



OPERATING AND SERVICE MANUAL

MODEL 202C/CR

SERIALS PREFIXED: 129 -

LOW FREQUENCY
OSCILLATOR

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SPECIFICATIONS

FREQUENCY RANGE: 1 cps to 100 kc in five ranges

RANGES: X1 1- 10 cps
X10 10- 100 cps
X100 100- 1000 cps
X1K 1- 10 kc
X10K 10- 100 kc

ACCURACY: ±2% under normal ambient temperature conditions, including calibration error, warmup, changes due to aging of components, tubes, etc.

DIAL: Six-inch diameter calibrated over 300° of arc. Total scale length approximately 80 inches.

FREQUENCY RESPONSE: ±1 db entire frequency range (reference 1 kc on X1K range).

OUTPUT: 160 milliwatts into 600-ohm rated load, or 10 volts. 20 volts open circuit.

OUTPUT BALANCE: Better than 0.1% at lower frequencies and approximately 1% at 100 kc. Output is balanced to ground at maximum amplitude setting. (May be operated with one side grounded if desired.)

INTERNAL IMPEDANCE: 600 ohms

DISTORTION: Less than 0.5% above 5 cps. Independent of load impedance.

HUM VOLTAGE: Less than 0.1% of rated output. Decreases as output is attenuated.

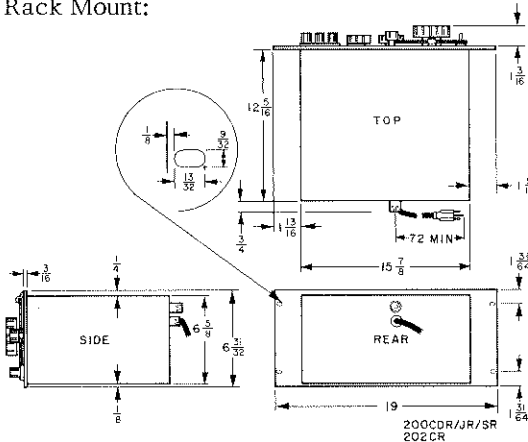
RECOVERY TIME: Less than 5 seconds at 1 cps

POWER SUPPLY: 115 or 230 volts ±10%, 50 to 1000 cps, approximately 75 watts

ACCESSORIES FURNISHED: None

ACCESSORIES AVAILABLE: Ⓢ AC-16A Cable Assembly, 4 feet of RG-58/U 50-ohm coaxial cable terminated at each end with a dual banana plug.
Ⓢ AC-16B Cable Assembly, 45 inches of RG-58/U 50-ohm coaxial cable terminated at one end with a dual banana plug and with a UG-88/U type BNC male connector at the other.

DIMENSIONS: Cabinet Mount: 7-1/2 in. wide, 11-1/2 in. high, 14-1/4 in. deep
Rack Mount:



WEIGHT: Cabinet Mount: 27 lbs, shipping weight approximately 34 lbs
Rack Mount: 30 lbs, shipping weight approximately 45 lbs



Figure 1-1. Model 202C Wide Range Oscillator

SECTION I

GENERAL DESCRIPTION

1-1. GENERAL.

The Model 202C Low Frequency Oscillator generates low distortion sine waves over the 1 to 100,000 cycle per second range. Special circuitry insures a waveform of high stability and low distortion that is independent of the load connected to the instrument. The internal impedance of the instrument is 600 ohms and it will provide either a balanced or unbalanced output.

The Model 202C is simple to operate with only three controls on the panel to determine output frequency and amplitude. The six-inch diameter frequency dial is easily read and provides an effective scale length of approximately 80 inches.

This instrument provides an excellent signal source for vibration testing equipment, seismograph response, determining electrocardiograph and electroencephalograph performance, testing geophysical prospecting equipment, and servo systems, as well as general audio frequency testing.

1-2. INSTRUMENT IDENTIFICATION.

Hewlett-Packard uses a two-section eight-digit serial number (e.g., 000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 202C described in this manual.

1-3. POWER CABLE.

For the protection of operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable, which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin.

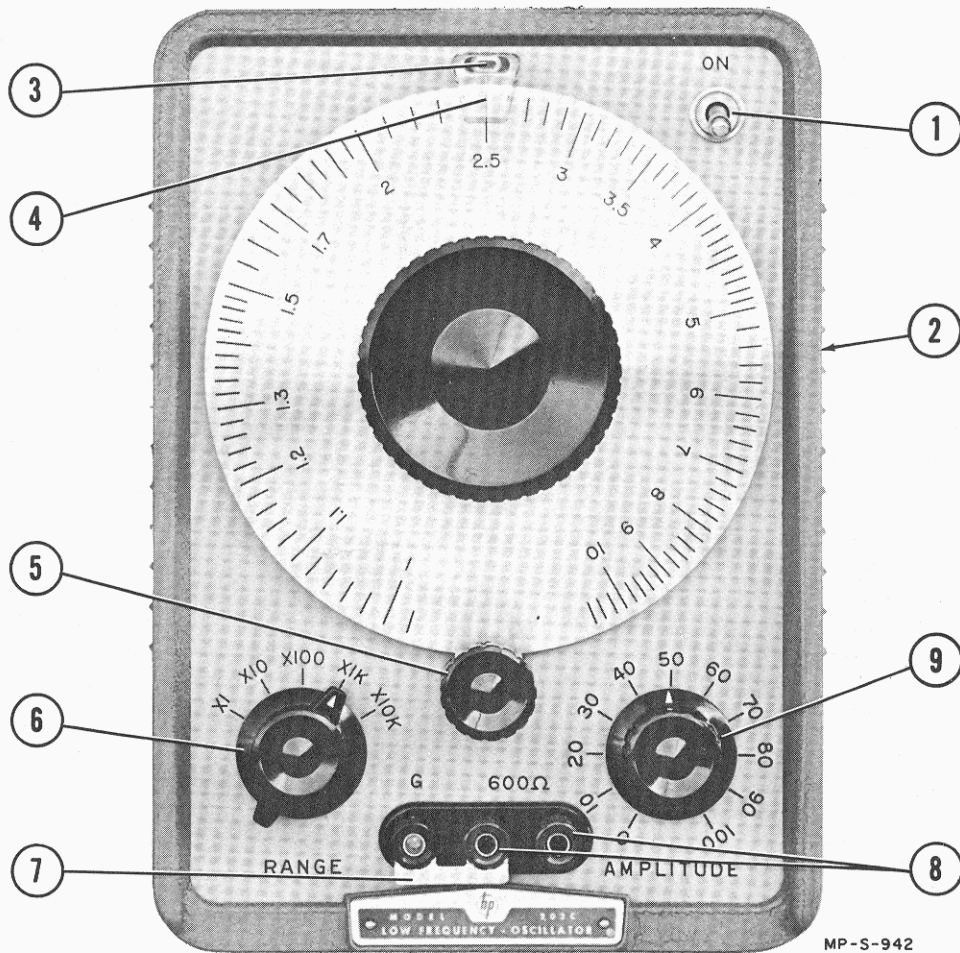
To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

1-4. 230-VOLT OPERATION.

This instrument is normally wired for operation from a nominal 115-volt supply. Operation from a 230-volt source is easily accomplished by reconnecting the dual primary windings on the power transformer in series. Refer to paragraph 4-5 for connection procedures.

1-5. INCOMING INSPECTION.

Upon receipt of your 202C, check the contents against the packing list and inspect the instrument for any obvious damage received in transit. To facilitate re-shipment, keep the packing material until an operational check has been performed (see paragraph 4-3). If there is any apparent damage, file a claim with the carrier and refer to the warranty page in this manual.



1. Turn on power to instrument.
2. Fuse on rear of instrument.
3. Glows when instrument is energized.
4. Read frequency of operation multiplied by RANGE switch position.
5. Vernier, adjust frequency.
6. Select frequency range of operation.
7. Jumper for 600-ohm unbalanced output.
8. Balanced output terminals internal impedance equals 600 ohms.
9. Adjust output voltage level. Output balanced to ground only with amplitude control in full clockwise position.

Figure 2-1. Controls and Terminals

SECTION II OPERATING INSTRUCTIONS

2-1. OPERATING PROCEDURE.

1) With the instrument plugged into a power source of specified voltage and frequency, and the power switch ON, allow a warmup period of approximately five minutes. Where maximum stability is desired, this warmup period should be extended to at least thirty minutes.

2) The frequency of the output voltage is determined by (a) the setting of the frequency dial and (b) the setting of the RANGE switch. For example, to obtain a 1000-cycle output, set the frequency dial at 10 and the RANGE switch at X100 (10 x 100 = 1000).

3) Make the connection between the Model 202C and the equipment under test at the terminals designated 600 Ω. (Connections are discussed in paragraph 2-3.)

The Model 202C may be operated into any load without effect on the distortion in the output waveform. The instrument may be considered as a 20-volt generator with a 600-ohm internal impedance, and the external load will effect the voltage available at the output terminals.

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

2-2. OUTPUT CIRCUIT OPTIONS.

The output circuit of the Model 202C 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, the captive ground strap is placed between the G terminal and the center terminal, as indicated in figure 2-2.

B. BALANCED OPERATION. Connections for balanced operation are indicated in figure 2-2. The AMPLITUDE control is a bridged tee attenuator in the output circuit and therefore it will produce a degree of unbalance at any setting other than maximum output (minimum attenuation). The unbalance produced by the AMPLITUDE control will be a function of frequency with the greatest unbalance being produced at 100 kc. In many applications the unbalance produced by the AMPLITUDE control will not be important. Where a perfectly balanced output is required an external balanced attenuator or a line matching transformer such as the Φ AC-60A/B is recommended.

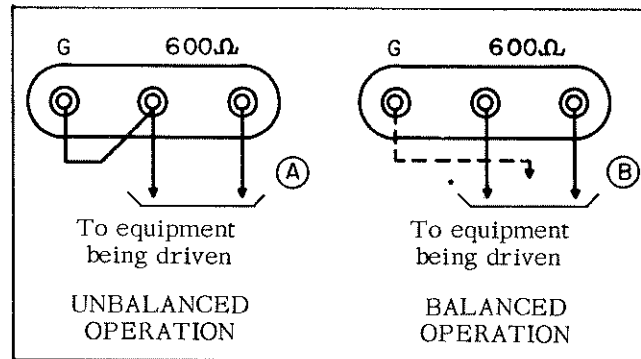


Figure 2-2. Output Connections

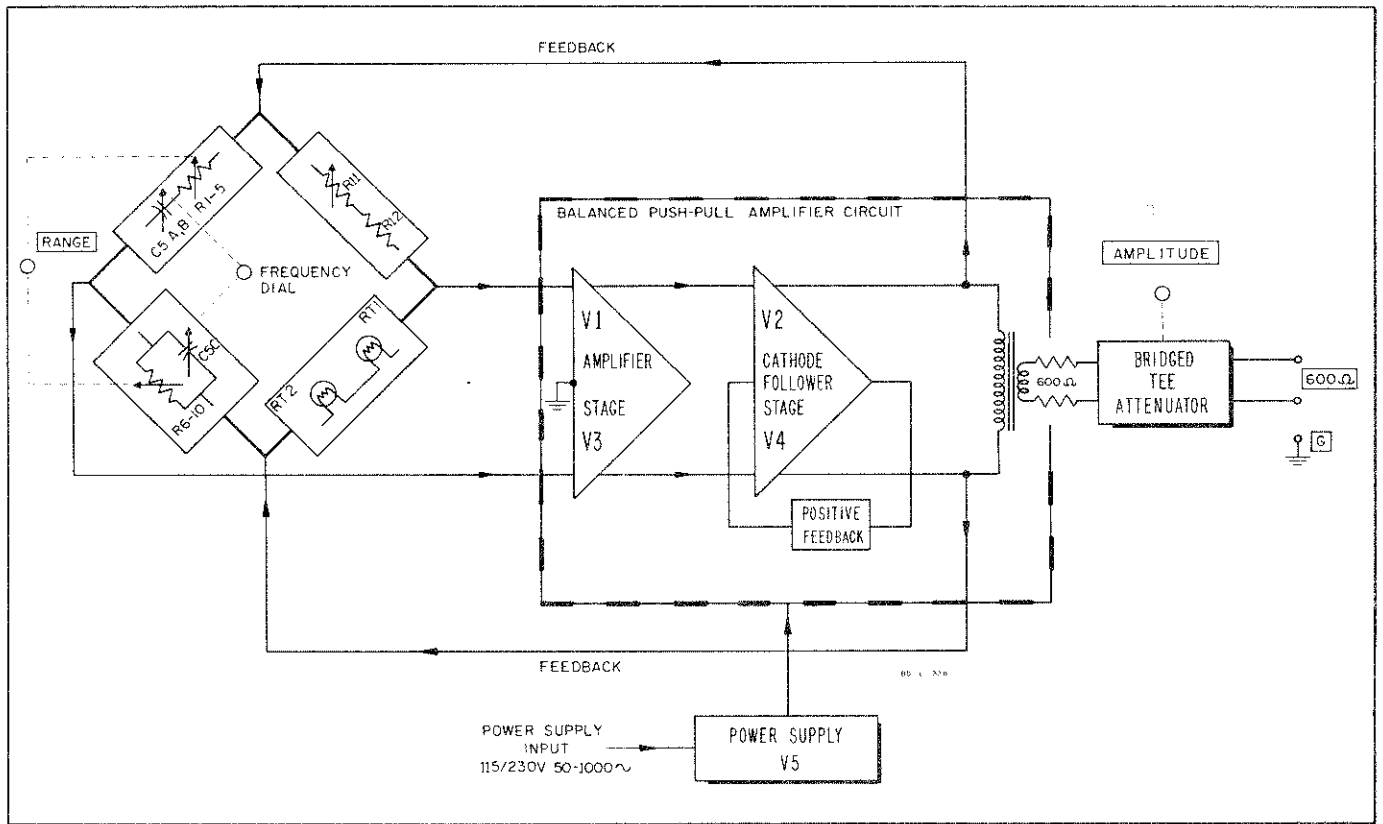


Figure 3-1. Model 202C Block Diagram

SECTION III

THEORY OF OPERATION

3-1. GENERAL.

