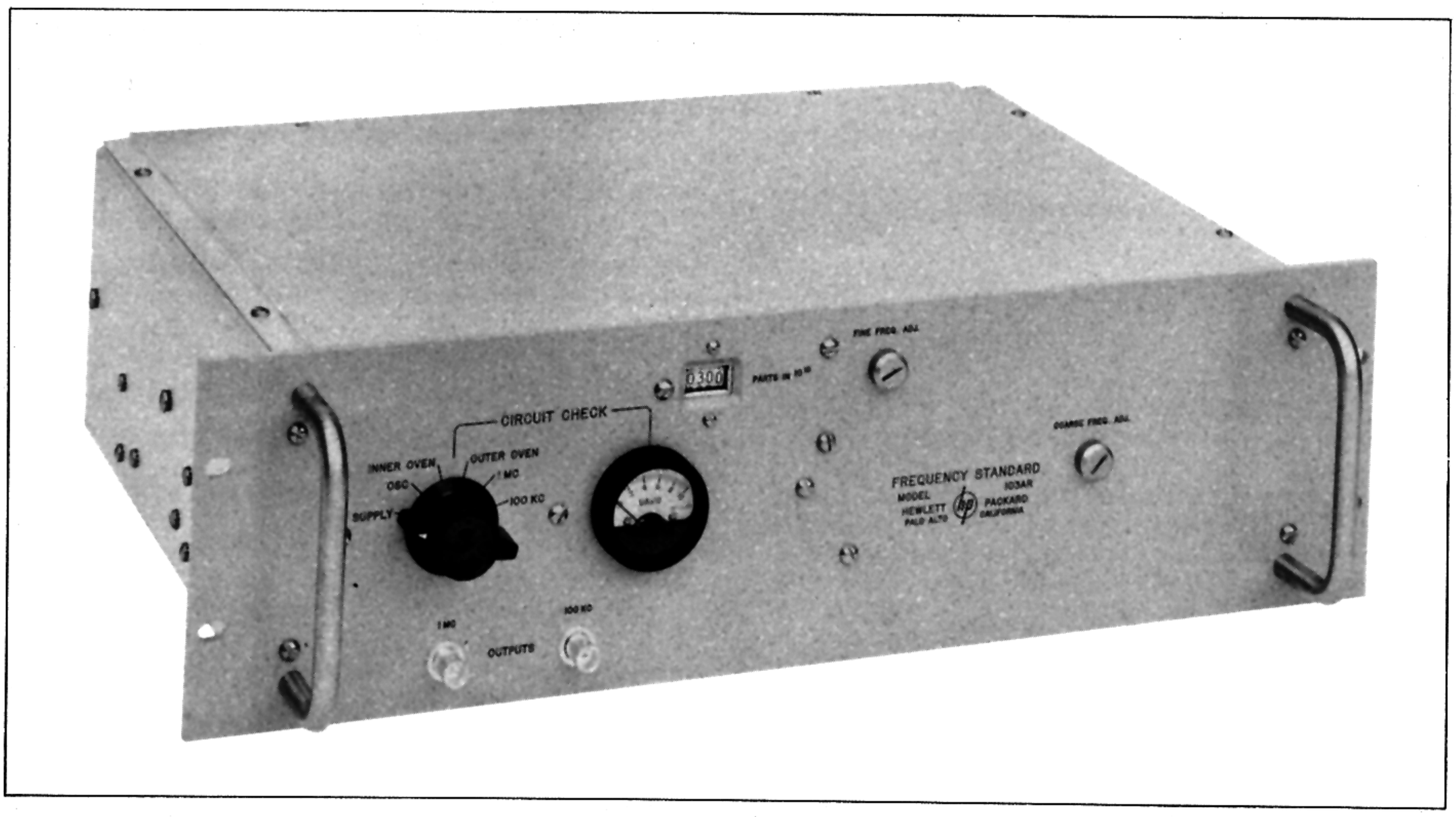


Figure 1-1. Model 103AR Quartz Oscillator

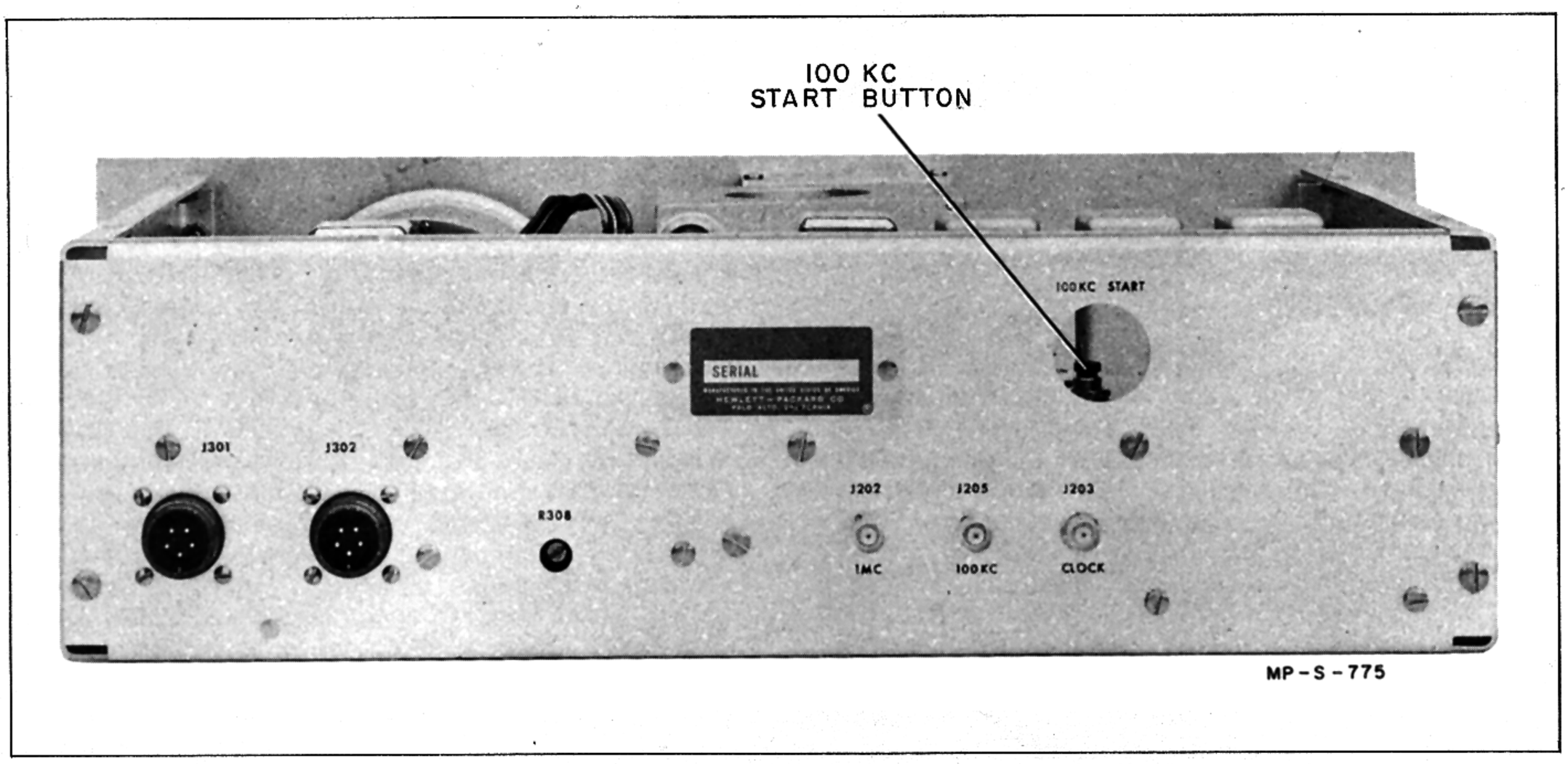


Figure 2-1. Rear View Model 103AR

SECTION II
PREPARATION FOR USE

2-1. UNPACKING & MECHANICAL INSPECTION.

2-2. Inspect the instrument for shipping damage as soon as it is unpacked. If reshipment is expected, save all packing material. Check for broken knobs, meter faces, or connectors. Inspect painted surfaces for scratched or abraided areas. If the instrument is damaged in any way, notify the carrier to report damage immediately. Carrier will arrange for repair or reshipment as necessary.

2-3. PACKING FOR STORAGE OR RESHIPMENT.

2-4. To protect valuable electronic equipment during storage or shipment, always use the best packaging methods available. Contract packaging companies in many cities can provide dependable packing on short notice. The following packaging methods are recommended:

a. Original. Place instrument in original container. Replace all packing pads and fillers in the exact position they originally occupied.

b. Rubberized Hair. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/square inch bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert filler between pads and container to insure a snug fit on all surfaces of the instrument.

c. Excelsior. Cover painted surfaces with protective wrapping paper. Pack instrument in a strong corrugated container (350 lb/square inch bursting test) with a layer of excelsior about 6 inches thick, packed firmly against all surfaces of the instrument.

2-5. ENVIRONMENTAL CONDITIONS DURING STORAGE AND SHIPMENT.

2-6. Environmental conditions during storage and shipment should normally be limited as follows:

a. Maximum altitude: 20,000 feet.

b. Maximum temperature: 65°C (144°F).

c. Minimum temperature: -40°C (-40°F).

2-7. INSTALLATION.

WARNING

If the oscillator is being used with a clock, the clock must have a positive ground. The oscillator uses a positive ground. If the clock has a negative ground and the oscillator is connected to the system, a short circuit will exist. Use an isolated power supply for oscillator or change the clock to use a positive ground.

2-8. Mount the oscillator in a standard size rack. Ambient temperature in the rack during operation should not exceed a maximum of 50°C (122°F) or a minimum of 0°C (32°F).

2-9. Connect the socket end of the power cable (supplied with the oscillator) to either of the power connectors, J301 or J302, at the rear of the instrument. Pin A of either connector must be connected to the positive terminal of the dc supply. Pin C must be connected to the negative terminal of the dc supply.

2-10. Set the CIRCUIT CHECK switch to SUPPLY. The meter should indicate between 7.0 and 9.0.

2-11. If the oscillator is not used with the clock, connect the appropriate output of the oscillator to input of the system used. If the oscillator is to be used with the clock, connect the clock 100 KC INPUT connector to the CLOCK connector at the rear of the oscillator. The oscillator has been adjusted at the fáctory for optimum performance and should require no adjustment.

a. OSC: Meter should indicate between 7.0 and 9.0.

b. INNER OVEN: Same as step a (7.0 and 9.0).

c. OUTER OVEN: Meter may indicate between 7.0 and 10.0, depending upon the oven temperature.

d. 100 KC: Meter should indicate zero.

e. 1 MC: Meter should indicate between 7.0 and 9.0.

2-12. STARTING THE REGENERATIVE FREQUENCY DIVIDER.

2-13. To start the regenerative frequency divider, depress the 100 KC START button. See figure 2-1. After the button is depressed, set the CIRCUIT CHECK switch to 100 KC. The meter should indicate between 7.0 and 9.0.

2-14. If the oscillator is being used with the clock, start the clock. Refer to the clock manual. If the clock does not start, check the oscillator. See section VIII of this manual. If it is determined the oscillator is operating properly, troubleshoot the clock.

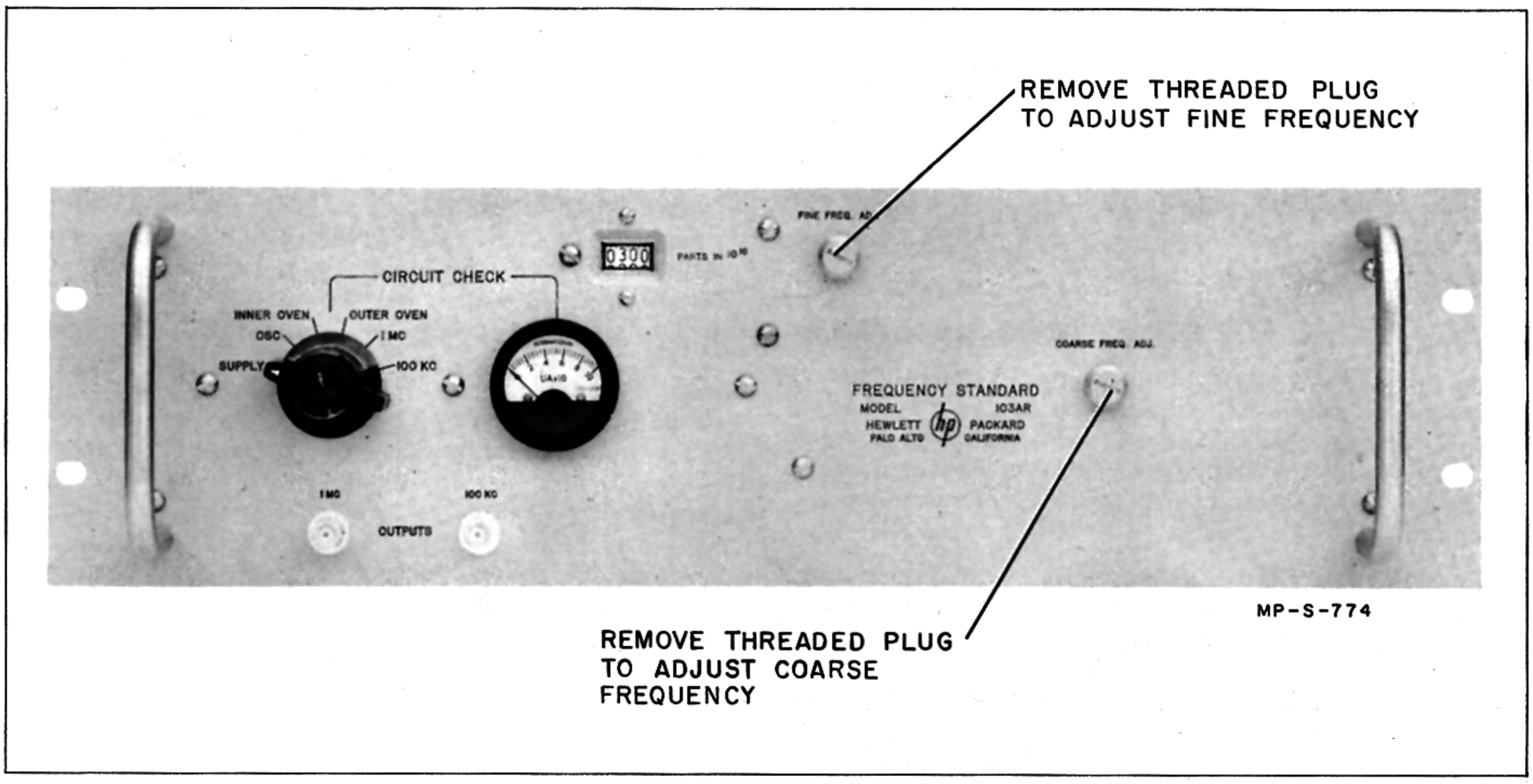


Figure 3-1. Front View Model 103AR

SECTION III
OPERATING INSTRUCTIONS

3-1. POWER SUPPLY.

3-2. Power is supplied to the oscillator immediately when the power cable is connected to the 724BR power supply or equivalent. The oscillator is not equipped with a power on-off switch. To remove power from the oscillator, disconnect the power connector from the rear of the instrument.

3-3. FRONT-PANEL CONTROLS.

3-4. The oscillator has three front-panel controls (see figure 3-1):

a. CIRCUIT CHECK switch: Enables the operator to monitor the operation of various circuits.

b. FINE FREQ. ADJ.: Available from the front panel when the threaded plug is removed. The control is geared to the PARTS IN 10^{10} counter and gives a visual indication as FINE FREQ. ADJ. is turned.

c. COARSE FREQ. ADJ.: Available from the front panel when the threaded plug is removed. Gives a larger change of frequency with no visual indication.

3-5. OUTPUT CONNECTORS.

3-6. The oscillator has five signal output connectors. The front panel has two output connectors, 100 KC and 1 MC OUTPUTS (see figure 3-1). The rear of the instrument has three output connectors, 100 KC, 1 MC, and CLOCK. The front panel 100 KC and 1 MC OUTPUTS are parallel with the rear 100 KC and 1 MC outputs (see figures 2-1 and 3-1).

3-7. OVEN TEMPERATURE AND STABILITY.

