

51A OSCILLATOR

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(B) Frequency Calibration	6	2.05 The power connection to the a-c supply is made through a power cord and polarized outlet, which are part of the oscillator. An ON-OFF switch and a safety switch are connected in the line side of the power circuit. Because of high voltages in the oscillator, the safety switch is provided to insure that the oscillator will be de-energized when the chassis is removed from its case. When furnished in a portable case, a third conductor is included in the power cord, connected to the chassis inside the oscillator, and terminated in a clip at the plug. This clip should be connected to ground to insure that the chassis is grounded for protection purposes.
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<u>1. GENERAL</u>		
1.01 This section describes the 51A oscillator and its operation.		
1.02 The 51A oscillator is primarily for use in testing Type K carrier telephone systems. It is capable of supplying single frequencies from 2 kc to 79 kc in 1 kc steps. A 0 to 1 kc control permits the frequencies to be continuously varied from 0 kc to -1 kc from the indicated value. The output may be varied from +16 dbm to approximately -75 dbm by means of COARSE and FINE controls. The output impedance is approximately 135 ohms.		
1.03 In using the 51A oscillator with K1 systems on which the d-c pilot wire circuit is superimposed, a d-c blocking condenser circuit is required and is provided external to the oscillator.		
1.04 The 51A oscillator is provided in portable form, equipped with a power supply cord and a removable cover. It is also arranged to be relay rack mounted. A set of vacuum tubes, as listed in Part 5, is supplied with each oscillator. This oscillator operates from a power source of 105 to 125 volts, 50 to 60 cycles a-c, consuming approximately 60 watts. It is not suitable for use on 25-cycle power.		