The Model 202C uses a balanced (push-pull) oscillator circuit from which the output is taken directly, avoiding the distortion of an isolating amplifier. Reaction of the load on the oscillator is avoided by the use of a zero source impedance cathode follower output stage. This arrangement results in a simple, trouble-free circuit having low distortion and high stability over the entire frequency range.

Functionally, the circuits of the Model 202C 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 power-supply circuit. These are shown in block diagram form in figure 3-1 and in detail on the schematic 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-controlling or amplitude-stabilizing 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, which, together with the large negative feedback at harmonic frequencies, results in a low distortion sine wave oscillation.

The bridge is driven by the balanced voltage developed at the cathodes of V2 and V4, the output cathode followers. 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 to achieve an oscillator of excellent stability and waveform is covered in texts such as Terman & Pettit's Electronic Measurements.

3-3. AMPLIFIER.

The oscillator is a balanced push-pull circuit which includes a voltage-amplifier stage (V1, V3) and a special cathode-follower stage (V2, V4). 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. Capacitors C10, C11, and C12, and coils L2 and L3 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 attenuator.

3-4. OUTPUT CIRCUIT.

Transformer coupling provides isolation between the oscillator circuit and the output circuit, and allows the output to be used either balanced or unbalanced. Since a single transformer will not operate suitably over the frequency range covered by the Model 202C, two transformers are provided. Connections between cathode-followers V2 and V4 and the proper transformer are made by the RANGE switch.

The secondary winding of the output transformer supplies a bridged tee attenuator, which is adjusted by the AMPLITUDE control on the front panel. The resistors in the secondary of the output transformer match the output cathode followers to the 600-ohm output attenuator.

Paragraph 2-3 covers the output circuit options and gives the limitations on balanced operation.

Table 4-1. Test Instruments Required

| Instrument Type | Minimum Required Specifications | Recommended ^(hp) Instruments |
|--|--|---|
| DC Electronic Voltmeter | Sensitivity: 1 volt full scale minimum Input Resistance: 10 megohms or higher | Model 410B or 412A Vacuum Tube Voltmeter |
| AC Electronic Voltmeter | Input Impedance: 2 megohms shunted by 40 pf (below the 0.3 volt range) Accuracy: $\pm 3\%$ from 5 cps to 500 kc | Model 403A Transistor Voltmeter |
| AC Electronic Voltmeter | Input Impedance: 10 megohms shunted by 25 pf (below the 0.3 volt range) Accuracy: $\pm 2\%$ from 20 cps to 1 mc | Model 400D/H/L Vacuum Tube Voltmeter |
| Distortion Analyzer | Capable of checking frequencies from 5 cps to 60 kc | Model H01 330B Distortion Analyzer |
| 600-ohm Resistor | 600 ohms $\pm 1\%$ to 100 kc | Model 470E Shunt Resistor |
| Electronic Counter or | Frequency and period readings available. Fre- quency measuring capabilities to at least 600 kc | Models 523C/CR, D/DR or 524C/D Electronic Counters |
| Frequency Standard and | Frequencies available: a) 10 cps b) 100 cps c) 1 kc d) 100 kc Output Voltage: 5 volts rms minimum Frequency Accuracy: $\pm 0.05\%$ | 100ER Frequency Standard |
| (Optional - recommended) Oscilloscope | Frequency Range: flat from 5 cps to at least 600 kc | Models 150A, 160B, 170A Oscilloscopes |

SECTION IV MAINTENANCE

4-1. INTRODUCTION.

This section contains test and maintenance information for the 202C Wide Range Oscillator. Included is a quick performance check that may be made with the instrument in its cabinet, as a part of routine maintenance or as a part of your incoming inspection.

The 202C should require little maintenance, since all component parts are operated well within the recommended ratings. Should failure occur, however, a troubleshooting paragraph, 4-8, has been included to assist you in quickly localizing the problem.

Tube replacement will probably correct a majority of the difficulties which may develop, however, some readjustment will be necessary after replacement of tubes, stabilization lamps (RT1 and RT2), and other critical parts. Refer to table 4-3 for any necessary adjustment after replacement of these parts.

Small errors may be introduced in the 202C because of the capacitance added to the circuit after cabinet replacement. Therefore, if any adjustments are required in the 202C throughout this section, slide the cabinet over the instrument after the adjustment to check instrument performance.

4-2. TEST EQUIPMENT REQUIRED.

Table 4-1 lists the test equipment required for maintenance and repair of the 202C. If equipment other than the recommended types are used in the following procedures, make sure it meets the minimum specifications listed in table 4-1.

4-3. PERFORMANCE CHECK.

The following procedure is to verify proper operation and should be accomplished with the instrument in its cabinet. A complete adjustment procedure is given in paragraph 4-7. Proceed as follows:

NOTE: To isolate troubles in the 202C, turn to paragraph 4-7 and follow all steps and note indications, but DO NOT adjust anything. Then refer to table 4-4 for possible causes of readings that are beyond test limits.

A. OUTPUT IMPEDANCE.

- 1) Set 202C RANGE to X100, frequency dial to 10.
- 2) Connect the 202C output to the 403A transistor voltmeter. Set the voltmeter RANGE to 30 volts.
- 3) Turn 202C AMPLITUDE fully clockwise. The voltmeter should read at least 20 volts.
- 4) Set 202C AMPLITUDE for exactly 20 volts as read on the voltmeter.
- 5) Connect a 600-ohm resistor such as the Φ Model 470E Shunt Resistor across the output of the 202C.

- 6) The voltage as read on the voltmeter should drop to 10 volts ± 0.5 volts.
- 7) Repeat steps 1 through 6 for the X1K range.

B. FREQUENCY RESPONSE.

- 1) Connect the 202C to an ac voltmeter and a 523D Electronic Counter as shown in figure 4-2. Substitute a 403A Transistor Voltmeter for the 400D/H/L in figure 4-2.
- 2) Set 202C RANGE to X1K, frequency dial to 1. Terminate output in 600 ohms.
- 3) Adjust 202C AMPLITUDE for a convenient reference around 0.9 on the voltmeter scale.
- 4) Starting with the X1 range, rotate the frequency dial across the band while observing the meter.
- 5) Repeat this process for each range. The voltmeter indication should not vary more than ± 1 db throughout the ranges checked.

C. DIAL ACCURACY.

- 1) Set 202C RANGE to X10K, frequency dial to 60. Observe the frequency reading on the 523D Counter.
- 2) Check the frequency at 10, 5, 2, and 1 on the dial.
- 3) Repeat this procedure for the remaining ranges. The frequency should be correct within $\pm 2\%$.

NOTE: For the lower end of the X10 range and the entire X1 range, it will be advantageous to measure the frequency indirectly by switching the 523D FUNCTION SELECTOR to 10 PERIOD AVERAGE. Table 4-2 lists the specifications in terms of period readings for each point on the X1 range. To check X10 range, divide the period limit in table 4-2 by 10.

Table 4-2. Frequency/Period Conversion

| Frequency (cps) | Frequency Limits | Period Limits |
|-----------------|------------------|---------------|
| 1 | 1.02 | 980.0 |
| | .98 | 1020.0 |
| 1.3 | 1.33 | 751.0 |
| | 1.27 | 788.0 |
| 2 | 2.04 | 490.0 |
| | 1.96 | 510.0 |
| 5 | 5.1 | 196.0 |
| | 4.9 | 204.0 |
| 10 | 10.2 | 98.0 |
| | 9.8 | 102.0 |
| 20 | 20.4 | 49.0 |
| | 19.6 | 51.0 |
| 50 | 51.0 | 49.0 |
| | 49.0 | 51.0 |

D. DISTORTION.

- 1) Connect the 202C to a H01 330B Distortion Analyzer as shown in figure 4-4.
- 2) Set 202C RANGE switch and frequency dial to one of the frequencies indicated in table 4-3.
- 3) The H01 330B switches should be set to the following positions:
 - a. AF-RF to AF
 - b. FREQUENCY to incoming frequency selected in step 2
 - c. Selector switch to SET LEVEL
 - d. RMS VOLTS-DB switch set to +20 db.
- 4) Adjust H01 330B INPUT control for a zero db reference on the H01 330B meter.
- 5) Switch selector to DISTORTION.
- 6) Adjust BALANCE and FREQUENCY controls for a dip on the meter.
- 7) Turn RMS VOLTS-DB switch counterclockwise while continually adjusting H01 330B BALANCE and FREQUENCY until the lowest possible dip is obtained. Specifications are listed in table 4-3.
- 8) Check the remaining frequencies listed in table 4-3 by following steps 1 through 7.

Table 4-3. Distortion Test Frequencies

| Range | Frequency | Specifications |
|-------|-----------|----------------|
| X1 | 5 cps | 46 db |
| X10 | 100 cps | 46 db |
| X100 | 2500 cps | 46 db |
| X1K | 5 kc | 46 db |
| X10K | 60 kc | 46 db |

4-4. CABINET REMOVAL.

To remove the 202C cabinet, proceed as follows:

- 1) Disconnect the 202C from the power source.
- 2) Remove the two screws at the rear of the cabinet. The 202CR rack mount unit has two additional screws on the front panel which must be removed.
- 3) Carefully slide the instrument forward, out of the cabinet.

4-5. 230-VOLT OPERATION.

The following describes circuit modifications necessary to change the 202C power transformer primary from 115-volt operation to 230-volt operation. Figure 4-1 further illustrates this procedure.

- 1) Remove the cabinet as per paragraph 4-4.

- 2) Remove the two bare wire jumpers from the terminal strip as indicated in figure 4-1.
- 3) Add an insulated jumper from the green/black transformer primary wire to the black/yellow one.
- 4) Replace fuse F1 with a 0.6 amp slow blow fuse (see table 5-1, Replaceable Parts).

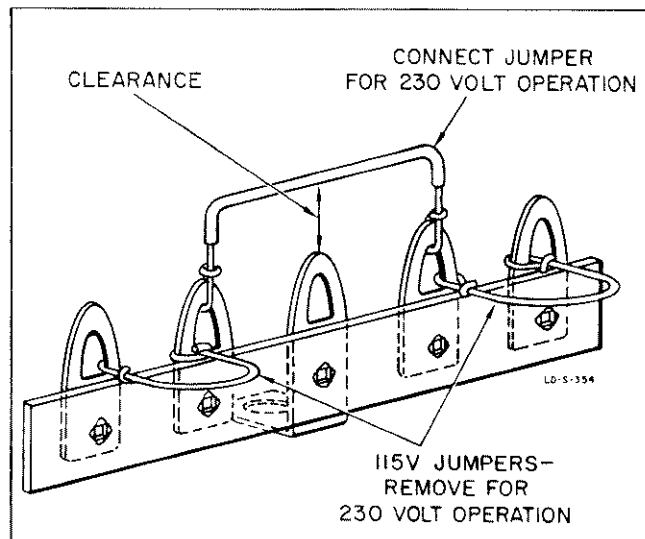


Figure 4-1. 230-Volt Operation

4-6. PERIODIC MAINTENANCE.