3-8. After the oscillator is initially connected to power, three weeks may be required for the crystal to stabilize to 5 parts in 10^{10}.

3-9. The oven is held to within approximately 1/500 of a degree. When the oscillator is tested at the factory, the oven is adjusted to the temperature of maximum stability of the individual crystal. As the oven temperature is varied, the oscillator frequency will vary as shown in figure 8-1.

NOTE

The operating point of the oven is set at the factory and cannot be changed unless another frequency standard with stability equal to or better than the oscillator is available. Under these conditions the operating point can be changed. See paragraph 8-11.

3-10. FINE FREQUENCY ADJUSTMENT.

3-11. The FINE FREQ. ADJ. is geared to the PARTS IN 10^{10} counter. As the FINE FREQ. ADJ. is turned, the counter registers the frequency change in the number of parts in 10^{10}. The counter is usable only to 600. After 600 the hundreds digit appears in red. When the red number is reached, it becomes necessary to use the COARSE FREQ. ADJ. (paragraph 3-13).

3-12. After the oscillator has stabilized, periodic corrections will be necessary. If the oscillator is used with the clock, when a time comparison is made, the time the clock has gained or lost divided by the period between measurements, in seconds, will give the oscillator error in 10^{10}. The PARTS IN 10^{10} counter is then advanced or retarded by turning the FINE FREQ. ADJ. For additional information see the hp Application Note 52, available from the Hewlett-Packard Company.

3-13. COARSE FREQUENCY ADJUSTMENT.

3-14. If it is necessary to set the COARSE FREQ. ADJ. proceed as follows:

a. Remove the COARSE FREQ. ADJ. threaded plug on front panel. The COARSE FREQ. ADJ. gives 10,000 parts in 10^{10} change for approximately 180^{o} rotation, thus 18^{o} rotation will give approximately 1000 parts in 10^{10} change, and $4\text{-}1/2^{o}$ will give approximately 250 parts in 10^{10} change.

b. Remove the FINE FREQ. ADJ. threaded plug. Adjust the FINE FREQ. ADJ. until the PARTS IN 10^{10} counter indicates 300.

c. Adjust the COARSE FREQ. ADJ. clockwise, $4\text{-}1/2^{o}$ for a frequency higher by 250 parts in 10^{10}, or counterclockwise $4\text{-}1/2^{o}$ for a frequency lower by 250 parts in 10^{10}. Adjustment is made by inserting a screwdriver in the COARSE FREQ. ADJ., pressing in and turning the screwdriver until the outer shaft becomes engaged with the COARSE FREQ. ADJ. capacitor shaft. Then adjust as needed.

d. Replace the COARSE and FINE FREQ. ADJ. threaded plugs.

e. The accuracy of the adjustment can be determined when the next time comparison measurement is made. Use the average of several time comparison measurements taken several days apart to adjust any error out of the oscillator.

f. If the oscillator is still out of the range of the FINE FREQ. ADJ., repeat steps b through e.

g. Replace threaded plugs.

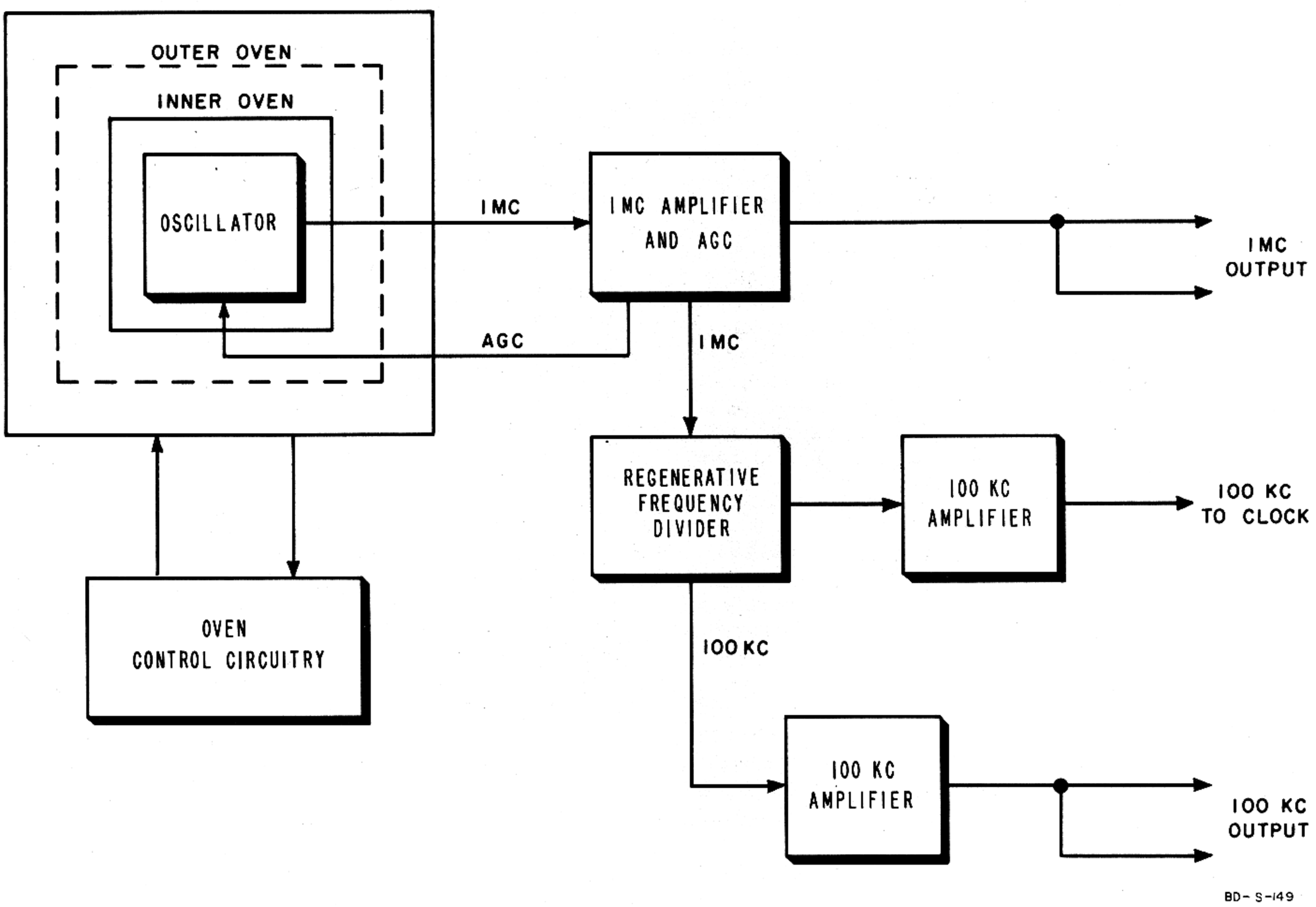


Figure 5-1. Simplified Block Diagram

SECTION IV
PERIODIC INSPECTION AND MAINTENANCE

4-1. DAILY INSPECTION.

4-2. The CIRCUIT CHECK meter indications typically are between 7.0 and 9.0 for each position of the switch. Excessive deviation from this indication indicates either marginal operation or a circuit malfunction. Keep a permanent record of CIRCUIT CHECK meter indications for maintenance purposes.

4-3. MAINTENANCE.

4-4. Little or no maintenance except daily inspection will be required for the oscillator. No lubrication is required.

SECTION V
PRINCIPLES OF OPERATION

5-1. INTRODUCTION.

5-2. Section V contains information relating to the operating theory of the oscillator. The block diagram gives an overall view and the functional diagram gives the theory of operation.

5-3. SIMPLIFIED BLOCK DIAGRAM.

5-4. Figure 5-1 is a simplified block diagram of the oscillator. The 1-mc crystal oscillator is contained in a constant temperature oven. The output of the oscillator is applied to 1-mc amplifiers and is available at two output connectors. Part of the 1-mc signal drives a regenerative frequency divider which provides a 100-kc signal. The 100 kc is amplified and supplied to output connectors.

5-5. OSCILLATOR OVEN.

5-6. The oscillator oven consists of two sections, an outer and inner oven. Both ovens operate continuously. The inner oven is 0.2 watt, the outer oven is 2 watt. When the oscillator is initially turned on, both ovens operate at maximum heat. As the oven temperature approaches the operating point, the inner and outer oven idle to low heat.

5-7. Figure 5-2 is a functional diagram of the oscillator. The oven and control circuitry consist of the following:

a. Oven control oscillator, Q301, Q302, and T301.

b. Detector, Q303.

c. Temperature sensing element, RT101. Thermistor RT101 has a negative temperature coefficient. Resistors R101, RT101, and the upper two secondaries of T301 form a bridge circuit.

d. Inner oven heater, R102, R103.

e. Inner oven heater amplifier, Q304.

f. Outer oven heater, R104, R105 (not shown on functional diagram).

g. Amplifier, Q305.

h. Outer oven heater amplifier, Q306.

5-8. Oscillation is sustained because of the regenerative feedback from the junction of R101 and RT101. The bridge approaches a balanced condition at correct oven temperature. The voltage waveforms at points A and B with respect to point C, and C with respect to ground at normal oven temperature, are shown in the waveform chart in figure 5-2. Waveform C is the resultant of A and B.

5-9. When the oven is cool, RT101 resistance is high. The bridge is very unbalanced. The voltage drop across RT101 is much larger than across R101. The voltage waveforms at points A, B, and C are now as shown in the chart at A1, B1, and C1. Waveform C1 is the resultant of the two waveforms at A1 and B1. The amplitude at C1 is now larger and causes the oven control oscillator output voltage to increase. A larger signal is applied to detector Q303 which then supplies a larger signal to the inner oven heater amplifier. This causes more current to flow through the inner oven heaters. The larger voltage drop across the inner oven heaters increases the forward bias on Q306, causing a larger outer heater current. When the oven chamber reaches its operating temperature, the bridge approaches balance and oscillator output decreases. Detector output therefore decreases, causing lower heater current.

5-10. The collector voltage of Q304 can be monitored by setting the CIRCUIT CHECK switch to INNER OVEN.

5-11. The emitter voltage of Q306 can be monitored by setting the CIRCUIT CHECK switch to OUTER OVEN.

5-12. Resistor R308 is a 23-position switch with resistance wire connected between contacts. As the switch is rotated clockwise or counterclockwise, the operating point of the oven will rise or fall. Resistor R308 changes the oven temperature approximately 0.1 degree per position. The operating point of the oven is nominally between 63 and 68 degrees centigrade.

5-13. 1 MC OSCILLATOR AND AMPLIFIERS.

5-14. Refer to the functional diagram in figure 5-2. Oscillator Q101 is a crystal controlled type. The frequency can be varied slightly by changing the capacity of the quartz crystal circuitry using the FINE and COARSE FREQ. ADJ. The FINE FREQ. ADJ. is geared to the PARTS IN 10^{10} counter. The output of the oscillator is applied to Q102, an isolation amplifier, then applied to Q103 and Q104. The collector circuit transformer of Q104 has an agc winding whose output is rectified by a voltage doubler and applied to the oscillator. The 1-mc signal is then applied to Q201 and Q202 and supplied to the output connectors. A portion of the 1-mc signal is rectified, filtered, and used in the metering circuits.

5-15. The oscillator output can be checked by setting the CIRCUIT CHECK switch to OSC. The 1-mc output can be checked by setting the CIRCUIT CHECK switch to 1 MC.

5-16. REGENERATIVE FREQUENCY DIVIDER AND 100 KC AMPLIFIERS.

5-17. The output of Q102 is also applied to Q203, amplified, and applied to a crystal mixer. Nothing further occurs until the 100 KC START button is depressed. Refer to the schematic diagram in figure 9-2. When the button is depressed, Q205, C251, L203, and C234 become a 100-kc oscillator. When the button is released, the oscillator becomes an 100-kc amplifier.

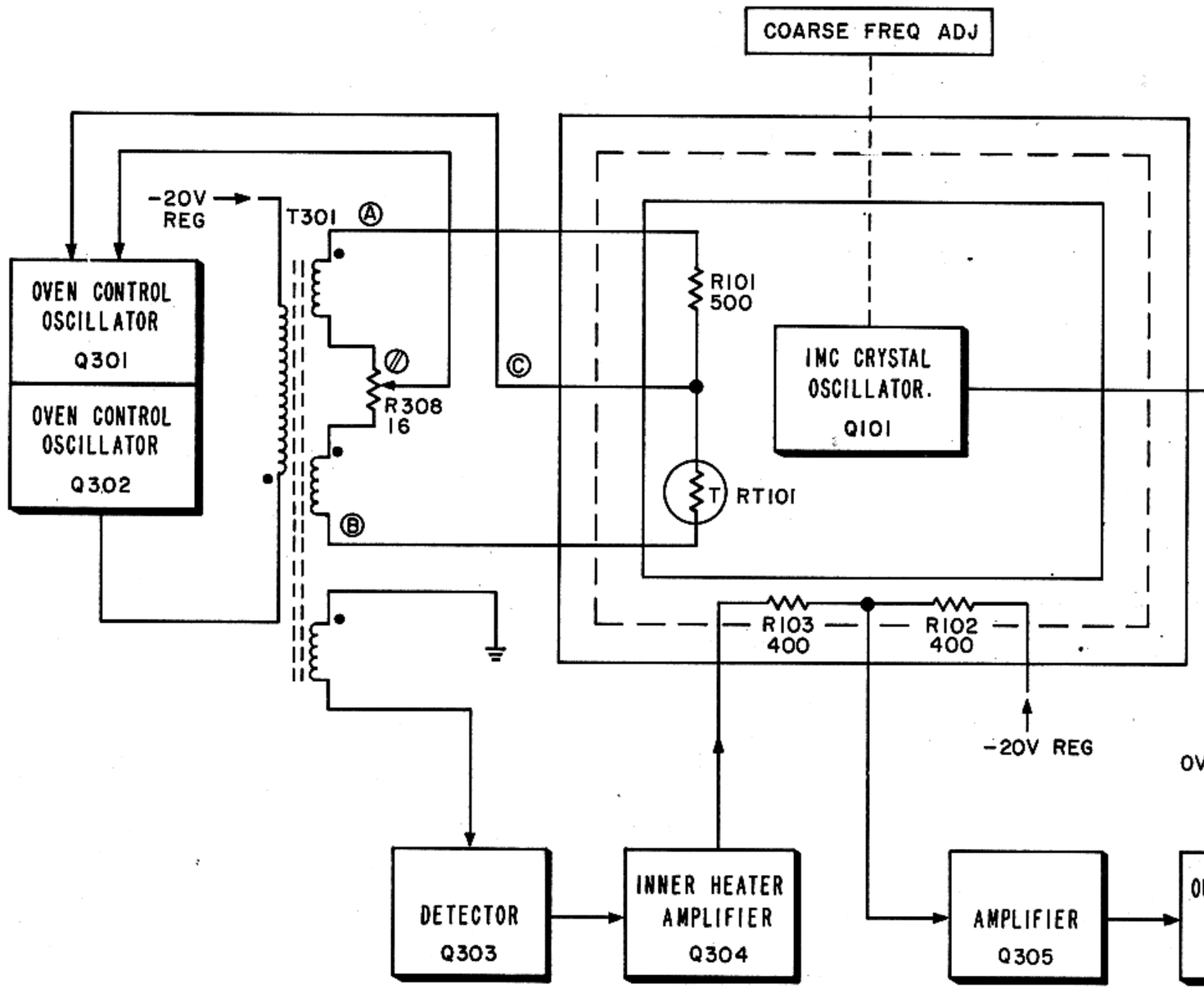
5-18. The 100-kc oscillator signal is momentarily applied to Q204, a X9 multiplier circuit. Q204 is operated in a non-linear manner to obtain harmonics in its output. One secondary of T204 is the collector load for Q204. The other secondary winding is an LC circuit resonant at 900 kc which rings upon excitation from Q204. The 900-kc signal is coupled to the primary of T204 and applied along with the 1-mc signal to the mixer. Refer to the block diagram in figure 5-2. The mixer heterodynes the two signals. Tank circuit L201 and C232 in the output of the mixer is resonant at 100 kc. The difference-frequency (100 kc) current develops a voltage across the tank circuit which is applied to Q205 and amplified.

