MODEL 111
CRYSTAL CALIBRATOR

Operating INSTRUCTIONS

MEASUREMENTS

A McGRAW-EDISON DIVISION

BOONTON NEW JERSEY

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Figure 1. Front View of Model 111 Crystal Calibrator

CHAPTER 1

INTRODUCTION

Section I. DESCRIPTION

1. GENERAL

a. The Model 111 Crystal Calibrator is a crystal-controlled, radio-frequency oscillator. Three separate oscillators are contained in the instrument operating at fundamental frequencies of .25, 1.0 and 10.0 megacycles.

b. The Model 111 is intended to provide a source of r.f. voltage at the fundamental and harmonic frequencies of the three oscillators contained in the unit for the calibration of receivers, transmitters, signal generators and similar electronic equipment.

Table I. Physical and Electrical Characteristics

Dimensions	Weight	Operating Voltage	Input Power	Output Frequency Accuracy	Usable Frequency Range	Tubes
6" x 9 1/2" x 5" deep	4¼ lbs.	117 volts 50-60 cycles	18 watts	±0.002% (15^{o} to 35^{o}C)	10 Mcs. Oscillator 10 to 1000 Mcs. 1 Mc. Oscillator 1 Mc. to 600 Mcs. .25 Mc. Oscillator .25 to 450 Mcs.	1-6BA6 1-12AU7 2-12AX7

CHAPTER 2

OPERATING INSTRUCTIONS

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

2. GENERAL

a. The finish on the case of this Calibrator may be damaged by careless use of sharp instruments while unpacking the instrument.

b. After removing the instrument from its shipping case inspect it for visual damage.

c. Connect the power cord to a source of 117 volt, 50/60 cycle current and rotate the VOLUME control clockwise to operate the line switch. Allow approximately 5 minutes for the circuits to become stabilized.

3. PRECAUTIONS

a. Care should be taken to avoid connecting a high d.c. or a.c. potential to the input terminal to avoid possible damage to the instrument. When connection to circuits containing high d.c. potential over 500 volts is necessary, always use an external blocking capacitor in series with the input lead.

Section II. CONTROLS AND THEIR USE

4. DESCRIPTION

a. The nomenclature of the various controls with a short description of their purpose is given below:

(1) MOD., switch; when in the ON position, provides audio tone for modulating carrier output. When placed in OFF position,connects output of detector to PHONES jack.

(2) OUTPUT, jack; supplies radio-frequency voltage at fundamental and harmonic frequencies for use when calibrating receivers and similar equipment.

(3) INPUT, binding posts; used to connect unknown frequency source to calibrator. When used with high level sources such as transmitters, enough stray coupling may be present without actual connection by leads.

(4) MEGACYCLES, switch; controls operation of radio-frequency oscillators. When in 10 position, the 10 megacycle crystal oscillator operates; in 1 position, both 1 megacycle and 10 megacycle oscillators operate; in .25 position, all three oscillators operate.

(5) VOLUME, potentiometer-switch; controls volume of signal applied to phones; operates line switch.

(6) PHONES, jack; supplies audio note, resulting from heterodyning of unknown frequency with oscillator frequency in mixer tube, to headset.

Section III. OPERATION

5. CHECKING FREQUENCY CALIBRATION OF SIGNAL GENERATORS

a. Connect a headset to the PHONES jack and place MOD. switch in OFF position.

b. Connect the output of the signal generator to INPUT binding posts.

c. To check frequency points at 10 megacycle intervals, proceed as follows:

(1) Place MEGACYCLES switch in 10 position.

(2) Adjust output of signal generator to about 10,000 microvolt level and tune generator to multiple of 10 to be checked (for example, 40 megacycles).

NOTE: Always adjust output voltage of signal generator to minimum required for satisfactory beat note. Excessive output will cause spurious beat notes that may cause confusion.

(3) Tune about this calibration point until audio note is heard in the headphones. This note will become zero when the generator is tuned to exactly 40 megacycles and will increase in frequency and become inaudible as the generator is tuned either above or below 40 megacycles.

(4) The volume may be adjusted by means of the VOLUME control or by means of the output control on the generator being checked.

d. This beat note will be heard whenever the generator is tuned through a multiple or sub-multiple of 10 (i.e.; 10, 20, 30, etc., or 5, 3.333, 2.5, 2, etc.)

e. To check intermediate 1 megacycle points (for example, 42 megacycles), place the MEGACYCLE switch in 1 position, tune the generator above 40 megacycles and count the beat notes. A beat will be heard at every megacycle point; the beat-note becomes zero when the generator is tuned to exact multiples of 1 megacycle.

f. To check quarter-megacycle points, the same procedure is followed but with the MEGACYCLE switch in .25 position.

6. CHECKING FREQUENCY CALIBRATION OF RADIO RECEIVERS

a. Place MOD. switch in ON position and attach a short piece of wire to OUTPUT jack. This wire will act as an antenna and afford means of coupling the calibrator and receiver.

NOTE: The correct amount of coupling will have to be determined experimentally, A short wire to the antenna connector on the receiver may be desirable to effect sufficient coupling to the calibrator. Above 30 megacycles, it is desirable to use a properly terminated co-axial line between OUTPUT jack and receiver input to prevent unwanted standing waves in the connecting leads.

b. Connect a pair of headphones to the output terminal of the receiver under test to facilitate calibration. It is also desirable to connect the receiver to an output meter to provide visual monitoring during these tests.

c. Place MEGACYCLES switch in the position most suitable for the receiver under test. For example, if the frequency range is above 10 Mcs., it will be convenient to first determine the location of 10 megacycle harmonics. If the frequency range is between 1 and 10 Mcs., however, the points that are multiples of one megacycle may be checked before determining the position of the quarter-megacycle calibration points.

d. Tune the receiver to the fundamental or required harmonic of the oscillator for a maximum volume in the headphones of the receiver. Exact tuning may be easier with the use of an output meter.

NOTE: Application of excessive signal or use of too much receiver gain may result in extraneous signals. Always reduce gain to minimize these effects.

7. CHECKING FREQUENCY CALIBRATION OF MODEL 59 MEGACYCLE METER

a. Connect headset to the PHONES jack of the Model 111 and place MOD. switch in OFF position.

b. Plug one of the unused Model 59 coils into the INPUT terminals of the calibrator. (It is preferable to use a lower frequency range A or B coil).

c. Couple a Model 59 oscillator loosely to this coil and tune slowly to a beat note with the desired harmonic.

(1) If the frequency scale of the Model 59 is off calibration, and particularly at the higher frequencies, it will be necessary to use the 10 megacycle points first, then the one megacycle points and finally the .25 megacycle beats; otherwise, the calibration of the dial will not be sufficiently accurate to permit selection of the correct quarter-megacycle harmonic beat.

d. After the frequency of the Model 59 has been adjusted to approximately zero beat with the desired harmonic, the coupling should be loosened slowly to determine whether there is any reaction on the beat note.

