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OPERATING AND SERVICING MANUAL

MODEL 200T
PRECISION TELEMETER
TEST OSCILLATOR

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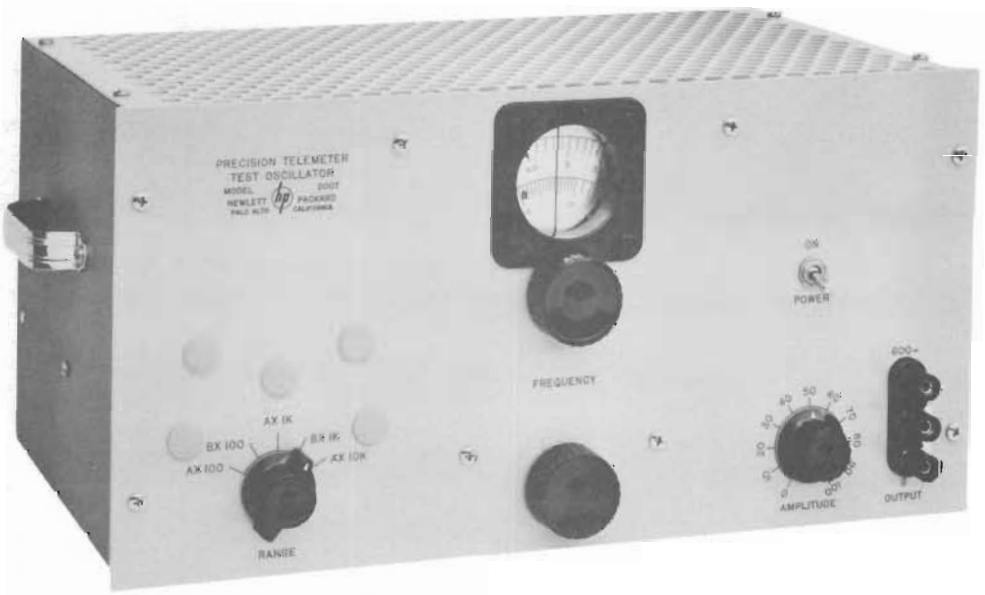

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SPECIFICATIONS

FREQUENCY RANGE:	250 cps to 100 kc with wide overlap at both ends of each range.
RANGES:	250 cps to 1000 cps; 800 cps to 3200 cps; 2500 cps to 10 kc; 8 kc to 32 kc; 25 kc to 100 kc.
CALIBRATION ACCURACY:	±1% long term. Screwdriver adjustments on front panel for precise calibration of each range.
FREQUENCY RESPONSE:	±1 db entire range (reference: 5 kc)
FREQUENCY STABILITY:	Short Term: Less than 0.02% +0.5 cycles drift per hour at constant ambient temperature after one hour warm-up. Temperature: Less than ±0.5% change, for ambient temperatures 10°C to 50°C (reference: 20°C). Power Supply Voltage Stability: Less than ±0.1% frequency change for variations of ±10% from nominal 115 volt line (103 volts to 127 volts).
OUTPUT:	160 milliwatts or 10 volts across 600-ohm rated load, or 20 volts open circuit.
INTERNAL IMPEDANCE	600 ohms. Output is balanced to ground within 1% for zero position of output attenuator. Unit may be operated one side grounded.
DISTORTION:	Less than 0.5% entire frequency range. Distortion not affected by load impedance.
HUM AND NOISE:	Less than 0.03% of rated output voltage.
POWER SUPPLY:	115/230 volts ±10%, 50 to 1000 cps, approximately 160 watts.
DIMENSIONS:	Cabinet Mount: 18-3/4 in. wide, 9-3/16 in. high, 11-3/4 in. deep. Rack Mount: 19 in. wide, 8-3/4 in. high, 10-15/16 in. deep behind panel.
WEIGHT:	Cabinet Mount: Net 27 lbs., shipping 36 lbs. Rack Mount: Net 28 lbs., shipping 36 lbs.

CONTENTS

SECTION I
GENERAL DESCRIPTION

1-1 GENERAL

The Model 200T Precision Telemeter Test Oscillator generates voltages of excellent waveform in the range from 250 to 100,000 cycles/sec. An output voltage of 10 volts across 600 ohms is available from this instrument. The distortion is less than 0.5% and is not affected by the load impedance. The output may be balanced to ground or the instrument may be operated with one side grounded.

The Model 200T is an excellent source of signals for precise, high-resolution frequency-checking applications such as evaluating telemetering circuits, testing carrier current equipment operation, and determining the characteristics of sharply-tuned filters.

In the design of the Model 200T particular attention was given to the requirements of telemetering applications. The bandspread dial is arranged to provide wide overlap so that the entire RDB spectrum for fm-fm telemetering is covered without splitting any channels. As a consequence, no band switching is required while testing telemetering systems.

1-2 POWER CABLE

The three conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin, added to a standard two-blade connector, which grounds the instrument chassis when used with the appropriate receptacle. To use this NEMA connector in a standard two-contact receptacle, an adapter may be used. The ground connection emerges from the adapter as a short lead which should be connected to a suitable ground for the protection of operating personnel.

1-3 POWER TRANSFORMER PRIMARY CONNECTIONS

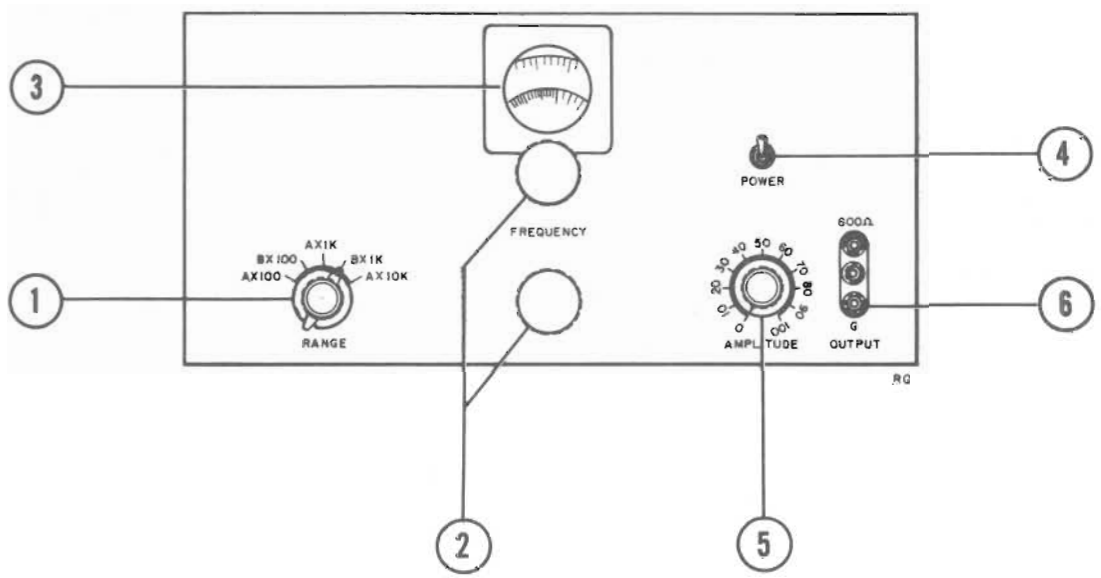
Connections to the primary winding of power transformer T1 are accessible from the under side of the chassis when the bottom plate is removed from the instrument.

If the instrument is to be operated from a 230-volt power source:

1) Reconnect the T1 primaries for 230-volt operation, as indicated on the schematic diagram.

2) Replace fuse F1 with a fuse of the type specified in the Table of Replaceable Parts (Section V) for 230-volt operation.

CONTROLS AND TERMINALS



1. Select frequency range of operation.
2. Vernier, adjust frequency.
3. Read frequency of operation multiplied by RANGE switch position. There is a two-band calibration of the FREQUENCY dial. The A band is calibrated from 2.5 to 10, and the B band from 8 to 32.
4. Turn on power to instrument. When the instrument is turned on, the index window will be illuminated.
5. Adjust output voltage level. Output balanced to ground only with AMPLITUDE control in full clockwise position.
6. Jumper for 600 Ω unbalanced output. Remove jumper for 600 Ω balanced output.

FUSE -- The fuseholder, located on the back of the instrument, contains the power line fuse. Characteristics of this fuse are given in the Table of Replaceable Parts (Section V).

Figure 2-1

SECTION II
OPERATING INSTRUCTIONS

2-1 CONTROLS AND TERMINALS

Refer to Figure 2-1 for an explanation of the controls and terminals.

2-2 OPERATING PROCEDURE

1) With the instrument plugged into a power source of specified voltage and frequency, and the power switch ON, allow a warm-up period of approximately thirty minutes.

2) The frequency of the output voltage is determined (a) by the setting of the frequency dial and (b) by the setting of the RANGE switch. For example, to obtain a 1000-cycle output, set the frequency dial at 10 on the B scale and the RANGE switch at BX100 (10 x 100 is 1000).

3) Turn the AMPLITUDE control to the zero position. Make the connection between the Model 200T and the equipment to be driven at the terminals designated 600 Ω. (Connections are discussed in paragraph 2-3, Output Circuit Options.)

The Model 200T may be operated into a load of any value without effect on the output waveform. The 200T may be considered as a 20-volt generator with a 600-ohm internal impedance.

4) Adjust the AMPLITUDE control to obtain the desired level of output voltage.

2-3 OUTPUT CIRCUIT OPTIONS

The output circuit of the Model 200T may be arranged for balanced or unbalanced operation. Typical connections for each are indicated in Figure 2-2.

