OPERATING INSTRUCTIONS

TYPE 1213-C UNIT TIME/FREQUENCY CALIBRATOR

A GR UNIT INSTRUMENT

. . . SINCE 1915
manufacturers of electronic apparatus for science and industry

GENERAL RADIO COMPANY

CAMBRIDGE 39, MASSACHUSETTS, USA

825-C

OPERATING INSTRUCTIONS

TYPE 1213-C UNIT TIME/FREQUENCY CALIBRATOR

Form 786-E
September, 1958

GENERAL RADIO COMPANY

CAMBRIDGE 39 MASSACHUSETTS

SPECIFICATIONS

Output frequencies:	10 Mc, 1 Mc, 100 kc, 10 kc.
Output amplitudes:	10 Mc: 5 v peak-to-peak; 30 v peak-to-peak at lower output frequencies from pulse amplifier; r-f harmonics usable to 1000 Mc from 10-Mc output, to 500 Mc from 1-Mc output, to 100 Mc from 100-kc output, and to 10 Mc from 10-kc output.
Output impedance:	Video cathode-follower, 300 ohms; r-f output obtained from crystal-diode harmonic generator.
Stability:	After 1-hr warm-up, drift rate with regulated plate supply is mainly the drift rate of the quartz crystal (approx 1 ppm/ 1°C). With unregulated power supply, an additional variation of ±½ ppm with line voltage change from 105 to 125 v.
Sensitivity:	Usable beat notes can be produced with 50 millivolts signal input to mixer over the harmonic ranges specified above under "Output amplitudes".
Tubes:	One each 6BE6, 5687, 6AU6, 6AN8, 6U8, two 5964.
Power required:	6.3 v ac, 3 amp; 300 v dc, 60 ma. Type 1203 or 1201 Unit Power Supply is recommended.
Accessories supplied:	Type 1213-P1 Differentiator, coaxial connector, and multipoint connector.
Mounting:	Aluminum panel and sides finished in black crackle; aluminum cover finished in clear laquer. Relay rack panel (Type 480-P4U3) is available for mounting both calibrator and power supply.
Dimensions:	Width 10½ in., height 5¾ in., depth 7 in., over-all.
Weight:	4 lb, 10oz.
Patent information:	U.S. Patent 2,548,457; licensed under patents of the American Telephone and Telegraph Co., Radio Corporation of America, and G. W. Pierce (pertaining to piezo electric crystals and associated circuits).

GENERAL RADIO EXPERIMENTER reference: Volume 31, No. 1, June, 1956.

TABLE OF CONTENTS

Figure 1.
Type 1213-C Unit Time/Frequency Calibrator, with Type 1201 Unit Power Supply.

TYPE 1213-C

UNIT TIME/FREQUENCY CALIBRATOR

Section 1
INTRODUCTION

1.1 PURPOSE. The Type 1213-C Unit Time/Frequency Calibrator (Figure 1) comprises, in a small unit-type case, all the circuits necessary for the frequency calibration of oscillators, receivers, and other wide-range devices at frequencies up to over 1000 Mc, and for the sweep-time calibration of oscilloscopes at intervals from 0.1 to 100 microseconds.

1.2 DESCRIPTION.

1.2.1 GENERAL. The basic circuits, shown in Figure 2, are:

a. a 5-Mc crystal-controlled oscillator coupled to a two-to-one multiplier,

b. a 10-Mc buffer stage,

c. a group of three multivibrators, controlled by a panel switch, dividing the 10-Mc crystal-controlled frequency from the buffer by factors of 10, 100, and 1000,

d. a harmonic generator that produces a continuous harmonic spectrum of the 10-Mc, 1-Mc, 100-kc, and 10-kc signals from the multivibrators,

e. a crystal mixer either to couple the harmonics out of the instrument through a coaxial lead or to produce and detect a beat against a signal fed into the mixer,

f. An amplifier stage to amplify the beat signal from the mixer to drive earphones or to produce video signals for oscilloscope calibration from the same panel-terminal pair. The FUNDAMENTAL FREQUENCY control and the amplifier mode switch (AUDIO BEAT SIGNAL - TIME MARKER) connect various circuit combinations to produce output frequencies and specialized amplifier characteristics. Power input to the unit is kept nearly constant by dummy load resistors so that the heating is uniform and switching operations have little effect on the standard frequency.