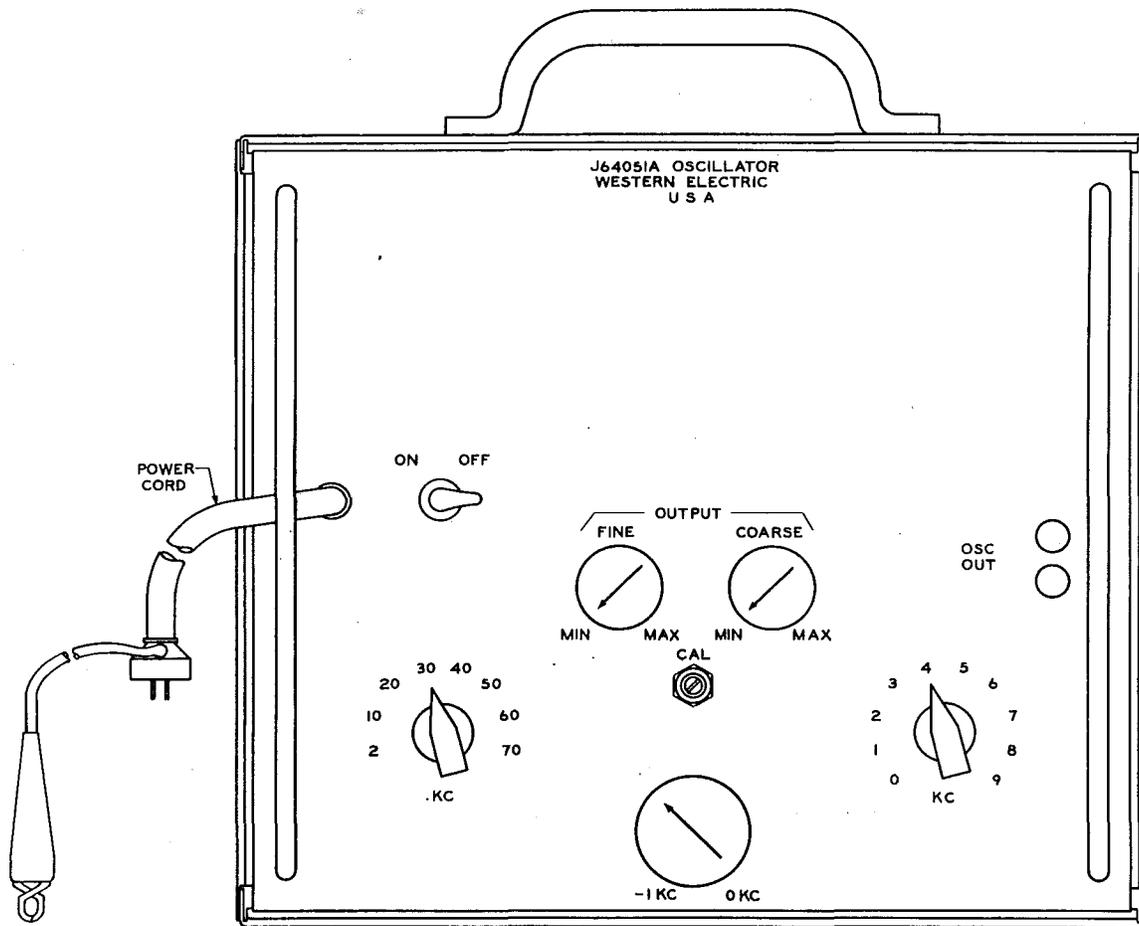


Fig. 1 - Face View of 51A Oscillator

(B) Circuit Theory

2.07 The circuit of the 51A oscillator is shown in detail on Drawing SD-59119-01; a theory schematic is shown in Fig. 2.

2.08 The oscillator circuit is of the bridge type. The first arm of the bridge consists of a resistance (R_1) and a condenser (C_1) in series; the second, a resistance (R_2) and a condenser (C_2) in parallel; whereas, the third and fourth arms are purely resistive consisting of a thermistor (R_3) and a lamp (R_L). The junction of the series and parallel resistance-condenser arms is connected to the grid of vacuum tube 1, and the junction of the resistive arms to the cathode of the same tube, the output voltage of vacuum tube 2 being applied to the other junctions of the bridge. For specific values of resistances and condensers, the series and parallel resistance-condenser arms will have identical phase angles at only one frequency, determined by the expression

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

For equal resistances and condensers in the two branches, this becomes,

$$f = \frac{1}{2\pi R C}$$

Thus, at this frequency, the voltage from grid to ground will be in phase with the voltage applied across the bridge by vacuum tube 2. As the other two arms are resistive, the voltage from cathode to ground will also be in phase with the applied voltage. Hence, the voltage between grid and cathode of vacuum tube 1 will be in phase with the voltage applied across the bridge, since the frequency of zero phase shift (frequency of oscillation) is determined by the product of the resistance and capacitance of arms 1 and 2. If the capacitance is held constant, the frequency of oscillation is then determined by the conductance of these two arms. Thus, a dual decade conductance arrangement may be used to control the frequency.

2.09 With equal resistances and equal condensers in arms 1 and 2 of the bridge, the impedance of arm 1 is twice that of arm 2