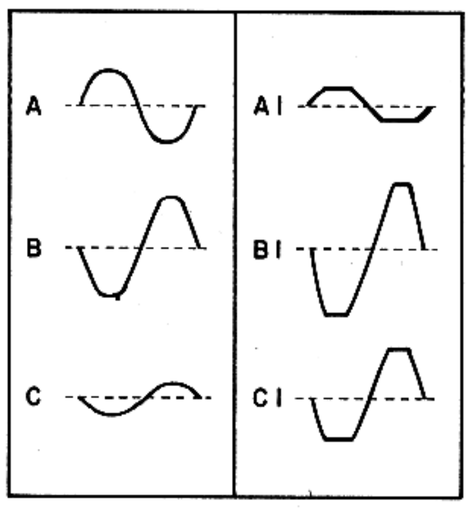
5-19. Part of the 100-kc signal is applied to emitter follower Q206, and is available at the CLOCK output connector. Refer to figure 5-2. Part of the 100-kc signal is applied to Q207, amplified, and available at the 100 KC OUTPUT connectors.

5-20. The 100 KC OUTPUT can be monitored by setting the CIRCUIT CHECK switch to 100 KC.

5-21. POWER SUPPLY (Regulator).

5-22. The regulator uses two breakdown diodes for a voltage reference and a third as a -7 volt regulated source. Refer to the schematic, figure 8-3. The supply voltage for the regulator is between 22 and 30 volts. The output of the regulator is -20 volts regulated. Diodes CR302A and CR302B supply the base of Q307 with a -20 volt reference level. If the output voltage of the regulator becomes more negative, the forward bias on Q307 decreases. The transistor emitter-collector impedance increases, the output voltage decreases until Q307 emitter-base bias approaches 0 volt. To check the regulator output, set the CIRCUIT CHECK switch to SUPPLY.





WAVEFORMS CHART

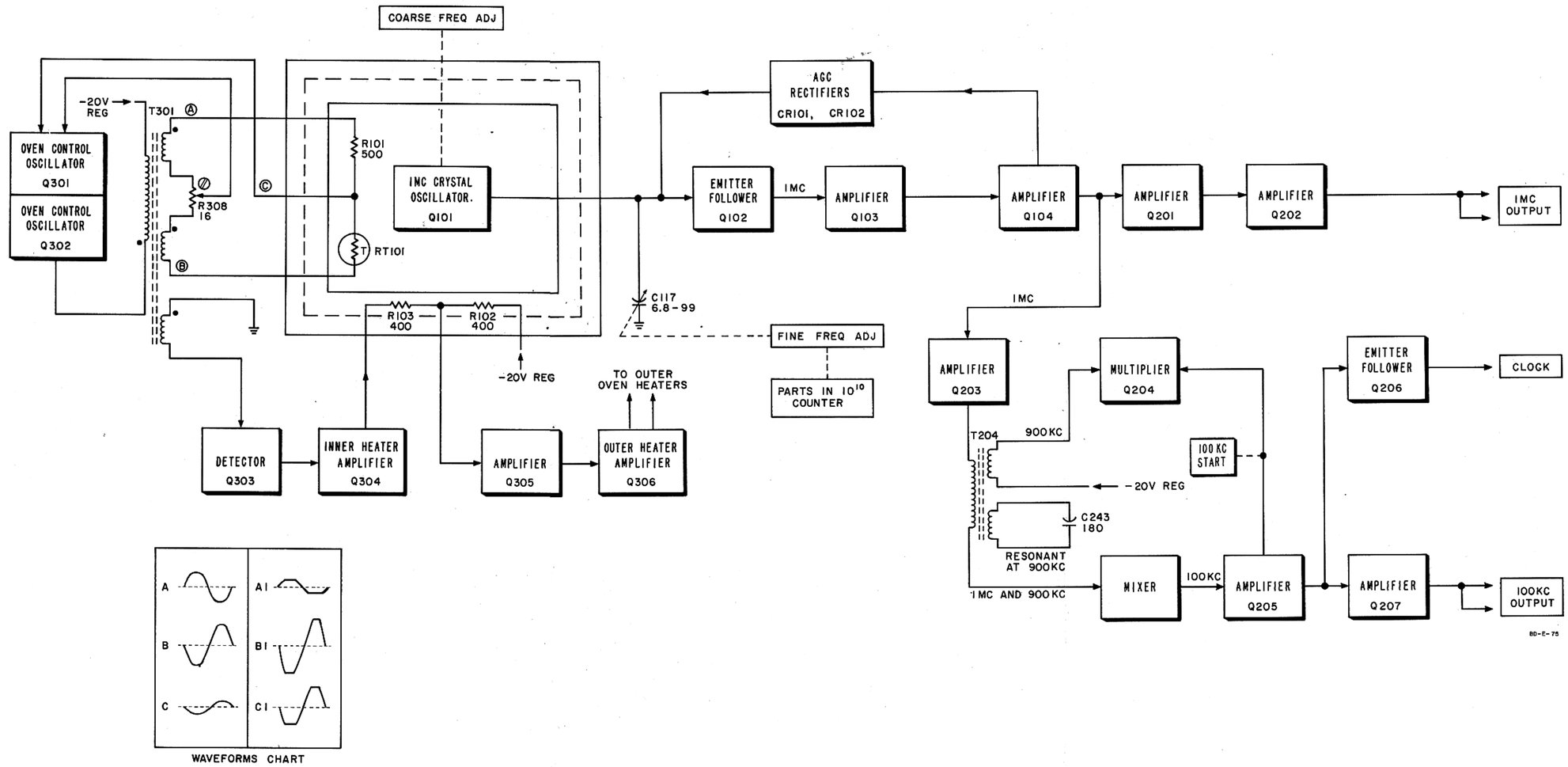


Figure 5-2. Functional Diagram

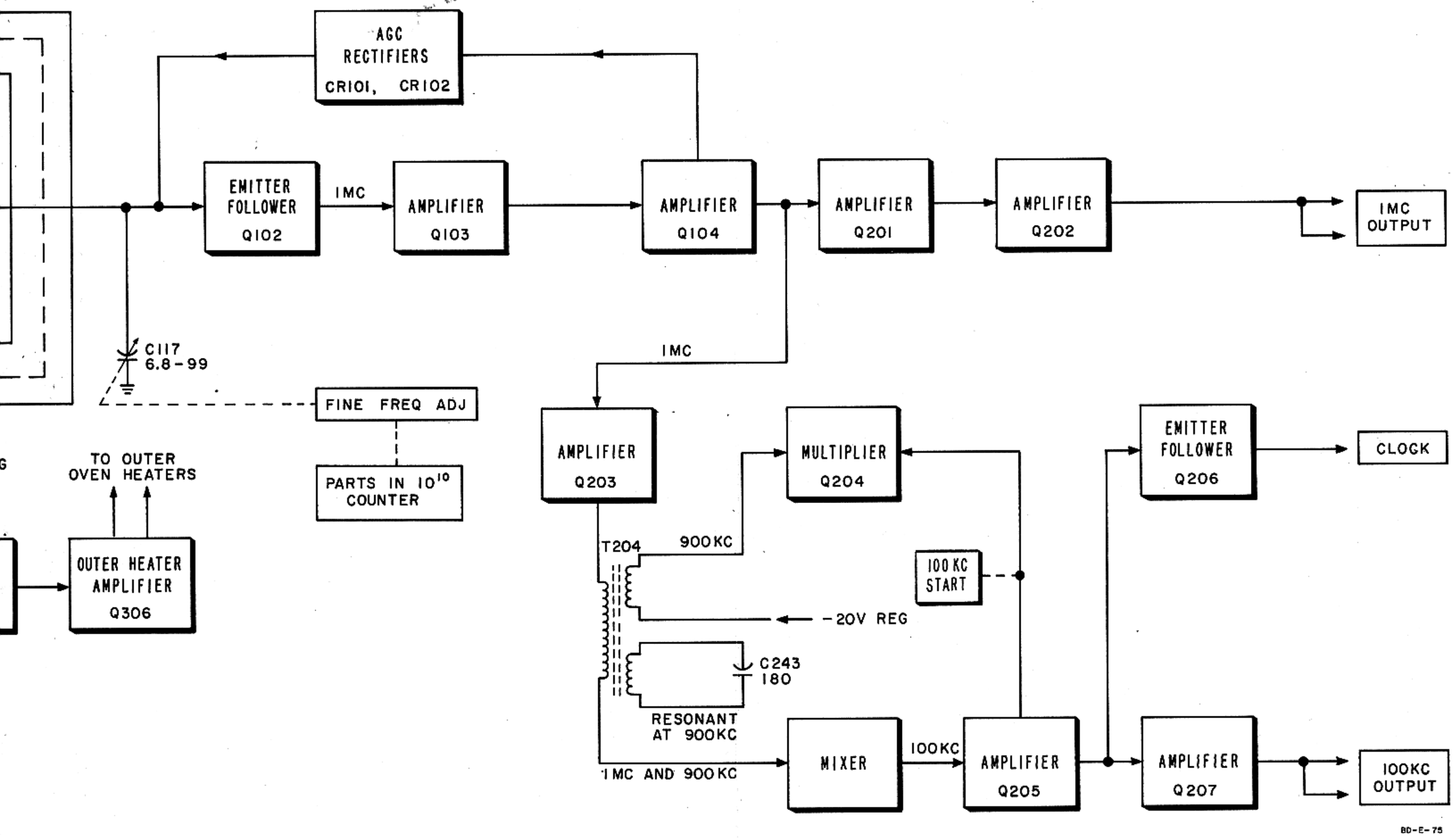


Figure 5-2. Functional Diagram

SECTION VI
TROUBLESHOOTING

6-1. GENERAL INFORMATION.

6-2. The oscillator covers can be removed for routine inspection and maintenance while in operation by removing the seven screws around the edges of top and bottom covers. Do not loosen any other screws.

6-3. The following method is recommended for finding circuit failures:

a. Sectionalization. Sectionalize trouble by evaluating front-panel symptoms. See paragraph 6-6.

b. Localization. Localize trouble by making voltage checks in the defective section. See paragraph 6-9.

c. Substitution. Check for failure of individual components by substitution, resistance measurements, etc.

6-4. TEST EQUIPMENT.

6-5. The following test equipment or its equivalent is required for troubleshooting the oscillator:

a. Oscilloscope: Frequency range, dc to 1 mc, such as hp Model 150A.

b. DC Vacuum Tube Voltmeter: Voltage range 0.1 to 30 volts, such as hp Model 412A.

c. AC Vacuum Tube Voltmeter: Frequency range 100 kc to 1 mc, such as hp Model 400D.

d. Signal Generator: Frequency range 100 kc to 1 mc, such as hp Model 650A.

6-6. SECTIONALIZATION.

6-7. To determine the general location of a faulty circuit, proceed as follows. Set the CIRCUIT CHECK switch to each position and note the meter indication. If a particular meter indication is not within the limits listed in table 6-1, troubleshoot the circuit to which the CIRCUIT CHECK switch is positioned.

6-8. If the CIRCUIT CHECK meter indicates all circuits except the 100-kc circuits are normal, and the 100-kc meter indication is "0", try restarting the regenerative frequency divider. Momentary power or signal interruption may have stopped the divider. See paragraph 2-12 to start the divider. If the regenerative divider will not start and 1-mc meter indication is normal, troubleshoot the regenerative divider circuits.

6-9. LOCALIZATION.

6-10. After determining which section of the oscillator is defective, make dc voltage checks on the emitter, base, and collector of the transistors involved. Typical dc voltages for each stage are shown on the schematics. The voltages in parentheses are measured with the regenerative frequency divider nonoperating.

Table 6-1. Circuit Check Meter Indications

CIRCUIT CHECK Switch Position	Meter Indication
SUPPLY	7.0 to 9.0
OSC	7.0 to 9.0
INNER OVEN	7.0 to 9.0
OUTER OVEN (cold)	full scale
OUTER OVEN (warm)	7.0 to 9.0 (at ambient temperature of 25°C)
1 MC	7.0 to 9.0
100 KC	7.0 to 9.0

Note: The 1 MC and 100 KC meter indications may be lower than above if outputs are connected to load

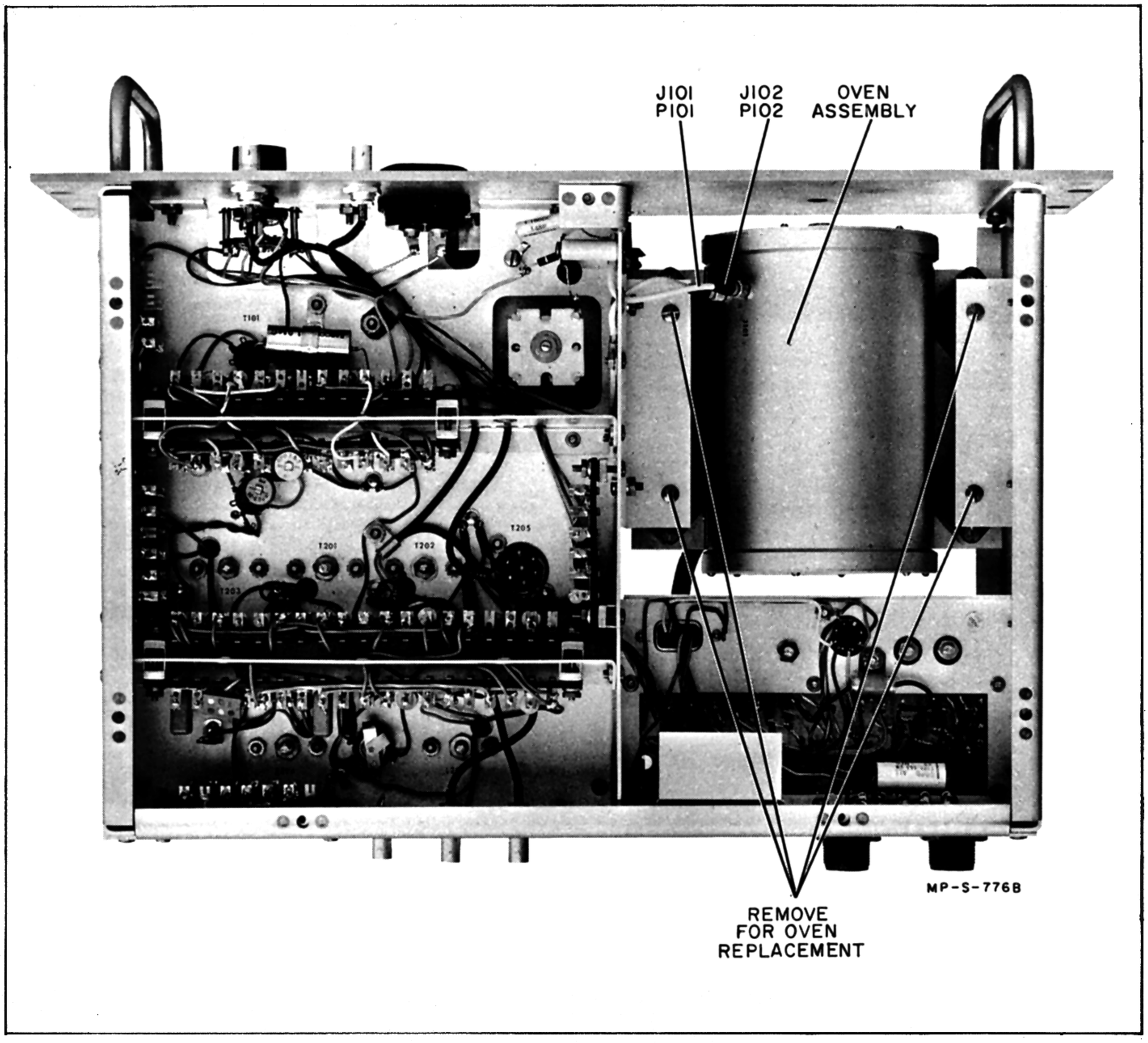


Figure 7-1. Bottom View Model 103AR

SECTION VII
REPAIRS

7-1. SECTIONS REQUIRING SPECIAL ATTENTION.

7-2. OSCILLATOR OVEN.

7-3. If it is determined the malfunction is located in the oven, DO NOT DISMANTLE the oven. It is a semi-sealed unit and must be sent to the factory for repairs. Guarantee is voided if oven is tampered with. To remove the oven, proceed as follows:

a. Remove power from the oscillator.

b. Disconnect P103 from J103, P101 from J101, and P102 from J102. See figures 7-1 and 7-2.

c. Remove the screw in the shock mount at each corner of the oven. See figure 7-1.

d. Carefully remove the oven from the frequency standard. Pack and prepare oven for shipment. See paragraph 2-3.