A. UNBALANCED OPERATION

To operate with one side grounded, a strap is placed between the G terminal and the center terminal, as indicated in Figure 2-2A.

B. BALANCED OPERATION

Connections for balanced operation are indicated in Figure 2-2B. (The broken line from the ground terminal indicates the output circuit is balanced to ground, within the tolerances given below.)

The AMPLITUDE control in the output circuit is a bridged-tee attenuator and at any setting except

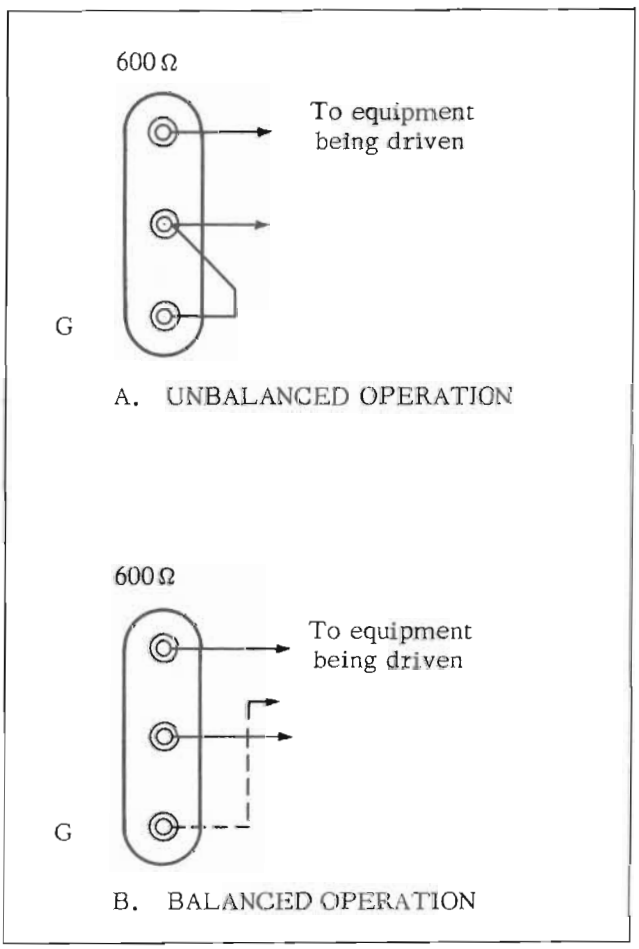


Figure 2-2. Typical Output Connections

minimum attenuation unbalances the circuit. Therefore for balanced operation the AMPLITUDE control must be set for maximum output (full clockwise). Output balance also is a function of frequency because of capacitive feedthrough at higher frequencies. Up to 10 kc, however, unbalance is less than 0.1%, and at 100 kc is approximately 0.3%. If small outputs are desired, or if balance at higher frequencies is critical, turn the AMPLITUDE control maximum clockwise, and connect an external balanced attenuator, designed for the frequencies involved, between the Model 200T and the load.

Figure 2-3 indicates the area where less than 1% unbalance may be obtained. This chart indicates balance obtainable at various settings of the AMPLITUDE control when operating into a 600-ohm load. Where other values of load are used, the chart does not apply directly but does apply for settings of the AMPLITUDE control that would produce the indicated voltage across a 600-ohm load.

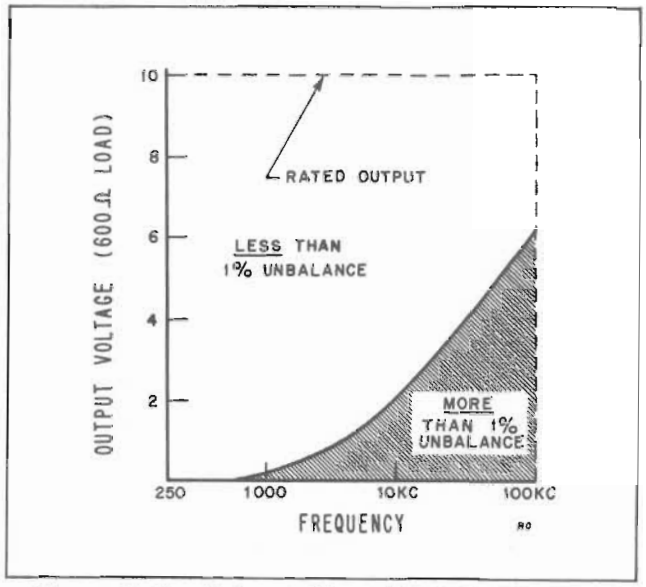


Figure 2-3. Balance Chart Operating into 600-ohm Load

SECTION III
CIRCUIT DESCRIPTION

3-1 GENERAL

The Model 200T uses a balanced (push-pull) oscillator circuit from which the output is taken directly, avoiding the complication and possible distortion of an isolating amplifier. Reaction of the load on the oscillator is avoided by the use of a zero source impedance output stage. This arrangement results in a simple, trouble-free circuit having low distortion and high stability over the entire frequency range.

Functionally, circuits of the Model 200T include a frequency-controlling bridge and balanced push-pull amplifier which constitute the oscillator circuit, an output circuit which may be arranged either for balanced or unbalanced operation, and a regulated power-supply circuit. These are shown in block diagram form in Figure 3-1 and in detail on the schematic diagram.

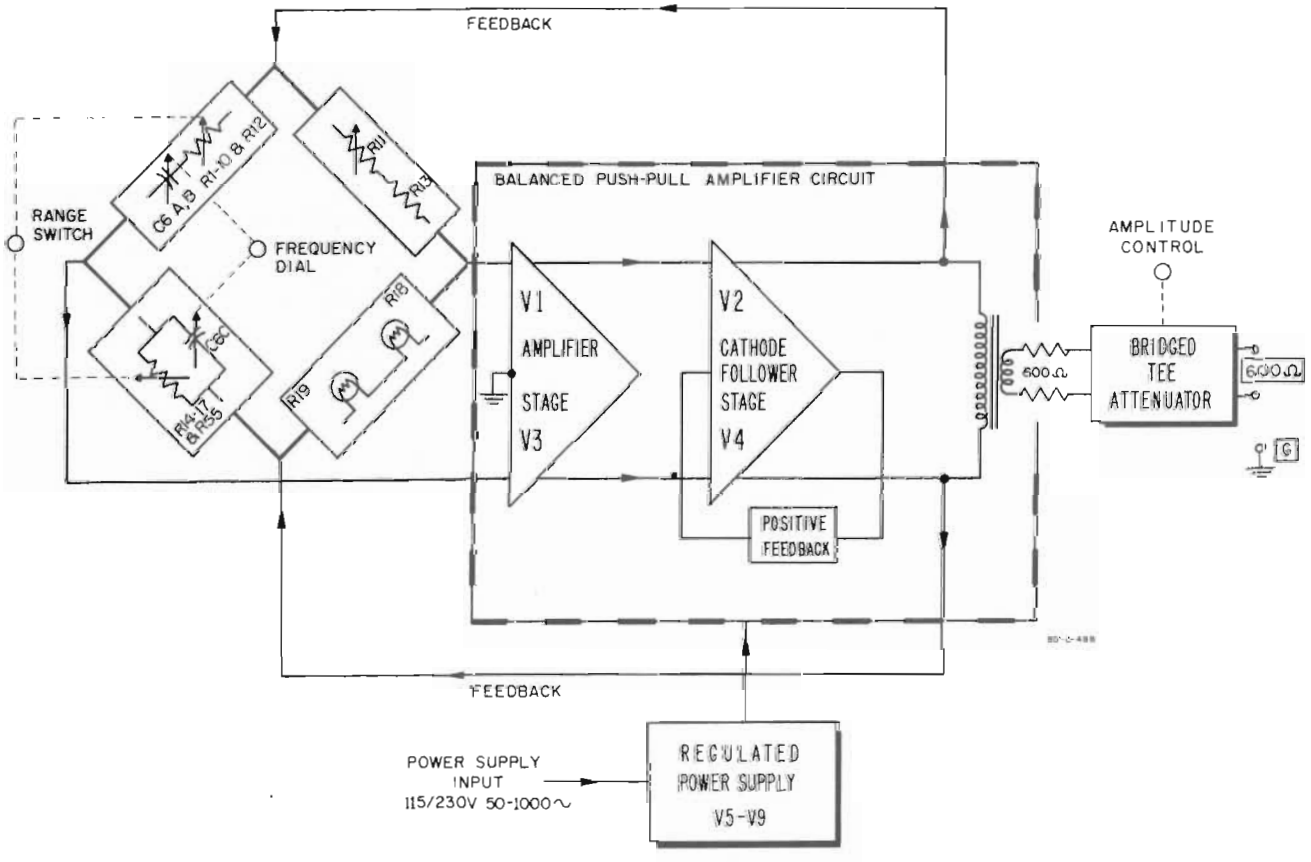


Figure 3-1. Model 200T Block Diagram

3-2 FREQUENCY-CONTROLLING BRIDGE

The frequency-controlling circuit is arranged as a floating bridge, symmetrical with respect to ground. With no connection to ground on any terminal of the bridge, stability of calibration is assured since any stray capacity and leakage to ground present at the bridge output terminals do not shunt either the frequency- or amplitude-controlling arms of the bridge. The frequency-controlling components (rc networks which are varied by operation of the RANGE switch and frequency dial) comprise two arms of the bridge, while the amplitude-stabilizing components (a voltage divider which includes a thermally-sensitive resistance) comprise the other two arms. The amplitude is stabilized at such a level that the amplifier tubes are operated in the substantially linear portion of their characteristics. This, together with the large negative feedback at harmonic frequencies, results in a very pure sine-wave oscillation.