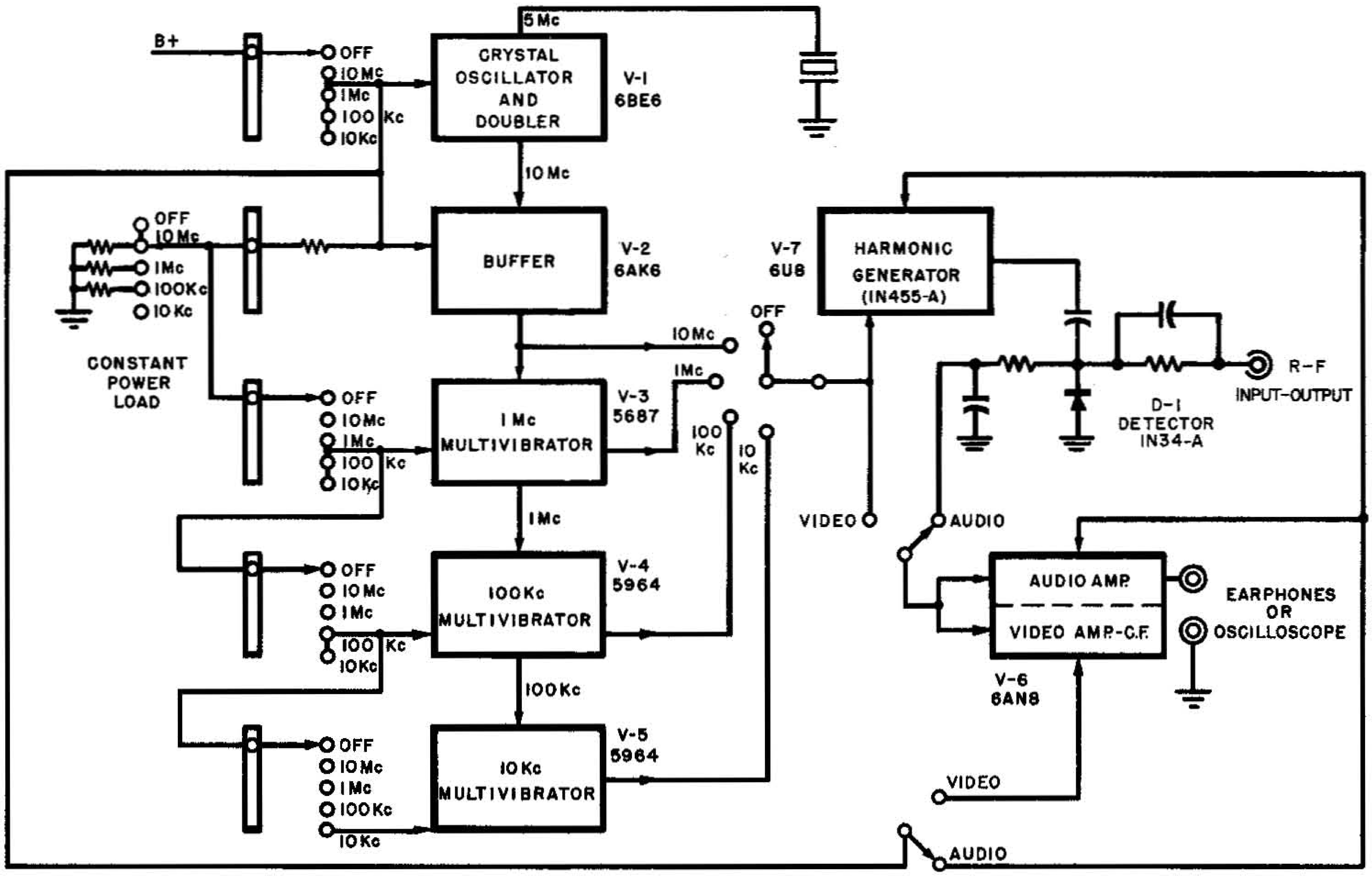

Figure 2. Block Diagram of Type 1213-C Unit Time/Frequency Calibrator.

1.2.2 CONTROLS. The following controls are on the panel of the Type 1213-C Unit Time/Frequency Calibrator:

NAME	DESCRIPTION	FUNCTION
Amplifier mode switch	2-position selector switch	Provides for audio amplification of beat note from mixer, or timing markers for oscilloscope calibration from same stages.
AUDIO GAIN	Continuous rotary control	Varies amplifier gain when mode switch is in AUDIO position.
FREQUENCY ADJUST	Continuous rotary control	Sets crystal frequency.
FUNDAMENTAL FREQUENCY	5-position selector switch	Sets output frequency and fundamental component of standard r-f spectrum.
TOUCH TO DECREASE FREQUENCY	Touch button	Momentarily deviates standard frequency without disturbing crystal oscillator center frequency setting.

1.2.3 CONNECTIONS. The following connections are on the Type 1213-C Unit Time/Frequency Calibrator:

NAME	DESCRIPTION	FUNCTION
OUTPUT	Jack-top binding posts (2)	Audio beat note from internal mixer or timing markers for oscilloscope calibration.
R-F INPUT TO DETECTOR R-F OUTPUT HARMONIC SERIES	Type 874 Co-axial Connector	Input for r-f to be calibrated or output for r-f standard harmonics.
Power	Multipoint Male connector	Power supply connection.

1.3 AUXILIARY EQUIPMENT. An external source of 300-volt power and a 6.3-volt heater supply are necessary. Either the Type 1203 Unit Power Supply or the Type 1201 Unit Regulated Power Supply is satisfactory. The Type 1201 Unit Regulated Power Supply is recommended because a slight increase in crystal frequency stability is gained with a varying line voltage, and 120-cycle hum is materially reduced in the audio amplifier. For power supplies other than the General Radio Unit Types, power input requirements are 300 volts at 45 ma and 6.3 volts at 3 amperes.

Section 2
PRINCIPLES OF OPERATION

2.1 OSCILLATOR AND BUFFER CIRCUITS (refer to Figure 7). Quartz crystal Q1 controls the frequency of the 5-Mc oscillator formed by the control grid (pin 1) and screen grid (pin 6) of V1. C3 and C5 are phase-splitting capacitors, C4 adjusts the center frequency of the crystal, and C2 is the front panel FREQUENCY ADJUST control. A tuned circuit consisting of L1 and C6 is resonated at 10 Mc and driven by the oscillating plate current of V1.

The 10-Mc signal from the oscillator plate is amplified by the buffer tube V2. The tuned plate circuit consists of L2 and C9, and V2 is neutralized by the decoupling network (R5 and C11) and feedback capacitor (C53). Constant impedance must be maintained on the plate of V2 as circuit functions are switched. In the 1-Mc, 100-kc, and 10-kc positions of S1 (FUNDAMENTAL FREQUENCY), C37 is substituted for the input capacitance of the harmonic generator and limiter V7. When the AUDIO BEAT SIGNAL-TIMING MARKERS switch is in the AUDIO BEAT SIGNAL position, C40 is substituted for the input capacitance of the video amplifier stage, V6A. A coupling network consisting of C13 and R10 permanently connects the buffer plate circuit with the grids of the 1-Mc multivibrator frequency divider (V3A and V3B) through D3 and D4. By means of C13, the triggering voltage applied to the 1-Mc multivibrator may be adjusted.

2.2 MULTIVIBRATORS. The three frequency-dividing multivibrators are all of similar design, each consisting of a dual triode tube with its two sections connected as symmetrical multivibrators. In the absence of an input signal, each multivibrator is set to operate at a free-running frequency about 15 percent less than the locked frequency. This time constant is adjusted by a pair of trimmer capacitors to produce this free-running frequency. In the 1-Mc multivibrator (V3), the timing network consists of C15, C16, C17, and C18, and resistors R12 and R13. Crystal diodes D3 and D4 decouple the discharging grids of V3 from the trigger circuit, thereby reducing the load due to the grid-cathode capacitance of the tube. In each of the three multivibrators, the right-hand-plate waveform drives the grids of the succeeding multivibrator and the left-hand plate is connected to the FUNDAMENTAL FREQUENCY switch through a coupling capacitor.