7-4. When the oven is returned from the factory and installed in the oscillator, connect the oscillator to power. If necessary adjust oven operating point. See paragraph 8-11 to set operating point.

7-5. TRANSISTORS Q102, Q103, and COMPONENTS.

7-6. Before any repairs are made on Q102 or Q103 circuits, disconnect P101 and P102 from the oven. This action prevents crystal damage.

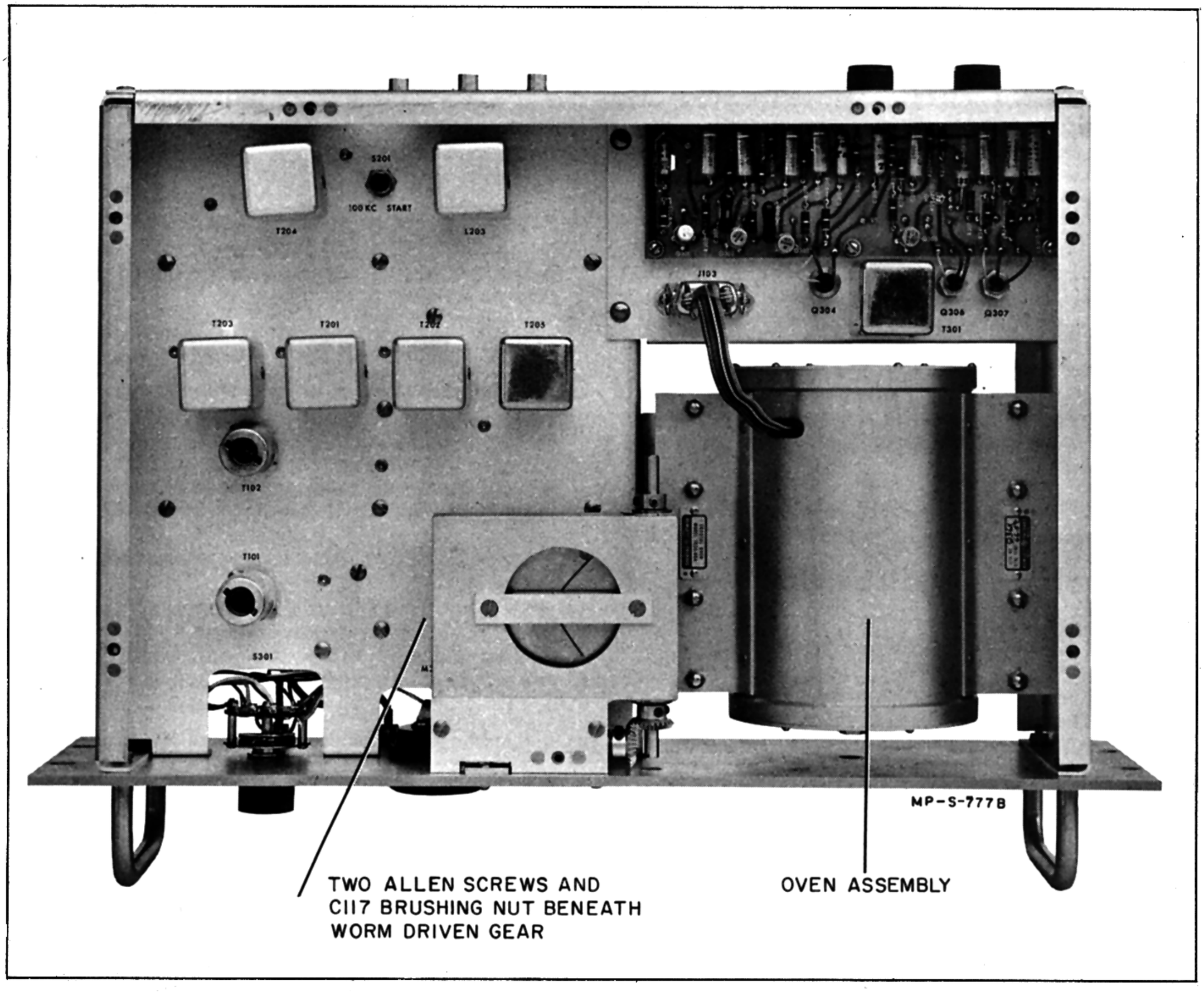


Figure 7-2. Top View Model 103AR

7-7. TRANSISTORS Q201, Q202, Q205, Q207, and COMPONENTS.

7-8. When components in Q201 or Q202 circuits are replaced, check the 1 MC OUTPUT. The output voltage should be between 1.0 and 1.1 volts with a 50-ohm load connected to the 1 MC OUTPUT. If necessary change R220 to obtain 1.0 to 1.1 volts. Then connect an oscilloscope such as the hp Model 150A to the emitter of Q202. The waveform should be a sine wave with little or no clipping or distortion.

7-9. When components in Q205 or Q207 are replaced, check the 100 KC OUTPUT. The output voltage should be between 1.0 and 1.1 volts with a 50-ohm load connected to the 100 KC OUTPUT. If necessary, change R280 to obtain 1.0 to 1.1 volts. Then connect an oscilloscope such as the hp Model 150A to the emitter of Q207. The waveform should be a sine wave with little or no clipping or distortion.

7-10. TRANSISTORS Q102, Q103, Q104, and COMPONENTS.

7-11. Before components in Q102, Q103, or Q104 circuits are replaced disconnect P101 and P102 from the oven. This action will prevent damage to the crystal.

7-12. TRANSISTOR AND COMPONENTS REPLACEMENT.

7-13. Power to the oscillator must be removed only when repairs to the oven control or power supply regulator circuits are being made. When making repairs to other circuits, power to the oscillator should not be removed. The wire supplying the collector voltage to the circuit under repair should be disconnected. After repairs are completed, the wire must be reconnected.

7-14. When transistors are soldered in the circuits, care must be used so transistors do not become overheated.

7-15. When replacing power transistors be careful so the mica insulating disc is not broken or cracked.

7-16. OUTPUT SIGNAL LOADING.

7-17. When the signal output voltages are being checked or adjusted, a 50-ohm load must be connected to the appropriate output connector.

7-18. CAPACITOR C117 REPLACEMENT.

7-19. To replace C117 disconnect P101 and P102 from oven before removing defective C117. Then note C117 rotor position. Set the replacement capacitor rotor to the same position as rotor of defective capacitor. This may prevent the oscillator error from being excessive. To remove C117 proceed as follows:

a. Unsolder and remove wires from C117.

b. Loosen the two allen screws on the worm driven gear. See figure 7-2.

c. Using a 3/8 inch flat open end wrench, remove the nut on the front bushing of C117.

d. Remove C117; then install new capacitor.

e. Replace and tighten nut on bushing. Tighten the two allen screws. Be sure the worm driven gear turns easily.

f. Replace and resolder wires to C117.

g. Reconnect P101 and P102.

h. Check frequency. If necessary adjust C117. See paragraph 3-10.

7-20. RESISTOR R308 REPLACEMENT.

7-21. If it becomes necessary to replace R308, proceed as follows:

a. Note the rotor position of R308.

b. Set the rotor of the replacement resistor to the same position as defective R308. Replace the defective resistor.

c. Apply power to the oscillator. Check the oscillator stability after several days operation.

If the stability has changed, adjust oven control R308. See paragraph 8-11.

SECTION VIII
TESTING AND ADJUSTMENT

8-1. PERFORMANCE CHECK.

8-2. If the oscillator appears to be operating properly, as indicated by correct output signals and CIRCUIT CHECK meter indications, all basic circuits in the oscillator are operating properly.

8-3. CIRCUITS REQUIRING ADJUSTMENT.

8-4. When certain components are replaced, adjustments may be necessary. Table 8-1 lists the components and circuits that may need adjustment.

8-5. ADJUSTMENTS.

8-6. AMPLIFIER Q103 and Q104 NEUTRALIZATION.

a. Connect an ac meter such as the hp Model 400D to the 1 MC OUTPUT connector. Disconnect P101 and P102 from J101 and J102.

b. Disconnect R129, a 2900-ohm resistor from the junction of R125 and R126. Connect loose end of R129 to same ground point to which R126 is connected.

c. Install a short across the secondary of T101. Be careful; make certain the short does not include C123.

d. Short the center conductor of P102 to ground at the point where R126 is grounded.

e. Using a signal generator such as the hp Model 650 Test Oscillator, apply a 1-mc ±5% signal to the collector of Q104 through a 150,000 ohm isolation resistor. Adjust C125 for maximum indication on the meter.

f. Remove the short from T101.

g. Adjust the signal generator above and below 1 mc. If maximum indication does not occur at 1 mc, set the signal generator to 1 mc. If maximum indication occurs at 1 mc, omit steps h and i.

h. If maximum indication in step g did not occur at 1 mc, adjust C126 until maximum indication on the meter occurs at 1 mc.

i. Repeat steps e through h.

j. Reconnect R129 to C124.

k. Disconnect the signal generator from the frequency standard.

m. Reconnect P101 and P102 to J101 and J102.

8-7. TUNED AMPLIFIER Q201.

a. Connect an ac meter such as the hp Model 400D to the 1 MC OUTPUT.

b. Adjust T201 for maximum meter indication.

8-8. TUNED AMPLIFIER Q202.

a. Connect an ac meter such as the hp Model 400D to the 1 MC OUTPUT.

b. Adjust T202 for maximum meter indication.

8-9. TUNED AMPLIFIER Q203.

a. Connect an ac voltmeter such as the hp Model 400D to the 100 KC OUTPUT.

b. Start the regenerative divider.

c. Adjust T203 for maximum indication on the meter.

8-10. REGENERATIVE DIVIDER Q204, Q205.

a. Connect a signal generator such as the hp Model 650A across tank circuit L201, C232. Apply a 100 kc ±5% signal to the tank circuit.

b. Connect an ac meter such as the hp Model 400D to the 100 KC OUTPUT connector.

c. Adjust L203 for maximum indication on the meter.

d. Disconnect the signal generator from the oscillator. Depress the 100 KC START button and adjust T204 for maximum indication on the meter.

e. Release the 100 KC START button. The regenerative divider should operate. If the divider fails to operate, repeat steps c and d.

f. Readjust L203 and T204 for maximum output.

8-11. OVEN CONTROL ADJUSTMENT.

a. Connect the 1-mc output of the oscillator to the vertical input of an oscilloscope such as an hp Model 150A with 152B Dual Channel Amplifier.

b. Connect the 1-mc output of a frequency standard of equal or better accuracy than the oscillator to the horizontal input of the oscilloscope.

c. Observe the presentation on the crt for a zero beat, identified by a stationary pattern.

d. Adjust the oscillator FINE FREQ. ADJ. for a stationary pattern (if not stationary in step c). Record the change of PARTS IN 10^{10} counter.

e. Adjust R308 one position, either way. Wait 45 minutes, to allow the oven temperature to stabilize.

f. Turn the FINE FREQ. ADJ. until a zero beat is observed on the oscilloscope. Record the change of PARTS IN 10^{10} counter.

g. Adjust R308 one position in the same direction as in step e.

h. After 45 minutes obtain a zero beat on the oscilloscope by adjusting the oscillator FINE FREQ. ADJ. Record the change on PARTS IN 10^{10} counter. If the change in parts in 10^{10} is becoming smaller, repeat steps f and g until a very small change in parts in 10^{10} is noted. The oscillator crystal operating point is then at the vertex of the curve in figure 8-1.

i. Repeat steps f and g four more times. The change in parts in 10^{10} should become larger. Plot the curve as shown in the sample curve of figure 8-1.

j. If the change in parts in 10^{10} in step h has been becoming larger instead of smaller, return R308 to its original position. Then adjust R308 one position in a direction opposite that in step e and note the change in parts in 10^{10}. The change in parts in 10^{10} should become smaller for each position R308 is changed.

k. Repeat steps f through j.

m. When a curve similar to figure 8-1 is obtained, adjust R308 back the number of positions necessary to place the crystal operating point at the vertex of the curve. For example, if from 328 to 340 parts in 10^{10} in figure 8-1, R308 was changed three times, then back R308 three positions. The crystal operating point will then be at the vertex of the curve.

Table 8-1. Circuits Requiring Adjustment

Area of Repair	Adjustment Required	Paragraph Reference
Q103,Q104	C125,C126	7-6, 8-5
Q201	T201	7-7, 8-7
Q202	T202	7-7, 8-9
Q203	T203	8-11
Q204,Q205	L203,T204	8-10