The bridge is fed by the balanced voltage developed at the cathodes of V2 and V4 in the output of the balanced amplifier. The output of the frequency-controlling branch of the bridge is applied to the grid of V3 and the output of the amplitude-stabilizing branch is applied to the grid of V1. The manner in which the voltage-versus-frequency and phase-versus-frequency characteristics of an rc network can be utilized with an amplifier of proper design to achieve an oscillator which delivers voltage of excellent stability and waveform is well covered in texts such as Terman & Pettit's Electronic Measurements.

Variable resistors R1, R3, R4, R5 and R6 in the frequency-controlling branch are provided for adjusting the calibration.

Variable resistor R11 is provided for adjustment of the amplitude-stabilizing branch of the bridge should it be found after replacement of lamp R18 or R19 that less or more than rated voltage is being delivered to the output terminals.

Variable capacitors C4, C7 and C9 are adjusted at the factory for optimum calibration and amplitude constancy with frequency. If recalibration of the Model 200T is required, it may be necessary to readjust these capacitors.

3-3 AMPLIFIER

The oscillator amplifier is a balanced push-pull circuit which includes a voltage-amplifier stage (V1, V3) and a special cathode-follower stage (V2, V4). Crisscross positive feedback is used in the cathode-follower stage to provide an essentially zero output impedance as seen by the cathode-to-cathode load. The feedback paths are from the plate of V2 to the control grid and screen of V4, and from the plate of V4 to the control grid and screen of V2. The degree of the positive feedback is a function of the load and increases as the load impedance decreases, thus tending to maintain the output constant regardless of load. The output stage is protected against a cathode-to-cathode short circuit by the resistors in series with the transformer secondary. These resistors also make the oscillator present a 600 ohm impedance to the attenuator. Capacitors C12, C13 and C14 are part of the frequency-compensating circuitry.

The output from the cathode-follower stage (1) returns feedback to the frequency-controlling bridge and (2) supplies the primary winding of the output transformer, which couples the oscillator output to the output circuit.

3-4 OUTPUT CIRCUIT

Transformer coupling provides isolation between the oscillator circuit and the output circuit, and allows the output to be obtained either balanced or unbalanced. The secondary winding of coupling transformer T2 supplies a conventional bridged-tee attenuator, the setting of which is adjusted by operation of the AMPLITUDE control on the control panel. As the control is turned counterclockwise, the loss inserted by the attenuator is increased. The source impedance at the output terminals is 600 ohms.

With the attenuator set for minimum loss, the output circuit is arranged for balanced operation, and is so designed that even at the higher frequencies, stray capacity and leakage resistance will cause less than 1% unbalance.

When it is desired to operate unbalanced, ground should be connected to the center output terminal, which is the termination for the connection brought out from terminal 4 of the output transformer secondary winding. Proper operation cannot be obtained if the ground is connected to the side of the circuit which includes the attenuator.

3-5 POWER SUPPLY

DC voltage for the oscillator tubes is furnished from an electronically-regulated power supply. AC for the tube heaters is supplied directly from 6.3-volt secondary windings of transformer T1.

The electronic regulator compares a sample of the output voltage with a reference voltage. Any difference between the two results in a compensating adjustment in the amount of resistance inserted in series with the main positive bus.

Current for the regulator is rectified by V5 connected to the high-voltage secondary of power transformer T1. The output of V5 is filtered by a pi-section LC filter. R44 and C18 provide further filtering for the negative bus.

Pentode V8 is the regulator control tube, and V6 and V7 in parallel constitute the series regulator. The plate of control tube V8 is tied to the grids of the series regulator tubes. A portion of the output voltage, sampled with respect to the negative bus, is applied via variable resistor R46 to the grid of control tube V8, the cathode of which is held at a constant potential by voltage regulator tube V9. With the circuit so arranged, any rise or drop in the level of the output voltage will cause a change in the potential on the grid of the control tube, and also will cause a change in the potential on the grids of the series regulator tubes. By means of this circuitry, the series regulator becomes a variable resistance which is electronically controlled to increase or decrease as required to maintain the output voltage at a constant level.

The level of the output from the regulator may be varied by adjusting the voltage applied to the grid of control tube V8.

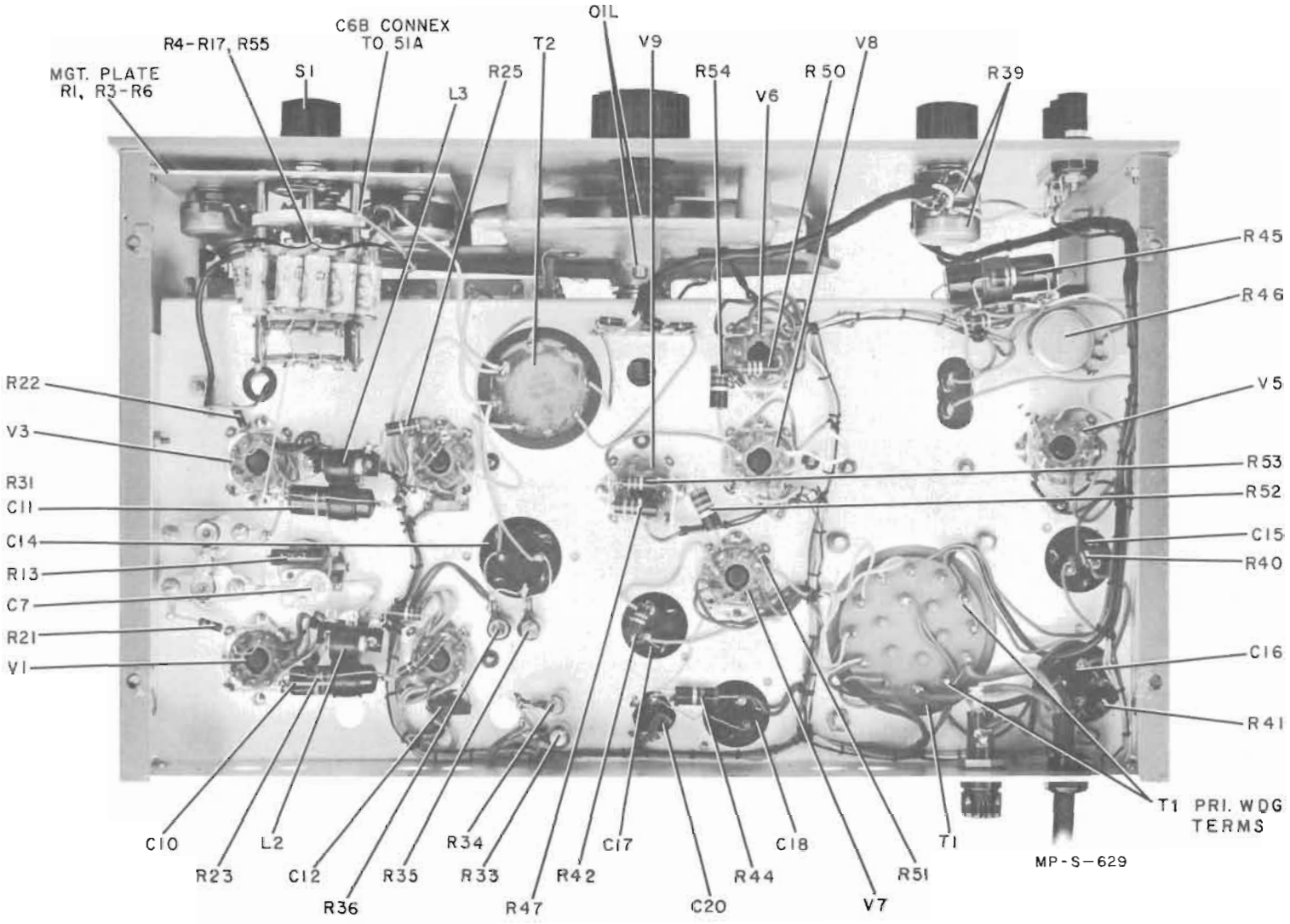


Figure 4-1. Bottom View Model 200T

SECTION IV
MAINTENANCE

4-1 GENERAL

The Model 200T Precision Telemeter Test Oscillator is a precision instrument designed conservatively for long component life, and it is probable that tube replacement will correct a majority of the difficulties which may develop. Tube replacement instructions are given in paragraph 4-10.

The maintenance data provided in this section assumes that maintenance personnel are thoroughly familiar with the operating procedures and circuit theory given in Section II and III.

As a guide in tracing the cause of substandard operation, a trouble-shooting chart (Table 4-1) is provided. The table indicates causes and remedies for certain specific troubles. Where the cause of the trouble is of a more obscure nature than the possibilities covered by the table, the failure should be traced to the section in trouble, and then localized within the section. General data on localization procedures is given in paragraph 4-6, Trouble Localization.

The recurrence of a specific trouble generally indicates that previous trouble shooting has remedied the effect but not the cause. And of course for satisfactory equipment performance, trouble clearance must aim at finding and eliminating the cause.

After locating the source and eliminating the cause of trouble, the instrument should be tested and adjusted. Rated performance specifications are given at the front of this manual.

4-2 OPERATIONAL CHECK

1) Turn instrument on and allow a 30 minute warm-up time.

2) Set RANGE switch to AX1K and the FREQUENCY dial at "5".

3) Connect a 600 ohm load across the output terminal.

4) Connect an ac vacuum tube voltmeter such as ℗ Model 400 series across the output terminal.

5) Set AMPLITUDE control to 100 (maximum clockwise) and measure the output voltage. The output voltage should be at least 10 volts rms.

6) Check frequency response of Model 200T using 5 kc as a reference. The frequency response should be within ±1 db over the entire range of the instrument.