As the FUNDAMENTAL FREQUENCY switch is set successively from the OFF position to 10 Mc, 1Mc, etc, the buffer signal and the signal from the multivibrator are connected to the grids of the harmonic generator, and by means of the AUDIO BEAT SIGNAL-TIMING MARKERS switch (S2), to the video amplifier. When the FUNDAMENTAL FREQUENCY switch is moved from the OFF position to a selected frequency, contacts 210 and 211 of S1 switch the power on, and the front section of the switch maintains the constant power load and switches the B-plus supply to the selected multivibrator.

2.3 HARMONIC GENERATOR AND MIXER CIRCUIT. When the AUDIO BEAT SIGNAL-TIMING MARKERS switch is in the AUDIO BEAT SIGNAL position, plate voltage is supplied to the harmonic generator stage, V7. The buffer or the multivibrator selected by the FUNDAMENTAL FREQUENCY switch is connected to the grid of V7, and the amplified signal from the network in the plate of V7 is applied through a coupling capacitor (C50) to the triode section of V7. When the FUNDAMENTAL FREQUENCY switch is in the 10-Mc position, C47 is grounded and the plate circuit of V7 is tuned to 10 Mc. When the switch is in the 1-Mc position, L3 and L4, together with the stray capacitance at the plate of V7, form a tuned circuit resonant at 1 Mc. With the switch in the 100-kc or 10-kc position, C48 is removed and V7 uses the full network consisting of R47, L3, and L4 as its plate load.

The output from the plate of the pentode section of V7 overdrives the triode section of V7. Pulses of plate current in the triode section of V7 produce voltage spikes across the harmonic-generating diode, D2. These pulses, which produce the standard-frequency harmonic series, are coupled, via C49, to D1, the high-frequency mixer.

The unknown signal is fed into J1 and is added to the standard-frequency spectrum across D1 and rectified. The r-f voltage is filtered by an r-c filter (R49, C39), the audio beat frequency appearing across R46, the diode load resistor. This audio beat signal is coupled through S2, C41, and R30 to the grid of the pentode section of V6, the audio amplifier.

2.4 AUDIO-VIDEO AMPLIFIER. V6 serves both as an audio amplifier for the beat note from the mixer and as a video amplifier-limiter and cathode follower to produce timing markers at the output binding post. The AUDIO BEAT SIGNAL-TIMING MARKERS switch, when in the AUDIO BEAT SIGNAL position, connects R31 and R33 as plate and screen resistors, respectively, for V6A, and connects R35 as the plate load resistor for the triode section of V6, with R37 as its cathode resistor. The two sections of V6 then serve as an audio amplifier with a gain of about 80 db. The sensitivity of this amplifier is controlled by R29, the AUDIO GAIN control. The rectified signal voltage at the grid of the harmonic generator is filtered by R41 and C46 and used to produce the audio gain control voltage at the grid of V6.

When V6 is used as a video amplifier to produce standard time intervals for oscilloscope calibration (mode switch in TIMING MARKERS position), the grid of the pentode section of V6 is connected to the buffer or to a selected multivibrator. S2 connects R34 to increase the screen voltage on the pentode section of V6 and connects R32 as the plate load resistor for the pentode. Contacts on the rear section of S2 place R39 in parallel with R35 to increase the plate voltage on the triode section, connect the cathode section of the triode to the output terminals, and add R36 as an additional cathode load resistance. By this switching action, V6 is converted to a pentode amplifier and limiter followed by a cathode-follower section to drive the output terminals.

Section 3
OPERATING PROCEDURE

3.1 GENERAL. The following instructions are divided into five major sections, representing the four basic output calibrating operations and the standardization procedure with a primary frequency standard, either remote or local.

3.2 CALIBRATION BY PRIMARY FREQUENCY STANDARD.

3.2.1 GENERAL. There are two possible methods of standardizing the crystal frequency of the Unit Time/Frequency Calibrator. One method, described in paragraph 3.2.2, is calibration by zero beat with WWV transmissions. Auxiliary equipment required are a radio receiver to receive the 5-, 10-, or 15-Mc WWV transmissions and either earphones or oscilloscope to observe the beat. The other method, described in paragraph 3.2.3, is calibration with a local frequency standard. Equipment required is an oscilloscope with which to view the Lissajous figure produced by the local standard against the Type 1213-C.

3.2.2 CALIBRATION WITH WWV.

a. Turn on the Unit Time/Frequency Calibrator and the radio receiver, tuning the latter to WWV transmission on 5, 10, or 15 Mc. Allow both instruments to warm up for about an hour.

b. Loosely couple the output radiation from the Type 1213-C to the antenna of the radio receiver. Adjust this coupling so that a good, clean beat note is established.

c. Set the FREQUENCY ADJUST knob of the Type 1213-C to produce a zero beat, as indicated either on earphones or oscilloscope.

d. If the FREQUENCY ADJUST control will not permit a zero beat setting, adjust the internal series capacitor (C4), with the panel control centered, to produce zero beat. C4 is internally shielded, and the crystal frequency will suffer no measurable change whether the adjustment is made with the cover on or off the instrument.

3.2.3 CALIBRATION WITH LOCAL STANDARD. The only requirement in the choice of a local standard for calibration is that it be able to produce a recognizable Lissajous figure at some setting of the FUNDAMENTAL FREQUENCY switch.

a. After allowing the Type 1213-C about an hour's warmup, feed its output to one set of oscilloscope deflection plates. Feed the output of the local standard to the other set of deflection plates.

b. Obtain a stationary Lissajous figure of the ratio appropriate to the two frequencies by adjusting the FREQUENCY ADJUST control of the Type 1213-C.

c. If a stationary pattern cannot be obtained, set the FREQUENCY ADJUST control to center scale and reset C4 as described in paragraph 3.2.2, step d.