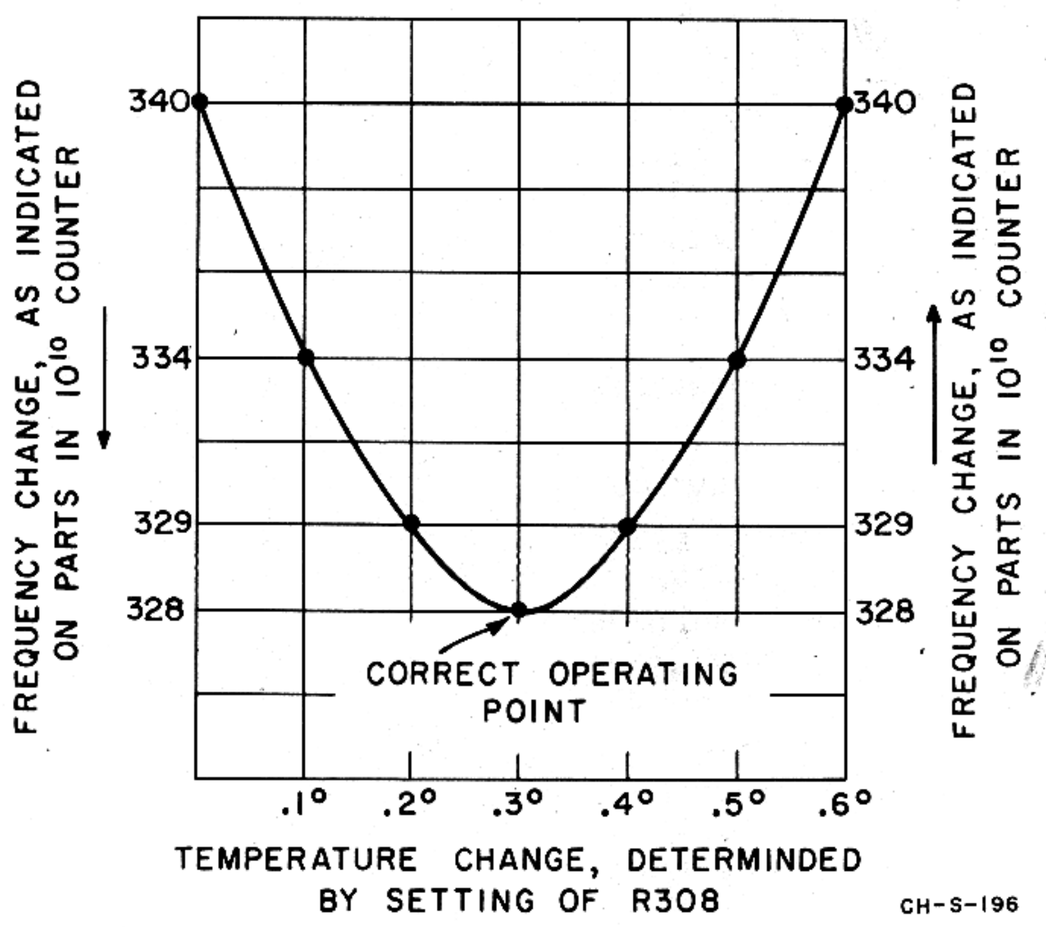
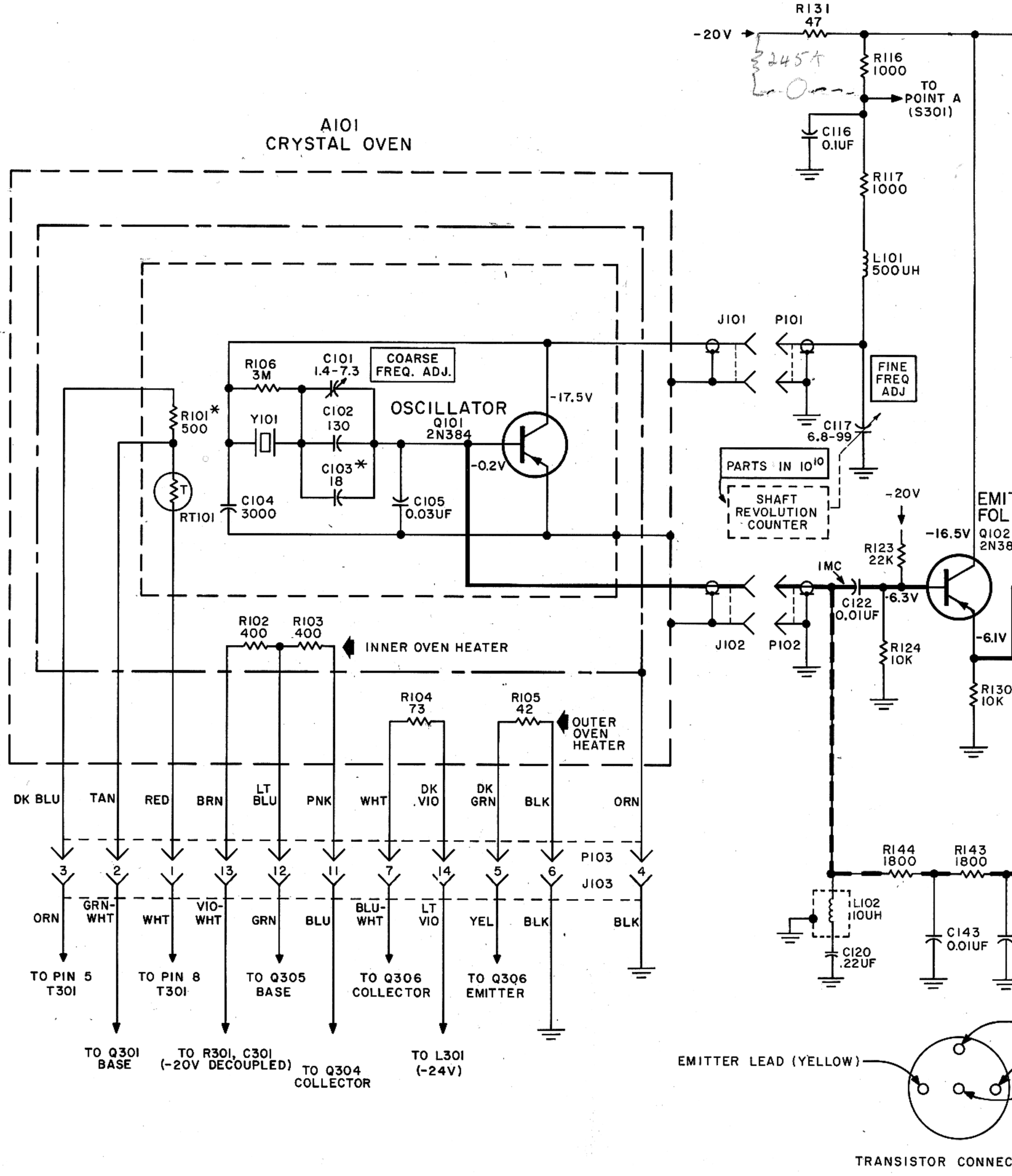
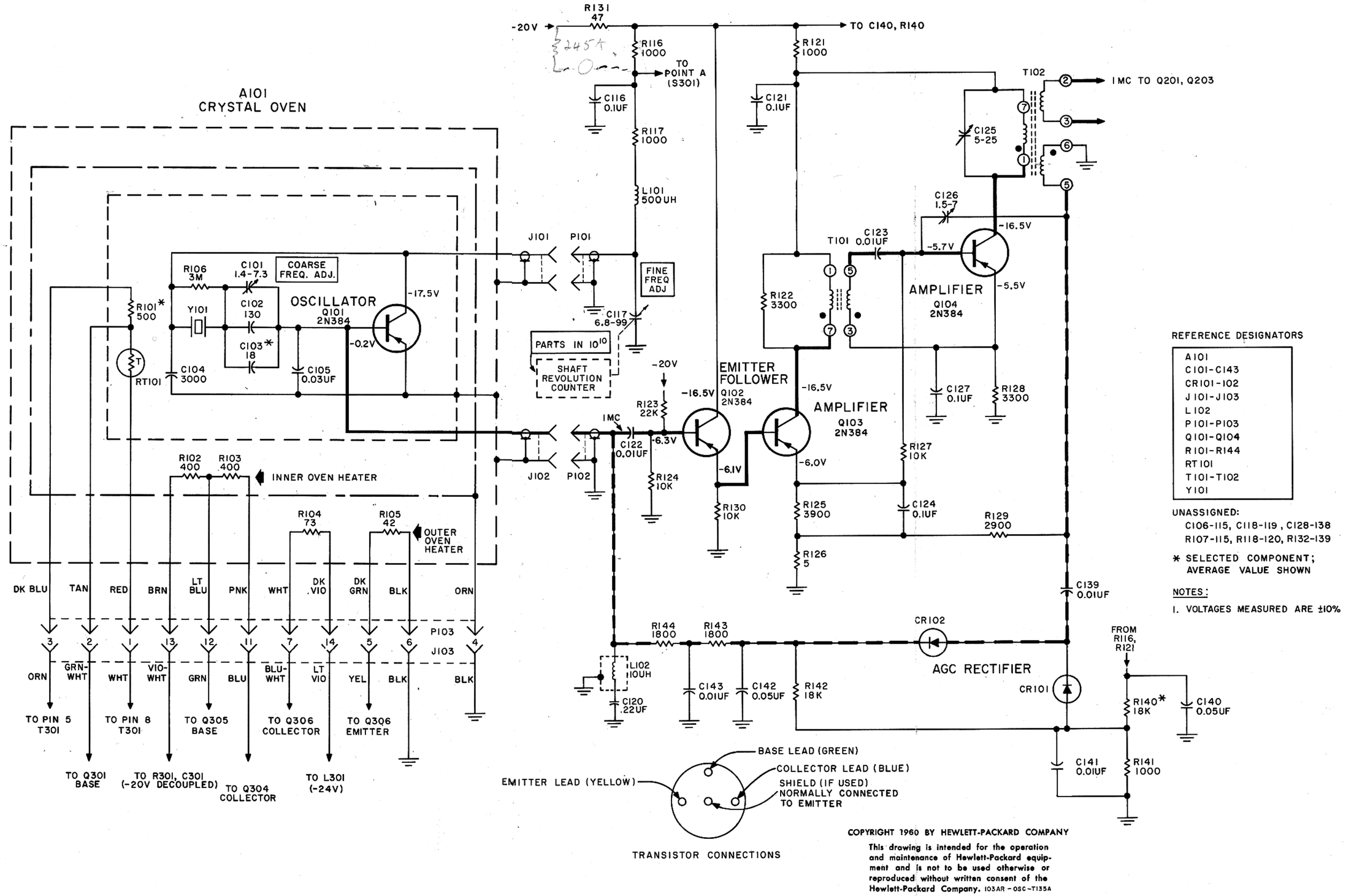


Figure 8-1. Sample Curve


A101
CRYSTAL OVEN
R131
47
-20V
245Ω
R116
1000
TO
POINT A
(S301)
C116
0.1UF
R117
1000
L101
500UH
J101
P101
FINE
FREQ
ADJ
C117
6.8-99
PARTS IN 10^10
SHAFT
REVOLUTION
COUNTER
-20V
-16.5V
R123
22K
IMC
C122
0.01UF
-6.3V
R124
10K
J102
P102
-6.1V
R130
10K
R144
1800
R143
1800
L102
110UH
C120
.22UF
C143
0.01UF
R106
3M
C101
1.4-7.3
COARSE
FREQ. ADJ.
R101*
500
Y101
C102
130
C103*
18
C104
3000
C105
0.03UF
OSCILLATOR
Q101
2N384
-17.5V
-0.2V
T
RT101
R102
400
R103
400
INNER OVEN HEATER
R104
73
R105
42
OUTER
OVEN
HEATER
DK BLU
TAN
RED
BRN
LT BLU
PNK
WHT
DK .VIO
DK GRN
BLK
ORN
P103
J103
3
2
1
13
12
11
7
14
5
6
4
ORN
GRN-WHT
WHT
VIO-WHT
GRN
BLU
BLU-WHT
LT VIO
YEL
BLK
BLK
TO PIN 5
T301
TO PIN 8
T301
TO Q305
BASE
TO Q306
COLLECTOR
TO Q306
EMITTER
TO Q301
BASE
TO R301, C301
(-20V DECOUPLED)
TO Q304
COLLECTOR
TO L301
(-24V)
EMITTER LEAD (YELLOW)
TRANSISTOR CONNEC



REFERENCE DESIGNATORS

A101
C101-C143
CR101-102
J101-J103
L102
P101-P103
Q101-Q104
R101-R144
RT101
T101-T102
Y101

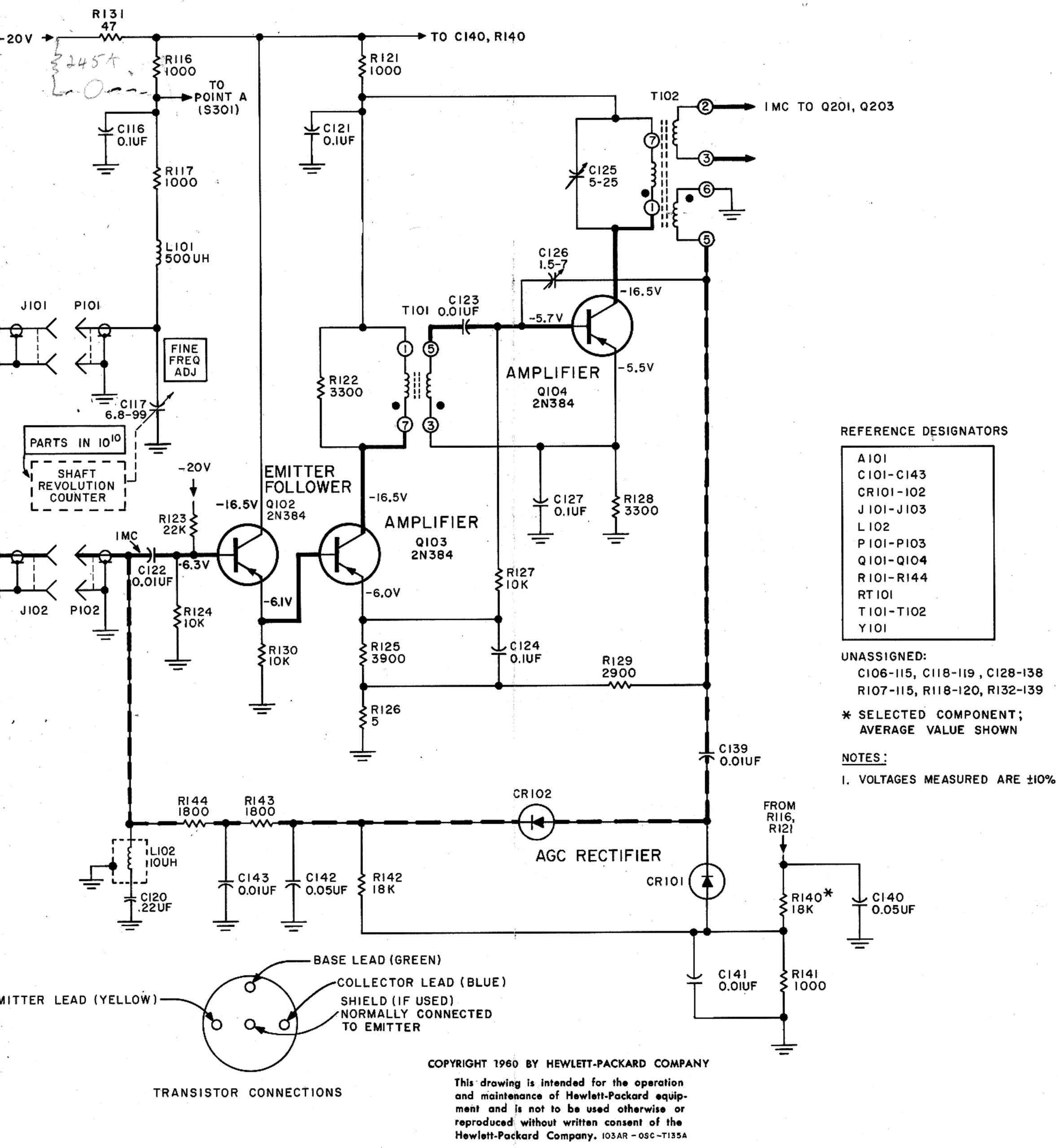
UNASSIGNED:
C106-115, C118-119, C128-138
R107-115, R118-120, R132-139

* SELECTED COMPONENT; AVERAGE VALUE SHOWN

NOTES:

1. VOLTAGES MEASURED ARE ±10%

Figure 8-2. Oscillator



REFERENCE DESIGNATORS

A101
C101-C143
CR101-102
J101-J103
L102
P101-P103
Q101-Q104
R101-R144
RT101
T101-T102
Y101

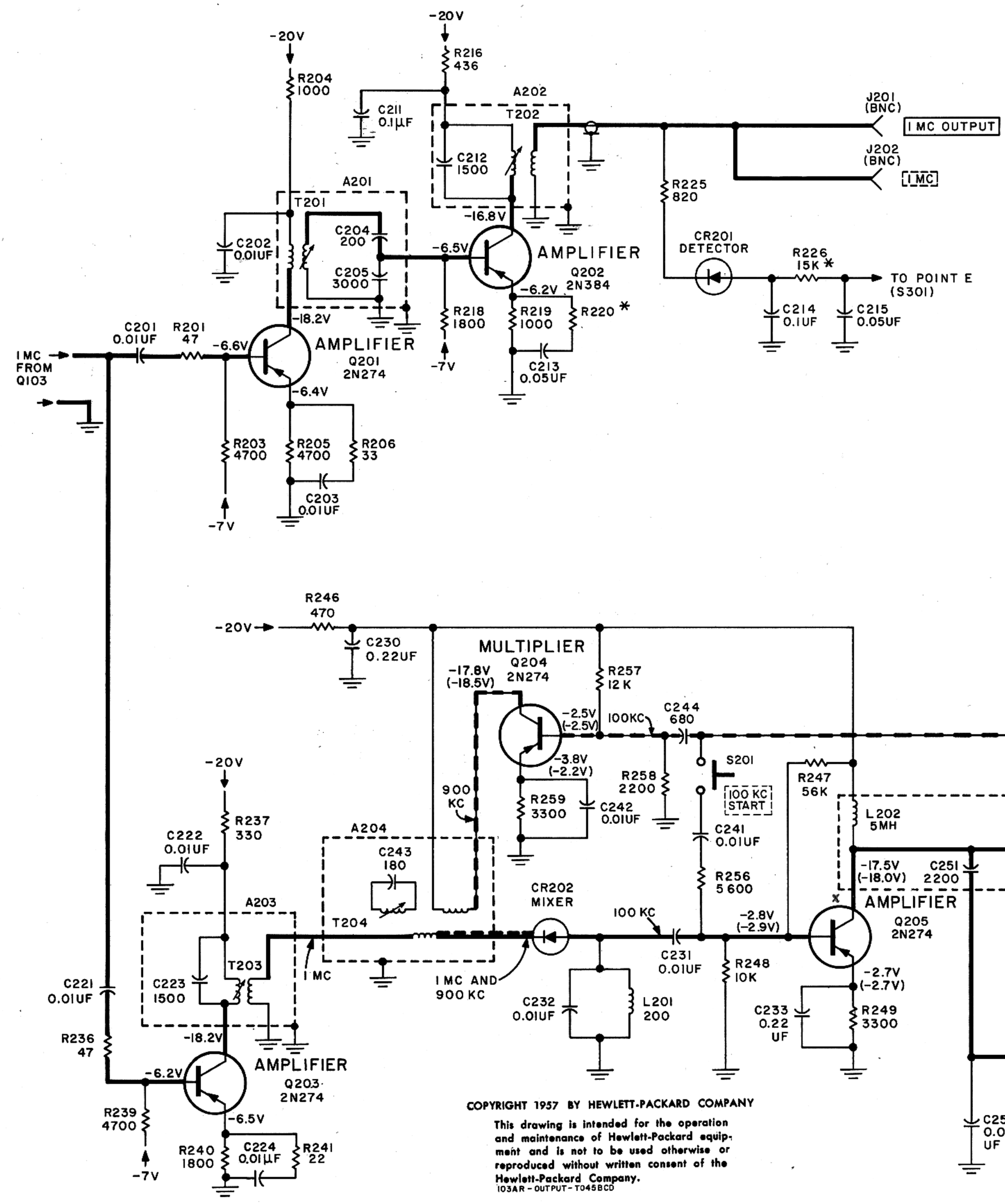
UNASSIGNED:
C106-115, C118-119, C128-138
R107-115, R118-120, R132-139