7) Connect a Distortion analyzer such as ℗ Model 330B/C/D across the output terminal. The distortion should be less than 0.5% over the entire frequency range.

8) Check FREQUENCY dial calibration. Refer to paragraph 4-15, Calibration.

4-3 COVER REMOVAL

The bottom plate is removed by unscrewing the four screws, one in each corner of the bottom plate, which fasten the plate to the chassis.

The cover is removed by unscrewing the eight screws which fasten the cover to the back and top of the instrument.

4-4 LUBRICATION, TUNING-CAPACITOR DRIVE MECHANISM

The tuning capacitor drive assembly should be oiled once a month if the instrument is in constant use, or every six months if the instrument has only occasional use . Before lubricating the instrument, all dust and dirt that has collected on the tuning mechanism should be removed. The following need lubrication:

1) Vernier drive-shaft bearing, one drop of light oil on shaft, at each end of bearing (see Figure 4-1).

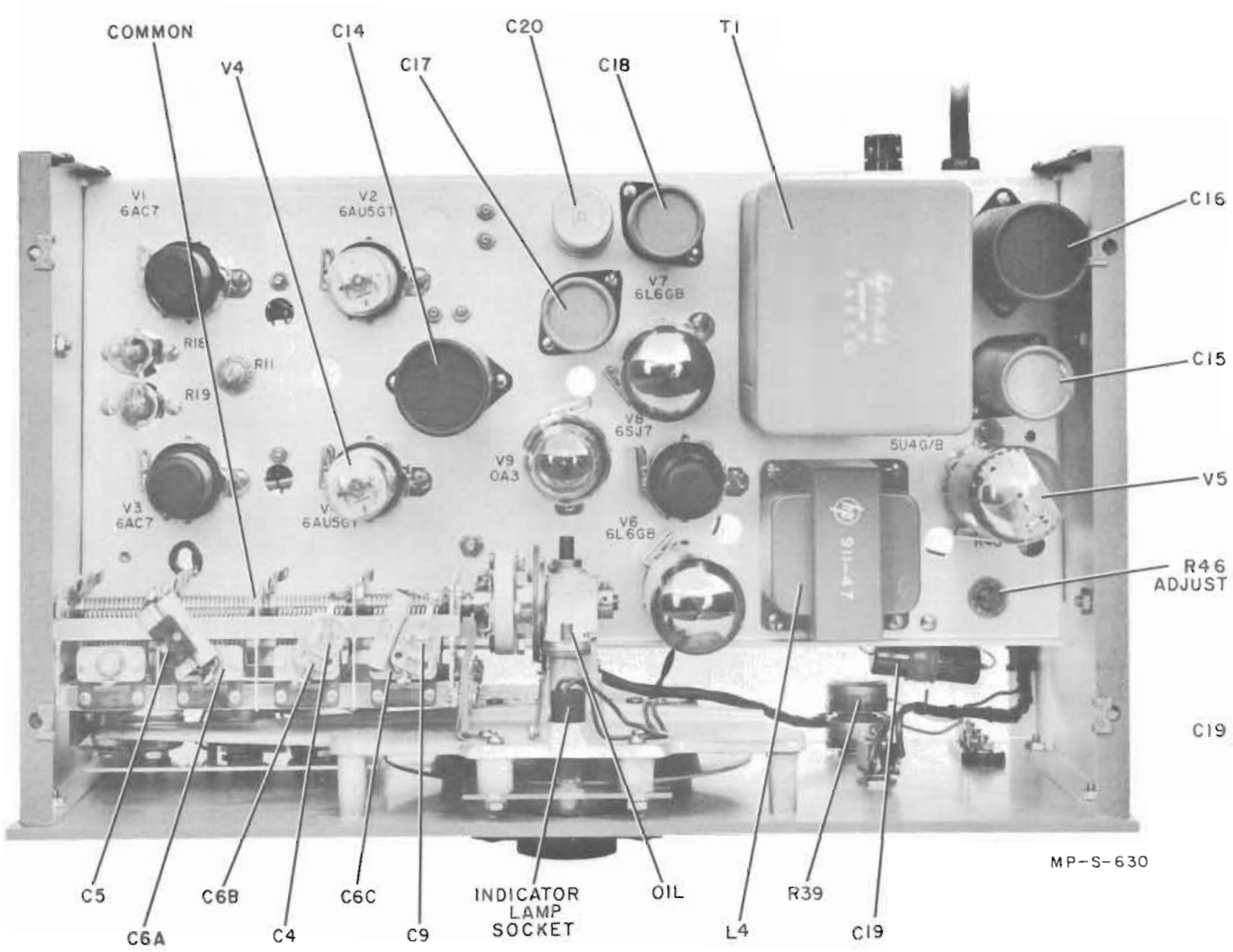


Figure 4-2. Top View Model 200T

2) Idler pulley bearing, one drop of light oil on pulley shaft. Idler pulley bearing is directly below indicator lamp socket (see Figure 4-2).

4-5 TROUBLE SHOOTING

Table 4-1 lists various symptoms of trouble and for each indicates the part or parts of the circuit which should be checked. In the main, for simplification, only tubes are referenced, but it should be remembered that components associated with referenced tubes also are failure possibilities. Within each section of the table, checking should be performed in the order given since it is assumed throughout a procedure that the parts checked previously are functioning correctly.

When testing the Model 200T, it is recommended that line voltage be applied to the instrument through a variable transformer, and that the transformer be adjusted to deliver 105 volts to the instrument. An instrument in good condition operates satisfactorily from any line voltage within rated range, but where there is marginal operation (from weak tubes, etc.) it will be easier to trace at low line voltages.

TABLE 4-1. TROUBLE SHOOTING

Symptom and Possible Cause	Test Procedure	Remedy
1. INSTRUMENT NOT OPERATING, INDEX WINDOW NOT LIGHTED:		
a. Fuse open due to defective fuse or overload in power supply	Replace fuse. If new fuse blows, remove V5 and replace fuse.	
	Blowing of 2nd fuse indicates:	
	(1) Short circuit in wiring associated with T1.	(1) Locate and clear short
	(2) Short circuit in filament wiring.	(2) Locate and clear short
	(3) Defective transformer T1.	(3) Replace transformer
	No opening of 2nd fuse with V5 removed indicates:	
	(1) Defective rectifier V5.	(1) Replace V5
	(2) Internal short circuit in V1, V2, V3 or V4.	(2) Locate and replace defective tube.
	(3) Short circuit in dc wiring.	(3) Locate and clear short.
	(4) Defective filter component. DC resistance from pin 8 of V5 to ground normally is approximately 90K; disconnect line voltage before measuring.	
b. Poor connection to line voltage.	Check power cable, and connections at both ends of cable.	

TABLE 4-1. TROUBLE SHOOTING

Symptom and Possible Cause	Test Procedure	Remedy
2. INSTRUMENT NOT OPERATING, INDEX WINDOW LIGHTED:		
a. Power supply not operating properly.	Check level of dc voltage at power supply output; should be 180 volts. Use dc voltmeter, such as Model 410B; connect voltmeter between pin 8 of V6 or V7 and chassis.	If voltmeter indication not 180 volts, refer to paragraph 4-7.
b. Defective tube in oscillator circuit.	Check for bad V1, 2, 3 or 4 by substituting tubes of same type known to be good.	Replace defective tube. See paragraph 4-10.
c. Short circuit in tuning capacitor C6, variable C4 or C9, or fixed capacitor C5 or C8.	To check capacitors C6A, 6B, 4 and 5: (1) Disconnect Model 200T from line. (2) Connect one ohmmeter lead to C6 terminal designated C6B on Figure 4-2 and other to chassis. (3) Set RANGE switch to AX100. (4) Ohmmeter should indicate approximately 480K. To check capacitors C6C, C8, C9: (1) Connect one ohmmeter lead to point on C6 designated COMMON on Figure 4-2 and other to chassis. (2) With 200T disconnected from line and RANGE switch on AX100, ohmmeter should indicate approximately 1,018M.	If resistance measurements indicate short, before making further checks, visually examine C5. If C5 is dirty, with air hose gently blow dust from plates and then again make resistance measurements.
d. Capacitor C6 shorted to ground.	Connect one ohmmeter lead to C6 terminal designated C6C on Figure 4-2 and other to chassis. With 200T disconnected from line and RANGE switch at any setting, ohmmeter should indicate approximately 10K.	If resistance measurement indicates short, check for defect in insulation between C6 and instrument chassis.
e. Defective lamp (R18, R19).	See paragraph 4-11.	
3. INSTRUMENT OPERATING PROPERLY ON ONLY PART OF THE RANGES:		
a. Dirty contacts on RANGE switch.	Examine RANGE switch for dirty contacts.	Contacts may be cleaned with E-Z aid or other silver dip.
b. Open RANGE switch resistor	Check resistors associated with affected range.	Replace resistor or RANGE switch. See par. 4-14 & 15.

TABLE 4-1. TROUBLE SHOOTING (CONT'D)

Symptom and Possible Cause	Test Procedure	Remedy
4. DISTORTION IN OUTPUT:		
a. Bad tube in oscillator circuit.	See paragraphs 4-9 and 4-10.	
b. Incorrect voltages on tube pins.	Check as described in 2a above.	
	Check dc voltages on tube sockets (see V & R Diagram); except as noted, voltages should be within ± 10% of values shown.	If voltages are incorrect, check resistors in circuits associated with incorrect voltages.
c. Dust on plates of tuning capacitor C6.	Inspect visually.	With air hose, gently blow out dust.
d. Defective lamp (R18,19)	See paragraph 4-11.	
5. NOISE PRESENT IN OUTPUT WAVEFORM WHEN AMPLITUDE CONTROL IS ROTATED; OUTPUT VOLTAGE UNSTABLE WHEN AMPLITUDE CONTROL IS ROTATED:		
a. Defective AMPLITUDE control (R39).		Replace R39.