The 202C should require a minimum of maintenance, since there are few moving parts. The following procedure performed once or twice a year should insure smooth operation.

- 1) Put one drop of oil in each of the three oil holes on the tuning drive mechanism.
- 2) Place a small amount of high quality contact cleaner on the RANGE switch contacts. Rotate the switch back and forth several times.
- 3) Using compressed air, gently blow any accumulated dust out of the tuning capacitor plates (C5).

4-7. ADJUSTMENT PROCEDURE.

The following is a complete adjustment procedure. Adjustments should be made only if it has been definitely determined that the 202C is not operating within specifications. If the instrument fails to perform within any of the limits given in the following procedure, refer to table 4-4 for possible cause and corrective action.

This procedure can also be an aid in troubleshooting. Simply follow the procedure until the trouble manifests itself as a reading that exceeds the test limit, and then refer to table 4-4 for possible causes.

NOTE: The test indications and limits given in this paragraph are NOT formal performance specifications. Specifications are given in the front of the manual.

In order to minimize the effects of hand capacity, a "tuning wand" or tuning screwdriver with a plastic shank should be used for all adjustments.

A. **TERMINOLOGY.** When the expression "slip the dial" is used in this text, it has the meaning here specified:

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

B. **PRELIMINARY CHECKS.** The following basic tests are given to avoid possible unnecessary adjustment of the 202C. If the instrument fails any of these tests, some component is probably at fault and should be replaced before attempting any adjustments. Proceed as follows:

- 1) Power Supply:
 - a. With the instrument turned off, check the resistance from C13 to ground and the resistance across C13. This resistance is typically many megohms. A very low reading (below 100K) indicates a shorted or leaky capacitor between the B+ line and ground.
 - b. Turn the instrument on, and allow it to warm up for at least 15 minutes.
 - c. Check to see that all tubes are glowing.
 - d. Using the 412A, 410B Electronic Voltmeters, or other suitable voltmeter, measure the positive and negative power supply voltages using ground as a reference. The positive voltage (approximately 225 volts) may be measured between the chassis and C14. The negative voltage (approximately 155 volts) is measured from the chassis to the junction of R30, R31, and R40 (figure 4-6). The difference between the negative and positive voltage should be 380 volts \pm 75 volts.

2) Amplitude Control Operation:

- a. With a 600-ohm load connected to the OUTPUT terminals, and the 202C output connected to the 400D/H/L AC Voltmeter, set 202C RANGE to X100.
- b. Turn 202C AMPLITUDE fully clockwise and note this reference reading.
- c. Now, while observing the voltmeter indication and switching to lower voltmeter ranges as necessary, slowly turn 202C AMPLITUDE fully counterclockwise. Note the voltmeter reading again. The attenuation should be smooth and the final reading should be at least 46 db below the reference in step B2b.

3) Recovery Time:

- a. Switch RANGE to X10K and frequency to 50 kc.
- b. Connect the output of the 202C to an oscilloscope.

c. Check each range down to the X10 range, observing the oscilloscope pattern after each change.

d. The oscilloscope presentation should become stable within 5 seconds after switching ranges.

C. **CALIBRATION.** Calibration procedure for the 202C is divided into two basic parts. The first procedure is intended to effect a flat frequency response for the 202C and is accomplished with the instrument set on the X10 range. The second, accomplished on the X100 range, is given to produce correct frequency dial tracking. Proceed as follows:

1) Frequency Response Adjustments:

- a. Turn 202C RANGE to X1K, frequency dial to 1.
- b. Connect the 202C to a 400D/H/L AC Voltmeter and a frequency measuring device (counter or frequency standard) as shown in figures 4-2 or 4-3.
- c. Using 202C AMPLITUDE, set a reference of 9 volts as read on the 400D/H/L.
- d. Turn the frequency dial to 10. The 400D/H/L should read within $\pm 1/4$ db of the reference in step C1c and the frequency should be correct within 2%.
- e. If 10KC is off more than 2%, set the frequency on with C6.

NOTE: Since replacing the cabinet raises the frequency slightly, it is advisable to set the frequency slightly low (e.g., 9900 cps) when making this adjustment.

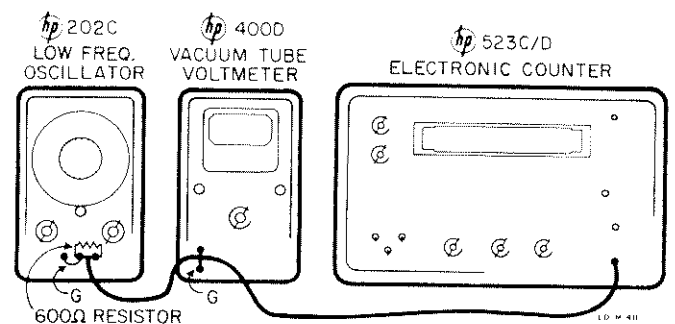


Figure 4-2. Calibration Test Setup

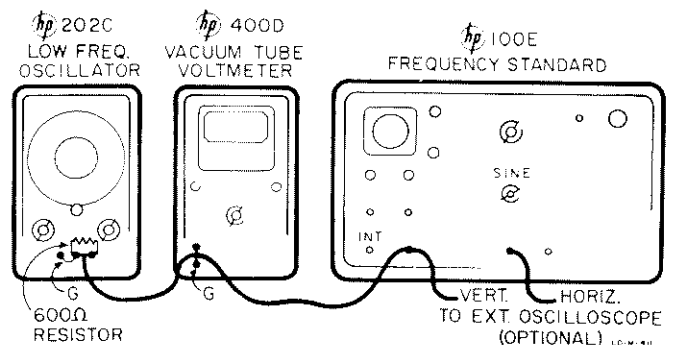


Figure 4-3. Alternate Calibration Setup

- f. Observe the output voltage and determine how much it differs from the reference.
 - g. Adjust C3 to correct for half this difference. Then adjust C6 so that the output frequency is again 10 kc.
 - h. Observe the output voltage. If it is more than $\pm 1/4$ db from the reference in step C1c repeat steps C1c through C1h until a flat response is obtained with 600 cps set on frequency (see note above).
- 2) Frequency Dial Tracking:
- a. Switch 200CD RANGE to 1K. Connect the equipment as shown in figures 4-2 or 4-3.
 - b. Check the frequency at 5. The frequency reading should be 1 kc $\pm 2\%$. If the frequency is off more than $\pm 2\%$ slip the dial to put it on frequency.
 - c. If it was necessary to slip the dial, repeat steps C1a through C1h.
 - d. If step C2c was necessary, repeat step C2b. It is possible that the entire dial will now track without further adjustment.
 - e. Check all numbered points on the dial, beginning at the high end. If some points exceed test limits ($\pm 2\%$), try to equalize the error by slipping the dial to get all points within these limits.
 - f. Switch RANGE to X10K, and set the 202C frequency dial to 10.
 - g. Adjust C7 to put 100 kc on frequency.
 - h. Check calibration on the remaining ranges. Calibration should be correct to $\pm 2\%$.

NOTE: It will be advantageous to set the counter FUNCTION SELECTOR to 10 PERIOD AVERAGE when measuring frequency on the X1 range (refer to table 4-2).

Finally, if the above procedures do not result in correct calibration start over by adjusting C3 and/or C6 as in steps C1a through h. Then work toward the low end by setting the dial to the next numbered point and bending one of the outer rotor plates in each section of C5 at the point of mesh. Continue this procedure to the low end of the dial to obtain approximately correct frequencies. Repeat the bending procedure from the high end, this time making fine adjustments of frequency with the other outer rotor plates. In this way, bending of any one plate is minimized.

When bending rotor plates, observe the following precautions: (1) Keep all bends as near the shaft as possible, (2) Keep all segments in line. The rotor plates should taper gradually inward or outward, depending on whether you must compress or expand the frequency range. This gradual taper is essential for linearity.

D. DISTORTION.

- 1) Connect the 202C to a 330B Distortion Analyzer as shown in figure 4-4.
- 2) Set 202C RANGE to X100 and the frequency dial to 10.
- 3) The 330B switches should be in the following positions:
 - a. AF-RF to AF
 - b. FREQUENCY to 100
 - c. Selector switch to SET LEVEL
 - d. RMS VOLTS-DB switch set to the +20 db position
- 4) Adjust 330B INPUT control for a zero db reference on the 330B meter.
- 5) Switch selector to DISTORTION.
- 6) Adjust BALANCE and FREQUENCY controls for a dip on the meter.
- 7) Turn RMS VOLTS-DB switch counterclockwise while continually adjusting 330B BALANCE and INPUT until the lowest possible dip is obtained.
- 8) Adjust R50 (dynamic balance) for a dip (minimum distortion) on the 330B meter. Repeat steps 7 and 8 until the lowest possible dip is obtained.
- 9) Repeat steps 1 through 8, adjusting all 330B controls for 50 cps (60 cps if 50 cps line frequency is being used) instead of 1000 cps.
- 10) Adjust R51 (Hum Balance) instead of Dynamic Balance in step 8.

E. OUTPUT VOLTAGE.

- 1) Connect the 202C, loaded, to a 400D AC Voltmeter.
- 2) Turn 202C AMPLITUDE fully clockwise, and adjust R11 for 11.5 volts on the 400D meter.

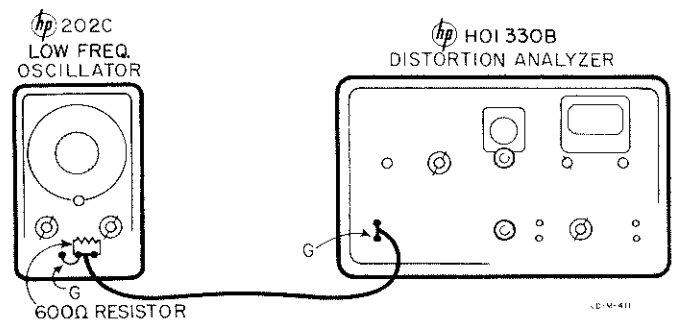


Figure 4-4. Distortion Test Setup

4-8. TROUBLESHOOTING.

The following is intended as a guide to assist in localizing troubles that may occur in the 202C. A good way to locate troubles is to follow the test procedure until the problem appears as a reading that does not meet the test limit. Then refer to table 4-4 for possible causes. The following suggestions are offered to save time in trouble isolation.

A. **POWER SUPPLY.** If the fuse has blown, replace it with a new slow blow fuse of correct rating. See table 5-1. If the new one does not blow, it is possible that the fuse was defective or the failure was due to a line surge. If the fuse blows again, turn the 202C off, short C14 to ground, and measure the resistance from B+ and B- to ground (observe polarity). This resistance is typically many megohms.

If the resistance is 100K or more, remove V5 and replace the fuse. If it blows again, the trouble is either in T3 or the heater circuit. If the fuse does not

blow, the problem is either a shorted tube or a high voltage breakdown of one of the capacitors between B+ and B-, or B+ and ground (usually C13 or C14).

B. **AMPLIFIER.** In the rest of the instrument, tube failure will most likely be the cause of trouble. DO NOT indiscriminately make adjustments in the 202C. If the instrument is not operating within specifications, try replacing tubes or RT1 and RT2 first. Check tubes by substitution. Results obtained through the use of a "tube checker" may be erroneous and misleading. Mark original tubes so if they are not replaced, they may be returned to the same socket. If tubes are replaced, refer to table 4-5 for required adjustments.

4-9. REPAIR AND REPLACEMENT.