* SELECTED COMPONENT; AVERAGE VALUE SHOWN

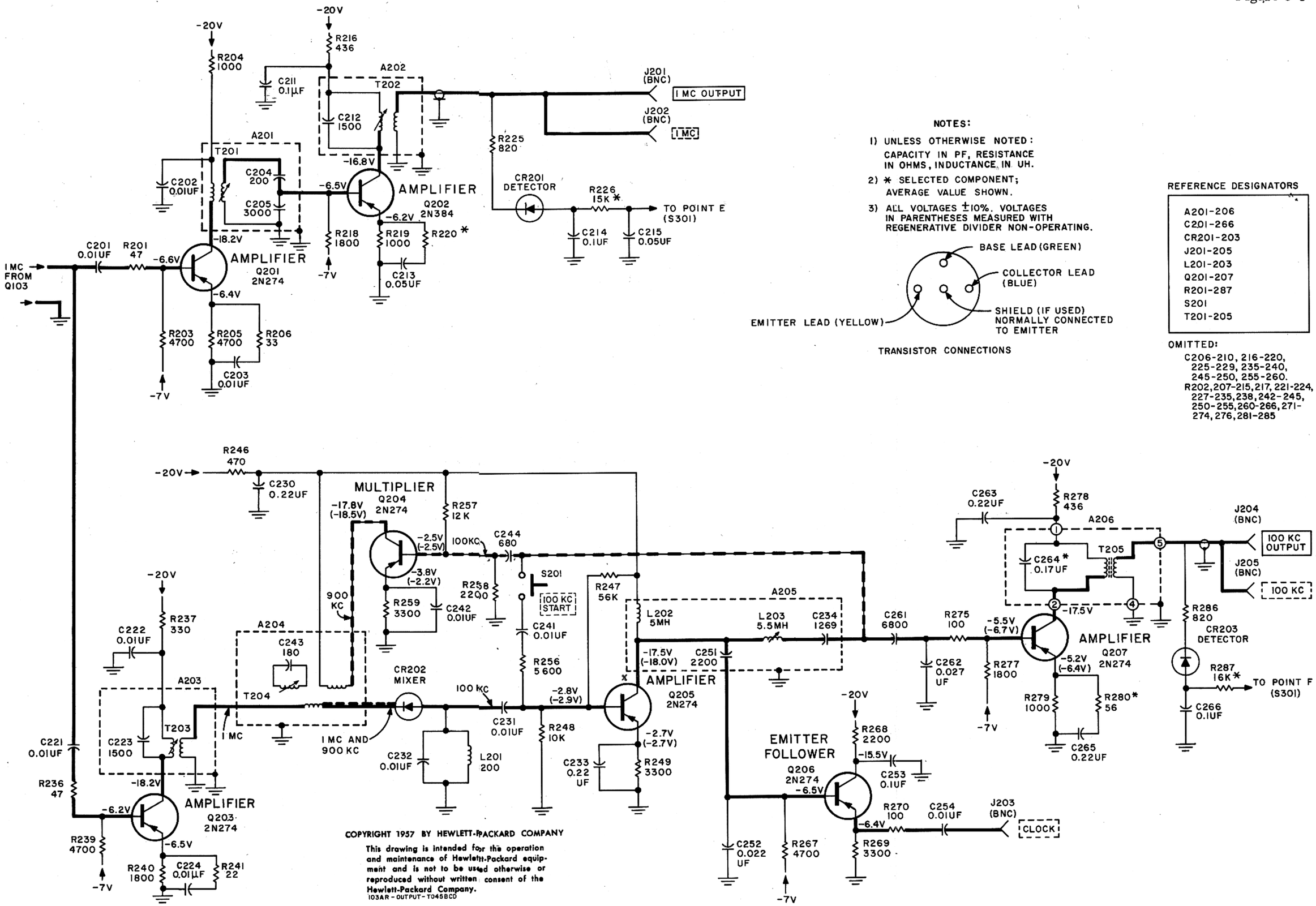
NOTES:

1. VOLTAGES MEASURED ARE ±10%

Figure 8-2. Oscillator



103AR - OUTPUT - T045BCD



NOTES:

1) UNLESS OTHERWISE NOTED: CAPACITY IN PF, RESISTANCE IN OHMS, INDUCTANCE IN UH.
2) * SELECTED COMPONENT; AVERAGE VALUE SHOWN.
3) ALL VOLTAGES ±10%. VOLTAGES IN PARENTHESES MEASURED WITH REGENERATIVE DIVIDER NON-OPERATING.

TRANSISTOR CONNECTIONS

REFERENCE DESIGNATORS

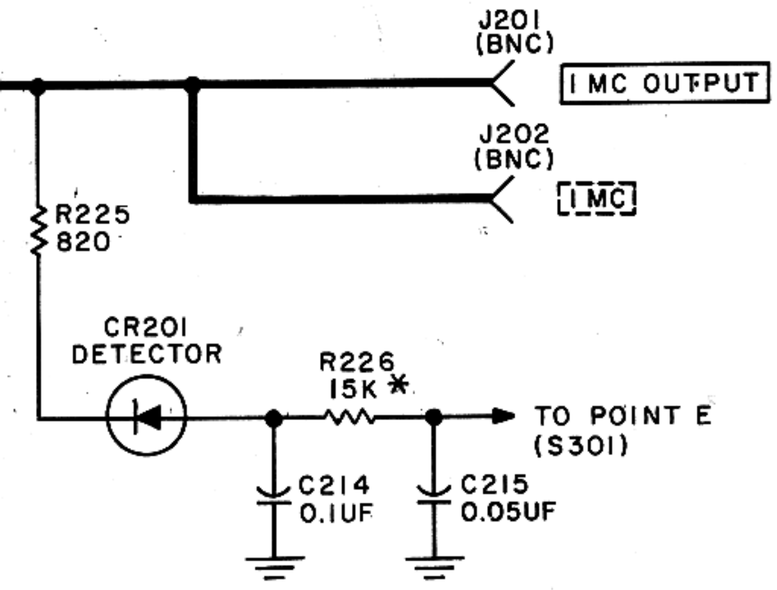
A201-206
C201-266
CR201-203
J201-205
L201-203
Q201-207
R201-287
S201
T201-205

OMITTED:

C206-210, 216-220, 225-229, 235-240, 245-250, 255-260.
R202, 207-215, 217, 221-224, 227-235, 238, 242-245, 250-255, 260-266, 271-274, 276, 281-285

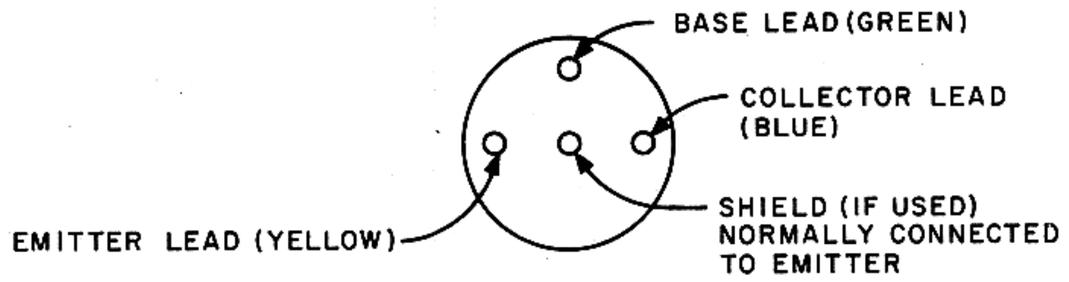
103AR-OUTPUT-T045BCD

Figure 8-3. Output



NOTES:

1) UNLESS OTHERWISE NOTED: CAPACITY IN PF, RESISTANCE IN OHMS, INDUCTANCE IN UH.
2) * SELECTED COMPONENT; AVERAGE VALUE SHOWN.
3) ALL VOLTAGES ±10%. VOLTAGES IN PARENTHESES MEASURED WITH REGENERATIVE DIVIDER NON-OPERATING.



TRANSISTOR CONNECTIONS

REFERENCE DESIGNATORS

A201-206
C201-266
CR201-203
J201-205
L201-203
Q201-207
R201-287
S201
T201-205

OMITTED:

C206-210, 216-220, 225-229, 235-240, 245-250, 255-260.
R202, 207-215, 217, 221-224, 227-235, 238, 242-245, 250-255, 260-266, 271-274, 276, 281-285

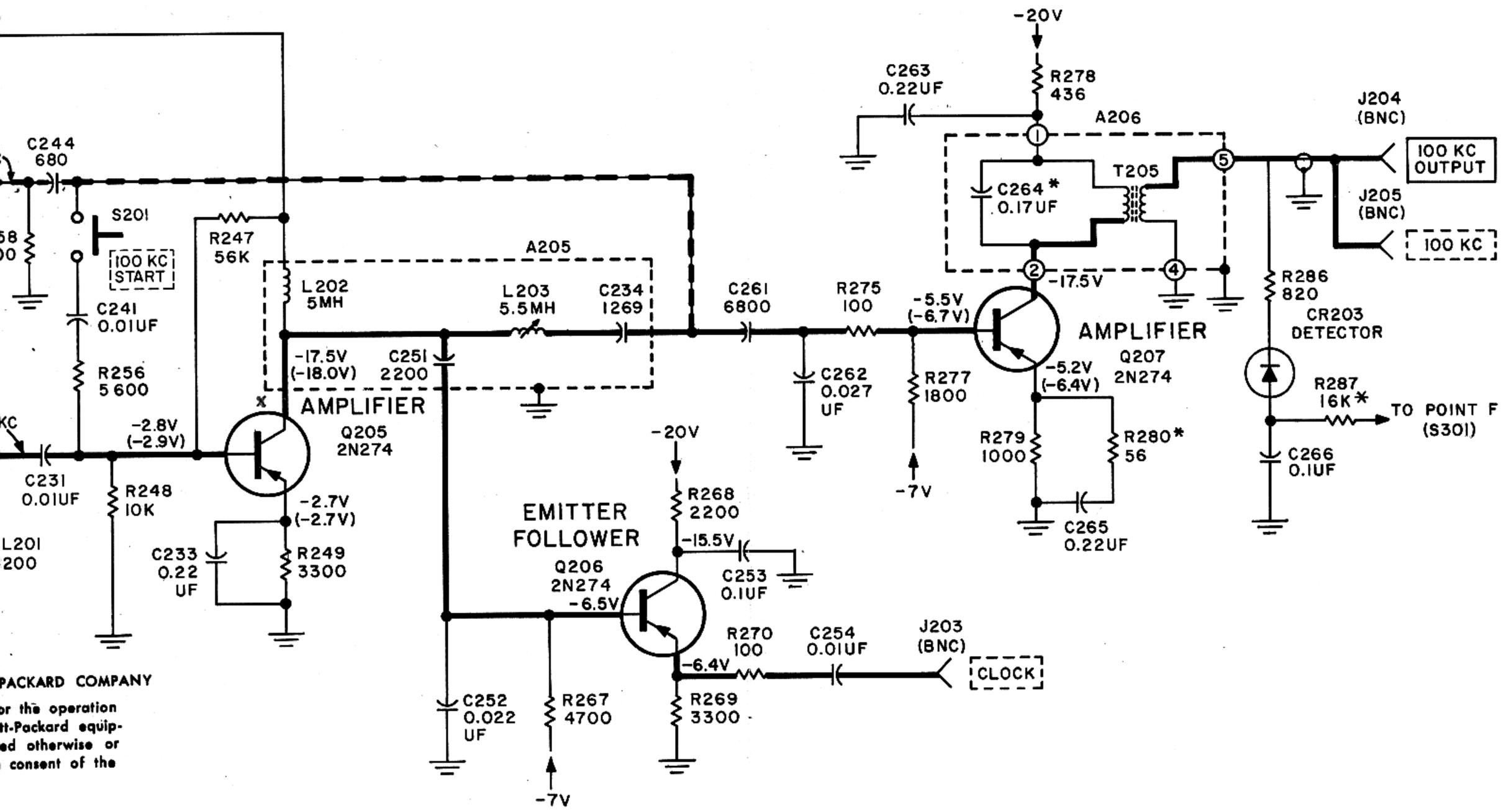
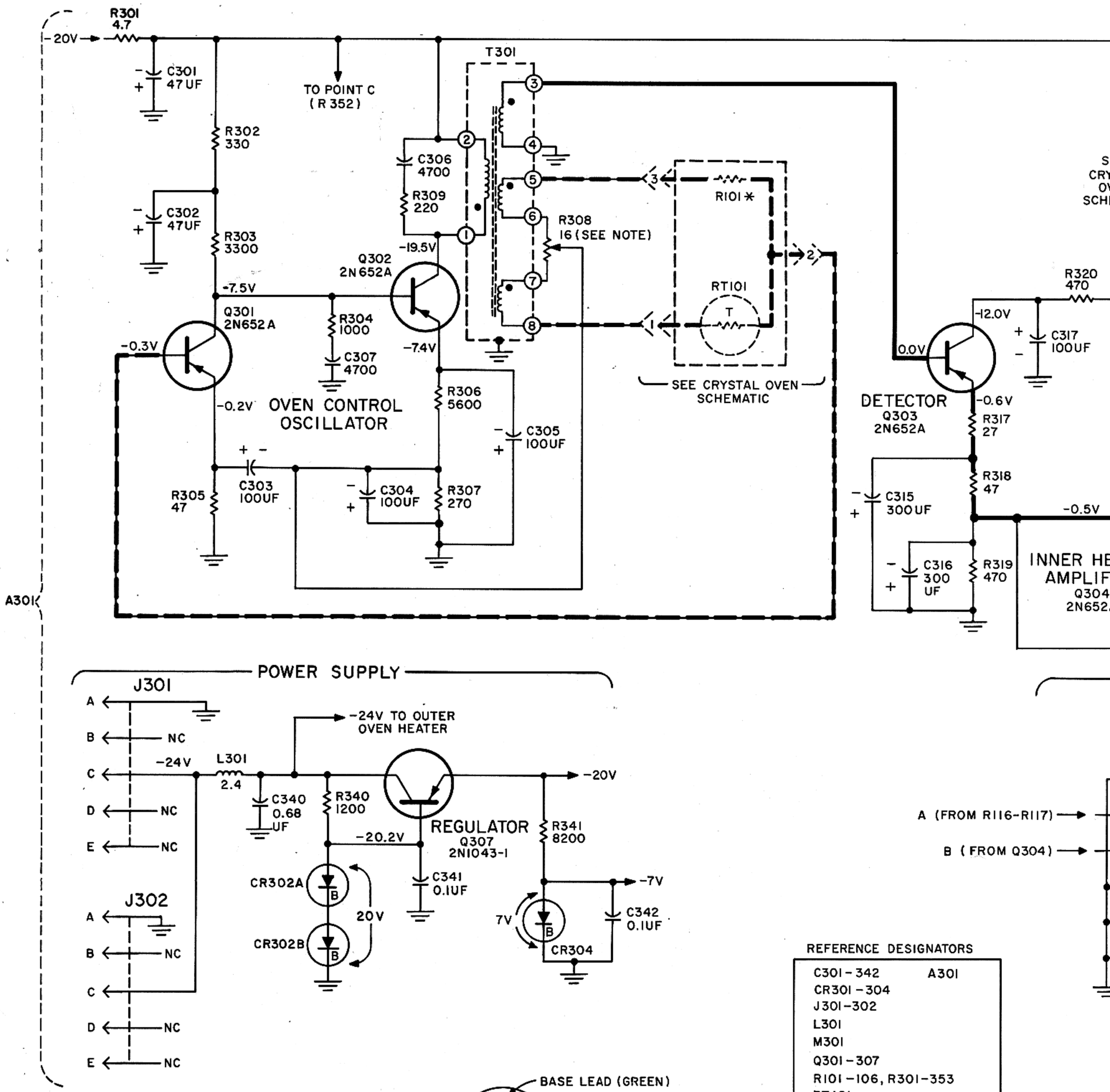