NOTE: Equally loose coupling should be employed when using the Model 59 as an accurately calibrated frequency source immediately following the above calibration. (Such an application might involve the setting up of a television high-frequency oscillator, for example). It is well to avoid placing the Model 59 probe in the immediate vicinity of large metallic conductors since they may also affect the calibrated frequency adversely.

8. CHECKING FREQUENCY CALIBRATION OF TRANSMITTERS

a. Connect headset to PHONES jack of Model 111 and place MOD. switch in OFF position.

b. Connect a short piece of wire to the upper INPUT binding post. Placing this wire in proximity to the transmitter will usually be sufficient to obtain a beat-note, as the transmitter frequency is tuned through a harmonic or sub-harmonic of the calibrator.

NOTE: It may be necessary to use a Model 59 Megacycle Meter or Model 80 Standard Signal Generator as an interpolation oscillator, if the transmitter frequency is fixed and does not fall within audible beat of the calibrator harmonic.

c. A variable interpolation oscillator is useful for determining which harmonic is being used. See Section I, e. of Model 59 Instruction Book for use of the Megacycle Meter as an interpolation oscillator.

9. USE OF THE MODEL 111 AS A MIXER

a. The Model 111 contains a triode mixer which can be utilized in several unusual applications. For example, a beat frequency type sweep alignment signal generator covering a range down to 10 Mcs. can be fed into the INPUT terminals of the 111 with the selector switch in the 10 Mc. position and the difference frequency will be available from the OUTPUT jack. This difference frequency can readily be adjusted to center about 455 Kc. for i.f. alignment purposes. In this application there will be no "pulling" of the 10 Mc. beating oscillator, since it is crystal controlled. The lowest beat frequency output available from the Model 111 used as a mixer in this fashion will be limited by the impedance of the circuit being driven from the OUTPUT jack. In series with the OUTPUT jack there is a 47 mmfd. blocking capacitor which has a reactive impedance of approximately 30,000 ohms at 100 Kcs. This means that the mixed output will be down 3 db at 100 Kc., if the load has a resistive impedance of 30,000 ohms.

The low frequency limit available from the OUTPUT of the Model 111 as a mixer can be extended by shunting a larger capacitor across the 47 mmfd. unit. (C12).

By use of the above arrangement a video sweep signal is available from 100 Kcs. to 10 Mcs. from many of the small, inexpensive beat frequency type sweep generators. These sweep generators are not capable of supplying such low frequencies directly because of "pulling" between their internal oscillators.

b. This mixer can also be used in a somewhat similar fashion to produce accurately known variable frequency output at frequencies in between the .25 Mc. beats. It is only necessary to apply to the INPUT a signal of variable frequency between 1 Kc. and 125 Kcs. to produce the above result.

c. The low frequency signal can readily be obtained from many of the resistance tuned Wein-bridge oscillators. An amplitude of only a few tenths of a volt is required. If the frequency of the Wein-bridge oscillator is known to 2% at 100 Kc., the resulting beat note at 100 Mcs. will be accurate to .003%. When using this mixing arrangement, it may be desirable to increase the value of C11 above 33 mmfd. for improved sensitivity below 1 Kc. This value of 33 mmfd. was chosen for general use as a calibrator to minimize hum and power line noise at low frequencies.

This low frequency mixing arrangement can be used with either the 10, 1 or .25 Mc. oscillators operating. If excessive signal from the low frequency oscillator is applied to the INPUT terminals, harmonics of the low frequency signal will be generated by the mixer and beat with the .25 Mc. oscillator to produce spurious output. This is the reason for limiting the signal level of the low frequency oscillator to a few tenths of volt.

d. For some special applications it may be desirable to use only the mixer and built-in audio amplifier. If this is desired, the selector (MEGACYCLES) switch should be placed in the 10 Mc. position, and the crystal removed from its socket temporarily. Two signals can then be applied in series or parallel to the input terminals and the resulting beat note detected by means of the audio amplifier and headphones. If it is not convenient to connect the two signals either in series or parallel, it is, of course, possible to apply one signal to pin 3 of V3-A*, and the other signal to the INPUT terminals. The signal applied to pin 3 of V3-A should be greater in magnitude than 1 volt for optimum sensitivity. Mixed sum and difference output will be available from the OUTPUT jack, if desired. The use of the mixer in this fashion permits direct use of other frequency standards or reference oscillators having peculiar modulation characteristics for special applications.

* A blocking capacitor should be included in series with this lead to avoid shorting the bias on V3-A.

- NOTE -

The extremely high gain audio amplifier used in this instrument may have a tendency to "whistle" if the gain control is fully advanced. When this occurs, reduce gain setting until note disappears.

CHAPTER 3

MAINTENANCE INSTRUCTIONS

Section I. EQUIPMENT REQUIRED

10. GENERAL

a. The following equipment is recommended for operational checks and for servicing the Model 111 Crystal Calibrator.

(1) Frequency meter or radio receiver covering the range .25 to 10 megacycles.

(2) Vacuum tube voltmeter* (0-100 volts) with a frequency range of 60 cycles to at least 10 megacycles. Input capacity less than 8 mmfd.

(3) Headphones.

(4) D.c. voltmeter (0-200 volts) having a sensitivity of at least 1000 ohms per volt.

(5) Signal Generator covering frequency range .25 to 10 megacycles.

Section II. TROUBLE SHOOTING

11. ANALYSIS OF TROUBLE

a. A brief description of troubles that may be encountered with possible causes and remedies is given in Table II:

Table II. Trouble Shooting Chart

Trouble	Possible Cause	Remedy
No power	Defective switch (S-3)	Replace switch
	Defective power cord	Replace cord
No 10 Mcs. output	No plate or filament voltage	Check voltages and clear trouble
	Tube defective (V1)	Replace tube (6BA6)
	Crystal defective	Replace crystal
	Tank circuit not tuned properly	Check alignment (See Par.22)
	Open or ground in wiring	Inspect wiring
No 1 Mc. output	Poor contact, switch (S1-B)	Clean contacts
	Defective tube (V2)	Replace tube (12AU7)
	Tank circuit not tuned properly	Re-align (See Par.20)
No .25 Mc. output	Defect in circuit wiring	Inspect wiring
	Poor contact, switch (S1-A)	Clean contacts
	Defective wiring	Inspect wiring
	Defective tube (V2)	Replace tube (12AU7)
No beat-note in headphones as signal generator connected to input is tuned over frequency range.	MOD. switch in ON position	Switch to OFF position
	Insufficient input voltage from signal generator	Increase output of signal generator
	Defective tube or wiring	Check tubes (V3, V4); inspect wiring
No modulation	MOD. switch in OFF position	Place switch in MOD. position
	Defective tube or wiring	Check tubes (V3, V4); inspect wiring
Beat-note weak at higher frequencies (approximately 300 Mcs. and above)	Misalignment of 10 Mcs. tank circuit	Re-align as described in Par. 22.
Steady beat-note with switch on 1 Mc. and MOD. switch OFF	Misalignment of 1 Mc. oscillator	Re-align as described in Par. 20
	Defective V1 or V2	Replace 6BA6 or 12AU7
Steady beat-note with switch on .25 Mc. and MOD. switch OFF	Misalignment of 1 Mc. oscillator and or the .25 Mc. oscillator	Re-align as described in Par. 21.
	Defective V1 or V2	Replace 6BA6 or 12AU7