A. **SERVICING PRINTED CIRCUIT BOARDS.**
Servicing parts on the etched circuit board requires special care to avoid excessive heat that might

Table 4-4. Troubleshooting

| Symptom | Probable Cause | Symptom | Probable Cause |
|--|---|--|--|
| Resistance to ground less than 100K ohms | C13A, B, C leaky C14 leaky C10, 11 shorted | 202C obviously micro- phonic | V1-V4 defective RT1, RT2 defective Tuning capacitor dirty or defective |
| Tubes not glowing, pilot light out | Blown fuse F1 S2 defective | Dial springs back when turned clockwise against the stop | Tuning capacitor closed too far when fully meshed |
| One or more tubes not glowing, pilot light on | One or more tubes burned out | Impossible to set low end on frequency | Tuning capacitor open too far when fully meshed |
| Power supply voltage variation exceeds test limit | C13A, B, C or C14 breaking down under high voltage V5 defective V1-V4 shorted | Dial springs back when turned counterclockwise against the stop | |
| Impossible to set 202C output to 20 volts (unloaded) | V1-V4 defective RT1, RT2 defective | Calibration bad on one range only | Dirty RANGE switch contacts C1, C2, C7, or C16 need adjusting One RANGE switch resistor has changed resistance |
| With RANGE set to X1- X100 ranges and output set to 20 volts rms, ad- dition of 600-ohm termi- nation does not lower output to 10 volts ± 0.5 v | T2 defective | Excessive distortion on X1-X100 ranges | R50 or R51 mis- adjusted T2 defective |
| Same as above with RANGE set at X1K or X10K | T1 defective | Excessive distortion on X1K-X10K ranges | R50 or R51 mis- adjusted T1 defective |
| Turning AMPLITUDE control causes jumpy output | R39 (AMPLITUDE control) defective | Excessive distortion on all ranges | V1-V4 defective RT1-RT2 defective Dust between tuning capacitor plates |
| Recovery time exceeds test limit | V1, V3 defective RT1, RT2 defective | Impossible to set 11.5 v output with 202C terminated with 600 ohms (adjustment procedure) | RT1, RT2 defective V1-V4 weak |

damage the board. Refer to figure 4-9 for information concerning parts replacement on etched circuit boards.

B. TUBE REPLACEMENT. If V2 or V4 are changed, be careful to replace the special tube shields in their original positions since they also function to increase tube reliability by lowering the operating temperature of the output tubes. When replacing tubes in the 202C, be sure to use the correct replacements as specified in the parts list (table 5-1). Refer to table 4-5 for any necessary adjustments after replacement.

C. TUNING CAPACITOR REPAIR. The tuning capacitor should not be loosened unless absolutely necessary, since doing so may cause misalignment of the tuning capacitor shaft with the shaft extension to the gears. If C5A, B, C has been removed or loosened for any reason, it should be readjusted mechanically before any electrical adjustment is attempted. In some cases, due to slippage, the tuning capacitor will not mesh far enough to allow perfect calibration at the extreme low end of the dial. When correctly set, the edge of the insulation protruding from the rotor plate spacer on C5 should line up with the topmost stator spacer when the dial is set fully clockwise.

D. RANGE SWITCH REPAIR. Resistor values on S1 have been carefully bridged and adjusted at the factory to the exact value required for proper tracking

on all ranges. If one range is found to be badly out of calibration and all other possibilities have been exhausted (especially dirty RANGE switch contacts) try adjusting the value of C1, C2, C7 or C16 (depending on the range affected) slightly. If any part of the RANGE switch is found to be defective, it is recommended that the switch be replaced as an assembly. Figure 4-6 shows all wiring detail for replacement.

Table 4-5. Replacement of Critical Parts

| Ref. | Function | Required Checks or Adjustments |
|----------|-------------------------------|--|
| V1, V3 | Voltage Amplifier | Recheck Calibration and distortion. Reset output voltage. See paragraph 4-7. |
| V2, V4 | Cathode Followers | Recheck distortion, paragraph 4-7C. Reset output voltage, paragraph 4-7E. |
| V5 | Rectifier | Check power supply voltage (par. 4-7B1). |
| RT1, RT2 | Amplitude Stabilization lamps | Reset output voltage, paragraph 4-7E. |