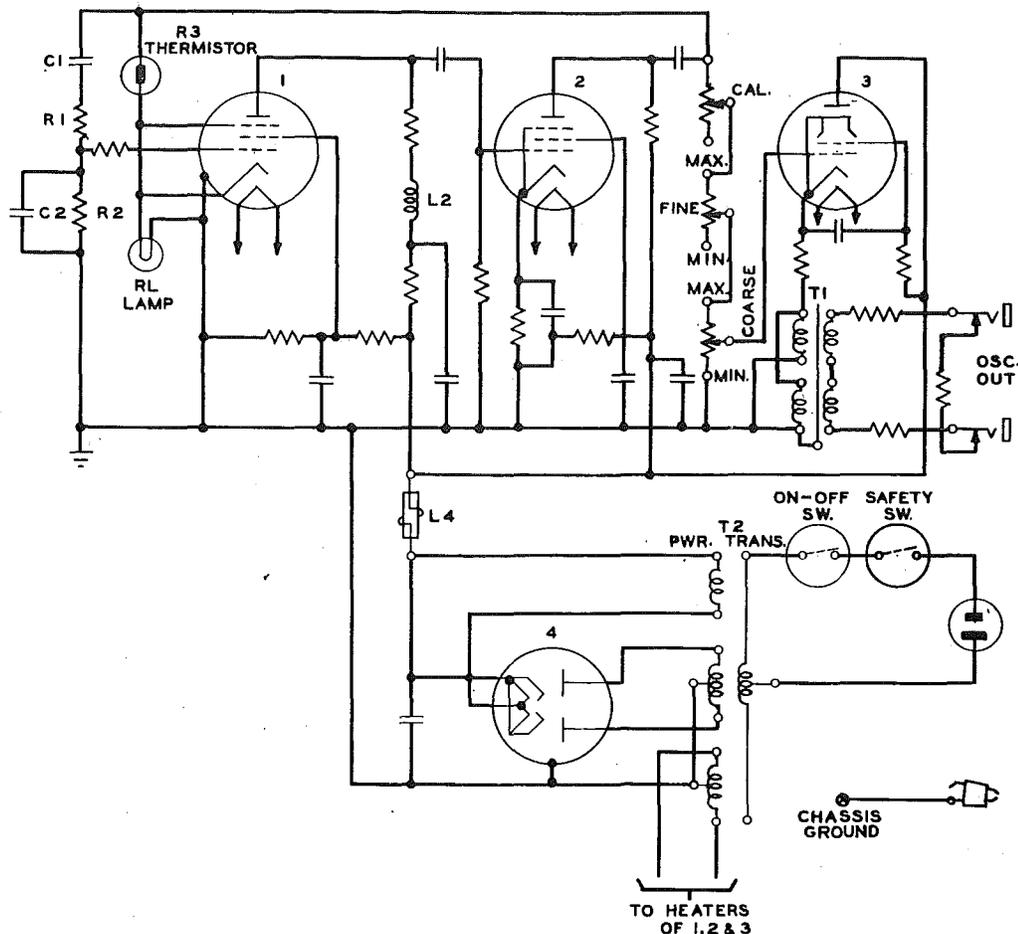


Fig. 2 - Theory Schematic

at the frequency of oscillation. The third and fourth arms of the bridge consist of a thermistor and lamp, respectively, the one having negative resistance voltage characteristic and the other a positive characteristic. These control the amplitude of the voltage between cathode and ground and hence across the grid and cathode of vacuum tube 1.

2.10 For normal operating conditions, the thermistor resistance is slightly greater than twice the resistance of the lamp so that there exists a resultant voltage between cathode and grid. If, due to a change in voltage or other cause, the gain of vacuum tubes 1 and 2 should be reduced, the resultant reduction of voltage across the input bridge will lower the lamp resistance and increase the thermistor resistance, thereby increasing the voltage applied to the first grid. In like manner, an increase in amplifier gain will increase the lamp resistance and decrease the thermistor resistance to reduce the voltage applied to the first grid. This results in a highly stabilized output with changes in frequency or fluctuations in supply voltage.

(C) Circuit Description

2.11 The first arm of the input bridge consists of a condenser C19 in series with a resistance comprised of R35, R36 and 0 to 1 kc potentiometer in parallel with the upper section of switches SW1 and SW2 forming a conductance decade. This arm is represented by condenser C1 and resistance R1 of the theory schematic (Fig. 2). The second arm of the bridge consists of a condenser C20 in parallel with a similar conductance decade comprised of the lower section of switches SW1 and SW2, and resistances R37, R38 and 0 to 1 kc potentiometer. This arm is represented by condenser C2 and resistance R2 of the theory schematic. Trimmer condensers C1 to C17 are provided across the resistances of the lower section of switches SW1 and SW2 to permit calibrating each frequency step. The switch SW1 has 8 steps, 2 kc, and every 10 kc from 10 to 70 kc. Switch SW2 covers the range of 0-9 kc in one kc steps and the dual control rheostat 0 to 1 kc permits continuous frequency variation from 0 to -1 kc between steps. The third arm of the bridge consists of a 1A thermistor TH and

the fourth arm, a lamp LPL. These two arms are represented in the theory schematic by the thermistor R3 and lamp RL. Condenser C21, in series with lamp LPL, prevents d-c cathode current from flowing through the lamp.