*Measurements Models 162 or 162-R

CHAPTER 4

AUXILIARY EQUIPMENT

12. GENERAL

a. The following equipment is recommended for operational checks and for servicing the Model 111 Crystal Calibrator.

not critical. (Over 500 ohms is preferable).

b. Co-axial input or output cable with proper termination is desirable at higher frequencies.

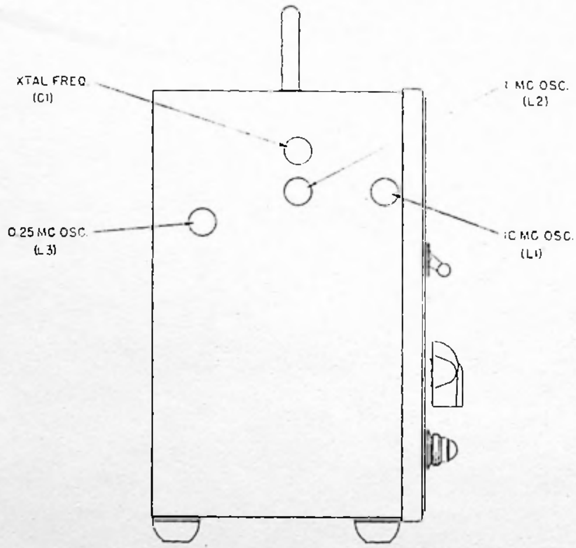


Figure 2 - Side View Showing Trimmer Ports

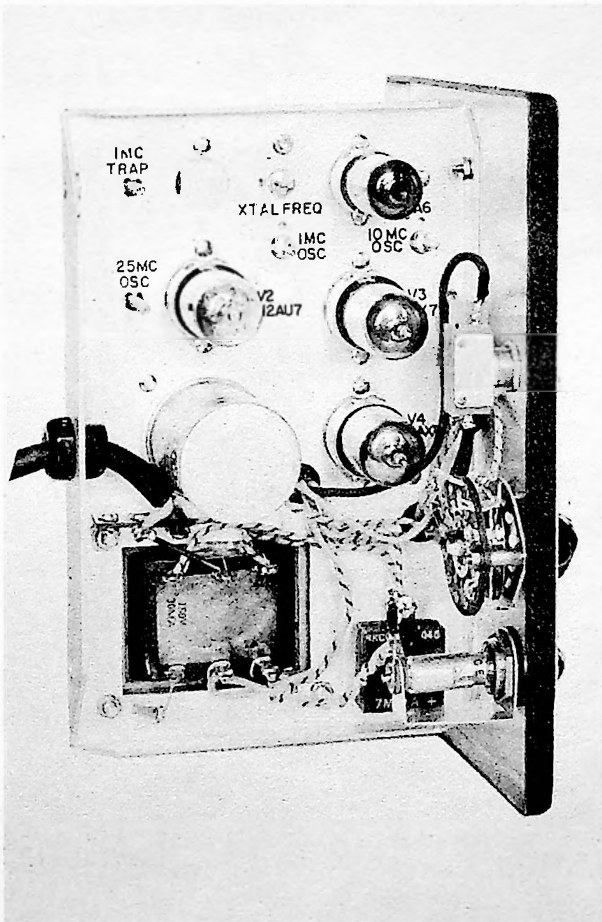


Figure 3 - Internal View Showing Trimmers

CHAPTER 5

TECHNICAL SERVICE AND MAINTENANCE INSTRUCTIONS

Section I. THEORY OF OPERATION

13. GENERAL

a. The Model 111 Calibrator consists of three oscillators operating at 10 megacycles, 1 megacycle and .25 megacycle, respectively. The 10 megacycle crystal oscillator drives the 1 megacycle oscillator in such a manner as to hold its frequency within the accuracy of the 10 megacycle crystal. This is possible since the two are harmonically related and the 1 megacycle oscillator circuit is said to be "locked" to the 10 megacycle crystal oscillator.

b. A similar relationship exists between the 1 megacycle and .25 megacycle oscillators, and the latter is "locked" to the former.

c. The combined output of the oscillators is applied to a detector tube where it is mixed with the signal applied to the INPUT terminals from an external source of r.f. The resultant beat-note is amplified by the audio amplifier and applied to the PHONES jack.

d. The audio amplifier may be connected as a relaxation type oscillator operating at about 1000 cycles by placing the MOD. switch in the ON position. This audio note modulates the carrier output.

e. A selenium rectifier is used in a half-wave circuit to supply d.c. plate voltage.

14. R.F. OSCILLATORS

a. 10 MEGACYCLE CIRCUIT

(1) The 10 megacycle oscillator consists of a 6BA6 tube with screen at r.f. ground. A tube connected in this manner may be considered as a triode, the screen acting as a by-passed plate. The cathode circuit consists of an inductance L5 and a capacitor C24 which has a resonant frequency below 10 Mc. and, therefore, acts like a capacitor at 10 Mc. This capacitor, together with the grid-to-cathode capacity of the tube forms a capacity divider for the voltage appearing on the crystal and thus forms a regenerative feedback. Since the screen is not physically solid, but merely a zero potential (r.f.) plane, most of the cathode current passes through to the actual plate thus transferring the energy but providing no common coupling parameter, and so interaction between the plate circuit and the oscillator is eliminated.

(2) Trimmer capacitor C1 tunes crystal Y-1 to exact frequency.

b. 1 MEGACYCLE CIRCUIT

(1) The 1 megacycle circuit is inoperative until the MEGACYCLES switch is placed in the 1 position thereby grounding the cathode of tube V2-A.

(2) This oscillator utilizes one-half of a 12AU7 tube (V2-A). A tapped tank circuit consisting of coil L2 and capacitors C3 and C4 tunes to 1 megacycle. Feedback voltage to the grid of tube V2-A is developed across capacitor C4.