3.3 OSCILLOSCOPE CALIBRATION.

3.3.1 GENERAL. The Type 1213-P1 Differentiator Unit produces brief (0.15-μsec) pulses, both positive and negative going, which are intended to provide convenient markers for oscilloscope calibration. The use of this device is optional, because the rapid transitions of the square-wave outputs will also serve as a time index.

The 10-kc (100-μsec) square wave from the Type 1213-C has no overshoot nor appreciable ramp-off; it can therefore be used to check oscilloscope amplifier and probe low-frequency compensation. (The 100-kc and 10-kc outputs of the Type 1213-C have a rise time of 0.30 μsec.)

Since the trace linearity of most oscilloscopes is in the order of a few percent, the Type 1213-C need not be calibrated against a primary standard.

3.3.2 PROCEDURE.

a. Turn on the oscilloscope and the Type 1213-C.

b. Connect the oscilloscope vertical input to the Type 1213-C output terminals.

c. Set the amplifier mode switch to the TIMING MARKERS position.

d. Set the FUNDAMENTAL FREQUENCY switch to the frequency appropriate to the oscilloscope time base to be calibrated.

e. Synchronize the oscilloscope on either internal signal or connect the oscilloscope synchronizing terminals to the Type 1213-C output terminals.

3.4 OSCILLATOR CALIBRATION BY MEANS OF TYPE 1213-C INTERNAL MIXER-AMPLIFIER SYSTEM.

3.4.1 PROCEDURE.

a. Turn on the Type 1213-C and the oscillator, and allow them to warm up. If the precision desired warrants, check the Type 1213-C frequency as described in paragraph 3.2.

b. Connect the oscillator output to the R-F INPUT TO DETECTOR terminals on the Type 1213-C.

c. Set the amplifier mode switch to AUDIO BEAT SIGNAL, and set the FUNDAMENTAL FREQUENCY switch to the desired position, depending on dial frequency increments to be established.

d. Plug the earphones into the AUDIO OUTPUT terminals. Audible beats will be heard as the oscillator dial is rotated.

e. When checking the oscillator calibration by means of this technique, observe the following two precautions:

(1) The accuracy of the oscillator dial calibration must be relied on to identify the harmonic used for dial calibration. For example, in order to establish a calibration point correctly at 1000 Mc, the oscillator calibration must be known within 0.5 percent in order to determine that the 100th 10-Mc harmonic is being used, rather than the 99th or 101st. The frequency of an uncalibrated oscillator can be set to 1000 Mc if equipment is available for calibration of a 100-Mc oscillator using the 10-Mc harmonics and for beating the 10th harmonic of this oscillator against the 1000-Mc oscillator to establish the 1000-Mc point. In the calibration of 1-Mc points (1-percent increments at 100 Mc), the 100-Mc point can be established if the oscillator calibration

is known to within 10 percent by the use of the 10-Mc harmonic spectrum, etc.

(2) Care must also be taken in oscillator calibration to insure that the beat note being heard is not due to harmonics of the unknown beating against the standard frequency spectrum generated within the Type 1213-C. For instance, suppose an oscillator is being calibrated in the 50- to 100-Mc region against 10-Mc standard harmonic spectrum lines. It is possible that beat notes will be heard at 50, 55, 60 Mc, etc. The second harmonic of 55 Mc (at 110 Mc), if strong enough, will beat against the 11th 10-Mc harmonic to produce a weak but audible signal. The AUDIO GAIN control has deliberately been made nonlinear so that these weaker, spurious signals can usually be eliminated, and the control should be so adjusted.

3.4.2 SETTING FIXED-FREQUENCY OSCILLATORS EXACTLY ON A HARMONIC OF THE TYPE 1213-C. In the adjustment of fixed-frequency oscillators which are supposed to be tuned to exact zero beat with a harmonic of the Type 1213-C (as, for example, in a-m, f-m, and television transmitters), it is often useful to determine the sense of the transmitter frequency error. The TOUCH TO DECREASE FREQUENCY button is provided for this purpose. Touching this button lowers the frequency of the crystal oscillator of the Type 1213-C. Thus, if the frequency of the fixed oscillator is slightly above a zero-beat point with an output harmonic of the Type 1213-C, the beat note will increase in frequency if the button is touched. If the frequency of the fixed oscillator is below the zero-beat point, the beat note will decrease in frequency when the button is touched. This knowledge is especially helpful when very near the zero beat, particularly when the adjustment is being made at a point remote from the Type 1213-C.

3.5 CALIBRATION BY MEANS OF THE OUTPUT HARMONIC SERIES OF THE TYPE 1213-C. The Type 874 Coaxial Connector on the panel of the Type 1213-C permits the connection of the spectrum of standard frequency harmonics to an external detector or receiver for calibration or monitoring purposes. Suppose, for instance, that the dial calibration of a radio receiver is to be checked. The procedure is as follows:

a. Loosely couple the output of the Type 1213-C from the R-F OUTPUT HARMONIC SERIES fitting to the receiver antenna terminals.

b. Turn on the Type 1213-C and the receiver, and allow them to warm up for about an hour.

c. Tune the receiver. The harmonic spectrum of the frequency selected by the FUNDAMENTAL FREQUENCY switch should be heard in the receiver output.

d. It is possible that a low-order harmonic will block the i-f amplifiers of certain high-frequency receivers and lower their sensitivity. Determine whether the intermediate frequency is harmonically related to the fundamental frequency selected for calibration. If so, a high-pass filter with sufficient rejection at the intermediate frequency will be required. If the radio receiver has an automatic volume control, the presence of blocking will be evidenced by a steady AVC voltage reading almost independent of r-f tuning.

3.6 INTERPOLATION METHOD OF CALIBRATION. As stated, the 10-kc harmonic series generated by the Type 1213-C permits direct calibration at 10-kc intervals up to 10 Mc or so.[1] However, with an interpolation oscillator used as shown in Figure 3, it is possible to calibrate at any multiple of 10 kc up to 1000 Mc. Thus any broadcast transmitter, for instance, can be standardized directly against WWV on any assigned channel up to 1000 Mc. An oscillator with a frequency range of 10 kc to 5 Mc, with an output up to about 1 volt, will interpolate between successive harmonics of the 10-Mc series up to 1000 Mc. The Type 1330-A Bridge Oscillator and the Type 1001-A Standard Signal Generator are recommended. Below 500 Mc an oscillator with a frequency range of 10 kc to 500 kc (such as the Type 1210 Unit R-C Oscillator) will interpolate between successive harmonics of the 1-Mc series.