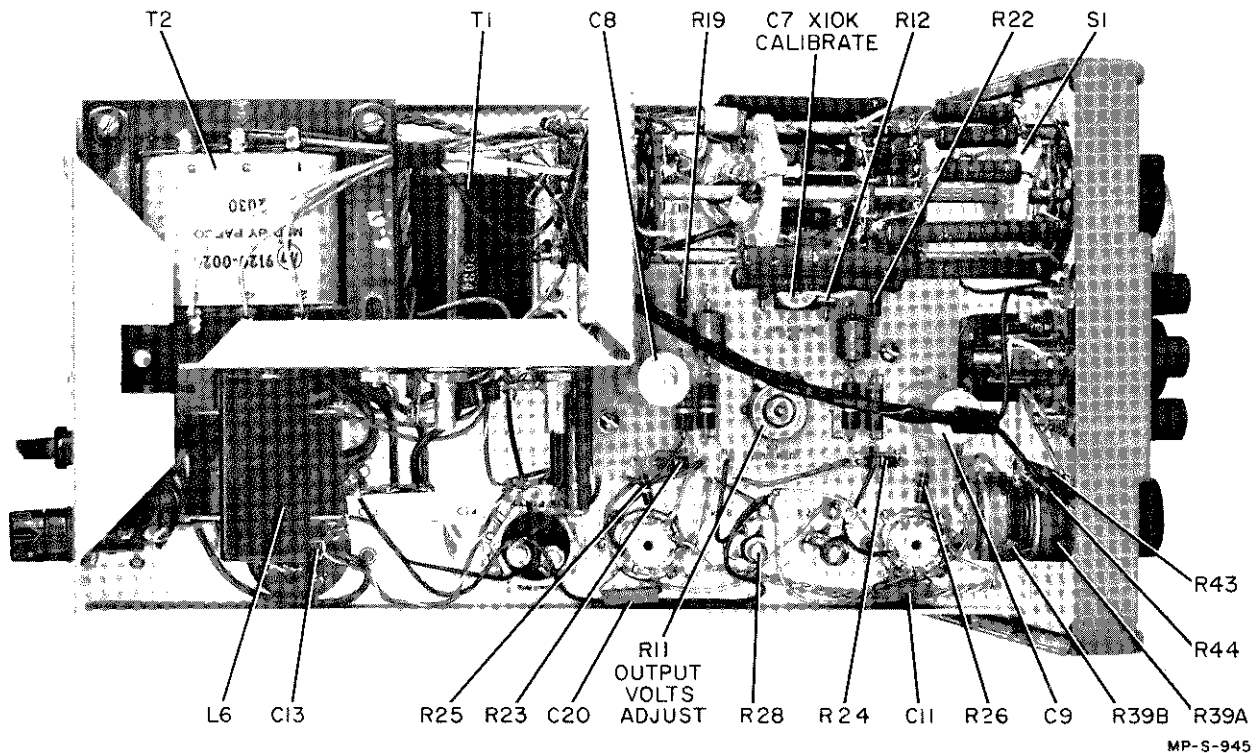


Figure 4-5. Bottom View Model 202C

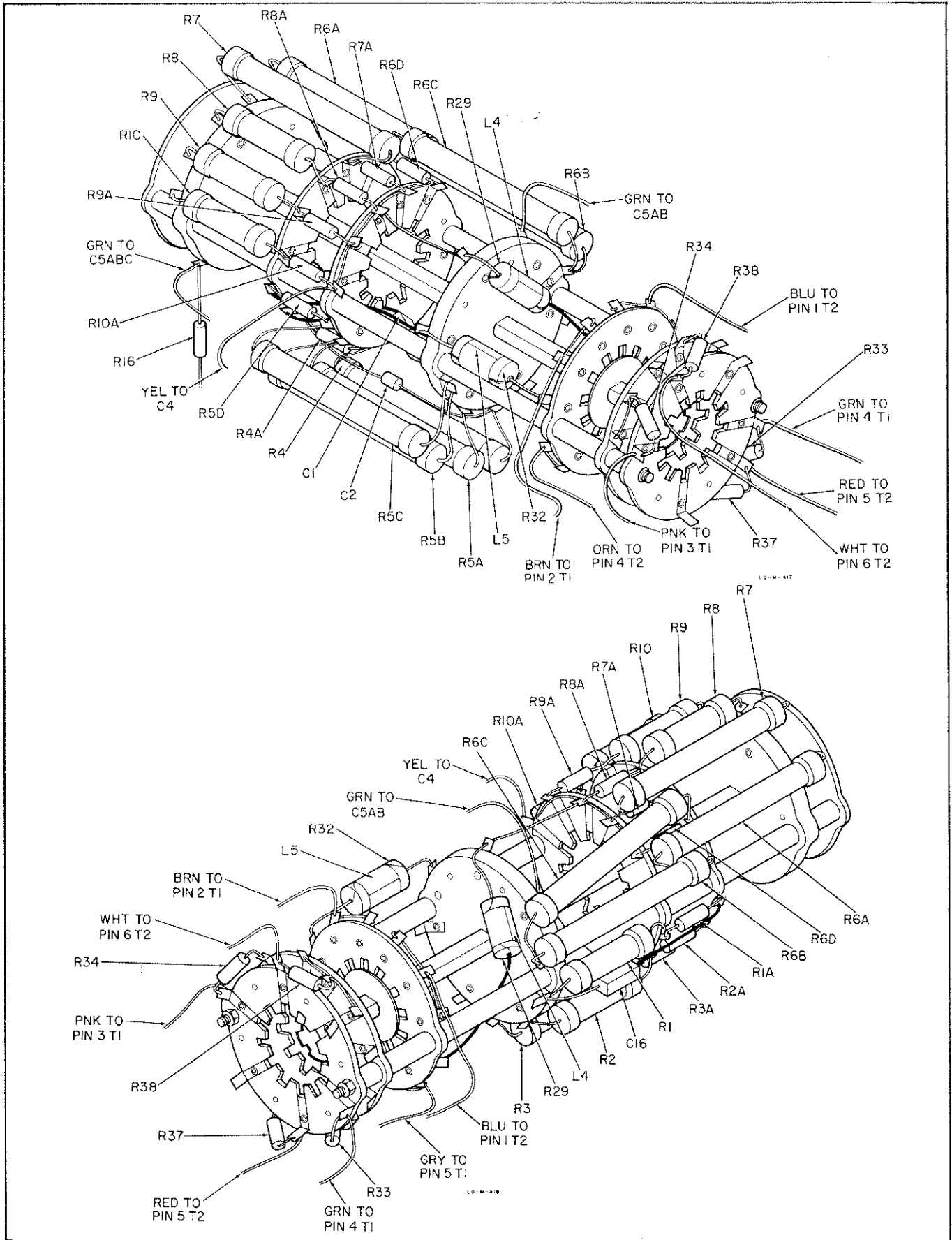


Figure 4-6. Range Switch Detail

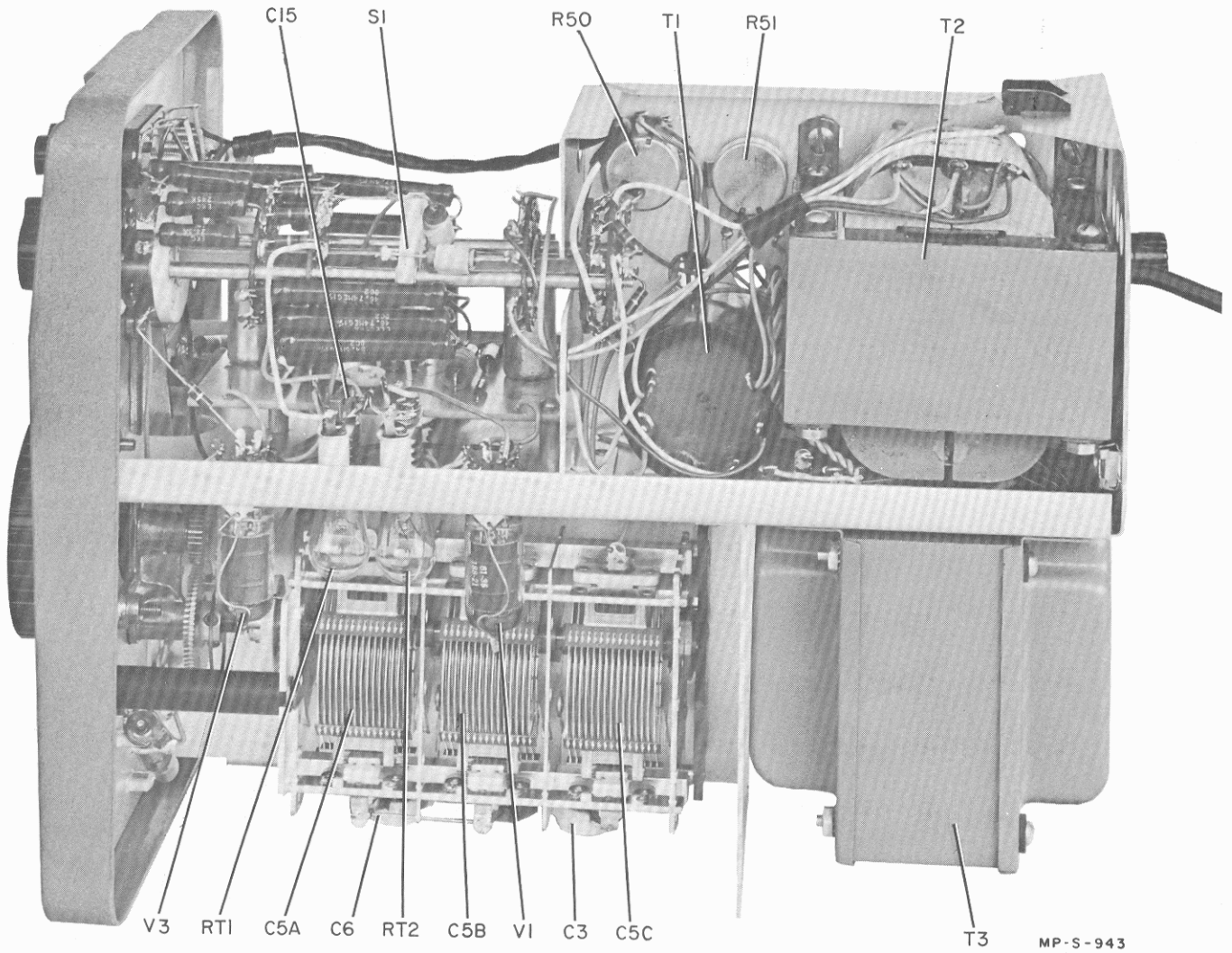


Figure 4-7. Right Side View Model 202C

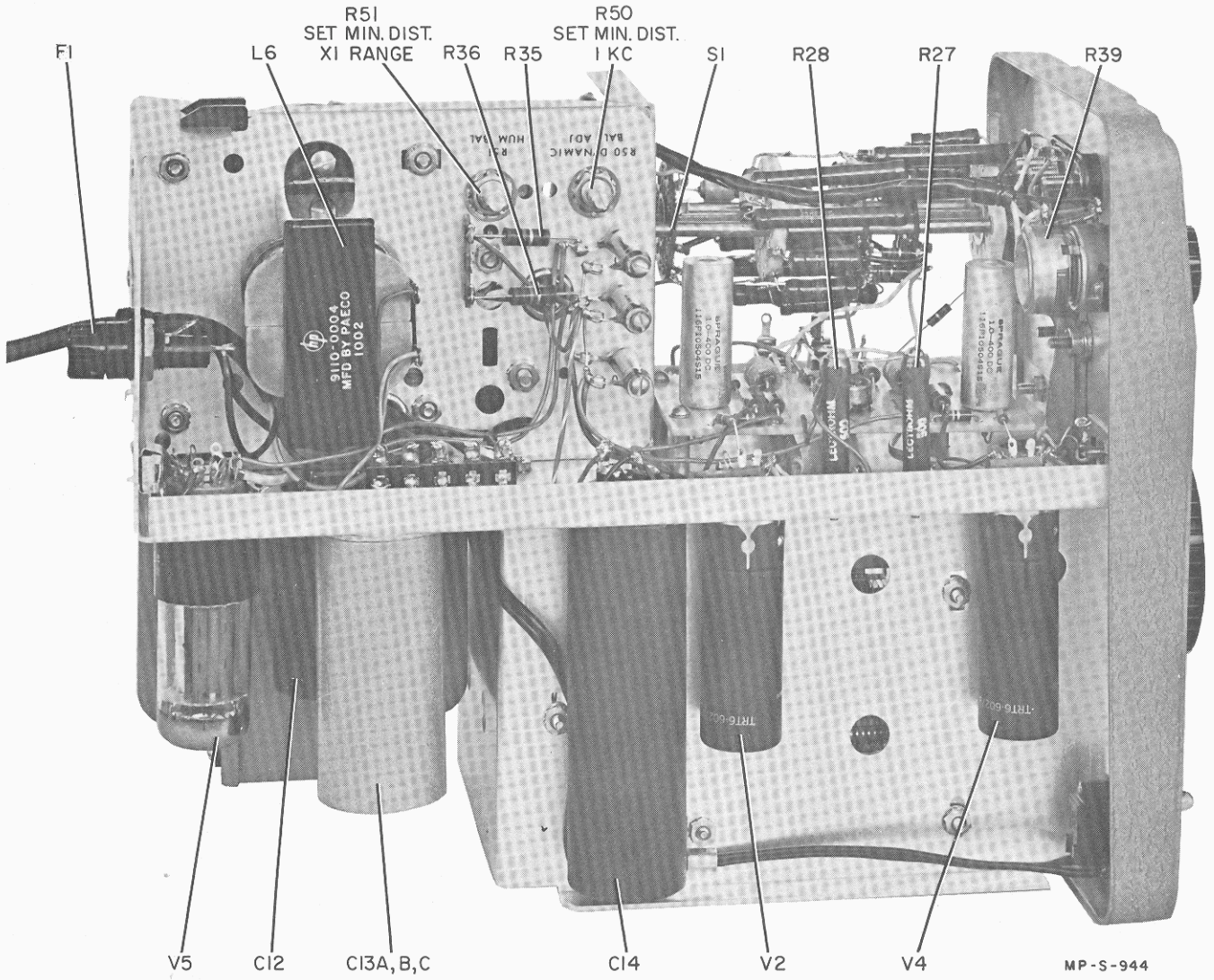


Figure 4-8. Left Side View Model 202C

SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

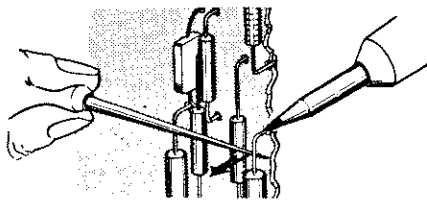
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

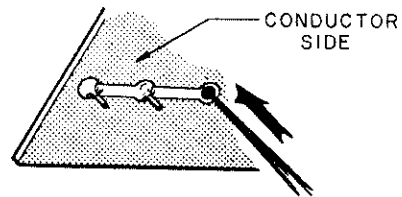
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

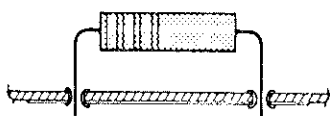
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



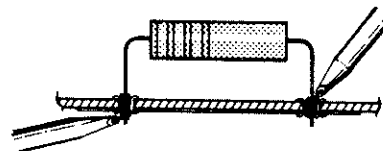
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.

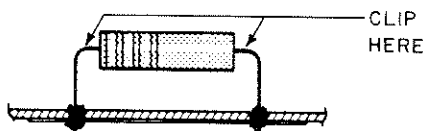


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

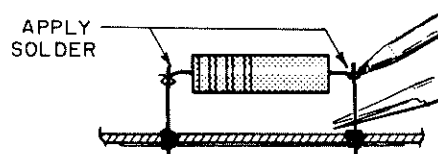


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 4-9. Servicing Etched Circuit Boards