(3) As d.c. voltage for tube V2-A is supplied through a portion of coil L1, 10 megacycle voltage is superimposed upon it and applied in phase to both grid and plate of V2-A. Under this condition tube V2-A operates as a locked oscillator only when its tank circuit is tuned to a subharmonic of the crystal frequency which, in this particular case, is the tenth. C26 is a temperature compensating capacitor.

c. .25 MEGACYCLE CIRCUIT

(1) This .25 megacycle circuit is inoperative until the MEGACYCLES switch is placed in the .25 position thereby grounding the cathode of tube V2-B.

(2) This oscillator utilizes the second triode in tube V2 and is connected in a manner similar to the 1 megacycle oscillator, the tank circuit consisting of coil L3 and capacitor C5 and C25.

(3) Coil L4 is tuned to 1 megacycle by means of capacitors C8 and C22 and an adjustable iron core.

(4) Application of d.c. voltage through L4 to tube V2-B results in 1 megacycle superimposed voltage (modulation) being applied in phase to both grid and plate of tube V2-B.

(5) Thus tube V2-B "locks" under control of tube V2-A, as previously described, but in this instance operation is at the fourth sub-harmonic (250 Kc.) of the controlling oscillator.

15. MIXER AND AUDIO AMPLIFIER

a. With the MOD. switch in OFF position, tube V3-A (one-half of a 12AX7) functions as a convential "mixer".

b. The application of an r.f. voltage to the grid of tube V3-A will result in audio beats being produced in the plate circuit whenever the fundamental or harmonic frequency of the injected voltage approximates the fundamental or harmonic of the voltages applied to tube cathode by the crystal-control oscillators.

NOTE: Excessively high r.f. input voltage will result in beats between beats, etc. and should be avoided.

c. The audio note is amplified by the 3-stage amplifier consisting of V3-B, V4-A and V4-B and applied through capacitor C17 to the phone jack, J-2. Resistors R9, R12 and capacitors C13, C20 form an r.f. filter to prevent radio frequency voltage being applied to the grid of tube V3-B.

d. The intensity of the audio output may be controlled by the VOLUME control, R17.

16. AUDIO OSCILLATOR

a. When the MOD. switch is placed in the ON position the output of tube V4-A is applied to the grid of tube V3-B.

b. Tubes V3-B and V4-A now form a relaxation type oscillator operating at approximately 1000 cycles per second.

NOTE: No attempt is made to accurately control the frequency of oscillation or the wave form. The purpose of this oscillator is merely to provide a modulated carrier for receiver calibration.

c. Audio frequency voltage appearing across capacitor C13 is superimposed on the d.c. voltage applied to the plate of the detector tube V3-A.

d. The r.f. oscillator voltage at the plate of the tube V3-A is modulated by the applied audio frequency and appears as a modulated carrier at the output jack, J-1.

17. POWER SUPPLY

a. All tube filaments are supplied by a single 6.3 volt secondary winding on transformer T-1. The dual filaments in the 12 volt tubes (V2, V3, V4) are connected for parallel operation.

b. Rectified plate voltage is obtained by means of a conventional half-wave rectifier. A selenium rectifier (CR-1) is used in place of a tube.

c. A resistance-capacitance filter consisting of resistors R18, R19, R20 and capacitors C9A, C9B, C9C removes the ripple component from the rectified voltage.

Section II. TROUBLE LOCATION

18. LOCALIZING THE TROUBLE

a. Considerable time may be saved by following a systematic procedure to localize the trouble.

b. Connect the power cord to a source of 117 volt, 60 cycle voltage and place switch S-3 in the ON position. Place the MOD. switch in the ON position and connect the antenna terminal of a receiver covering the proper frequency range to the OUTPUT jack. Connect ground terminal of receiver to GND. jack. Place MEGACYCLES switch in 10 position.

c. Tune receiver to 10 megacycles and listen for audio note.

(1) If no sound is heard, trouble may be caused by lack of "B" voltage or filament voltage.

(2) A tunable "hissing" sound but no audio modulation indicates proper operation of r.f. oscillator and trouble is in audio oscillator.

d. Place MEGACYCLES switch in 1 position and listen for intermediate frequency points between 10 and 20 megacycles. There should be nine (11 to 19, inclusive).

e. Place MEGACYCLES switch in .25 position and listen for intermediate quarter-megacycle points between each megacycle point. There should be three.

f. Connect a signal generator to the IN-PUT terminal; place MEGACYCLES switch in 10 position and MOD. switch in OFF position. Connect headset to PHONES jack and rotate VOLUME control to maximum clock-wise position.

(1) Adjust output of signal generator to give about 10,000 microvolts (exact value not critical) and tune generator through 10 Mc. points.

(a) If no audio beat is heard in headset, trouble is most likely in audio amplifier.

(b) If instrument operated satisfactorily during tests described in Paragraph c. trouble may be in MOD. switch or in tube V4-B.

g. Normal d.c. voltages measured to ground from tube terminals are shown in Table III. The line voltage should be 117 volts; the MEGACYCLES switch should be placed in .25 position and the MOD. switch in OFF position.

h. Normal filament voltage is 6.3 volts, a.c.

Section III. ALIGNMENT PROCEDURES

19. ALIGNING 1 MEGACYCLE TRAP

a. With power off, remove instrument from case.

b. Connect a vacuum tube voltmeter from C8 side of coil L4 to ground.

c. Connect a signal generator to the same points and set to 1 megacycle. Add a series resistor to make the total impedance of the signal generator about 1000 ohms.

d. Tune coil L4 by means of screw labeled "1 MC Trap" to produce a maximum reading on voltmeter.

e. Remove series resistor and note by changing signal generator frequency that a dip occurs between .2 and .3 megacycles.

f. Remove generator and voltmeter.

20. ALIGNING OF 1 MEGACYCLE TANK CIRCUIT

a. Set L-2 to minimum with non-metallic screw driver by turning the screw marked 1 Mc. OSC to the extreme counter-clockwise position.

b. Connect signal generator across INPUT terminals, tune frequency to 1.0 megacycle and adjust output for approximately 10,000 microvolts.

c. Connect headset into PHONES jack.

d. Place MOD. switch in OFF position.

e. Connect power cord to 117 volt source and place switch S-3 in ON position.

f. Remove crystal Y-1 from socket.

g. Place MEGACYCLES switch in 1 position.

h. Tune coil L2 by means of non-metallic screw driver until zero beat note is heard in headset.