Interpolation is possible because the input circuit of the Type 1213-C causes sum and difference frequencies (sidebands) to be generated when two signals are applied simultaneously.

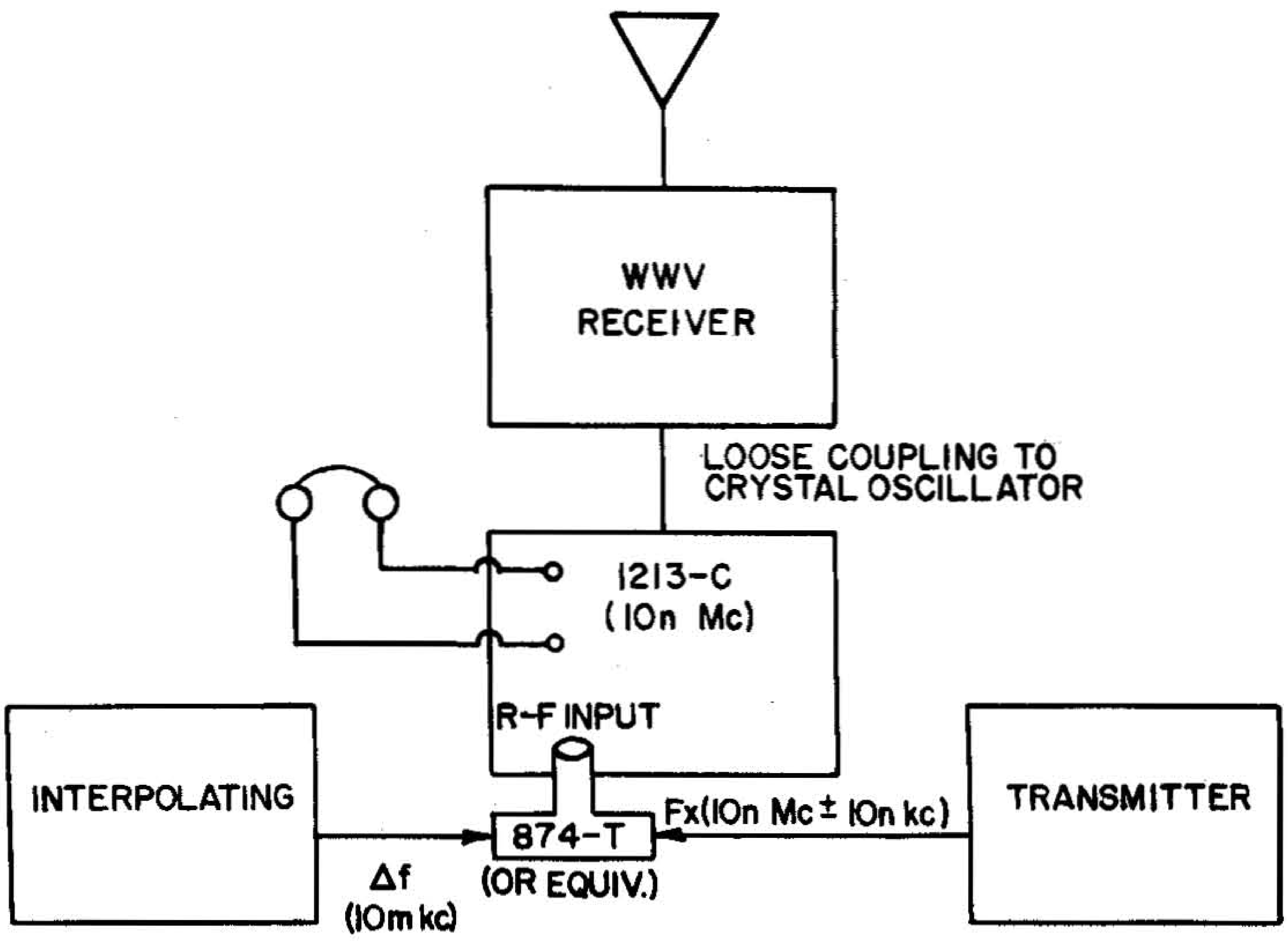

Figure 3.
Setup for Interpolation Method of Calibration.

---

[1] This is a conservative limit. In most instruments the 10-kc harmonic series is continuous up to 30 Mc or higher.

As an example, suppose an unknown frequency F_x is spaced ΔF kc away from the nearest "picket" of the internally applied "picket fence" (harmonic series). If a signal of frequency ΔF is simultaneously applied by the interpolating oscillator, the sideband ($F_x + \Delta F$ or $F_x - \Delta F$) will fall upon this nearest "picket". If ΔF is first standardized at its computed value, F_x may be adjusted to zero-beat this sideband, just as if ΔF were not involved.

The following precautions must be observed in this method of interpolation:

a. The interpolating oscillator must be standardized at ΔF kc against the 10-kc harmonic series of the Type 1213-C. Therefore ΔF must be an exact multiple of 10 kc, and must be equal to the frequency difference, in kilocycles, between the unknown (F_x) and the nearest harmonic of 1 Mc (or of 10 Mc, when the latter is to be used in the first setting of F_x).

b. To avoid spurious beats involving harmonics of the interpolating frequency (ΔF), the interpolating oscillator must be reasonably free of distortion, and its output must be kept below that at which harmonics are generated in the input circuit of the Type 1213-C. To obtain the correct level, set the Type 1213-C to 1 Mc, set the interpolating oscillator to 500 kc, and reduce the oscillator level to the point at which no beat note is produced. (Even at this reduced level adequate beats will be produced against the 10 kc series, so that ΔF can be standardized as above.

c. Since the Type 1213-C will respond equally to either sideband, the undesired sideband constitutes the nearest spurious beat involving both F_x and ΔF. This spurious beat is separated from the desired beat by $2\Delta F$ or by $(1 \text{ Mc} - 2\Delta F)$ note 2, whichever is the smaller, when the 1-Mc harmonic series is used. An independent measurement must be made to assure that F_x is not in error by this amount.