2.12 In order that the variation in resistance of the 0 to 1 kc potentiometer due to aging will not affect the frequency calibration of the oscillator, the potentiometer is set at 0 kc (minimum resistance) during calibration. Thus, operation of the potentiometer towards the -1 kc position will increase the bridge arm resistances, thereby reducing the frequency from the value indicated by the switches SW1 and SW2.

2.13 Pentode tubes 1 and 2 comprise a voltage amplifier having negligible phase shift over the oscillator frequency range. A retard coil L1 in the cathode circuit of vacuum tube 1 presents a high impedance over the desired frequency range so as not to affect the bridge operation. Coil L2 in the plate lead of vacuum tube 1 compensates for the shunt capacitance of the first stage so that the phase shift through the amplifier will be negligible. Condenser C33 across the thermistor compensates for the capacitance of the cathode circuit of tube 1. Resistance R59 and condenser C36 improves the output impedance of the oscillator.

2.14 The potentiometers CAL, FINE and COARSE control the amplitude of the voltage applied to vacuum tube 3 and, hence, the oscillator output. CAL is a screwdriver control to adjust the output to +16 dbm when the controls FINE and COARSE are at MAX. The FINE and COARSE potentiometers are fine and coarse output controls, respectively.

2.15 The output voltage of the amplifier is applied both to the input bridge and to the grid of the cathode follower, vacuum tube 3. This vacuum tube translates the energy from high impedance to low impedance with low distortion, and prevents the impedance of the circuit connected to the output jacks from affecting the frequency of oscillation. The oscillator output appears at jacks on the panel.

2.16 The input power is obtained from 50 to 60 cycle a-c supply. A full-wave rectifier tube 4 and power transformer T2 supply screen, plate and filament voltage for the vacuum tubes. The power transformer has two low voltage secondary windings, for supplying the tube heaters, and a high voltage winding for supplying the plates of the rectifier tube. After rectification, the voltage is filtered by retard coil L4 and electrolytic condensers.

3. PERFORMANCE

3.01 The following data represent the performance which may be expected from this oscillator. It is assumed that good vacuum

tubes are used and that the oscillator is used after a warming-up period of at least 30 minutes at a room temperature between 60° F. and 100° F.

3.02 After a warming-up period of about 30 minutes the drift in the output frequency over periods of time such as two hours, should be less than 0.1% of the scale setting provided the a-c power voltage has not changed more than 5 volts. After a warming-up period of an hour and a half, the drift in the output frequency over periods of time such as two hours, should be less than 0.05% of the frequency setting provided the a-c power voltage has not changed more than 5 volts.

3.03 The accuracy of any frequency setting shortly after calibration is expected to be within ± 50 cycles for the range of 10 kc to 70 kc. The accuracy below 10 kc or above 70 kc after calibration is expected to be within ± 100 cycles of the indicated value.

3.04 A representative frequency variation versus a-c power supply voltage characteristic referred to the frequency for 110 volts a-c supply is shown in Fig. 3.

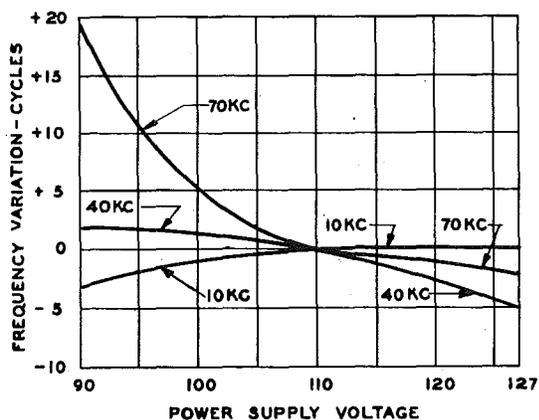


Fig. 3 - Representative Frequency Variation - Power Supply Voltage Characteristic

3.05 Any output power between approximately -75 dbm and +16 dbm can be supplied to a 135-ohm circuit at frequencies between 1 kc and 79 kc. The range of the FINE control is approximately 2.5 db for all settings of the COARSE control.