21. ALIGNING .25 MEGACYCLE TANK CIRCUIT

a. Tune generator connected to INPUT terminals to .25 megacycles; adjust output for approximately 10,000 microvolts.

b. Place MEGACYCLES switch in 10 position and MOD. switch in OFF position.

c. Remove crystal Y-1 from socket.

d. Connect a jumper from the low side of resistor R5 to ground to start .25 megacycle oscillator.

e. Tune coil L3 by means of non-metallic screw driver until the beat-note heard in the phones becomes zero.

f. Remove jumper from resistor R5 and replace crystal Y1 in socket.

g. Disconnect signal generator.

22. ALIGNING 10 MEGACYCLE TANK CIRCUIT

a. With power off, check that the cathode circuit is tuned to 7.5 Mcs. ± .3 Mc. with Model 59.

b. Turn power on and place Megacycles switch in 10 position.

c. Connect a.c. vacuum tube voltmeter, such as Measurements Model 62, to the input terminals.

d. Tune coil L1 until maximum voltage is indicated on meter. This will be of the order of 2.5 to 3 volts.

e. Place MEGACYCLES switch in 1 position and check for a drop to approximately 1.5 volts.

23. FINAL ALIGNMENT

a. After completing the preliminary alignment procedures described in Paragraphs 18 through 21, allow instrument to operate for one hour in its outer case with MEGACYCLES switch in .25 position to make sure parts are heat-stabilized.

(1) Connect Model 62 Vacuum Tube Voltmeter across INPUT terminals and frequency meter to OUTPUT jack, J-1.

TUBE		PLATE			SUPPRESSOR			SCREEN			GRID			CATHODE		
NO.	TYPE	PIN	Range	VOLTS	PIN	Range	VOLTS	PIN	Range	VOLTS	PIN	Range	VOLTS	PIN	Range	VOLTS
V1	6BA6	5	250v	125	2	Ground		6	250v	90	1	2.5v	-.45	7	2.5v	0
V2	12AU7	1	250v	125	-	-	-	-	-	-	2	50v	-45	3	Ground	
		6	250v	125	-	-	-	-	-	-	7	50v	-15	8	10v	10
V3	12AX7	1	50v	42	-	-	-	-	-	-	2	10v	-4	3	2.5v	1.7
		6	50v	50	-	-	-	-	-	-	7	10v	-3	8	Ground	
V4	12AX7	1	50v	45	-	-	-	-	-	-	2	10v	-7	3	Ground	
		6	250v	90	-	-	-	-	-	-	7	2.5v	-.4	8	Ground	

PILOT BULB +5.4 v.d.c. from either terminal to ground

SELENIUM RECTIFIER +130 v.d.c. from (+) terminal to ground

TUBE		HEATER						
NO.	TYPE	PIN	Range	D.C. VOLTS	between PIN	PIN	Range	A.C. VOLTS
V1	6BA6	3 or 4	10v	5.4	3	4	10v	6.3
V2	12AU7	5 or 9	10v	5.4	5	9	10v	6.3
V3	12AX7	5 or 9	10v	5.4	5	9	10v	6.3
V4	12AX7	5 or 9	10v	5.4	5	9	10v	6.3

Range in Table denotes full-scale voltmeter range

THE CONTROLS OF THE MODEL 111 WERE SET AS FOLLOWS:

RANGE SWITCH: 0.25 Mc.
MODULATION SWITCH: "ON" POSITION
VOLUME CONTROL: "MAX" POSITION

NOTE: ALL OF THE VOLTAGES SHOWN WERE MEASURED WITH A VOLTMETER HAVING A SENSITIVITY OF 20,000 OHMS-PER-VOLT ON THE D.C. RANGES AND 1,000 OHMS-PER-VOLT ON THE A.C. RANGES. VOLTAGES MEASURED FROM PIN TO GROUND UNLESS OTHERWISE NOTED.

Table III. Tube Voltage Chart

(a) Connect headset to output circuit of frequency meter.

NOTE. For maximum accuracy it is recommended that WWV be tuned in on 10 megacycles on a suitable receiver and used as the primary standard.

(2) Place MEGACYCLES switch in 10 position.

(a) Adjust capacitor C1 for zero beat at 10 megacycles.

(3) Place MEGACYCLES switch in 1 position.

(a) The frequency should not change more than 20 cycles.

(b) If this requirement is not met, detune L1 slightly counterclockwise with a non-metallic screw driver. Do not detune for more than a 5% decrease in Model 62 reading.

(4) Place MEGACYCLES switch in .25 position.

(a) Voltage across the INPUT terminals should rise up to about 2 volts.

(b) The 10 megacycle frequency should not shift more than 10 cycles.

24. LOCKING CHECK

a. Place MEGACYCLES switch in 10 position and check for zero beat at 10 and 20 megacycles on frequency meter.

b. Place MEGACYCLES switch in 1 position and check for intermediate zero beats between 10 and 20 megacycles.

(1) If 1 megacycle oscillator is operation at correct frequency there should be nine zero-beat notes between 10 and 20 megacycles.

NOTE: It will be found that the adjustable iron cores for both the 1 Mc. and .25 oscillators have an appreciable locking range. They should be set at the electrical center of this range at 20° C. The mechanical center will not be the same as the electrical center.

c. Place MEGACYCLES switch in .25 position and check for intermediate zero beats between adjacent megacycle points.

(1) If .25 megacycle oscillator is operating at correct frequency there should be 3 zero-beats between each megacycle position, i.e., 10 to 11, 11 to 12, etc.

d. Locking action should be positive and immediate upon switching from 10 to 1 to .25 Mc. Line voltage should have no effect on locking.

25. FINAL TEST

a. Replace instrument in case.

b. Connect frequency meter to OUTPUT jack and check zero-beat notes with MEGACYCLE switch in 10, 1 and .25 position.

c. Place MOD switch in ON position and listen for audio note as MEGACYCLES switch is placed in each position.

APPENDIX I

1. GENERAL

a. Prior to storage or shipment, remove instrument from case and dust chassis and components with compressed air. Make certain tubes and crystal are securely seated in sockets.

b. Replace instrument in case and tighten case screws.

c. Wrap instrument in ordinary shipping paper to prevent dust or excelsior from settling on interior surfaces.

2. SHIPPING

a. Place wrapped instrument in fibreboard carton or wooden box.

(1) Container should be sufficiently large to permit inclusion of at least 2 inches of excelsior or similar cushioning material on all sides.