4-6 TROUBLE LOCALIZATION

When the cause of instrument failure or substandard operation is of a more obscure nature than the possibilities covered by the trouble-shooting chart, the failure should be localized to a section of the circuit, and then isolated within the section. Basic sections of the circuit are defined in the Block Diagram Figure 3-1. Testing to localize trouble always should start with the power supply. After isolating trouble to a section of the circuit which includes more than one tube, the next step is to determine the tube circuit involved. A replacement tube should be tried before attempting any other tests. If trouble persists, voltage and resistance measurements should be made. Typical dc voltages and resistances to ground from tube socket pins are given in Figure 4-4.

4-7 POWER-SUPPLY LOCALIZATION CHECK

If trouble is localized to the power-supply section, the following checks will be helpful in trouble shooting.

1) Set line voltage to exactly 115 volts.

2) The dc voltage from pin 8 of V5 to chassis should be +440 volts ± 10%.

Low voltage at this point may be due to defective 5U4GA/B rectifier tube V5 or defective transformer T1.

To check V5, with the voltmeter still connected between pin 8 and chassis, reduce line voltage from 115 to 105 volts. The voltmeter reading

should drop immediately when the ac line voltage is reduced, and then remain steady. If the dc voltage continues to drop at a slow rate, rectifier V5 probably is weak and should be replaced.

3) The voltage from pin 3 of series regulator V6 or V7 to chassis should be 410 volts ±10%.

Low voltage at this point may be due to defective component in filter.

4) The dc voltage between pin 8 of V6 or V7 and chassis should be 180 volts.

If the regulator output is not 180 volts and adjustment of R46 (see paragraph 4-8, Voltage Regulator Adjustment) cannot bring it to 180 volts, it may be necessary to replace V5, V6, V7, V8 and/or V9.

5) Measure the dc voltage between pin 8 of V6 or V7 and chassis while varying the ac line voltage from 103.5 to 126.5 volts (115 volts ±10%). The regulator output should remain at 180 volts with ±10% line-voltage change.

If the 180-volt level is not maintained, check V9, V8, and V6-V7.

4-8 VOLTAGE REGULATOR ADJUSTMENT

The level of the voltage regulator output must be 180 volts. To check the regulator output, measure the voltage between pin 8 of V6 or V7 and the chassis with a dc voltmeter, such as an hp Model 410B. If the regulator output is not 180 volts, adjust variable resistor R46 to obtain a 180-volt reading. The screwdriver adjustment for R46 is accessible from the top of the instrument when the cover is removed.

4-9 CHECK FOR CAUSE OF DISTORTION

To check for the cause of distortion, the dc voltage between the cathodes of V2 and V4 should be measured. There should be less than 1 volt between the V2-V4 cathodes, and the voltage read with the RANGE switch on AX1K should be the same as with the switch on AX100. A 20,000 ohms-per-volt or better, voltmeter may be used for making the measurements. Proceed as follows:

1) Allow a five-minute warm-up period before making the voltage measurements. Connect one terminal of the voltmeter to pin 3 of V2 and the other to pin 3 of V4.

2) Set the RANGE switch to AX100, the frequency dial at "10", and note the meter indication.

3) Set the RANGE switch on AX1K, and note the meter indication: if it differs from that obtained with the switch on AX100, excessive grid current in V3 is indicated.

Before replacing V3 with a new 6AC7, interchange V1 and V3, and again measure the voltage between the V2-V4 cathodes with the RANGE switch on AX100 and AX1K.

If the V1-V3 interchange has not corrected the trouble, replace V3 with another 6AC7. To determine whether the replacement 6AC7 has the proper characteristics for the oscillator circuit, again measure the distortion; it should not exceed 0.5%.

4-10 TUBE REPLACEMENT

A. OSCILLATOR

If V1, V2, V3, or V4 is replaced, distortion measurements should be made to determine that distortion in the Model 200T output voltage does not exceed the rated 0.5%. Distortion may be measured with an instrument which directly indicates percent of distortion, such as hp Model 330 series Noise and Distortion Analyzer.

If distortion is outside rated limits, another tube of the same type should be substituted for the replacement tube, and distortion again measured.

If excessive distortion persists, the cause may be: 1) excessive grid current in V3, or 2) the replacement tube does not have the proper characteristics for the oscillator circuit.

To determine the probable cause of the distortion, the dc voltage between the cathodes of V2 and V4 should be measured (paragraph 4-9, Check for Cause of Distortion).

B. POWER SUPPLY

After replacement of V5, V6, V7, V8, or V9, the level of the output from the regulator should be checked. With a line voltage of 115 volts, from pin 8 of V6 or V7 to chassis 180 volts should be measured with a voltmeter of 122 megohms, or better, input resistance. If a 180-volt reading is not obtained, adjust variable resistor R46 to obtain 180 volts.

4-11 REPLACEMENT OF LAMPS R18 & R19

Lamps R18 and R19 are operated well below rating, and they should have a long life. However, severe mechanical vibration can damage the lamps.

To check lamp operation, measure the level of the output voltage. It should be 24 volts open circuit or 12 volts into 600 ohms. A vacuum tube voltmeter, such as an ℌ Model 400D is suitable for making the measurements. Proceed as follows:

1) Set the Model 200T on any one of the upper ranges and for any frequency above 60 cps; permit a warm-up period of about five minutes.

2) Turn the AMPLITUDE control maximum clockwise.

3) Connect the voltmeter to the 600Ω terminals. The voltmeter indication should be 24 volts open circuit.

4) If the output voltage is not at the correct level:

a. Adjust variable resistor R11 to obtain 24 volts. The screwdriver adjustment for R11 is brought out to the upper side of the deck, and is accessible through the top of the instrument when the cover is off.

b. If a 24-volt output cannot be obtained by adjustment of R11, replace either or both lamps R18 and R19.

After replacement of the lamps, adjust R11 to obtain 24 volts open circuit.

4-12 REPLACEMENT OF ELECTROLYTIC CAPACITORS

The electrolytic capacitors in this instrument are high quality units which should not be replaced unless they are proved defective by accurate tests. To insure original performance, use exact replacement-electrolytic capacitors.

4-13 REPLACEMENT OF VARIABLE RESISTORS AND CAPACITORS

1) R11 -- After replacement of R11, the level of the output voltage should be measured (see paragraph 4-11, Replacement of Lamps R18 and 19), and R11 should be adjusted to obtain an output of 24 volts open circuit.

2) R39 -- After replacement of R39, position the knob so that the marker will be at "0" with the control in the maximum counterclockwise position.

3) R1, R3, R4, R5, R6 -- These variable resistors are calibrating resistors in one arm of the frequency-controlling bridge. After replacement of any one of these resistors, calibration of the affected range should be checked. Calibration procedure is given in paragraph 4-15.

4) R46 -- After replacement check the output of the regulator as described in paragraph 4-8, Voltage Regulator Adjustment.

5) Capacitors -- Variable capacitors C4 and C9 are mounted on the top of tuning capacitor C6, and variable capacitor C7 is located on the under side of the chassis. After replacement of any one of the variable capacitors, check the calibration, paragraph 4-15.

4-14 REPLACEMENT OF RANGE SWITCH

The Model 200T RANGE switch may be ordered and replaced as a unit. After the replacement, the instrument normally will not require calibration. If it is desired to check the calibration after switch replacement, or if aging of components makes recalibration of the instrument necessary, see paragraph 4-15, Calibration.

The calibration procedures require special equipment and skilled personnel. If it is desired to have replacement and/or recalibration done by the Hewlett-Packard Company or any authorized ℌ-field repair station, contact your ℌ representative for shipping instructions.

Removal of the old RANGE switch and installation of the new are straightforward operations, and no special instructions are required.

The switch is positioned correctly when the higher value resistor, R17-55, are toward the bottom of the instrument.

4-15 CALIBRATION

CAUTION: The Model 200T is capable of generating frequencies with an accuracy of ±1%. The instrument will function within this accuracy when properly calibrated. Though the Model 200T has been designed with adjustable padding resistors so that calibration may easily be maintained within