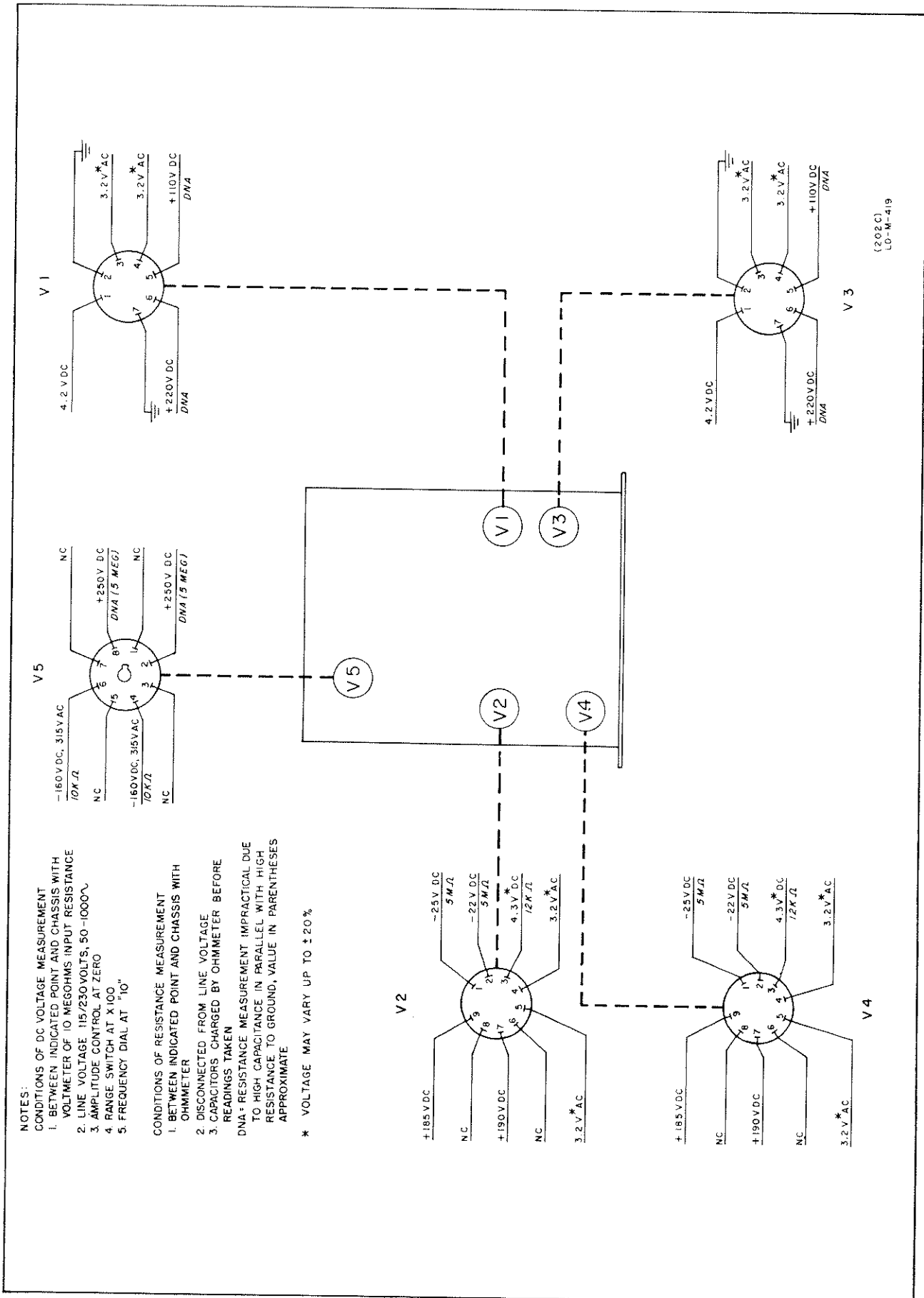


Figure 4-10. Model 202C Voltage and Resistance Diagram

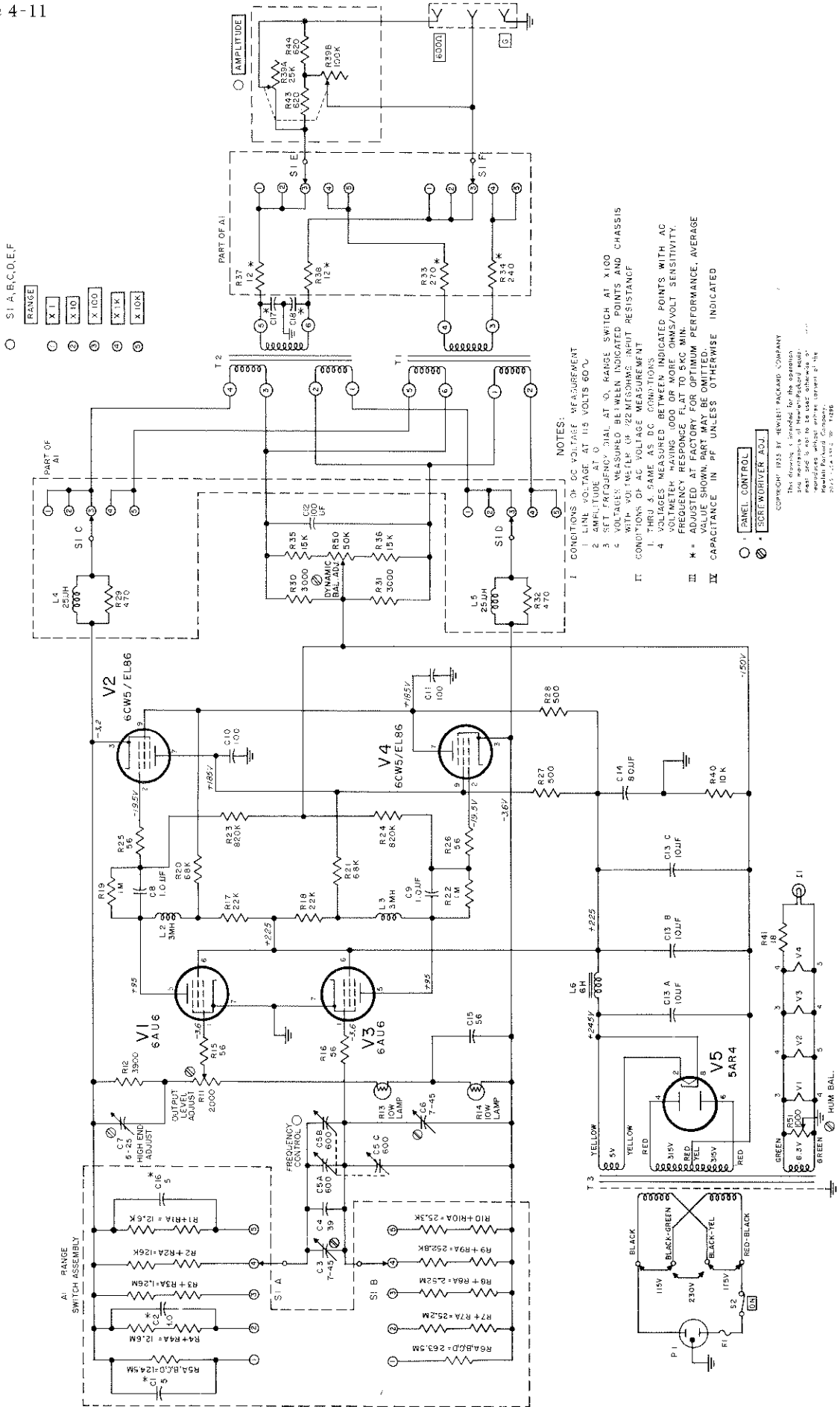


Figure 4-11. Schematic Diagram

SECTION V REPLACEABLE PARTS

5-1. INTRODUCTION.

This section contains information for ordering replacement parts for the Model 202C Wide Range Oscillator.

Table 5-1 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 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) Total quantity used in the instrument (TQ col).
- 6) Recommended spare quantity for complete maintenance during one year of isolated service (RS 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 table 5-1, give a complete description of the part and include its function and location.

Table 5-1. Replaceable Parts

| Ckt Ref. | Description | Mfr * | Ⓜ Stock No. | TQ* | RS* | |
|----------|---|-------|-------------|-----|-----|--|
| A1 | Assembly, range switch: includes C1 R1 thru R10 C2 R29 C16 R32 thru R34 L4, 5 R37, R38 | 28480 | 202C-19W | 1 | 1 | |
| C1 | Component not separately replaceable part of A1 assembly. Optimum value selected at factory; average value shown on schematic | | | | | |
| C2 | Component not separately replaceable part of A1 assembly. Optimum value selected at factory; average value shown on schematic | | | | | |
| C3 | Capacitor: variable, ceramic, 7-45 pf, 500 vdcw | 72982 | 0130-0001 | 2 | 1 | |
| C4 | Capacitor: fixed, ceramic, 39 pf ± 5%, 500 vdcw | 96095 | 0150-0002 | 1 | 1 | |

Table 5-1. Replaceable Parts (Cont'd)

| Ckt Ref. | Description | Mfr * | hp Stock No. | TQ* | RS* | | |
|----------|--|-------|--------------|-----|-----|--|--|
| C5 | Capacitor: variable, air, 3 sections, 0-600 pf/sect. | 76854 | 0121-0018 | 1 | 1 | | |
| C6 | Same as C3 | | | | | | |
| C7 | Capacitor: variable, ceramic, 5-25 pf | 72982 | 0130-0012 | 1 | 1 | | |
| C8,9 | Capacitor: fixed, paper, 1.0 μ f \pm 20%, 400 vdcw | 56289 | 0160-0064 | 2 | 1 | | |
| C10,11 | Capacitor: fixed, mica, 100 pf \pm 10%, 500 vdcw | 76433 | 0140-0054 | 2 | 1 | | |
| C12 | Capacitor: fixed, electrolytic, non-polarized, 100 μ f, 100 vdcw | 56289 | 0180-0013 | 1 | 1 | | |
| C13 | Capacitor: fixed, electrolytic, 3 sections, 10 μ f/sect., 450 vdcw | 56289 | 0180-0017 | 1 | 1 | | |
| C14 | Capacitor: fixed, electrolytic, 80 μ f -20%+100%, 450 vdcw | 14655 | 0180-0020 | 1 | 1 | | |
| C15 | Capacitor: fixed, mica, 56 pf \pm 1%, 500 vdcw | 00853 | 0140-0081 | 1 | 1 | | |
| C16 | Same as C1 | | | | | | |
| C17,18 | Optimum value selected at factory Part may be omitted | | | | | | |
| F1 | Fuse, cartridge: 1 amp, slow blow (for 115 volt operation) | 71400 | 2110-0007 | 1 | 10 | | |
| | Fuse, cartridge: 1/2 amp, slow blow (for 230 volt operation) | 71400 | 2100-0008 | | | | |
| I1 | Lamp, incandescent: 6-8 volt, 0.15 amp, #47 | 24455 | 2140-0009 | 1 | 1 | | |
| L1 | Not assigned | | | | | | |
| L2,3 | Coil, R. F. : 3 mh | 28480 | 200CD-60C | 2 | 1 | | |
| L4,5 | Component not separately replaceable; part of A1 assembly (wound on R29 & R32) | | | | | | |
| L6 | Coil: 6h at 125MA, 264 ohms | 98734 | 9110-0004 | 1 | 1 | | |
| P1 | Cord, power | 70903 | 8120-0050 | 1 | 1 | | |
| R1 | Component not separately replaceable; part of A1 assembly | | | | | | |

*See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

| Ckt Ref. | Description | Mfr * | Stock No. | TQ* | RS* | | |
|----------------|---|-------|-----------|-----|-----|--|--|
| R2 thru R10 | Component not separately replaceable; part of A1 assembly | | | | | | |
| R11 | Resistor: variable, composition, linear taper, 2000 ohms $\pm 30\%$, 1/3 W | 11237 | 2100-0090 | 1 | 1 | | |
| R12 | Resistor: fixed, composition, 3900 ohms $\pm 10\%$, 1 W | 01121 | 0690-3921 | 1 | 1 | | |
| R13, 14 | Lamp, incandescent: 10 W, 250 V | 24455 | 2140-0007 | 2 | 2 | | |
| R15, 16 | Resistor: fixed, composition, 56 ohms $\pm 10\%$, 1/2 W | 01121 | 0687-5601 | 4 | 1 | | |
| R17, 18 | Resistor: fixed, composition, 22,000 ohms $\pm 10\%$, 1 W | 01121 | 0690-2231 | 2 | 1 | | |
| R19 | Resistor: fixed, composition, 1 megohm $\pm 5\%$, 1/2 W | 01121 | 0686-1055 | 2 | 1 | | |
| R20, 21 | Resistor: fixed, composition, 68,000 ohms $\pm 10\%$, 1 W | 01121 | 0690-6831 | 2 | 1 | | |
| R22 | Same as R19 | | | | | | |
| R23, 24 | Resistor: fixed, composition, 820,000 ohms $\pm 10\%$, 1/2 W | 01121 | 0687-8241 | 2 | 1 | | |
| R25, 26 | Same as R15 | | | | | | |
| R27, 28 | Resistor: fixed, wirewound, 500 ohms $\pm 10\%$, 10 W | 35434 | 0816-0003 | 2 | 1 | | |
| R29 | Component not separately replaceable; part of L4 on A1 assembly | | | | | | |
| R30, 31 | Resistor: fixed, wirewound, 3000 ohms $\pm 10\%$, 10 W | 35434 | 0816-0002 | 2 | 1 | | |
| R32 | Component not separately replaceable; part of L5 on A1 assembly | | | | | | |
| R33, 34 | Component not separately replaceable; part of A1 assembly. Optimum value selected at factory; average value shown on schematic | | | | | | |
| R35, 36 | Resistor: fixed, composition, 15,000 ohms $\pm 10\%$, 1 W | 01121 | 0690-1531 | 2 | 1 | | |
| R37, 38 | Component not separately replaceable; part of A1 assembly. Optimum value selected at factory; average value shown on schematic | | | | | | |
| R39 | Resistor: variable, composition, 600 ohms $\pm 20\%$, 2 W | 01121 | 2100-0113 | 1 | 1 | | |

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

| Ckt Ref. | Description | Mfr * | Ⓢ Stock No. | TQ* | RS* | | |
|----------------------|--|-------|-------------|-----|-----|--|--|
| R40 | Resistor: fixed, wirewound, 10,000 ohms $\pm 10\%$, 10 W | 35434 | 0816-0008 | 1 | 1 | | |
| R41 | Resistor: fixed, composition, 18 ohms $\pm 10\%$, 1 W | 01121 | 0690-1801 | 1 | 1 | | |
| R42 | Not assigned | | | | | | |
| R43, 44 | Resistor: fixed, composition, 620 ohms $\pm 5\%$, 1/2 W | 01121 | 0686-6215 | 2 | 1 | | |
| R45 thru R49 | Not assigned | | | | | | |
| R50 | Resistor: variable, composition, linear taper, 50,000 ohms $\pm 20\%$ | 71590 | 2100-0013 | 1 | 1 | | |
| R51 | Resistor: variable, composition, linear taper, 1000 ohms | 71590 | 2100-0036 | 1 | 1 | | |
| S1 | Component not separately replaceable; part of A1 assembly | | | | | | |
| S2 | Switch, toggle: SPST | 04009 | 3101-0001 | 1 | 1 | | |
| T1 | Transformer, output: high frequency | 98734 | 9120-0027 | 1 | 1 | | |
| T2 | Transformer, output: low frequency | 98734 | 9120-0026 | 1 | 1 | | |
| T3 | Transformer, power | 98734 | 9100-0036 | 1 | 1 | | |
| V1 | Tube, electron: 7 pin, 6AU6 | 80131 | 1923-0021 | 2 | 2 | | |
| V2 | Tube, electron: 6CW5/EL86 | 80131 | 1923-0044 | | | | |
| V3 | Same as V1 | | | | | | |
| V4 | Same as V2 | | | | | | |
| V5 | Tube, electron: 5AR4 | 80131 | 1930-0003 | 1 | 1 | | |
| XV2, 4 | Socket, tube, ceramic: 9 pin | 91662 | 1200-0072 | 2 | 1 | | |
| <u>MISCELLANEOUS</u> | | | | | | | |
| | Assembly, etched board: Includes | 28480 | 202C-65A | 1 | 1 | | |
| | C7 R12 R21 | | | | | | |
| | C8 R15 R22 | | | | | | |
| | C9 R17 R23 | | | | | | |
| | L2 R18 R24 | | | | | | |
| | L3 R19 R25 | | | | | | |
| | R11 R20 R26 | | | | | | |