TABLE IV
TABLE OF REPLACEABLE PARTS

REV. 5/1/61

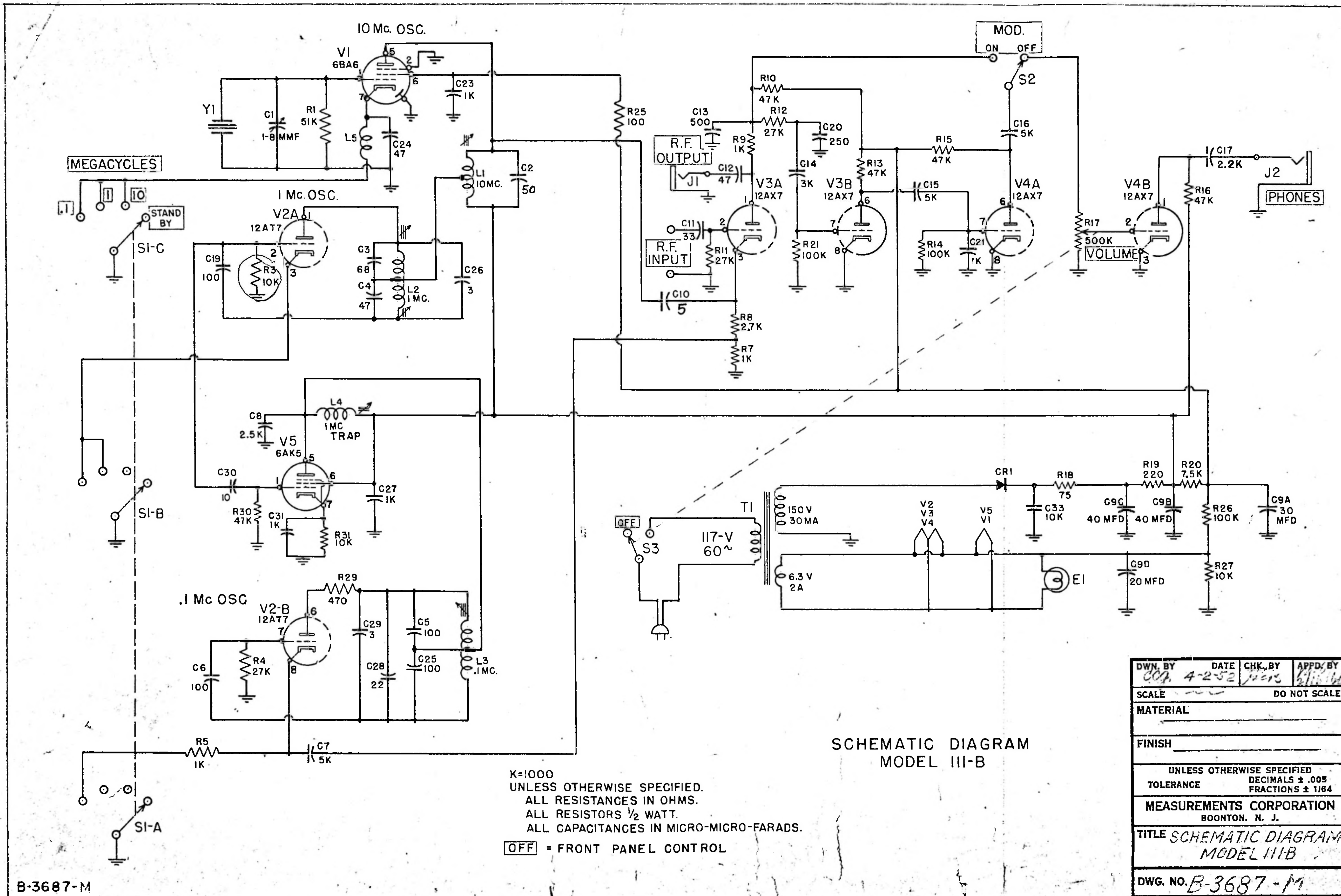
MODEL 111 CRYSTAL CALIBRATOR **MAJOR UNIT:**

Reference Symbol	DESCRIPTION	FUNCTION
C1	CAPACITOR: variable, trimmer; thermoplastic dielectric; 1-8 mmf.; 500 VDCW; Q factor 1000 min. at 1 Mc.; max. operating temp. 75° C. Measurements Div. Part H-4114.	Shunt vernier tuning capacitor for 10 Mc. crystal.
C2	CAPACITOR: fixed; sil. mica; 50 mmf ± 10%; 500 vdcw. Measurements Div. Part H-6655.	Tuning capacitor for 10 Mc. tank circuit.
C3	CAPACITOR: fixed; ceramic; NPO 68 mmf. ± 3.4 mmf.; 500 VDCW; .156" dia. x .812" long; 2 radial leads. Measurements Div. Part H-4119.	Tuning capacitor for 1 Mc. oscillator.
C4	CAPACITOR: fixed; ceramic; NPO 47 mmf. ± 2.35 mmf.; 500 vdcw; Measurements Div. Part H-4118.	Same as C3.
C5	CAPACITOR: fixed; ceramic; NPO 100 mmf. ± 5 mmf.; 500 VDCW; .156" dia. x .812" long; 2 radial leads. Measurements Div. Part H-4120.	Tuning capacitor for .25 Mc. oscillator.
C6	CAPACITOR: Same as C5.	Grid blocking capacitor.
C7	CAPACITOR: fixed; ceramic; 5000 mmf. min.; 5000 VDCW; 19/32" dia. x 3/16" thick. Measurements Div. Part H-4122.	R.F. coupling.
C8	CAPACITOR: fixed; mica; 2500 mmf. ± 10%; 500 VDCW; 53/64" x 53/64" x 9/32"; 2 axial leads. Measurements Div. Part H-4123.	Plate supply R.F. by-pass and 1 Mc. trap tuning capacitor.
C9A C9B C9C C9D	CAPACITOR: fixed; dry electrolytic; 2 sec. 40 mfd.; 150 VDCW; 1 sec. 30 mfd.; 150 VDCW; 1 sec. 20 mfd.; 25 VDCW; 1 3/8" dia. x 2" long; alum. case common; 4 solder term. brought out of the same end. Measurements Division. Part H-4127.	30-40-40 mfd. plate supply filter capacitors. 20 mfd. filter for filament bias.
C10	CAPACITOR: fixed; sil. mica; 5 mmf ± 20%; 500 vdcw. Measurements Div. Part H-6654.	R.F. coupling.
C11	CAPACITOR: fixed; ceramic; NPO 33 mmf. ± 3 mmf.; 500 VDCW; .121" dia. x .437" long; 2 radial leads. Measurements Div. Part H-4117.	Input blocking capacitor.
C12	CAPACITOR: Same as C4.	R.F. output coupling capacitor.
C13	CAPACITOR: fixed; molded silver mica; 500 mmf.;± 10%; 500 VDCW; 23/32" x 15/32" x .20"; 2 axial leads. Measurements Div. Part H-4128.	R.F. by-pass capacitor.
C14	CAPACITOR: fixed; mica; 3000 mmf. ± 10%; 500 VDCW; 53/64" x 53/64" x 9/32"; 2 axial leads. Measurements Div. Part H-4125.	Coupling capacitor and part of audio network.
C15	CAPACITOR: Same as C7.	A.F. coupling capacitor.
C16	CAPACITOR: Same as C7.	Plate coupling capacitor.
C17	CAPACITOR: fixed; ceramic; .0022 mf. GMV; Measurements Div. Part H-6619-5.	A.F. output coupling capacitor.
C19	CAPACITOR: Same as C5.	Grid-blocking, 1 Mc. osc.