3.06 The output stability with variations in a-c supply voltage referred to the output at 30 kc and 110 volts a-c supply voltage is shown in Fig. 4. This output characteristic is substantially the same at all frequencies.

3.11 A representative frequency variation versus temperature characteristic with respect to 70° F. is shown in Fig. 6.

4. OPERATION

4.01 The principal operating procedures for the oscillator consist in connecting the power cord to a 50 or 60 cycle supply, connecting the ground conductor clip to grounded metal, operating the ON-OFF power switch to ON, waiting until temperature stability is reached and setting for the desired frequency and output. A warming-up period of from 30 to 60 minutes is necessary to obtain good stability of output and frequency.

4.02 The output is obtained from the OSC OUT jacks on the oscillator panel and patched directly to the circuit under test. P3P cords equipped with 305A plugs are shielded and are suitable for patching the oscillator output. When the oscillator is to be connected to a circuit having d-c voltages on the tip and ring leads, it should be protected by series blocking condensers to prevent damaging the output transformer winding.

(A) Output Calibration

4.03 The oscillator output should be calibrated to +16.0 dbm at 30 kc as follows:

(1) Set the 2 to 70 kc switch at 30. Set the 0 to 9 kc switch at 0. Set the 0 to 1 kc control at 0. Set the COARSE and FINE output controls to MAX.

(2) Where the 30A transmission measuring set is available, patch the OSC OUT jacks to the ATTENUATOR IN jacks of the 30A set. Set the attenuator for 16 db with the 30 db pad "out." Operate the ADJUST-COMPARE key to ADJUST. Operate the

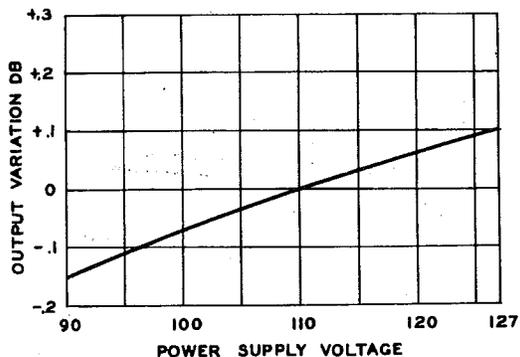


Fig. 4 - Representative Output Variation - Power Supply Voltage Characteristic

3.07 The oscillator output impedance is substantially 135 ohms throughout the frequency range. The impedance at 30 kc should be 135 ohms \pm 5%. The impedance at frequencies in the range of 10 kc to 70 kc should be 135 ohms \pm 10%.

3.08 The operation of the output control to vary the amplitude of the output signal will not affect the output impedance.

3.09 The total power of any spurious frequencies including harmonics and power supply interference is at least 35 db below the fundamental and is substantially independent of the amplitude or frequency of the fundamental output signal.