---

[2] In the case of the 10-Mc harmonic series, the nearest spurious beat is removed by $2\Delta F$ or $(10\text{Mc} - 2\Delta F)$, whichever is the smaller.

Section 4
SERVICE AND MAINTENANCE

4.1 GENERAL. The following information, together with that given in preceding sections, should enable the user to locate and correct ordinary difficulties resulting from normal use. Major service problems should be referred to our Service Department, which will cooperate as much as possible by furnishing information and instructions as well as by supplying replacement parts needed.

When notifying our Service Department of any difficulties in the operation or service of the instrument, always mention the serial and type numbers of the instrument. Also include in correspondence a complete report of trouble encountered and steps taken to eliminate the trouble. Before returning an instrument or parts for repair, write to our Service Department, requesting a Returned Material Tag, which includes shipping instructions. Use of this tag will insure proper handling and identification when an instrument or parts are returned for repair. A purchase order covering repair to material returned should also be forwarded to avoid unnecessary delay.

4.2 CIRCUIT ADJUSTMENTS.

4.2.1 GENERAL. The following adjustment procedure is the general procedure for adjustment of this instrument in our laboratory. It should never be necessary to follow the entire procedure. Only adjustments necessitated by tube or component replacement need be made.

4.2.2 OSCILLATOR BUFFER CIRCUIT.

4.2.2.1 Adjustment of Quartz-Crystal Frequency. The crystal coarse frequency adjustment is C4. By means of this adjustment, calibrate the quartz crystal in the oscillator against a primary frequency standard as outlined in paragraph 3.2. Set the panel FREQUENCY ADJUST control to 5 (midscale) and adjust C4 for zero beat with the primary frequency standard.

4.2.2.2 10-Mc Doubler Adjustment. This adjustment should be made whenever either V1 or V2 is replaced. Connect a d-c vacuum-tube voltmeter through a 1-megohm resistor to the grid (pin 1) of V2 and to ground, and adjust C6 for maximum d-c grid voltage.

4.2.2.3 10-Mc Buffer Adjustment. Connect the vertical amplifier of an oscilloscope to the grid (pin 2) of V7. With the FUNDAMENTAL FREQUENCY switch set at 1 Mc, adjust L2 for maximum amplitude of the 10-Mc component.

4.2.3 MULTIVIBRATOR ADJUSTMENTS.

4.2.3.1 1-Mc Multivibrator.

a. Set the function switch to AUDIO BEAT SIGNAL, and the FUNDAMENTAL FREQUENCY switch to 1 Mc.

b. Connect a pair of headphones to the OUTPUT terminals.

c. Ground pin 1, V2.

d. Connect an r-f signal generator, set at 800 kc, to the R-F INPUT terminal.

e. Connect the vertical input of a wide-band oscilloscope (bandwidth 5 Mc or greater) through a 4.7-$\mu\mu$f capacitor either to anchor terminal No. 25 on the harmonic generator chassis or to contact 206 of S1.

f. Adjust C16 and C18 for zero beat, maintaining the plate waveform on the oscilloscope symmetrical.

g. Adjust C13 for maximum capacitance. (Note: On some instruments C13 is a fixed capacitance. In the adjustment of such an instrument, skip down to step k.)

h. Unground pin 1 of V2.

i. Set the signal generator to 1 Mc.

j. Decrease the capacitance of C13 while retuning L2 to maintain resonance (as indicated by the 10-Mc maximum on the oscilloscope) until the 1-Mc multivibrator fails to synchronize. This is the correct setting of C13.

k. Ground pin 1 of V2, taking synchronization off the multivibrator.

l. Readjust C16 and C18 for zero beat at 880 kc, maintaining symmetry by monitoring the multivibrator plate waveform (step d).

m. Unground pin 1, V2.

4.2.3.2 100-kc Multivibrator.

a. Disable the 1-Mc multivibrator by clipping the anode of D4 to ground. (Do not remove the tube.)

b. Connect the vertical input of an oscilloscope with a calibrated time base through a 4.7-$\mu\mu$f capacitor either to anchor terminal No. 4 on the etched circuit board or to contact 207 of S1.

c. Observe the plate waveform of V4A on a calibrated horizontal axis, using an oscilloscope writing rate of from 2 to 4 microseconds per division. Using C22 and C24, set the duration of the positive and negative plate excursions to be equal and 5.8 microseconds in duration. Or, using the alternative method described in paragraph 4.2.3.1, set the multivibrator to 85 kc.

4.2.3.3 10-kc Multivibrator.

a. Disable the 100-kc multivibrator by grounding either grid 5 or grid 6 of V4.

b. Connect the vertical input of an oscilloscope with a calibrated time base through a 4.7-$\mu\mu$f capacitor either to anchor terminal No. 7 on the etched circuit board or to contact 208 rear of S1.

c. Observe the plate waveform of V5A on a calibrated horizontal axis, using an oscilloscope writing rate of from 20 to 40 microseconds per division. Using C30 and C32, set the duration of the positive and negative plate excursions to be equal and 58 microseconds in duration. Or, using the alternative method described in paragraph 4.2.3.1, set the multivibrator to 8.5 kc.

4.2.4 HARMONIC-GENERATOR ADJUSTMENTS.

4.2.4.1 General. L3 and L4 in the harmonic generator are adjusted to produce maximum drive for the crystal mixer, which will in turn produce maximum drive for the harmonic generator. There are two methods of adjustment, described in the following paragraphs.

4.2.4.2 Primary Method.

a. Connect either a d-c vacuum-tube voltmeter or a 20,000-ohm-per-volt meter across R46, a 51-kilohm resistor on S2.

b. Set the FUNDAMENTAL FREQUENCY switch to 10 Mc and adjust L4 for maximum meter reading.

c. Set the FUNDAMENTAL FREQUENCY switch to 1 Mc and adjust L3 for maximum indicated voltage across R46.