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

| Ckt Ref. | Description | Mfr * | Ⓢ Stock No. | TQ* | RS* | | |
|----------|--|-------|-------------|-----|-----|--|--|
| | Assembly, attenuator output: Includes R39, R43, R44 | 28480 | 200CD-34 | 1 | 1 | | |
| | Assembly, connector: black, binding post with link | 28480 | G-76J | 1 | 1 | | |
| | Binding post: red | 28480 | AC-10D | 2 | 1 | | |
| | Coupler, flex: 1/4 in. shaft | 76487 | 1500-0009 | 1 | 1 | | |
| | Fuseholder | 75915 | 1400-0084 | 1 | 1 | | |
| | Handle, cabinet | 0000Z | 1440-0002 | 1 | 0 | | |
| | Insulator | 28480 | AC-54D | 1 | 0 | | |
| | Knob: vernier | 28480 | G-74F | 1 | 0 | | |
| | Knob: AMPLITUDE | 28480 | G-74K | 1 | 0 | | |
| | Knob: RANGE | 28480 | G-74N | 1 | 0 | | |
| | Knob: frequency dial | 28480 | G-74Z | 1 | 0 | | |
| | Lampholder: (for R13, R14) | 72765 | 1450-0013 | 2 | 1 | | |
| | Shield, tube: (for V1, V3) | 98978 | 1220-0029 | 2 | 0 | | |
| | Lampholder, pilot lamp | 72765 | 1450-0012 | 1 | 0 | | |
| | Spring, compression: for vernier drive | 0000C | 1460-0019 | 1 | 1 | | |
| | Vernier, drive disc: on shaft | 28480 | G-14A | 1 | 0 | | |
| | Vernier, drive disc | 28480 | G-14B | 1 | 0 | | |
| | Window, dial: for curved dial | 28480 | G-99K | 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 | CODE NO. | MANUFACTURER | ADDRESS | CODE NO. | MANUFACTURER | ADDRESS |
|----------|--|-----------------------|----------|--|--------------------------------|----------|--|-----------------------|
| 00334 | Humidial Co. | Colton, Calif. | 07126 | Digitran Co. | Pasadena, Calif. | 48620 | Precision Thermometer and Inst. Co. | Philadelphia, Pa. |
| 00335 | Westrex Corp. | New York, N.Y. | 07137 | Transistor Electronics Corp. | Minneapolis, Minn. | 49956 | Raytheon Mfg. Co. | Waltham, Mass. |
| 00373 | Garlock Packing Co., Electronic Products Div. | Camden, N.J. | 07138 | Westinghouse Electric Corp. Electronic Tube Div. | Elmira, N.Y. | 54294 | Shallcross Mfg. Co. | Selma, N.C. |
| 00656 | Aerovox Corp. | New Bedford, Mass. | 07261 | Avnet Corp. | Los Angeles, Calif. | 55026 | Simpson Electric Co. | Chicago, Ill. |
| 00779 | Amp, Inc. | Harrisburg, Pa. | 07263 | Fairchild Semiconductor Corp. | Mountain View, Calif. | 55933 | Sonotone Corp. | Elmsford, N.Y. |
| 00781 | Aircraft Radio Corp. | Boonton, N.J. | 07910 | Continental Device Corp. | Hawthorne, Calif. | 55938 | Sorenson & Co., Inc. | So. Norwalk, Conn. |
| 00853 | Sangamo Electric Co., Cap. Div. | Marion, Ill. | 07933 | Rheem Semiconductor Corp. | Mountain View, Calif. | 56137 | Spaulding Fibre Co., Inc. | Tonawanda, N.Y. |
| 00866 | Goe Engineering Co. | Los Angeles, Calif. | 07980 | Boonton Radio Corp. | Boonton, N.J. | 56289 | Sprague Electric Co. | North Adams, Mass. |
| 00891 | Carl E. Holmes Corp. | Los Angeles, Calif. | 08145 | U.S. Engineering Co. | Los Angeles, Calif. | 59446 | Telex, Inc. | St. Paul, Minn. |
| 01121 | Allen Bradley Co. | Milwaukee, Wis. | 08358 | Burgess Battery Co. | Niagara Falls, Ontario, Canada | 61775 | Union Switch and Signal, Div. of Westinghouse Air Brake Co. | Pittsburgh, Pa. |
| 01255 | Litton Industries, Inc. | Beverly Hills, Calif. | 08717 | Sloan Company | Burbank, Calif. | 62119 | Universal Electric Co. | Pittsburgh, Pa. |
| 01281 | Pacific Semiconductors, Inc. | Culver City, Calif. | 08718 | Cannon Electric Co. Phoenix Div. | Phoenix, Ariz. | 64959 | Western Electric Co., Inc. | New York, N.Y. |
| 01295 | Texas Instruments, Inc. Semiconductor Components Div. | Dallas, Texas | 08792 | CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc. | Lowell, Mass. | 65092 | Weston Inst. Div. of Daystrom, Inc. | Newark, N.J. |
| 01349 | The Alliance Mfg. Co. | Alliance, Ohio | 09026 | Babcock Relays, Inc. | Costa Mesa, Calif. | 66346 | Wollensak Optical Co. | Rochester, N.Y. |
| 01561 | Chassi-Trak Corp. | Indianapolis, Ind. | 09134 | Texas Capacitor Co. | Houston, Texas | 70276 | Allen Mfg. Co. | Hartford, Conn. |
| 01930 | Amerock Corp. | Rockford, Ill. | 09250 | Electro Assemblies, Inc. | Chicago, Ill. | 70309 | Allied Control Co., Inc. | New York, N.Y. |
| 01961 | Pulse Engineering Co. | Santa Clara, Calif. | 09569 | Mallory Battery Co. of Canada, Ltd. | Toronto, Ontario, Canada | 70485 | Atlantic India Rubber Works, Inc. | Chicago, Ill. |
| 02114 | Ferroxcube Corp. of America | Saugerties, N.Y. | 10411 | Ti-Tal, Inc. | Berkeley, Calif. | 70563 | Amperite Co., Inc. | New York, N.Y. |
| 02286 | Cole Mfg. Co. | Palo Alto, Calif. | 10646 | Carborundum Co. | Niagara Falls, N.Y. | 70903 | Belden Mfg. Co. | Chicago, Ill. |
| 02660 | Amphenol Electronics Corp. | Chicago, Ill. | 11236 | CTS of Berne, Inc. | Berne, Ind. | 70998 | Bird Electronic Corp. | Cleveland, Ohio |
| 02735 | Radio Corp. of America Semiconductor and Materials Div. | Somerville, N.J. | 11237 | Chicago Telephone of California, Inc. So. Pasadena, Calif. | So. Pasadena, Calif. | 71002 | Birnbach Radio Co. | New York, N.Y. |
| 02771 | Vocaline Co. of America, Inc. | Old Saybrook, Conn. | 11312 | Microwave Electronics Corp. | Palo Alto, Calif. | 71218 | Bud Radio Inc. | Cleveland, Ohio |
| 02777 | Hopkins Engineering Co. | San Fernando, Calif. | 11870 | Melabs, Inc. | Palo Alto, Calif. | 71286 | Camloc Fastener Corp. | Paramus, N.J. |
| 03508 | G.E. Semiconductor Products Dept. | Syracuse, N.Y. | 12697 | ClaroStat Mfg. Co. | Dover, N.H. | 71313 | Allen D. Cardwell Electronic Prod. Corp. | Plainville, Conn. |
| 03705 | Apex Machine & Tool Co. | Dayton, Ohio | 14655 | Cornell Dubilier Elec. Corp. | So. Plainfield, N.J. | 71400 | Bussmann Fuse Div. of McGraw- Edison Co. | St. Louis, Mo. |
| 03797 | Eldema Corp. | El Monte, Calif. | 15909 | The Daven Co. | Livingston, N.J. | 71450 | CTS Corp. | Elkhart, Ind. |
| 03877 | Transiron Electronic Corp. | Wakefield, Mass. | 16758 | Delco Radio Div. of G. M. Corp. | Kokomo, Ind. | 71468 | Cannon Electric Co. | Los Angeles, Calif. |
| 03888 | Pyrofilm Resistor Co. | Morristown, N.J. | 18873 | E. I. DuPont and Co., Inc. | Wilmington, Del. | 71471 | Cinema Engineering Co. | Burbank, Calif. |
| 03954 | Air Marine Motors, Inc. | Los Angeles, Calif. | 19315 | Eclipse Pioneer, Div. of Bendix Aviation Corp. | Teferboro, N.J. | 71482 | C. P. Clare & Co. | Chicago, Ill. |
| 04009 | Arrow, Hart and Hegeman Elect. Co. | Hartford, Conn. | 19500 | Thomas A. Edison Industries, Div. of McGraw-Edison Co. | West Orange, N.J. | 71590 | Centralab Div. of Globe Union Inc. | Union, N.Y. |
| 04062 | Elmenco Products Co. | New York, N.Y. | 19701 | Electra Manufacturing Co. | Kansas City, Mo. | 71700 | The Cornish Wire Co. | Milwaukee, Wis. |
| 04222 | Hi-Q Division of Aerovox | Myrtle Beach, S.C. | 20183 | Electronic Tube Corp. | Philadelphia, Pa. | 71744 | Chicago Miniature Lamp Works | New York, N.Y. |
| 04298 | Elgin National Watch Co., Electronics Division | Burbank, Calif. | 21520 | Fansteel Metallurgical Corp. | No. Chicago, Ill. | 71753 | A. O. Smith Corp., Crowley Div. | Chicago, Ill. |
| 04404 | Dymec Division of Hewlett-Packard Co. | Palo Alto, Calif. | 21335 | The Fafnir Bearing Co. | New Britain, Conn. | 71785 | Cinch Mfg. Corp. | West Orange, N.J. |
| 04651 | Special Tube Operations of Sylvania Electronic Systems | Mountain View, Calif. | 21964 | Fed. Telephone and Radio Corp. | Clifton, N.J. | 71984 | Dow Corning Corp. | Chicago, Ill. |
| 04713 | Motorola, Inc., Semiconductor Prod. Div. | Phoenix, Arizona | 24446 | General Electric Co. | Schenectady, N.Y. | 72136 | Electro Motive Mfg. Co., Inc. | Midland, Mich. |
| 04732 | Filtron Co., Inc. Western Division | Culver City, Calif. | 24455 | G. E., Lamp Division | Nela Park, Cleveland, Ohio | 72354 | John E. Fast & Co. | Willimantic, Conn. |
| 04773 | Automatic Electric Co. | Northlake, Ill. | 24655 | General Radio Co. | West Concord, Mass. | 72619 | Dialight Corp. | Chicago, Ill. |
| 05006 | Twentieth Century Plastics, Inc. | Los Angeles, Calif. | 26462 | Grobet File Co. of America, Inc. | Carlstadt, N.J. | 72656 | General Ceramics Corp. | Brooklyn, N.Y. |
| 05277 | Westinghouse Electric Corp., Semi-Conductor Dept. | Youngwood, Pa. | 26992 | Hamilton Watch Co. | Lancaster, Pa. | 72758 | Girard-Hopkins | Keasbey, N.J. |
| 05593 | Illumitronic Engineering Co. | Sunnyvale, Calif. | 28480 | Hawlett-Packard Co. | Palo Alto, Calif. | 72765 | Drake Mfg. Co. | Oakland, Calif. |
| 05624 | Barber Colman Co. | Rockford, Ill. | 33173 | G. E. Receiving Tube Dept. | Owensboro, Ky. | 72765 | Hugh H. Eby Inc. | Chicago, Ill. |
| 05729 | Metropolitan Telecommunications Corp., Metro Cap. Div. | Brooklyn, N.Y. | 35434 | Lectrohm Inc. | Chicago, Ill. | 72825 | Gudeman Co. | Philadelphia, Pa. |
| 05783 | Stewart Engineering Co. | Soquel, Calif. | 37942 | P. R. Mallory & Co., Inc. | Indianapolis, Ind. | 72928 | Gudeman Co. | Chicago, Ill. |
| 06004 | The Bassick Co. | Bridgeport, Conn. | 39543 | Mechanical Industries Prod. Co. | Akron, Ohio | 72982 | Erie Resistor Corp. | Erie, Pa. |
| 06555 | Beede Electrical Instrument Co., Inc. | Penacook, N.H. | 40920 | Miniature Precision Bearings, Inc. | Keene, N.H. | 73061 | Hansen Mfg. Co., Inc. | Princeton, Ind. |
| 06812 | Torrington Mfg. Co., West Div. | Van Nuys, Calif. | 42190 | Muter Co. | Chicago, Ill. | 73138 | Helipot Div. of Beckman Instruments, Inc. | Fullerton, Calif. |
| 07115 | Corning Glass Works Electronic Components Dept. | Bradford, Pa. | 43990 | C. A. Norgren Co. | Englewood, Colo. | 73293 | Hughes Products Div. of Hughes Aircraft Co. | Newport Beach, Calif. |
| | | | 44655 | Ohmite Mfg. Co. | Skokie, Ill. | 73445 | Amperex Electronic Co., Div. of North American Phillips Co., Inc. | Hicksville, N.Y. |
| | | | 47904 | Polaroid Corp. | Cambridge, Mass. | 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 |

From: F.S.C. Handbook Supplements
H4-1 Dated April 1961
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00015-16
Revised: 20 September 1961