3.10 A representative output versus frequency characteristic with respect to the output at 35 kc is shown in Fig. 5.

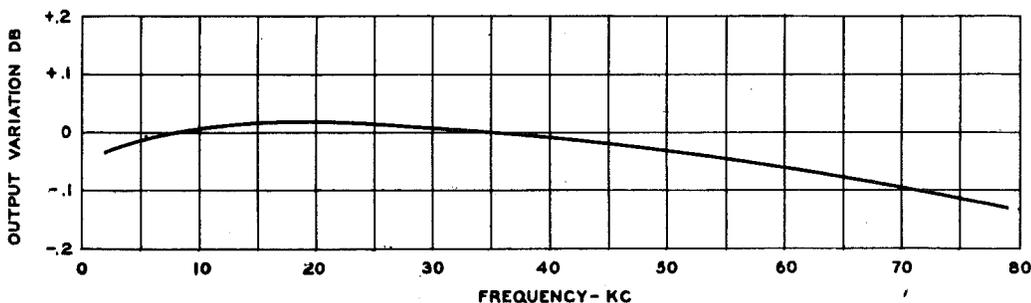


Fig. 5 - Representative Output Variation - Frequency Characteristic

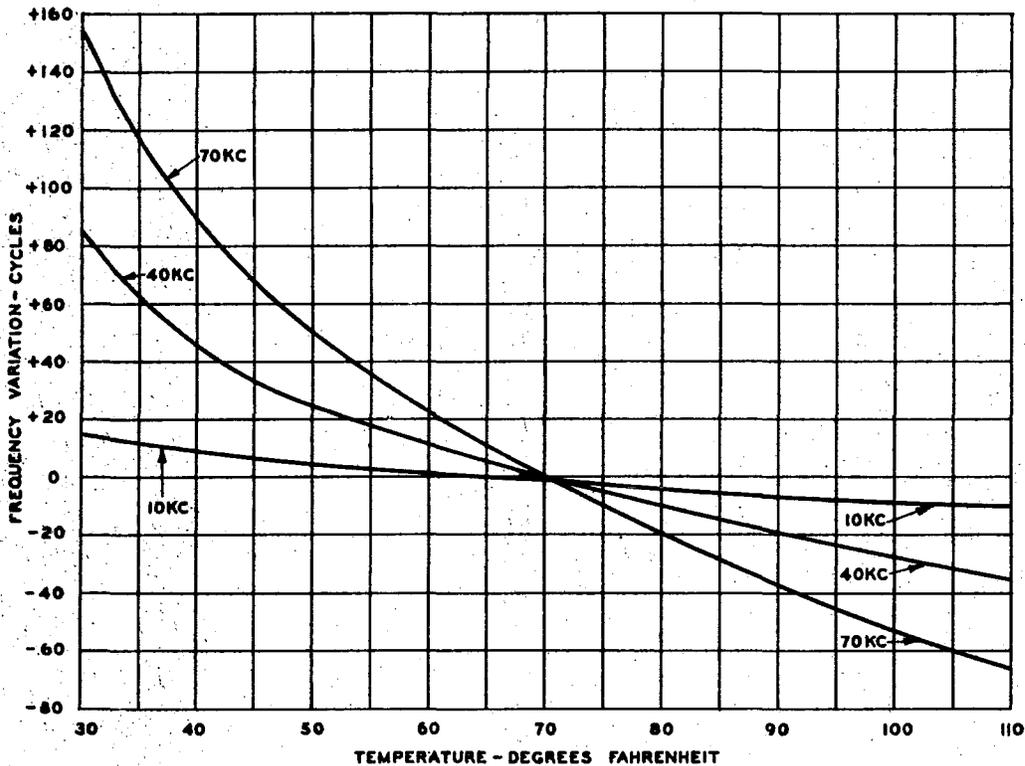


Fig. 6 - Representative Frequency Variation - Temperature Characteristic

three +10 db protection keys one at a time to the OUT position. If the reading on the 30A set meter is not 0 db, with all three keys operated, adjust the CAL output control of the 51A oscillator with a screwdriver to obtain a reading of 0 db.

(3) Where the 31A transmission set is available, insert a 323A plug (135 ohms) in the OSC OUT jacks. Bridge the input cord of the 31A set across the 323A plug. Set the INPUT switch of the 31A set to DET. Set the DET SENS switch of the 31A set to A + 10. The meter of the 31A set should read 6 on the A scale. If it does not, adjust the CAL output control of the 51A oscillator to obtain a reading of 6 on the A scale of the meter.

4.04 After this calibration, the output for any other frequency should be within ± 0.2 db of the calibrated output.

(B) Frequency Calibration

4.05 When calibrating the 51A oscillator for frequency, a warming-up period of at least one hour should be allowed to insure good temperature stability of the oscillator components. The ambient temperature at time of calibration should be between 60° and 90° F. The a-c line voltage should be between 105 and 115 volts.