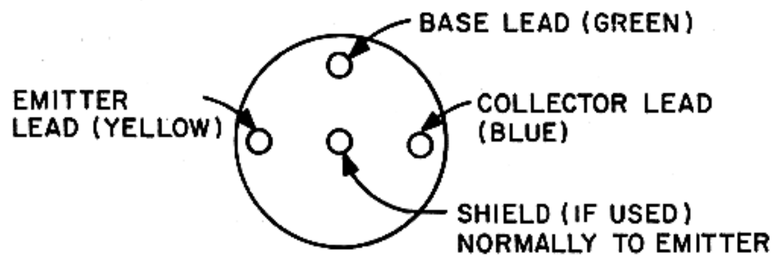
Figure 8-3. Output



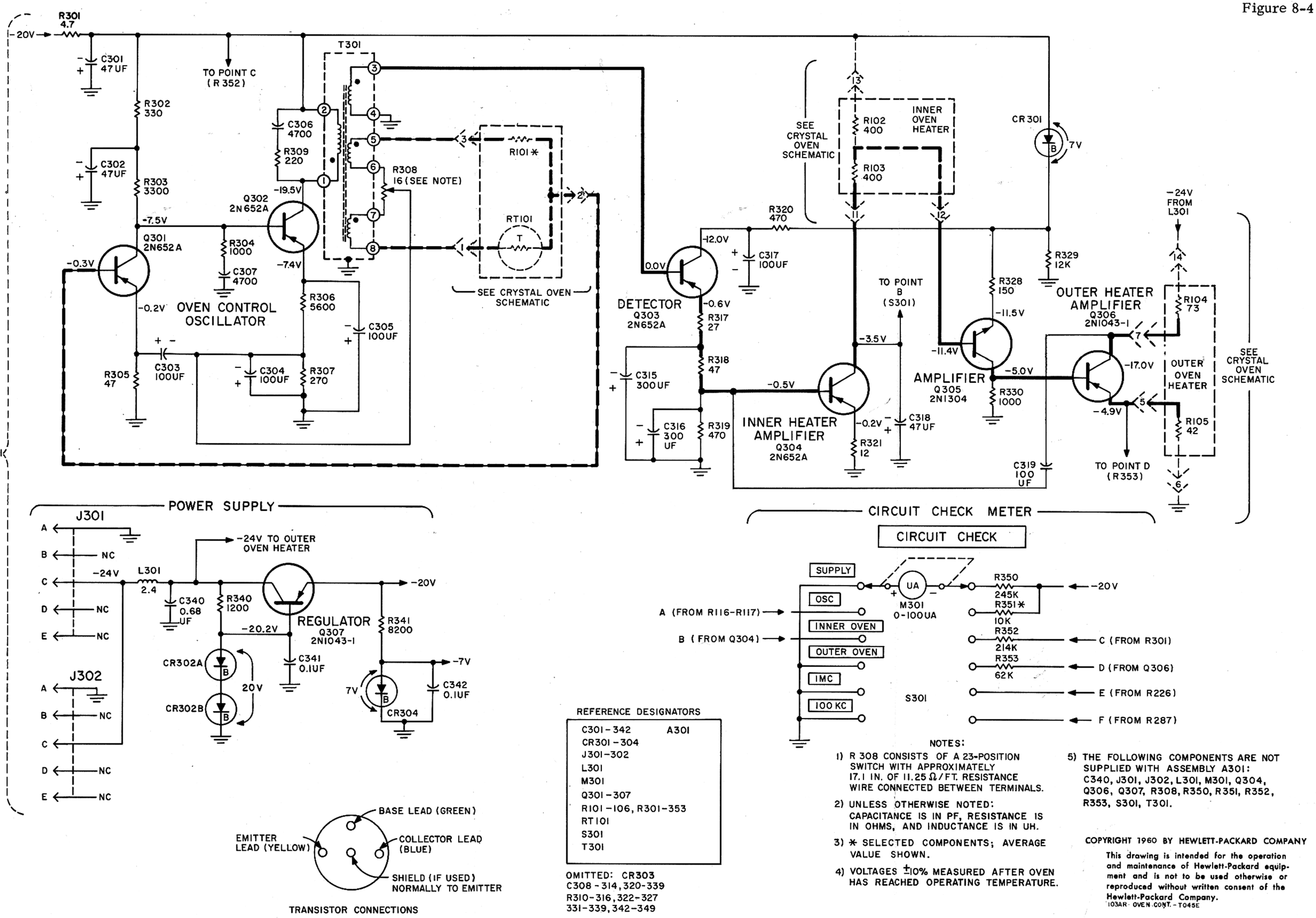
REFERENCE DESIGNATORS

C301-342	A301
CR301-304	
J301-302	
L301	
M301	
Q301-307	
R101-106, R301-353	
RT101	
S301	
T301	

OMITTED: CR303
C308-314, 320-339
R310-316, 322-327
331-339, 342-349



TRANSISTOR CONNECTIONS



REFERENCE DESIGNATORS

C301-342	A301
CR301-304	
J301-302	
L301	
M301	
Q301-307	
R101-106, R301-353	
RT101	
S301	
T301	

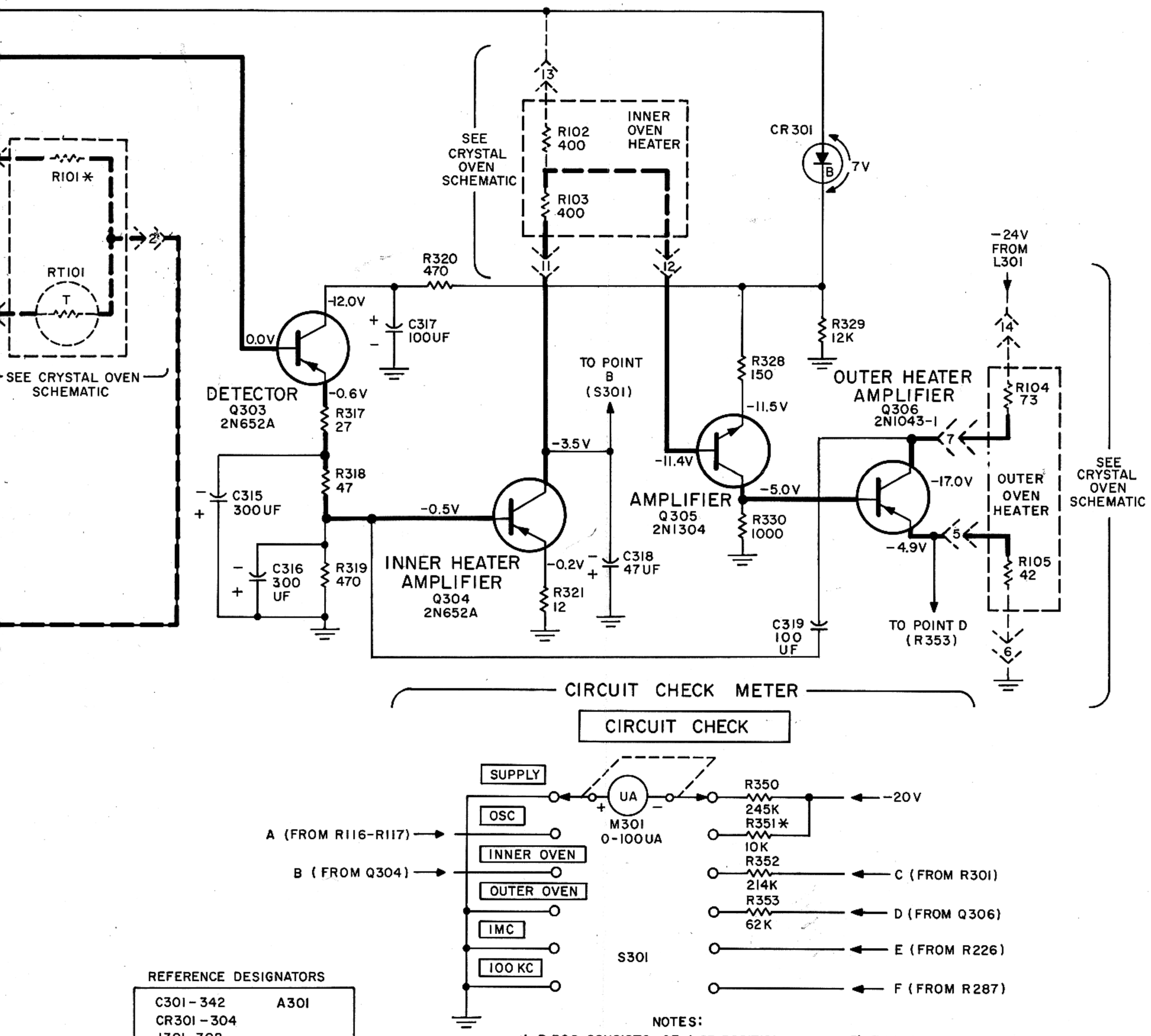
OMITTED: CR303
C308-314, 320-339
R310-316, 322-327
331-339, 342-349

NOTES:

1) R 308 CONSISTS OF A 23-POSITION SWITCH WITH APPROXIMATELY 17.1 IN. OF 11.25 Ω/FT. RESISTANCE WIRE CONNECTED BETWEEN TERMINALS.
2) UNLESS OTHERWISE NOTED: CAPACITANCE IS IN PF, RESISTANCE IS IN OHMS, AND INDUCTANCE IS IN UH.
3) * SELECTED COMPONENTS; AVERAGE VALUE SHOWN.
4) VOLTAGES ±10% MEASURED AFTER OVEN HAS REACHED OPERATING TEMPERATURE.
5) THE FOLLOWING COMPONENTS ARE NOT SUPPLIED WITH ASSEMBLY A301: C340, J301, J302, L301, M301, Q304, Q306, Q307, R308, R350, R351, R352, R353, S301, T301.

103AR-OVEN CONT.-T045E

Figure 8-4. Oven Control



REFERENCE DESIGNATORS

C301-342	A301
CR301-304	
J301-302	
L301	
M301	
Q301-307	
R101-106, R301-353	
RT101	
S301	
T301	

OMITTED: CR303
C308-314, 320-339
R310-316, 322-327
331-339, 342-349

NOTES:

1) R 308 CONSISTS OF A 23-POSITION SWITCH WITH APPROXIMATELY 17.1 IN. OF 11.25 Ω/FT. RESISTANCE WIRE CONNECTED BETWEEN TERMINALS.
2) UNLESS OTHERWISE NOTED: CAPACITANCE IS IN PF, RESISTANCE IS IN OHMS, AND INDUCTANCE IS IN UH.
3) * SELECTED COMPONENTS; AVERAGE VALUE SHOWN.
4) VOLTAGES ±10% MEASURED AFTER OVEN HAS REACHED OPERATING TEMPERATURE.
5) THE FOLLOWING COMPONENTS ARE NOT SUPPLIED WITH ASSEMBLY A301: C340, J301, J302, L301, M301, Q304, Q306, Q307, R308, R350, R351, R352, R353, S301, T301.

103AR-OVEN CONT.-T045E

Figure 8-4. Oven Control

SECTION IX
REPLACEABLE PARTS

9-1. INTRODUCTION.

9-2. This section contains information for ordering replacement parts for the Model 103AR Quartz Oscillator.

9-3. Table 9-1 lists replaceable parts in alpha-numerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed in table 9-2. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included in table 9-3. Detailed information includes the following:

a. Reference designator.

b. Full description of the part.

c. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

d. Hewlett-Packard stock number.

e. Total quantity used in the instrument (TQ col).

f. Recommended spare quantity for complete maintenance during one year of isolated service (RS col).

9-4. ORDERING INFORMATION.

9-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales office or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland

9-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

9-7. To order a part not listed in table 9-1, give a complete description of the part and include its function and location.

Table 9-1. Reference Designator to ℌ Stock Number (Sheet 1 of 4)

Circuit Ref.	ℌ Stock No.	Note
A1 thru A100	Not assigned	
A101	103A-69A	
A102 thru A200	Not assigned	
A201	103A-60B	
A202	103A-60A	
A203	103A-60C	
A204	103A-60D	
A205	103A-60E	
A206	103A-9C	
A207 thru A300	Not assigned	
A301	103A-65A	
C1 thru C100	Not assigned	
C101	Part of A101	b
C102	Part of A101	b
C103	Part of A101	b
C104	Part of A101	b
C105	Part of A101	b
C106 thru C115	Not assigned	
C116	0170-0055	
C117	0121-0034	
C118 thru C119	Not assigned	
C120	0170-0038	
C121	0170-0055	
C122	0150-0012	
C123	0150-0012	
C124	0170-0055	
C125	0130-0012	
C126	0130-0011	
C127	0170-0055	
C128 thru C138	Not assigned	
C139	0150-0012	
C140	0150-0052	

b. Component not separately replaceable.

Table 9-1. Reference Designator to ⓗp Stock Number (Sheet 2 of 4)

Circuit Ref.	ⓗp Stock No.	Note
C141	0150-0012	
C142	0150-0052	
C143	0150-0012	
C144 thru C200	Not assigned	
C201	0150-0012	
C202	0150-0012	
C203	0150-0012	
C204	Part of A201	b
C205	Part of A201	b
C206 thru C210	Not assigned	
C211	0150-0084	
C212	Part of A202	b
C213	0150-0052	
C214	0170-0055	
C215	0150-0052	
C216 thru C220	Not assigned	
C221	0150-0012	
C222	0150-0012	
C223	Part of A203	b
C224	0150-0012	
C225 thru C229	Not assigned	
C230	0170-0038	
C231	0150-0012	
C232	0140-0009	
C233	0170-0038	
C234	Part of A205	b
C235 thru C240	Not assigned	
C241	0150-0012	
C242	0140-0008	
C243	Part of A204	b
C244	0140-0007	
C245 thru C250	Not assigned	
C251	Part of A205	b
C252	0170-0024	
C253	0170-0055	
C254	0150-0012	
C255 thru C260	Not assigned	
C261	0140-0164	
C262	0170-0066	
C263	0170-0038	
C264	Part of A206	b
C265	0170-0038	
C266	0170-0055	
C267 thru C300	Not assigned	
C301	0180-0097	c
C302	0180-0097	c
C303	0180-0083	c
C304	0180-0098	c
C305	0180-0098	c
C306	0140-0162	c
C307	0140-0162	c
C308 thru C314	Not assigned	
C315	0180-0084	c
C316	0180-0084	c
C317	0180-0098	c
C318	0180-0097	c
C319	0180-0113	
C320 thru C339	Not assigned	
C340	0170-0039	c
C341	0170-0055	c
C342	0170-0055	c
CR1 thru CR100	Not assigned	
CR101	1910-0011	
CR102	1910-0011	
CR103 thru CR200	Not assigned	
CR201	1910-0011	
CR202	1910-0011	
CR203	1910-0011	
CR204 thru CR300	Not assigned	
CR301	1902-0008	
CR302A, B	1902-0007	
CR303	Not assigned	
CR304	1902-0006	
J1 thru J100	Not assigned	
J101	Part of A101	b
J102	Part of A101	b
J103	1251-0143	
J104 thru J200	Not assigned	
J201	103A-16E	
J202	103A-16D	
J203	1250-0083	
J204	Part of J201	
J205	Part of J202	
J206 thru J300	Not assigned	
J301	1251-0111	
J302	1251-0111	

b. Component not separately replaceable.
c. Part of A301. Component is separately replaceable or may be replaced with assembly.