4.2.4.3 Secondary Method. The procedure outlined in paragraph 4.2.4.2 may not yield optimum sensitivity for the mixer with every mixer crystal (D1). An alternative method is to adjust L3 and L4 for the maximum extent of the harmonic spectrum as follows:

a. Connect an oscillator or signal generator producing a signal in the 1000-Mc region to J1 and feed the high-frequency energy into the mixer. Using earphones at the output terminals, obtain an audible beat between a 10-Mc harmonic in the 1000-Mc region and the oscillator.

b. Having previously adjusted L4 for maximum voltage across R46, decrease the oscillator output until the beat note is barely audible and retouch the adjustment of L4 for maximum loudness.

c. Repeat this procedure for the 1-Mc harmonic spectrum, retouching L3 for maximum loudness with an oscillator feeding a signal between 100 and 500 Mc into the mixer.

4.3 TROUBLE-SHOOTING.

4.3.1 GENERAL. The flexibility offered by the switching system of the instrument greatly simplifies the isolation and correction of any failures that may occur. In the event of trouble, first use a radio receiver or oscillator to check the r-f input-output system and an oscilloscope to observe the timing marker outputs. Having observed the symptoms of the malfunction, enter Table 1. Match the conditions with one of the vertical columns and refer to the paragraph given at the bottom of the column. A specific tube or component can then be located by reference to the test voltages and resistances, Table 2.

TABLE 1

TROUBLE-SHOOTING CHART

(refer to paragraph 4.3.1)

Switch setting and equipment connection													
Radio receiver tuned to 5Mc and connected to TOUCH button	A	A	P	P	P	P	P	P	P	P	P	U	All signals from r-f and oscilloscope terminals normal; instrument lacks sensitivity for injected r-f unknown.
S2 in TIMING MARKERS, rcvr or CRO connected to timing marker output													
S1 at 10 Mc	A	A	A	P	A	P	P	P	P	P	P	U	
S1 at 1 Mc	A	U	U	P	A	A	P	P	U	P	P	U	
S1 at 100 kc	A	U	U	P	A	U	A	P	U	U	P	U	
S1 at 10 kc	A	U	U	P	A	U	U	A	U	U	U	U	
S2 in AUDIO, rcvr or CRO connected to rf output													
S1 at 10 Mc	A	A	A	A	P	P	P	P	P	P	P	U	
S1 at 1 Mc	A	U	U	A	P	A	P	P	U	P	P	U	
S1 at 100 kc	A	U	U	A	P	U	A	P	U	U	P	U	
S1 at 10 k	A	U	U	A	P	U	U	A	U	U	U	U	
Refer to paragraph	4.3.2	4.3.3	4.3.4	4.3.5	4.3.6	4.3.7	4.3.7	4.3.7	4.3.8	4.3.8	4.3.8	4.3.9	4.3.10
Probable Failure	Pwr Supply	V1	V2	V7	V6	V3	V4	V5	V3	V4	V5	V1 Q1	D1

A - Signal absent P - Signal present U - Signal present but unstable

TABLE 2

TEST VOLTAGES AND RESISTANCES

TUBE (TYPE)	FUNDAMENTAL FREQUENCY SWITCH	PIN	FUNCTION	D-C VOLTS TO GND	RES TO GND
V1 (6BE6)	10 Mc	1	grid	−2.0	2.2 M
		2	cathode	0	0
		5	plate	300	1.0
		6	screen	42	220 k
V2 (6AU6)	10 Mc	1	grid	−3.0	100 k
		5	plate	295	1.0 k
		6	screen	41	1.2 M
		7	cathode	0	0
V3 (5687)	1 Mc	1	plate	40	9.0 k
		2	grid	− 9.0	*
		3	cathode	0	0
		6	cathode	0	0
		7	grid	−9.0	*
		9	plate	40	9.0 k
V4 (5964)	100 kc	1	plate	45	30 k
		2	plate	45	30 k
		5	grid	−14	280 k
		6	grid	−14	280 k
		7	cathode	0	0

TUBE (TYPE)	FUNDAMENTAL FREQUENCY SWITCH	PIN	FUNCTION	D-C VOLTS TO GND	RES TO GND
V5 (5964)	10 kc	1	plate	40	110 k
		2	plate	40	110 k
		5	grid	−20	910 k
		6	grid	−20	910 k
		7	cathode	0	0
V6 (6AN8)	10 Mc	1	plate	80	100 k
		2	grid	0	10 M
		3	cathode	3.5	1.5 k
		6	plate	45	1.1 M
		7	screen	20	6.8 M
		8	grid	0	1 M
		9	cathode	0	0
V7 (6U8) (pentode)	10 Mc	2	grid	-15	1 M
		3	screen	145	18 k
		6	plate	135	22 k
		7	cathode	0	0
V7 (6U8) (triode)	10 Mc	1	plate	160	**
		8	cathode	0	0
		9	grid	***	0.37 M

* 1500 ohms or 40 k, depending on ohmmeter polarity.

** 22 k or 300 k, depending on ohmmeter polarity.

*** −60 volts across R29. Voltmeter on grid will detune L4.

1. Above voltages are true values at normal operation, at switch positions noted. Input resistance of d-c voltmeter must be at least 10 times the values listed in the resistance column.
2. Voltage measurements are made with a B supply of 300 v dc and a heater supply of 6.3 v ac.
3. Resistance measurements are made with the power supply removed and with the B supply terminals shorted to ground.
4. AUDIO-TIMING switch is set to AUDIO for all checks.
5. GAIN control is set to maximum clockwise position.

4.3.2 INSTRUMENT DEAD. Check the power supply and connection. Measure the plate voltage at terminal No. 15 of PL1. Observe tube heaters for presence of heater potential.

4.3.3 NO 5-MC OR 10-MC OUTPUT. MULTIVIBRATORS FREE RUN. When the input signal to a multivibrator is lost, the multivibrator "free runs", and appears to be low in frequency by about 10 or 15 percent. Therefore, when the oscillator (V1) or the buffer (V2) fails, there will still be an output signal from the three multivibrators, but not on the correct frequency. Under these conditions, the output frequency or time markers will lack stability. When there is no output at 5 Mc from the TOUCH TO DECREASE FREQUENCY button to a radio receiver antenna, and no output from the 10-Mc buffer, the trouble must lie in the oscillator tube or its circuit components. Check the voltages around V1 against those given in Table 2, and check V1.