TABLE OF REPLACEABLE PARTS

MODEL 111 CRYSTAL CALIBRATOR **MAJOR UNIT:**

Reference Symbol	DESCRIPTION	FUNCTION
C20	CAPACITOR: fixed; mica; 250 mmf. ± 10%; 500 VDCW; 23/32" x 15/32" x .20"; 2 axial leads. Measurements Div. Part H-4124.	Tuning capacitor. A.F. net-work.
C21	CAPACITOR: fixed; ceramic; 1000 mmf. min. Measurements Div. Part H-4121.	R.F. by-pass.
C22	CAPACITOR: fixed; molded paper; 22,000 mmf. ± 10%; 400 VDCW; 53/64" x 53/64" x 11/32"; 2 axial leads. Measurements Div. Part H-4126.	.25 Mc. series trap tuning capacitor.
C23	CAPACITOR: Same as C21.	Screen by-pass.
C24	CAPACITOR: Same as C4.	Cathode tuning capacitor.
C25	CAPACITOR: Same as C5.	Same as C-5.
C26	CAPACITOR: fixed; ceramic; N-750 3 mmf. ±0.5 mmf; 500 VDCW; .121" dia. x .375" long; 2 radial leads. Measurements Div. Part H-4115.	Temperature compensating capacitor on 1 Mc. osc.
C27	CAPACITOR: fixed, ceramic; 10,000 mmf., Min; 500 VDCW; 1-1/8" lg. x 3/16" dia: 2 radial wire leads. Measurements Div. Part. H-5065.	B^+ filter.
		Temperature compensation.
R1	RESISTOR: fixed; composition; 51,000 ohms ± 5%; ½ w.; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3727-513.	V1 grid return.
R3	RESISTOR; fixed; composition; 27,000 ohms ± 10%; ½ w.; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-273.	V2-A grid return.
R4	RESISTOR: Same as R3.	V2-B grid return.
R5	RESISTOR: fixed; composition; 1000 ohms ± 10%; ½ watt; 3/8" x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-102.	V2-B cathode bias and coupling.
R6	RESISTOR: fixed; composition; 100 ohms + 10%; ½ watt; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-100.	B+ filter.
R7	RESISTOR: Same as R5.	V3-A cathode bias and coupling.
R8	RESISTOR: fixed; composition; 2700 ohms ± 10%; ½ watt; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-272.	V3-A cathode bias and coupling.
R9	RESISTOR: Same as R5.	R.F. filter.
R10	RESISTOR: fixed; composition; 47,000 ohms ± 10%; ½ watt; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-473.	Audio frequency plate load. Tube V3-A.
R11	RESISTOR: Same as R3.	Mixer grid return.
R12	RESISTOR: Same as R3.	Tuning resistor A.F. net-work.
R13	RESISTOR: Same as R10.	Plate load. Tube V3-B.



K=1000
UNLESS OTHERWISE SPECIFIED.
ALL RESISTANCES IN OHMS.
ALL RESISTORS ½ WATT.
ALL CAPACITANCES IN MICRO-MICRO-FARADS.
OFF = FRONT PANEL CONTROL

SCHEMATIC DIAGRAM
MODEL 111-B

DWN. BY	DATE	CHK. BY	APP'D. BY
CCA	4-2-52		

SCALE — DO NOT SCALE

MATERIAL

FINISH

TOLERANCE UNLESS OTHERWISE SPECIFIED DECIMALS ± .005 FRACTIONS ± 1/64

MEASUREMENTS CORPORATION
BOONTON, N. J.

TITLE SCHEMATIC DIAGRAM MODEL 111-B

DWG. NO. B-3687-M

B-3687-M

TABLE OF REPLACEABLE PARTS

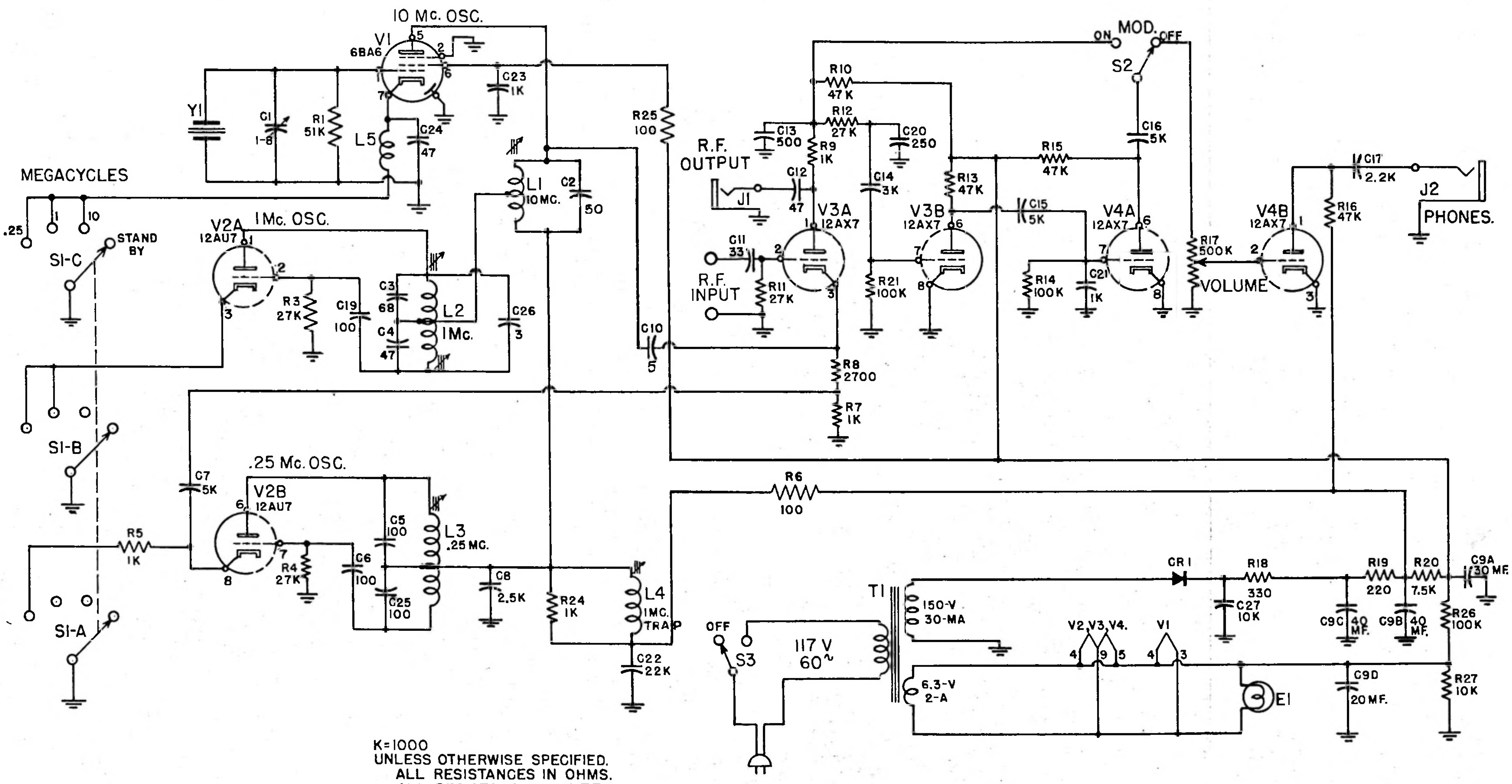
MODEL 111 CRYSTAL CALIBRATOR **MAJOR UNIT:**