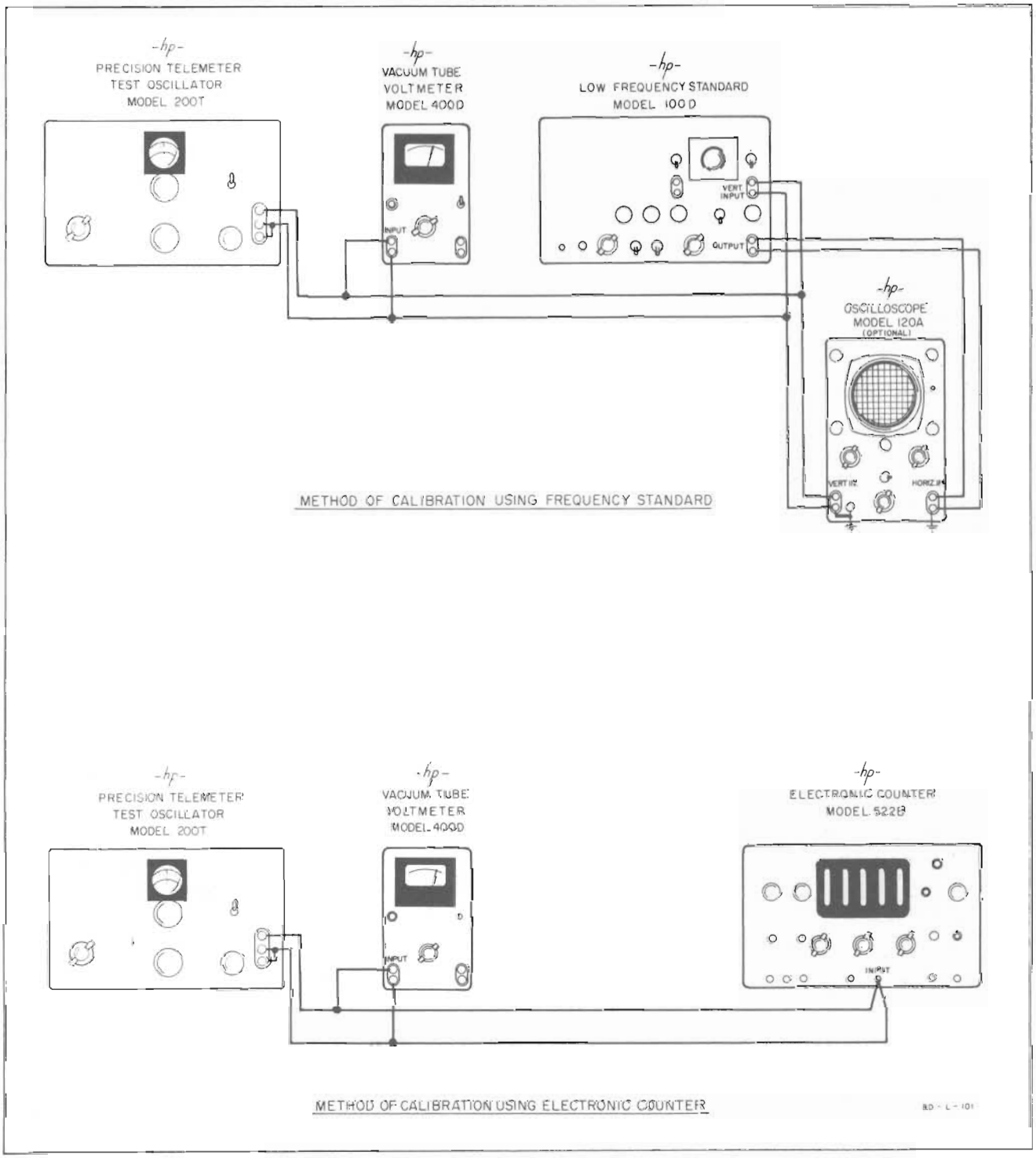


Figure 4-3. Equipment Arrangements, Calibration Procedure

rated accuracy, special equipment and skill in using it are required for the calibration procedure. Unless both are available it is recommended that the Model 200T be sent to an authorized repair station for this work.

A. EQUIPMENT REQUIRED

1) RMS calibrated vacuum tube voltmeter, such as one of the hp Model 400 series.

2) Alignment tool (insulated screwdriver).

3) Frequency-measuring device:
Secondary frequency standard with comparison facilities, such as an hp Model 100D/E Secondary Frequency Standard. (If larger scope pattern than provided by the Model 100D/E is desired, an external oscilloscope may be used with the Model 100D.) Or a frequency counter, such as an hp Model 522B, 523 series or 524 series Electronic Counter.

B. TERMINOLOGY

When the following expressions are used in the test, they have the meaning here specified.

Slip the dial -- 1) Remove center knob on frequency dial. 2) Loosen four screws which secure dial plate to drive shaft. 3) Reset dial to position indicated in text. 4) Tighten four securing screws (center knob may be replaced at end of procedure).

On calibration -- Frequency indication centered beneath dial indicator index is the same as output frequency.

C. RESISTOR ADJUSTMENTS

A variable resistor for each range is provided for adjustment of the calibration. The screwdriver adjustment for each of these variable resistors is brought out to the front panel, and is identified by the RANGE switch designation for the range. In the following procedure, the variable resistors are called by their range designations instead of the number they carry on the schematic diagram.

D. CONNECTIONS

Connection arrangements are indicated in Figure 4-3. Connect output of Model 200T to input of measuring equipment.

E. PRE-CALIBRATION PROCEDURE

1) Turn on Model 200T; allow at least 30-minutes warm-up period. Remove cover from Model 200T.

2) Turn FREQUENCY dial maximum counter-clockwise.

Check that stop marks (black dot or dots to right of high end of scale) exactly line up with index line on dial indicator.

If markers do not align with index line, slip dial, and line up stop marks with index line.

F. CALIBRATION OF AX1K RANGE

1) Set RANGE switch on AX1K, and turn FREQUENCY dial to "2.5".

If "2.5" not on calibration, adjust variable resistor AX1K to bring "2.5" on calibration. The screwdriver adjustment for resistor AX1K is accessible at the control panel.

Set voltage reference, for example 9 volts. (Adjust AMPLITUDE control to get voltmeter indication of 9 volts.)

2) Turn FREQUENCY dial to "10". Adjust either trimmer C4 or C9 (Figure 4-2) to bring "10" on calibration. (Seldom necessary to adjust both trimmers.)

Note output voltage. Correct for half of voltage error with trimmer adjust. Adjust other trimmer to correct frequency error.

3) Turn dial to "2.5" again, and check output voltage. Repeat steps 1 and 2 until calibration is on and output is constant at both "2.5" and "10".

4) Check tracking across range. Make note approximate percent calibration is off across range.

If range within specifications, proceed to BX1K calibration.

If range is not within specifications, it may be necessary to bend capacitor plates as described in paragraph 4-16, Tracking Adjustments. As check that capacitive adjustment is required, proceed with BX1K calibration. If tracking across BX1K range is off in same direction as AX1K range, proceed as described in paragraph 4-16.

G. CALIBRATION OF BX1K RANGE

1) Set RANGE switch on BX1K, and turn FREQUENCY dial to "8". Adjust variable resistor BX1K to bring "8" on calibration.

2) Check tracking across range. Make note approximate percent calibration is off across range. Note: Low end is on calibration. If high end is off by small amount, place low end off in same direction by half-high end error to obtain better calibration across range.

If range is within specifications, proceed to AX10K calibration.

If range not within specifications, and tracking on AX1K range is off in same direction, follow procedure given in paragraph 4-16, Tracking Adjustment.

H. CALIBRATION OF AX10K RANGE

1) Set RANGE switch on AX10K, and turn dial to "2.5". Adjust AX10K to bring "2.5" on calibration.

2) Turn dial to "10". If "10" not on calibration, adjust variable capacitor C7 to bring "10" on calibration.

3) Check tracking across range. It should be within specifications.

I. CALIBRATION OF AX100 AND BX100 RANGES

In the following procedure, the low end of each range is set on calibration, and then tracking across the range is checked. If high end is found off by small amount, place low end off in same direction by half high-end error to obtain better calibration across range.

1) Set RANGE switch on AX100, and turn frequency dial to "2.5". Adjust variable resistor AX100 to bring "2.5" on calibration. Check tracking across range.

2) Set RANGE switch on BX100, and turn frequency dial to "8". Adjust variable resistor BX100 to bring "8" on calibration. Check tracking across range.

4-16 TRACKING ADJUSTMENTS

A. HIGH END OF RANGE

Follow steps 1, 2, and 3 in paragraph 4-15F, Calibration of AX1K Range. The high end of the dial should now track within specifications.

B. LOW END OF RANGE

Check rest of dial, and find which cardinal points are off calibration.

For each point outside of specifications, bend associated tuning-capacitor plates as described below to bring point within specifications.

Note: Bending plates for points above "7" on dial usually is unnecessary and impractical.

C. BENDING TUNING-CAPACITOR PLATES

1) Bend only plate segments associated with dial point off calibration.

In each section of tuning-capacitor rotor, border on outside plates is split into segments.

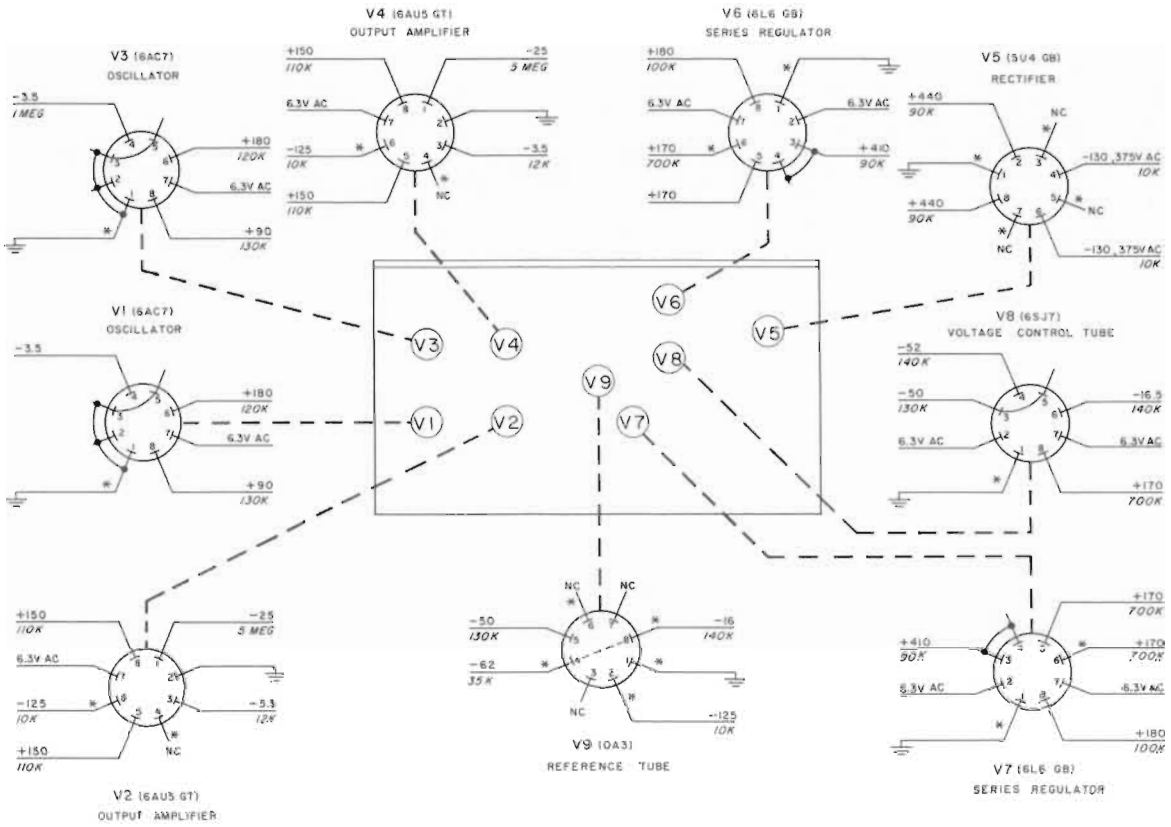
Segments associated with each dial point are those engaging stator when dial point is under dial indicator index. Plate segments are referred to as plates.