4.06 The oscillator is calibrated by means of a cathode ray oscilloscope against 4 kc reference frequency. A 17-type oscillator may be used as a secondary standard to facilitate calibrating. Each step of the frequency selecting switches (2 to 70 and 0 to 9) is provided with a trimmer condenser for adjusting the step to its indicated frequency. These condensers may be adjusted with a long screwdriver inserted in the ventilating holes in the bottom of the oscillator case. The calibrating frequencies, the switch settings, the condenser to be adjusted and the oscilloscope pattern are given in Table I.

TABLE I

Cali- brated Freq. Kc	2-70 Switch Posi- tion	0-9 Switch Posi- tion	0-1 kc Control Position	Adjust Con- dens- er	No. Lines Oscil- loscope Pattern
40	40	0	0	C4	1
41	"	1	"	C17	4
42	"	2	"	C16	2
43	"	3	"	C15	4
44	"	4	"	C14	1
45	"	5	"	C13	4
46	"	6	"	C12	2
47	"	7	"	C11	4
48	"	8	"	C10	1
49	"	9	"	C9	4
8	2	6	"	C8	1
16	10	6	"	C7	1
24	20	4	"	C6	1
36	30	6	"	C5	1
56	50	6	"	C3	1
64	60	4	"	C2	1
76	70	6	"	C1	1

4.07 The following covers the procedure for calibrating the oscillator at 40 kc.

- (1) Connect the OSC OUT jacks to one set of plates of the oscilloscope.
- (2) Connect the 17-type oscillator to the other set of plates of the oscilloscope.
- (3) Set the 2 to 70 kc switch to 40 and the 0 to 9 kc switch to 0. Set the 0 to -1 kc control to 0.
- (4) Calibrate the 17-type oscillator and set it as accurately as possible to 40 kc.
- (5) Adjust the C4 condenser until an approximate steady single line figure is obtained on the oscilloscope.
- (6) Substitute the 4 kc reference frequency for the 17-type oscillator. Readjust the C4 condenser until an approximate single line figure is obtained.

4.08 In a similar manner calibrate the oscillator to the other frequencies given in Table I.

5. MAINTENANCE

5.01 The maintenance of the 51A oscillator consists essentially in checking for defective tubes and calibration of the oscillator output and frequency. If the vacuum tubes

are good, and yet unsatisfactory operation is noted, it may be necessary to return the oscillator to the manufacturer, unless the difficulty is some obvious defect, such as a defective electrolytic condenser or a broken wire.

Caution: Since high voltages exist between certain apparatus terminals, the power supply cord should always be removed from its receptacle before proceeding with any maintenance or trouble tests requiring the removal of the chassis from the case. This is desirable, even though a cover switch is provided and the ON-OFF switch is operated to OFF.

5.02 The vacuum tubes used in the 51A oscillator should be tested in a Hickok 530B Tube Tester and should meet the specified transconductance limits. A full set of tubes is supplied with each oscillator and should be inserted in sockets in accordance with designations on the circuit label and on the chassis. Additional vacuum tubes for the 51A oscillator can be obtained in accordance with the following list:

Tube	Code No.
1	RCA - 6SJ7 Vacuum Tube
2	RCA - 6G6-G " "
3	RCA - 6V6-GT " "
4	RCA - 5Z4 " "

5.03 The output of the oscillator for maximum setting of the FINE and COARSE controls should be checked occasionally and the CAL control adjusted for an output of +16 dbm as described under Output Calibration, Part 4(A).

5.04 An approximate check of the accuracy of the oscillator frequency can be made by comparison test, using beat method with an oscillator which generates known frequencies in the range of the 51A oscillator. If excessive deviations are noted, it should be recalibrated if suitable equipment and reference frequencies are available. If these are not available, it should be returned to the Western Electric Company. An accurate calibration of the oscillator is described under Frequency Calibration, Part 4(B).

6. LIST OF DRAWINGS

Drawings Not Attached

SD-59119-011 - Schematic
SD-59119-012 - Wiring Diagram
ED-59119-01 - Equipment Drawing