Table 9-1. Reference Designator to ℌ Stock Number (Sheet 3 of 4)

Circuit Ref.	ℌ Stock No.	Note
L1 thru L100	Not assigned	
L101	9140-0022	
L102	9140-0124	
L103 thru L200	Not assigned	
L201	9140-0019	
L202	Part of A205	b
L203	Part of A205	b
L204 thru L300	Not assigned	
L301	9140-0001	
M1 thru M300	Not assigned	
M301	1120-0083	
P1 thru P100	Not assigned	
P101	1250-0109	
P102	1250-0109	
P103	Part of A101	b
Q1 thru Q100	Not assigned	
Q101	Part of A101	b
Q102	1850-0029	
Q103	1850-0029	
Q104	1850-0029	
Q105 thru Q200	Not assigned	
Q201	1850-0037	
Q202	1850-0029	
Q203	1850-0037	
Q204	1850-0037	
Q205	1850-0037	
Q206	1850-0037	
Q207	1850-0037	
Q208 thru Q300	Not assigned	
Q301	1850-0054	
Q302	1850-0054	
Q303	1850-0054	
Q304	1850-0054	
Q305	1851-0017	
Q306	1850-0061	
Q307	1850-0061	
R1 thru R100	Not assigned	
R101	Part of A101	b
R102	Part of A101	b
R103	Part of A101	b
R104	Part of A101	b
R105	Part of A101	b
R106	Part of A101	b
R107 thru R115	Not assigned	
R116	0687-1021	
R117	0687-1021	
R118 thru R120	Not assigned	
R121	0687-1021	
R122	0687-3321	
R123	0687-2231	
R124	0687-1031	
R125	0687-3921	
R126	0727-0004	
R127	0687-1031	
R128	0687-3321	
R129	0727-0123	
R130	0687-1031	
R131	0687-4701	
R132 thru R139	Not assigned	
R140	0687-1831	
R141	0687-1021	
R142	0687-1831	
R143	0687-1821	
R144	0687-1821	
R145 thru R200	Not assigned	
R201	0687-4701	
R202	Not assigned	
R203	0687-4721	
R204	0687-1021	
R205	0687-4721	
R206	0687-3301	
R207 thru R215	Not assigned	
R216	0727-0074	
R217	Not assigned	
R218	0687-1821	
R219	0727-0100	
R220	0687-5601	a
R221 thru R224	Not assigned	
R225	0687-8211	
R226	0686-1535	a
R227 thru R235	Not assigned	
R236	0687-4701	
R237	0687-3311	
R238	Not assigned	
R239	0687-4721	
R240	0687-1821	
R241	0687-2201	
R242 thru R245	Not assigned	
R246	0687-4711	
R247	0687-5631	
R248	0687-1031	
R249	0687-3321	
R250 thru R255	Not assigned	

a. Optimum value selected at factory. Average value shown.
b. Component not separately replaceable.

Table 9-1. Reference Designator to ⓗ Stock Number (Sheet 4 of 4)

Circuit Ref.	ⓗ Stock No.	Note
R256	0687-5621	
R257	0687-1231	
R258	0687-2221	
R259	0687-3321	
R260 thru R266	Not assigned	
R267	0687-4721	
R268	0687-2221	
R269	0687-3321	
R270	0687-1011	
R271 thru R274	Not assigned	
R275	0687-1011	
R276	Not assigned	
R277	0687-1821	
R278	0727-0074	
R279	0727-0100	
R280	0687-5601	a
R281 thru R285	Not assigned	
R286	0687-8211	
R287	0686-1635	a
R288 thru R300	Not assigned	
R301	0698-0001	c
R302	0687-3311	c
R303	0687-3321	c
R304	0687-1021	c
R305	0687-4701	c
R306	0687-5621	c
R307	0687-2711	c
R308	3100-0261	c
R309	0687-2211	c
R310	0687-4701	c
R311 thru R316	Not assigned	
R317	0687-2701	c
R318	0687-4701	c
R319	0687-4711	c
R320	0687-4711	c
R321	0687-1201	c
R322 thru R327	Not assigned	
R328	0687-1511	c
R329	0687-1231	c
R330	0687-1021	c
R331 thru R339	Not assigned	
R340	0687-1221	c
R341	0687-8221	c
R342 thru R349	Not assigned	
R350	0730-0080	
R351	0687-1031	a
R352	0727-0222	
R353	0730-0055	
RT1 thru RT100	Not assigned	
RT101	Part of A101	b
S1 thru S200	Not assigned	
S201	3101-0014	
S202 thru S300	Not assigned	
S301	3100-0260	
T1 thru T100	Not assigned	
T101	103A-9A	
T102	103A-9B	
T103 thru T200	Not assigned	
T201	Part of A201	b
T202	Part of A202	b
T203	Part of A203	b
T204	Part of A204	b
T205	Part of A206	b
T206 thru T300	Not assigned	
T301	103A-9D	
XT1 thru XT100	Not assigned	
XT101	1200-0017	
XT102	1200-0017	
Y1 thru Y100	Not assigned	
Y101	Part of A101	b

a. Optimum value selected at factory. Average value shown.
b. Component not separately replaceable.
c. Part of A301. Component is separately replaceable or may be replaced with assembly.

Table 9-2. Electrical Components (Sheet 1 of 5)

℗ Stock No.	Description	Mfr *		TQ*	RS*		
103A-7A	Assembly, Capacitor, sealed	28480		1	1		
103A-9A	Transformer: AGC Interstage	28480		1	1		
103A-9B	Transformer: AGC Output Interstage	28480		1	1		
103A-9C	Assembly, transformer: 100 kc Output (includes C264, T205)	28480		1	1		
103A-9D	Assembly, transformer: Oven Control	28480		1	1		
103A-60A	Assembly, transformer: 1 mc Output (includes C212, T202)	28480		1	1		
103A-60B	Assembly, transformer: 1 mc Buffer (includes C204, C205, T201)	28480		1	1		
103A-60C	Assembly, transformer: Divider Buffer (includes C223, T203)	28480		1	1		
103A-60D	Assembly, transformer: 900 kc Mult. (includes C243, T204)	28480		1	1		
103A-60E	Assembly, filter: 100 kc (includes C234, C251, L202, L203)	28480		1	1		
103A-65A	Assembly, Oven Control Circuit Board (includes C301-C307, C315-C318, C341, C342, CR301, CR302A, B, CR304, Q301-Q303, Q305, R301-R307, R309, R317-R321, R328-R330, R340, R341)	28480		1	1		
103A-69A	Assembly, Crystal Oven (includes C101, C102, C104, C105, J101, J102, P103, Q101, R106, RT101, Y101)	28480		1	1		
103A-16D	Connector: includes coaxial cable	28480		1	1		
103A-16E	Connector: includes coaxial cable	28480		1	1		
0130-0011	Capacitor: variable, ceramic, 1.5-7 pf	72982		1	1		
0130-0012	Capacitor: variable, ceramic, 5-25 pf	72982		1	1		
0140-0007	Capacitor: fixed, mica, 680 pf ±10%, 500 vdcw	76433		1	1		

* See introduction to this section

Table 9-2. Replaceable Parts (Sheet 2 of 5)

Ckt Ref.	Description	Mfr *		TQ*	RS*		
0140-0008	Capacitor: fixed, mica, 0.01 μf ±10%, 300 vdcw	76433		1	1		
0140-0009	Capacitor: fixed, mica, 0.01 μf ±5%, 500 vdcw	00656		1	1		
0140-0162	Capacitor: fixed, mica, 4700 pf ±10%, 300 vdcw	72136		2	1		
0140-0164	Capacitor: fixed, mica, 6800 pf ±5%, 500 vdcw	72136		1	1		
0150-0012	Capacitor: fixed, ceramic, 0.01 μf ±20%, 1000 vdcw	71590		14	4		
0150-0052	Capacitor: fixed, ceramic, 0.05 μf ±20%, 400 vdcw	05729		4	1		
0150-0084	Capacitor: fixed, ceramic, 0.1 μf -20% +80%, 50 vdcw	56289		1	1		
0170-0024	Capacitor: fixed, mylar, 0.022 μf ±20%, 200 vdcw	56289		1	1		
0170-0038	Capacitor: fixed, mylar, 0.22 μf ±10%, 200 vdcw	56289		5	2		
0170-0039	Capacitor: fixed, mylar, 0.68 μf ±10%, 100 vdcw	84411		1	1		
0170-0055	Capacitor: fixed, mylar, 0.1 μf ± 20%, 100 vdcw	56289		9	2		
0170-0066	Capacitor: fixed, mylar, 0.027 μf ±10%, 200 vdcw	56289		1	1		
0180-0083	Capacitor: fixed, tantalum electrolytic, 100 μf -15% + 20%, 6 vdcw	10411		1	1		
0180-0084	Capacitor: fixed, tantalum electrolytic, 300 μf -15% +20%, 6 vdcw	10411		2	1		
0180-0097	Capacitor: fixed, tantalum electrolytic, 47 μf ±10%, 35 vdcw	56289		3	1		
0180-0098	Capacitor: fixed, tantalum electrolytic, 100 μf ±20%, 20 vdcw	56289		3	1		
0180-0113	Capacitor: fixed, tantalum electrolytic 100 μf, + 5% -15%, 30 vdcw	56289		1	1		
0686-1535	Resistor: fixed, composition, 15,000 ohms ±5%, 1/2 W	01121		1	1		
0686-1635	Resistor: fixed, composition, 16,000 ohms ±5%, 1/2 W	01121		1	1		

* See introduction to this section

Table 9-2. Replaceable Parts (Sheet 3 of 5)

Ckt Ref.	Description	Mfr *		TQ*	RS*		
0687-1011	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W	01121		2	1		
0687-1021	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121		7	2		
0687-1031	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W	01121		5	2		
0687-1201	Resistor: fixed, composition, 12 ohms ±10%, 1/2 W	01121		1	1		
0687-1221	Resistor: fixed, composition, 1200 ohms ±10%, 1/2 W	01121		1	1		
0687-1231	Resistor: fixed, composition, 12,000 ohms ±10%, 1/2 W	01121		2	1		
0687-1511	Resistor: fixed, composition, 150 ohms ±10%, 1/2 W	01121		1	1		
0687-1821	Resistor: fixed, composition, 1800 ohms ±10%, 1/2 W	01121		5	2		
0687-1831	Resistor: fixed, composition, 18,000 ohms ±10%, 1/2 W	01121		2	1		
0687-2201	Resistor: fixed, composition, 22 ohms ±10%, 1/2 W	01121		1	1		
0687-2211	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W	01121		1	1		
0687-2221	Resistor: fixed, composition, 2200 ohms ±10%, 1/2 W	01121		2	1		
0687-2231	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121		1	1		
0687-2701	Resistor: fixed, composition, 27 ohms ±10%, 1/2 W	01121		1	1		
0687-2711	Resistor: fixed, composition, 270 ohms ±10%, 1/2 W	01121		1	1		
0687-3301	Resistor: fixed, composition, 33 ohms ±10%, 1/2 W	01121		1	1		
0687-3311	Resistor: fixed, composition, 330 ohms ±10%, 1/2 W	01121		2	1		
0687-3321	Resistor: fixed, composition, 3300 ohms ±10%, 1/2 W	01121		6	2		
0687-3921	Resistor: fixed, composition, 3900 ohms ±10%, 1/2 W	01121		1	1		

* See introduction to this section

Table 9-2. Replaceable Parts (Sheet 4 of 5)

Ckt Ref.	Description	Mfr *		TQ*	RS*		
0687-4701	Resistor: fixed, composition, 47 ohms ±10%, 1/2 W	01121		6	2		
0687-4711	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	01121		3	1		
0687-4721	Resistor: fixed, composition, 4700 ohms ±10%, 1/2 W	01121		4	1		
0687-5601	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	01121		2	1		
0687-5621	Resistor: fixed, composition, 5600 ohms ±10%, 1/2 W	01121		2	1		
0687-5631	Resistor: fixed, composition, 56,000 ohms ±10%, 1/2 W	01121		1	1		
0687-8211	Resistor: fixed, composition, 820 ohms ±10%, 1/2 W	01121		2	1		
0687-8221	Resistor: fixed, composition, 8200 ohms ±10%, 1/2 W	01121		1	1		
0698-0001	Resistor: fixed, composition, 4.7 ohms ±5%, 1/2 W	01121		1	1		
0727-0004	Resistor: fixed, deposited carbon, 5 ohms ±1%, 1/2 W	19701		1	1		
0727-0074	Resistor: fixed, deposited carbon, 436 ohms ±1/2%, 1/2 W	19701		2	1		
0727-0100	Resistor: fixed, deposited carbon, 1000 ohms ±1%, 1/2 W	19701		2	1		
0727-0123	Resistor: fixed, deposited carbon, 2900 ohms ±1%, 1/2 W	19701		1	1		
0727-0222	Resistor: fixed, deposited carbon, 214,000 ohms ±1%, 1/2 W	19701		1	1		
0730-0055	Resistor: fixed, deposited carbon, 62,000 ohms ±1%, 1 W	19701		1	1		
0730-0080	Resistor: fixed, deposited carbon, 245,000 ohms ±1%, 1 W	19701		1	1		
1120-0083	Meter: 0-100 μamps	81030		1	1		
1200-0017	Socket, tube: 7 pin	71785		2	1		

* See introduction to this section

Table 9-2. Electrical Components (Sheet 5 of 5)

℗ Stock No.	Description	Mfr *		TQ*	RS*		
1250-0083	Connector: female, BNC, UG1094/U	91737		1	1		
1250-0109	Connector: coaxial cable plug	98278		2	1		
1251-0111	Connector: male, 5 pin	71468		2	1		
1251-0143	Connector: female, 14 pin	02660		1	1		
1850-0029	Transistor: 2N384, specially selected for ℗ type 1850-0029	28480		4	4		
1850-0037	Transistor: 2N274	02735		6	6		
1850-0054	Transistor: 2N652A	04713		4	4		
1850-0061	Transistor: 2N1043	01295		2	2		
1851-0017	Transistor: 2N1304	01295		1	1		
1902-0006	Diode, silicon: avalanche	01281		1	1		
1902-0007	Diode, silicon: avalanche series, matched pair	04713		1	1		
1902-0008	Diode, silicon: avalanche	81483		1	1		
1910-0011	Diode, germanium	73293		5	5		
3100-0260	Switch, rotary: 1 section, 6 position	76854		1	1		
3100-0261	Switch, rotary: 1 section, 23 position	76854		1	1		
3101-0014	Switch, Push: SPDT	82389		1	1		
9140-0001	Inductor, fixed: 2.3 μh	0000M		1	1		
9140-0019	Inductor, fixed: 200 μh	99848		1	1		
9140-0022	Inductor, fixed: 500 μh	99848		1	1		
9140-0124	Inductor, fixed: 10 μh	98734		1	1		

* See introduction to this section

Table 9-3. Miscellaneous Components (Sheet 1 of 1)

Ckt Ref.	Description	Mfr *	ⓗ Stock No.	TQ*	RS*		
	Cable, power	28480	103A-16A	1	1		
	Connector, female: 5 pin MS 3106E-14S-5S (mates with J301, J302)	71468	1251-0126	1	1		
	Connector, male: 11 pin (mates with power output connector on ⓗ Model 724A/B)	02660	1251-0052	1	1		
	Counter, direct drive	79142	1140-0003	1	1		
	Ball, stainless steel	76210	1410-0086	1	1		
	Bearing, surface	28480	103A-17A	1	1		
	Knob	28480	G-74N	1	1		
	Shield, tube (for XT101, XT102)	71785	1220-0011	2	0		
	Spring	91260	1460-0023		1		
	Retainer	28480	103A-17B	1	1		

* See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.

From: F.S.C. Handbook Supplements
H4-1 Dated October 1961
H4-2 Dated April 1961

00015-18
Revised: 15 November 1961

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
00001	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000DD	General Transistor	Los Angeles, Calif.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.

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OPERATING AND SERVICING MANUAL

FOR

SPECIFICATION H02-103A/AR

QUARTZ OSCILLATOR

Specification H02-103A/AR is a standard ℎ𝑝 Model 103A/AR Quartz Oscillator in which a special 1.00273791 MC crystal has been installed.

This special instrument has the following Overall Stability Specifications; Long-Term: 2 parts in 10^9 per day. Short-Term: Better than 5 parts in 10^{10} averaged over 1 second intervals.

In all other respects this instrument is electrically identical to the standard ℎ𝑝 Model 103A/AR Quartz Oscillator and the information in the Operating and Service Manual for the standard instrument applies to this special instrument.

Encl:
103A

maa
362

103AR

CLOCK RM

7/4/72 — Bob Hogarth

(keep)

From Carl Chestnut - 03

HEWLETT-PACKARD COMPANY

103AR

QUARTZ OSCILLATOR

THIS MANUAL COVERS A SPECIAL MODIFICATION OF THE INSTRUMENT. SEE INSIDE COVER

103AR