2) Bend plates carefully, with screwdriver or fingers. Each of the six plates associated with dial point should be bent by same amount.

To raise the frequency of oscillation, spread plates.

To lower the frequency, squeeze plates.

Bending operation must always start with highest-frequency point involved. For example, if calibration is off at "6", "5", and "4", start bending at plates associated with "6".



NOTES:

VOLTS DC UNLESS OTHERWISE NOTED.

CONDITIONS OF DC VOLTAGE MEASUREMENT
1. BETWEEN INDICATED POINT AND CHASSIS WITH A VOLTMETER OF 122 MEGOHMS INPUT RESISTANCE.
2. LINE VOLTAGE 115/230 VOLTS, 50-1000~
3. AMPLITUDE CONTROL AT ZERO.
4. RANGE SWITCH AT AX100.
5. FREQUENCY DIAL AT 10.

* = NO TUBE ELEMENT.

CONDITIONS OF RESISTANCE MEASUREMENT
1. BETWEEN INDICATED POINT AND CHASSIS WITH OHMMETER.
2. DISCONNECTED FROM LINE VOLTAGE.
3. CAPACITORS CHARGED BY OHMMETER BEFORE READINGS TAKEN.

CONDITIONS OF AC VOLTAGE MEASUREMENT
1. BETWEEN INDICATED POINT AND NEGATIVE BUS.

Figure 4-4. Model 200T Voltage and Resistance Diagram

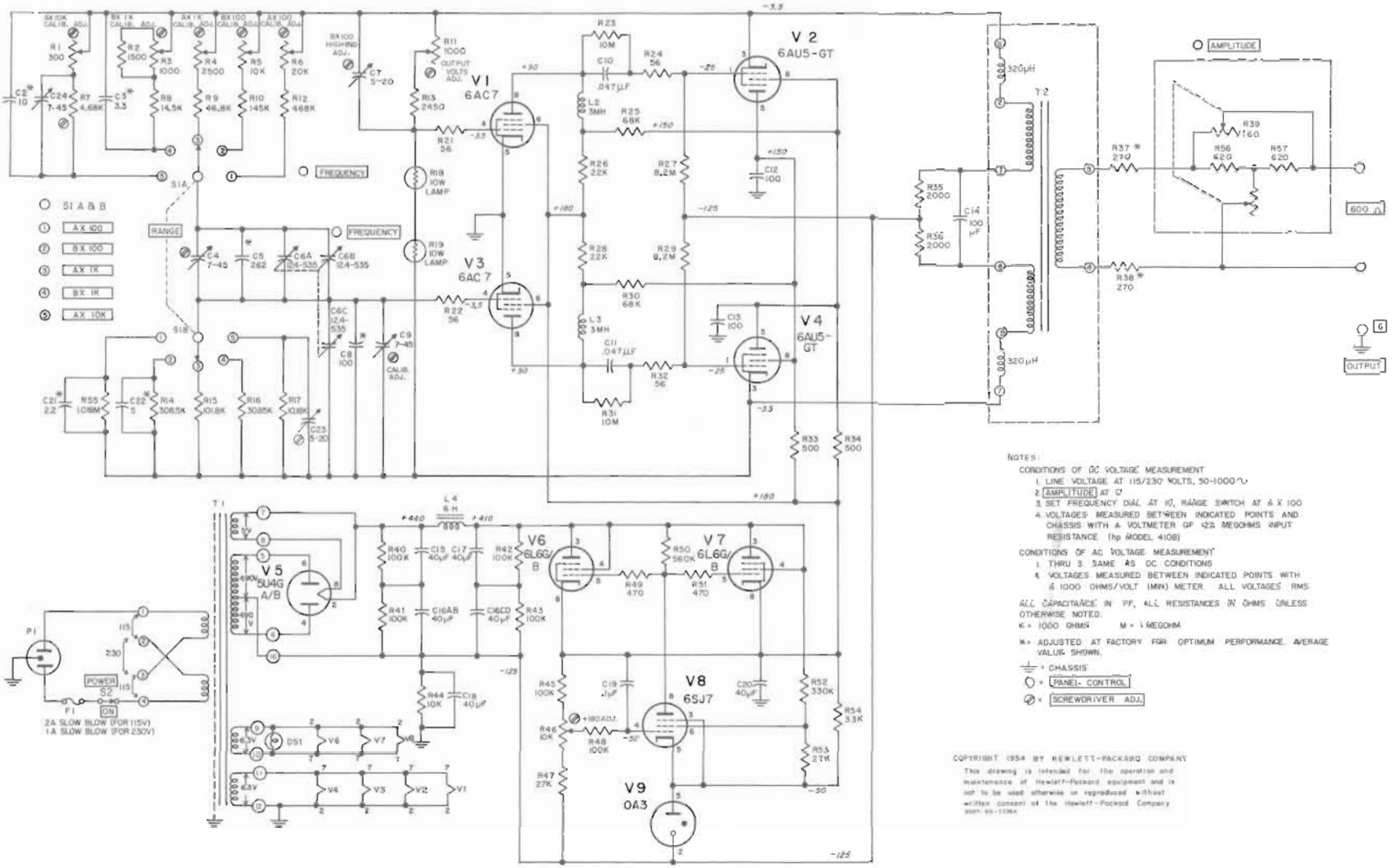


Figure 4-5. Model 200T Precision Telemeter Test Oscillator

SECTION V
TABLE OF REPLACEABLE PARTS

5-1 INTRODUCTION

This section contains information for ordering replacement parts for the Model 200T Precision Telemeter Test Oscillator.

The table 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 opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

1) Reference designator.

2) Full description of the part.

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

4) Hewlett-Packard stock number.

5) Manufacturer's part number.

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

5-2 ORDERING INFORMATION

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

Specify the following information for each part:

1) Model and complete serial number of instrument.

2) Hewlett-Packard stock number.

3) Circuit reference designator.

4) Description.

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ℎp STOCK NO.	TQ*	RS*		
C1	Not assigned						
C2	Capacitor: fixed, ceramic, 10 pf ± 0.5 pf, 500 vdcw	04222	0150-0009	1	1		
C3	Capacitor: fixed, titanium dioxide, 3.3 pf ± 10%, 500 vdcw	78488	0150-0022	1	1		
C4	Capacitor: variable, ceramic, 7-45 pf, 500 vdcw	72982	0130-0001	3	1		
C5	Consists of the following, two each: Capacitor: fixed, ceramic, 100 pf ± 5%, 500 vdcw	04222	0150-0007	2	1		
	One each: Capacitor: fixed, mica, 62 pf ± 5%, 500 vdcw Optimum value adjusted at factory Average value shown	04222	0140-0064	1	1		
C6	Capacitor: variable, air, 4 sections, 12.4 pf to 535 pf	76854	0121-0002	1	1		
C7	Capacitor: variable, ceramic, 5-20 pf, 500 vdcw	72982	0130-0006	2	1		
C8	Capacitor: fixed, ceramic, 100 pf ± 5%, 500 vdcw Optimum value selected at factory Average value shown	04222	0150-0007	1	1		
C9	Same as C4						
C10, 11	Capacitor: fixed, paper, .047 μf ± 10%, 600 vdcw	56289	0160-0005	2	1		
C12, 13	Capacitor: fixed, mica, 100 pf ± 10%, 500 vdcw	00853	0140-0054	2	1		
C14	Capacitor: fixed, electrolytic, 100 μf 100 vdcw	56289	0180-0013	1	1		
C15	Capacitor: fixed, electrolytic, 40 μf 450 vdcw	56289	0180-0024	4	1		
C16	Capacitor: fixed, electrolytic, 4 sections, 20 μf/sect., 450 vdcw	56289	0180-0025	1	1		