Reference Symbol	DESCRIPTION	FUNCTION
R14	RESISTOR: fixed; composition; 100,000 ohms ± 10%; ½ watt; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-104.	Grid return. Tube V4-A.
R15	RESISTOR: Same as R10.	Plate load. Tube V4-A.
R16	RESISTOR: Same as R10.	Plate load. Tube V4-B.
R17	RESISTOR: variable; with a.c. switch; composition element; 500,000 ohms; standard audio log. taper; SPST switch. Measurements Div. Part H-3415.	Grid return and audio output control. Tube V4-B.
R18	RESISTOR: fixed; composition; 330 ohms ± 10%; ½ watt; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-331.	Current limiting.
R19	RESISTOR: fixed; composition; 220 ohms ± 10%; ½ watt; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-221.	B+ filter.
R20	RESISTOR: fixed; composition; 7,500 ohms ± 5%; ½ watt; 3/8" long x 9/64" dia.; 2 axial wire leads. Measurements Div. Part H-3727-752.	B+ filter.
R21	RESISTOR: Same as R14.	Grid return. Tube V3-B.
R24	RESISTOR: Same as R5.	1 Mc. trap load resistor.
R25	RESISTOR: Same as R6.	V1 screen dropping resistor.
R26	RESISTOR: Same as R14.	Voltage divider for heater-cathode bias supply.
R27	RESISTOR: fixed; composition; 10,000 ohms ± 10%; ½ watt; 3/8" long x 9/64" dia.; 2 axial leads. Measurements Div. Part H-3728-103.	Same as R26.
L1	COIL: RF Oscillator; 10 mc; single layer; center tapped. Measurements Div. Part H-2934.	10 Mc. tank inductance.
L2	COIL: RF Oscillator; 1 mc; universal wound; 2 sections; tapped between sections. Measurements Div. Part A-2931.	1 Mc. tank inductance.
L3	COIL: RF Oscillator; 25 mc; universal wound; 2 sections; tapped between sections. Measurements Div. Part H-2933.	.25 Mc. tank inductance.
L4	COIL: RF Trap; single layer; close wound. Measurements Div. Part H-2932.	1 Mc. trap incuctance.

TABLE OF REPLACEABLE PARTS

MODEL 111 CRYSTAL CALIBRATOR — **MAJOR UNIT:**

Reference Symbol	DESCRIPTION	FUNCTION
L5	COIL: Universal wound; single section. Measurements Div. Part H-6496.	10 Mc. osc. cathode tank ind.
T1	TRANSFORMER: Power, plate and filament type; input 117 volts, 60 cycle single phase; 2 output windings; sec. #1. 150 volts at 30 ma.; sec. #2 6.3 volts at 2 amps.; half-shell type metal case: 6 terminal solder lugs; 2 mtg. holes, centers $2\frac{1}{4}$". Measurements Div. Part H-2930.	Plate and filament power source.
Y1	CRYSTAL; Frequency 10 Mc. $\pm$ .005%; temp. co-eff. $\frac{1}{2}$ part per million per degree C; operating temp: $+ 10^{0}$ to $+ 60^{0}$ C; mtg. pins dia. .050" x .218" lg. and spaced .486". Measurements Div. Part H-852.	Crystal for 10 Mc. osc.
CR1	RECTIFIER: Selenium; d.c. output, 160 volts at 75 ma.; r.m.s. a.c. supply voltage 117 volts; rectifier max. r.m.s. supply voltage 160 volts; max. peak inverse voltage 400 volts; 2 solder lugs; mtg. hole has clearance for #6 screw. Measurements Div. Part H-2948.	Rectifies A.C. voltage for plate supply.
S1A S1B S1C	SWITCH: Rotary; 3 pole, 3 position; non-shorting rotor teeth; silver plated contacts; Bakelite stator wax impregnated; 17 solder terms.; single hole mtg.; 3/8"-32 bushing $\frac{1}{4}$" high; shaft $\frac{1}{4}$" dia. x 3/8" long. Measurements Div. Part H-3538.	Frequency selector switch.
S2	SWITCH: Toggle; SPDT; 1 amp.; 250 volts; ball handle 3/8" long; 3 solder terms.; single hole mtg., 15/32"-32 x 3/8" high. Measurements Div. Part H-4132.	Modulation selector switch.
S3	SWITCH: Mounted on R17.	Power control.
E1	LAMP: Incandescent; 12-14 volts: .24A. ; min. bayonet base; T $3\frac{1}{4}$ bulb; Measurements Div. Part H-6487	Pilot light.
KNOB	KNOB: Bar type; 1", black Bakelite. Measurements Div. Part H-4133.	
J1	SOCKET: Measurements Div. Part H-4130.	R.F. output.
J2	JACK: Phone jack; 3/8"-32 busing 5/16" long. Measurements Div. Part H-4131.	Audio output.
V1	TUBE: Electron; 6BA6.	10 Mc. oscillator.
V2	TUBE; Electron; 12AU7.	1 Mc. oscillator. .25 Mc. oscillator.
V3	TUBE: Electron; 12AX7.	Mixer and harmonic generator; audio amplifier.
V4	TUBE: Electron; Same as V3.	Audio amplifier.



K=1000
UNLESS OTHERWISE SPECIFIED.
ALL RESISTANCES IN OHMS.
ALL RESISTORS 0.5 WATT.
ALL CAPACITANCES IN MICRO-MICRO-FARADS.

MODEL III SCHEMATIC WIRING DIAGRAM

B-2941-R

MEASUREMENTS
BOX 180, BOONTON
NEW JERSEY