APPENDIX

CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

| CODE NO. | MANUFACTURER | ADDRESS | CODE NO. | MANUFACTURER | ADDRESS | CODE NO. | MANUFACTURER | ADDRESS |
|----------|--|------------------------|----------|---|------------------------|----------|---|------------------------|
| 73905 | Jennings Radio Mfg. Co. | San Jose, Calif. | 82389 | Switchcraft, Inc. | Chicago, Ill. | 95354 | Methode Mfg. Co. | Chicago, Ill. |
| 74455 | J. H. Winns, and Sons | Winchester, Mass. | 82647 | Texas Instruments, Inc., Metals and Controls Div., Spencer Products | Attleboro, Mass. | 95987 | Weckesser Co. | Chicago, Ill. |
| 74861 | Industrial Condenser Corp. | Chicago, Ill. | 82866 | Research Products Corp. | Madison, Wis. | 96067 | Huggins Laboratories | Sunnyvale, Calif. |
| 74868 | Industrial Products Co. | Danbury, Conn. | 82877 | Rotron Manufacturing Co., Inc. | Woodstock, N.Y. | 96095 | Hj-Q Division of Aerovox | Olean, N.Y. |
| 74970 | E. F. Johnson Co. | Waseca, Minn. | 82893 | Vector Electronic Co. | Glendale, Calif. | 96296 | Solar Manufacturing Co. | Los Angeles, Calif. |
| 75042 | International Resistance Co. | Philadelphia, Pa. | 83148 | Electro Cords Co. | Los Angeles, Calif. | 96330 | Carlton Screw Co. | Chicago, Ill. |
| 75173 | Jones, Howard B., Division of Cinch Mfg. Corp. | Chicago, Ill. | 83186 | Victory Engineering Corp. | Union, N.J. | 96341 | Microwave Associates, Inc. | Burlington, Mass. |
| 75378 | James Knights Co. | Sandwich, Ill. | 83298 | Bendix Corp., Red Bank Div. | Red Bank, N.J. | 96493 | J. W. Miller Co. | Los Angeles, Calif. |
| 75382 | Kulka Electric Mfg. Co., Inc. | Mt. Vernon, N.Y. | 83594 | Burroughs Corp., Electronic Tube Div. | Plainfield, N.J. | 96501 | Excel Transformer Co. | Oakland, Calif. |
| 75818 | Lenz Electric Mfg. Co. | Chicago, Ill. | 83777 | Model Eng. and Mfg., Inc. | Huntington, Ind. | 97539 | Automatic and Precision Mfg. Co. | Yonkers, N.Y. |
| 75915 | Littelfuse Inc. | Des Plaines, Ill. | 83821 | Loyd Scruggs Co. | Festus, Mo. | 97966 | CBS Electronics, Div. of C.B.S., Inc. | Danvers, Mass. |
| 76005 | Lord Mfg. Co. | Erie, Pa. | 84171 | Arco Electronics, Inc. | New York, N.Y. | 98141 | Axel Brothers Inc. | Jamaica, N.Y. |
| 76210 | C. W. Marwedel | San Francisco, Calif. | 84396 | A. J. Giesener Co., Inc. | San Francisco, Calif. | 98220 | Francis L. Mosley | Pasadena, Calif. |
| 76433 | Micamold Electronic Mfg. Corp. | Brooklyn, N.Y. | 84411 | Good All Electric Mfg. Co. | Ogallala, Neb. | 98278 | Microdot, Inc. | So. Pasadena, Calif. |
| 76487 | James Millen Mfg. Co., Inc. | Malden, Mass. | 84970 | Sarkes Tarzian, Inc. | Bloomington, Ind. | 98291 | Sealectro Corp. | New Rochelle, N.Y. |
| 76530 | Monadnock Mills | San Leandro, Calif. | 85454 | Boonton Molding Company | Boonton, N.J. | 98405 | Garad Corp. | Redwood City, Calif. |
| 76545 | Mueller Electric Co. | Cleveland, Ohio | 85474 | R. M. Bracamonte & Co. | San Francisco, Calif. | 98734 | Palo Alto Engineering Co., Inc. | Palo Alto, Calif. |
| 76854 | Oak Manufacturing Co. | Chicago, Ill. | 85660 | Koiled Kords, Inc. | New Haven, Conn. | 98925 | Clevite Transistor Prod. Div. of Clevite Corp. | Waltham, Mass. |
| 77068 | Bendix Corp., Bendix Pacific Div. | No. Hollywood, Calif. | 85911 | Seamless Rubber Co. | Chicago, Ill. | 98978 | International Electronic Research Corp. | Burbank, Calif. |
| 77221 | Phaostron Instrument and Electronic Co. | South Pasadena, Calif. | 86684 | Radio Corp. of America, RCA Electron Tube Div. | Harrison, N.J. | 99109 | Columbia Technical Corp. | New York, N.Y. |
| 77342 | Potter and Brumfield, Inc. | Princeton, Ind. | 87473 | Western Fibrous Glass Products Co. | San Francisco, Calif. | 99133 | Varian Associates | Palo Alto, Calif. |
| 77630 | Radio Condenser Co. | Camden, N.J. | 88140 | Cutler-Hammer, Inc. | Lincoln, Ill. | 99515 | Marshall Industries, Electron Products Division | Pasadena, Calif. |
| 77634 | Radio Essentials Inc. | Mt. Vernon, N.Y. | 89473 | General Electric Distributing Corp. | Schenectady, N.Y. | 99707 | Control Switch Division, Controls Co. of America | El Segundo, Calif. |
| 77638 | Radio Receptor Co., Inc. | Brooklyn, N.Y. | 90179 | U.S. Rubber Co., Mechanical Goods Div. | Passaic, N.J. | 99800 | Delevan Electronics Corp. | East Aurora, N.Y. |
| 77764 | Resistance Products Co. | Harrisburg, Pa. | 90970 | Bearing Engineering Co. | San Francisco, Calif. | 99821 | North Hills Electric Co. | Great Neck, L.I., N.Y. |
| 78283 | Signal Indicator Corp. | New York, N.Y. | 91418 | Radio Materials Co. | Chicago, Ill. | 99848 | Wilco Corporation | Indianapolis, Ind. |
| 78471 | Tilley Mfg. Co. | San Francisco, Calif. | 91506 | Augat Brothers, Inc. | Attleboro, Mass. | 99934 | Renbrandt, Inc. | Boston, Mass. |
| 78488 | Stackpole Carbon Co. | St. Marys, Pa. | 91637 | Dale Products, Inc. | Columbus, Neb. | 99942 | Hoffman Semiconductor Div. of Hoffman Electronics, Corp. | Evanson, Ill. |
| 78553 | Tinnerman Products, Inc. | Cleveland, Ohio | 91662 | Elco Corp. | Philadelphia, Pa. | 99957 | Technology Instruments Corp. of Calif. | No. Hollywood, Calif. |
| 78790 | Transformer Engineers | Pasadena, Calif. | 91737 | Gremar Mfg. Co., Inc. | Waketfield, Mass. | | | |
| 78947 | Ucinite Co. | Newtonville, Mass. | 91827 | K F Development Co. | Redwood City, Calif. | | | |
| 79142 | Yeeder Roof, Inc. | Hartford, Conn. | 91929 | Micro-Switch Div. of Minneapolis Honeywell Regulator Co. | Freeport, Ill. | | | |
| 79251 | Wenco Mfg. Co. | Chicago, Ill. | 92196 | Universal Metal Products, Inc. | Bassett Puente, Calif. | | | |
| 79963 | Zierick Mfg. Corp. | New Rochelle, N.Y. | 93332 | Sylvania Electric Prod. Inc., Semiconductor Div. | Woburn, Mass. | 0000C | Connor Spring Mfg. Co. | San Francisco, Calif. |
| 80031 | Mecco Division of Sessions Clock Co. | Morristown, N.J. | 93369 | Robbins and Myers, Inc. | New York, N.Y. | 0000F | Malco Tool and Die | Los Angeles, Calif. |
| 80130 | Times Facsimile Corp. | New York, N.Y. | 93410 | Stevens Mfg. Co., Inc. | Mansfield, Ohio | 0000H | Philco Corp. (Lansdale Division) | Lansdale, Pa. |
| 80131 | Electronic Industries Association Any brand tube meeting EIA standards | Washington, D.C. | 93983 | Insuline-Van Norman Ind., Inc. Electronic Division | Manchester, N.H. | 0000I | Telefunken (c/o American Elite) | New York, N.Y. |
| 80207 | Unimax Switch, Div. of W. L. Maxson Corp. | Wallingford, Conn. | 94144 | Raytheon Mfg. Co., Receiving Tube Div. | Quincy, Mass. | 0000L | Winchester Electronics, Inc. | Santa Monica, Calif. |
| 80248 | Oxford Electric Corp. | Chicago, Ill. | 94145 | Raytheon Mfg. Co., Semi- conductor Div. | Newton, Mass. | 0000M | Western Coil Div. of Automatic Ind., Inc. | Redwood City, Calif. |
| 80411 | Acro Manufacturing Co. | Columbus, Ohio | 94148 | Scientific Radio Products, Inc. | Loveland, Colo. | 0000N | Nahm-Bros. Spring Co. | San Leandro, Calif. |
| 80486 | All Star Products Inc. | Defiance, Ohio | 94154 | Tung-Sol Electric, Inc. | Newark, N.J. | 0000P | Ty-Car Mfg. Co., Inc. | Holliston, Mass. |
| 80583 | Hammerlund Co., Inc. | New York, N.Y. | 94197 | Curtiss-Wright Corp., Electronics Div. | Carlstadt, N.J. | 0000T | Texas Instruments, Inc. Metals and Controls Div. | Versailles, Ky. |
| 80640 | Stevens, Arnold, Co., Inc. | Boston, Mass. | 94310 | Tru Ohm Prod. Div. of Model Engineering and Mfg. Co. | Chicago, Ill. | 0000U | Tower Mfg. Corp. | Providence, R.I. |
| 81030 | International Instruments, Inc. | New Haven, Conn. | 94682 | Worcester Pressed Aluminum Corp. | Worcester, Mass. | 0000V | Imperial Electronics, Inc. | Buena Park, Calif. |
| 81415 | Wilkor Products, Inc. | Cleveland, Ohio | 95236 | Allies Products Corp. | Miami, Fla. | 0000W | Webster Electronics Co. Inc. | New York, N.Y. |
| 81453 | Raytheon Mfg. Co., Industrial Tube Division | Quincy, Mass. | 95238 | Continental Connector Corp. | Woodside, N.Y. | 0000X | Spruce Pine Mica Co. | Spruce Pine, N.C. |
| 81483 | International Rectifier Corp. | El Segundo, Calif. | 95263 | Leecraft Mfg. Co., Inc. | New York, N.Y. | 0000Y | Midland Mfg. Co. Inc. | Kansas City, Kans. |
| 81860 | Barry Controls, Inc. | Watertown, Mass. | 95264 | Lerco Electronics, Inc. | Burbank, Calif. | 0000Z | Willow Leather Products Corp. | Newark, N.J. |
| 82042 | Carter Parts Co. | Skokie, Ill. | 95265 | National Coil Co. | Sheridan, Wyo. | | | |
| 82142 | Jeffers Electronics Division of Speer Carbon Co. | Du Bois, Pa. | 95275 | Vitramon, Inc. | Bridgeport, Conn. | | | |
| 82170 | Allen B. DuMont Labs, Inc. | Cliffon, 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. | | | | | | |

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

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

00015-16
Revised: 20 September 1961

MANUAL CHANGES

MODEL 202C

LOW FREQUENCY OSCILLATOR

Serials Prefixed: 129-

Manual Printed: 9/61

The following changes adapt this manual to instruments having the serial prefixes listed below:
(Ch. # = Change Number; Ser. Pre. = Serial Prefix)

| Ch. # | Ser. Pre. | New Data |
|-------|-----------|--|
| 1 | 129- | <p>Table 5-1, C4: Change to capacitor, fixed, mica, 39 pf $\pm 2\%$, 500 vdcw; $\text{\textcircled{P}}$ Stock No. 0140-0116; Mfr. 76433.</p> <p>Under <u>Miscellaneous</u> Delete coupler, flexible, for 1/4" shaft: $\text{\textcircled{P}}$ Stock No. 1500-0009 and add the following: Coupler, yoke; $\text{\textcircled{P}}$ Stock No. 1500-0002; Mfr. 76487; TQ, 2. Insulator, flexible coupling; $\text{\textcircled{P}}$ Stock No. G-32H; Mfr. 28480; TQ, 1.</p> |