* See introduction to this section

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ℌ STOCK NO.	TQ*	RS*		
C17, 18	Same as C15						
C19	Capacitor: fixed, paper, 0.1 μf ±10%, 600 vdcw	56289	0160-0001	1	1		
C20	Same as C15						
C21	Capacitor: fixed, titanium dioxide 2.2 pf ±10%, 500 vdcw	78488	0150-0015	1	1		
C22	Capacitor: fixed, ceramic, 5 pf ±0.5 pf, 500 vdcw	04222	0150-0008	1	1		
C23	Same as C7						
C24	Same as C4						
DS1	Lamp, incandescent: 6-8V, 2 pin base, #12	24455	2140-0012	1	1		
F1	Fuse: 2 amp, slow-blow (115V operation)	71400	2110-0006	1	10		
	Fuse: 1 amp, slow-blow (230V operation)	71400	2100-0007				
L1	Not assigned						
L2, 3	Reactor: 3 MH	28480	200CD-60C	2	1		
L4	Reactor: 6h 125 MA, 240 ohms	28480	9110-0017	1	1		
P1	Cable, power	70903	8120-0050	1	1		
R1	Resistor: variable, wirewound, linear taper, 300 ohms ±20%, 2 W	71450	2100-0038	1	1		
R2	Resistor: fixed, composition, 1500 ohms ±10%, 1 W	01121	0690-1521	1	1		

* See introduction to this section

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℔ STOCK NO.	TQ*	RS *		
R3	Resistor: variable, composition, linear taper, 1000 ohms ± 20%, 1/2 W 71450	2100-0194	1	1		
R4	Resistor: variable, composition, linear taper, 2500 ohms ± 20%, 1/2 W 71450	2100-0190	1	1		
R5	Resistor: variable, composition, linear taper, 10,000 ohms ± 20%, 1/2 W 71450	2100-0156	2	1		
R6	Resistor: variable, composition, linear taper, 20,000 ohms ± 20%, 1/3 W 71450	2100-0161	1	1		
R7	Resistor: fixed, wirewound, 4680 ohms ± 1%, 1 W 91827	0811-0015	1	1		
R8	Resistor: fixed, wirewound, 14,500 ohms ±1%, 1 W 91827	0811-0017	1	1		
R9	Resistor: fixed, wirewound, 46,800 ohms ±1%, 1/2 W 91827	0811-0014	1	1		
R10	Resistor: fixed, wirewound, 145,000 ohms ±1%, 1/2 W 91827	0811-0016	1	1		
R11	Resistor: variable, composition, linear taper, 1000 ohms ±20%, 2 W 71590	2100-0036	1	1		
R12	Resistor: fixed, wirewound, 468,000 ohms ±1%, 1/2 W 91827	0811-0013	1	1		
R13	Resistor: fixed, deposited carbon, 2450 ohms ±1%, 1 W 19701	0730-0018	1	1		
R14	Resistor: fixed, wirewound, 308,500 ohms ±0.1%, 1/2 W 91827	0811-0010	1	1		
R15	Resistor: fixed, wirewound, 101,800 ohms ±0.1%, 1/2 W 91827	0811-0008	1	1		

* See introduction to this section

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	TQ*	RS*		
R16	Resistor: fixed, wirewound, 30,850 ohms ±0.1%, 1/2 W	91827	0811-0011	1	1		
R17	Resistor: fixed, wirewound, 10,180 ohms ±0.1%, 1 W	91827	0811-0009	1	1		
R18, 19	Lamp, incandescent: 250V, 10 W	24455	2140-0007	2	1		
R20	Not assigned						
R21, 22	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	01121	0687-5601	4	1		
R23	Resistor: fixed, composition, 10 megohms ±5%, 1/2 W	01121	0686-1065	2	1		
R24	Same as R21						
R25	Resistor: fixed, composition, 68,000 ohms ±10%, 1 W	01121	0690-6831	2	1		
R26	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W	01121	0690-2231	2	1		
R27	Resistor: fixed, composition, 8.2 megohms ±10%, 1/2 W	01121	0687-8251	2	1		
R28	Same as R26						
R29	Same as R27						
R30	Same as R25						
R31	Same as R23						
R32	Same as R21						
R33, 34	Resistor: fixed, wirewound, 500 ohms ±10%, 10 W	35434	0816-0003	2	1		
R35, 36	Resistor: fixed, wirewound, 2000 ohms ±5%, 10 W	35434	0816-0012	2	1		
R37, 38	Resistor: fixed, composition, 270 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-2711	2	1		

* See introduction to this section

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℔ STOCK NO.	TQ*	RS*		
R39	Output Attenuator: 600 ohms Bridged T (includes R56, R57)	28480	200CD-34	1	1		
R40 thru R43	Resistor: fixed, composition, 100,000 ohms ±10%, 1 W	01121	0690-1041	5	2		
R44	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W	01121	0693-1031	1	1		
R45	Same as R40						
R46	Same as R5						
R47	Resistor: fixed, composition, 27,000 ohms ±10%, 2 W	01121	0693-2731	1	1		
R48	Resistor: fixed, composition, 100,000 ohms ±10%, 2 W	01121	0693-1041	1	1		
R49	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	01121	0687-4711	2	1		
R50	Resistor: fixed, composition, 560,000 ohms ±10%, 1 W	01121	0690-5641	1	1		
R51	Same as R49						
R52	Resistor: fixed, composition, 330,000 ohms ±10%, 2 W	01121	0693-3341	1	1		
R53	Resistor: fixed, composition, 27,000 ohms ±10%, 1 W	01121	0690-2731	1	1		
R54	Resistor: fixed, composition, 33,000 ohms ±10%, 2 W	01121	0693-3331	1	1		
R55	Resistor: fixed, wirewound, 1.018 megohms ±0.1%, 1/2 W	91827	0811-0012	1	1		
R56, 57	Resistor: fixed, composition, 620 ohms ±5%, 1/2 W	01121	0686-6215	2	1		

* See introduction to this section

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	TQ*	RS*		
S1	Range Switch Assembly Switch, rotary, less resistors	28480 76854	200T-19W 3100-0090	1	1		
S2	Switch, toggle: SPST	04009	3101-0001	1	1		
T1	Transformer, power	28480	9100-0060	1	1		
T2	Transformer, output: includes two 320 μh coils	28480	9120-0017	1	1		
V1	Tube, electron: 6AC7	80131	1923-0014	2	2		
V2	Tube, electron: 6AU5GT	80131	1923-0020	2	2		
V3	Same as V1						
V4	Same as V2						
V5	Tube, electron: 5U4GA/B	80131	1930-0008	1	1		
V6, 7	Tube, electron: 6L6GB	80131	1923-0035	2	2		
V8	Tube, electron: 6SJ7	80131	1923-0037	1	1		
V9	Tube, electron: OA3	80131	1940-0006	1	1		
	MISCELLANEOUS						
	Binding Post Assembly: red	28480	AC-10D	1	1		
	Binding Post Assembly: black	28480	AC-10C	1	1		
	Binding Post Assembly: with link	28480	G-76J	1	1		
	Coupling network: consisting of resistors: 22K, 10M, 56 and 68K; Reactor: 3.0mh; capacitor: 0.047 μf	28480	200CD-68	2	1		
	Cable: capacitor drive	28480	G-18A	1	1		
	Disc, vernier drive, on shaft	28480	G-14D	1	0		

* See introduction to this section

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	TQ*	RS*		
	Disc, vernier drive	28480	G-14H	1	0		
	Escutcheon, frequency dial	28480	G-99A	1	0		
	Fuseholder	75915	1400-0084	1	1		
	Insulator, binding post: black	28480	AC-54B	1	0		
	Insulator, standoff: ceramic,	72656	0340-0020	4	0		
	Jewel, pilot light	72765	1450-0020	1	0		
	Knob: AMPLITUDE	28480	G-74K	1	0		
	Knob: RANGE	28480	G-74N	1	0		
	Knob: FREQUENCY	28480	G-74R	2	0		
	Lampholder, for 2-pin base	72765	1450-0022	2	1		
	Window, frequency dial	28480	I-100N	1	0		

* 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.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	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. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
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.
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.
04404	Dymec Inc.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
10646	Carborundum Co.	Niagara Falls, N.Y.
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.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, 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.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, 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.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
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.
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	Chicago Telephone Supply Co.	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 Div. 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.	New Haven, 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.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	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 Mfg. Co., Inc.	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.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
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.
78790	Transformer Engineers	Pasadena, Calif.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80130	Times Facsimile Corp.	New York, N.Y.

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated Oct. 1960

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, 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 Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
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	Spencer Thermostat, Div. of Texas Instruments, Inc.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
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.
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.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	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., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semi-conductor Div.	Newton, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excell 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.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
99109	Columbia Technical Corp.	New York, N.Y.
99112	Varian Associates	Palo Alto, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics, Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

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

00000A	Amp, Inc.	Hawthorne, Calif.
00000B	Chicago Telephone of Calif.	S. Pasadena, Calif.
00000C	Conoc Spring Mfg. Co.	San Francisco, Calif.
00000D	Connex Corp.	Oakland, Calif.
00000E	Fisher Switches, Inc.	San Francisco, Calif.
00000F	Malco Tool and Die	Los Angeles, Calif.
00000G	Microwave Engineering Co.	Palo Alto, Calif.
00000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
00000I	Telefunken (c/o American Elite)	New York, N.Y.
00000J	Ti Tal, Inc.	Berkeley, Calif.
00000K	Transitron Electronic Sales Corp.	Wakefield, Mass.
00000L	Winchester Electronics, Inc.	Santa Monica, Calif.
00000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
00000N	Wahm-Bros. Spring Co.	San Leandro, Calif.
00000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
00000R	Metro Cap. Div., Metropolitan Telecommunications Corp.	Brooklyn, N.Y.

00015-3
Revised: 2 March 1961

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated Oct. 1960

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY
Laboratory Instruments for Speed and Accuracy
1501 PAGE MILL ROAD PALO ALTO, CALIF. U.S.A.
CABLE "HEWPACK"