4.3.4 5-MC OUTPUT PRESENT BUT NO 10-MC SIGNALS. MULTIVIBRATORS FREE RUN. When a radio receiver or oscilloscope indicates the presence of a 5-Mc signal at the TOUCH TO DECREASE FREQUENCY button, but there is no 10-Mc signal from either the mixer or video output terminals, check the buffer stage, V2, and check test voltages against those given in Table 2.

4.3.5 NO OUTPUT AT R-F TERMINALS. OUTPUT FROM TIMING MARKER TERMINALS PRESENT. When an oscilloscope indicates output from the timing marker terminals but there is no signal present at the r-f out-in terminals with the AUDIO-TIMING MARKER switch in the AUDIO position, check the voltages in the harmonic generator circuit, V7 and its components, against those given in Table 2.

4.3.6 NO OUTPUT FROM TIMING MARKER TERMINALS. OUTPUT AT R-F TERMINAL. When an oscilloscope or radio receiver connected to the r-f output jack indicates the presence of radio frequency, but no signal can be obtained from earphones or from oscilloscope terminals, check voltages of V6 and its components against those listed in Table 2.

4.3.7 ONE MULTIVIBRATOR OUTPUT (1 MC - 10 MC) MISSING IN BOTH AUDIO AND TIMING MARKER POSITIONS; ONE OR MORE MULTIVIBRATORS UNSTABLE. When a 10-Mc harmonic spectrum and a 10-Mc timing signal both appear, but no output appears at the output terminal in the 1-Mc switch position, check the 1-Mc multivibrator, V3. Note that with the switch in the 100-kc and 10-kc positions there will be a signal of an incorrect and probably unstable frequency.

Correct 10-Mc and 1-Mc outputs with a missing 100-kc output and an unstable 10-kc output indicates difficulty in the 100-kc multivibrator unit only. With only the 10-kc output missing, it is necessary to test only V5 and its components.

4.3.8 ALL MULTIVIBRATOR OUTPUTS PRESENT BUT ONE OR MORE OF INCORRECT FREQUENCY OR UNSTABLE. Instability in the 1-Mc multivibrator output will cause the 100-kc and 10-kc units to be unstable also. When all three lower-frequency output signals exhibit instability, check V3 and adjust C16 and C18 to compensate for the aged tube or changed component responsible. (This type of failure is more likely to occur in this type of circuit as tubes age toward the reject point or as component values drift.) Another possible cause of failure of V3 to synchronize properly is a loss of trigger voltage due to a gradual weakening of the buffer stage, V2.

Instability of the 100-kc and 10-kc units points to a failure of the 100-kc unit to synchronize. Replace V4 or adjust C22 and C24 for correct operation as outlined in paragraph 4.2.3.2.

4.3.9 LACK OF FREQUENCY STABILITY IN ALL OUTPUT SIGNALS FROM INSTRUMENT. A general lack of frequency stability throughout the instrument is an indication either of a defective quartz crystal unit or an unusual difficulty in the oscillator tube (V1) or its components. Replace V1, and if the trouble persists, check its associated components and voltages, possibly replacing V1's screen resistor. At this point, if the oscillator is still malfunctioning, it will probably be necessary to order a replacement crystal from General Radio Company.

4.3.10 ALL R-F AND VIDEO SIGNAL OUTPUTS PRESENT, BUT INSTRUMENT LACKS SENSITIVITY TO INJECTED R-F SIGNAL AT R-F IN/OUT TERMINAL. This is an indication of a lack of mixer efficiency. The component most worthy of inspection is diode D1, the germanium mixer crystal. Replace this component.

Section 5
PARTS LIST

					GR No. (NOTE A)
RESISTORS (NOTE B)	R1	2.2 M	±5%	½ w	REC-20BF
	R2	220 k	±1%	¼ w	REF-65
	R3	100 k	±5%	½ w	REC-20BF
	R4	270 k	±5%	½ w	REC-20BF
	R5	1 k	±5%	½ w	REC-20BF
	R6	75 k	±5%	½ w	REC-20BF
	R7	22 k	±5%	½ w	REC-20BF
	R8	5 k	±5%	10 w	REPO-44
	R9	7.5 k	±5%	10 w	REPO-44
	R10	1 k	±5%	½ w	REC-20BF
	R11	5.1 k	±5%	2 w	REC-41BF
	R12	43 k	±5%	½ w	REC-20BF
	R13	43 k	±5%	½ w	REC-20BF
	R14	5.1 k	±5%	2 w	REC-41BF
	R15	100	±5%	½ w	REC-20BF
	R16	100	±5%	½ w	REC-20BF
	R17	22 k	±5%	1 w	REC-30BF
	R18	270 k	±5%	½ w	REC-20BF
	R19	270 k	±5%	½ w	REC-20BF
	R20	22 k	±5%	1 w	REC-30BF
	R21	100	±5%	½ w	REC-20BF
	R22	100	±5%	½ w	REC-20BF
	R23	100	±5%	1 w	REC-30BF
	R24	910 k	±5%	½ w	REC-20BF
	R25	910 k	±5%	½ w	REC-20BF
	R26	100 k	±5%	1 w	REC-30BF
	R27	100	±5%	½ w	REC-20BF
	R28	100	±5%	½ w	REC-20BF
	R29	250 k	±10%		POSC-12
	R30	1 M	±5%	½ w	REC-20BF
	R31	1.1 M	±5%	½ w	REC-20BF
	R32	8.2 k	±10%	1 w	REC-30BF
	R33	6.8 M	±5%	½ w	REC-20BF
	R34	91 k	±5%	½ w	REC-20BF
	R35	100 k	±5%	½ w	REC-20BF
	R36	1.5 k	±5%	½ w	REC-20BF
	R37	1.5 k	±5%	½ w	REC-20BF
	R38	1 M	±5%	½ w	REC-20BF
	R39	22 k	±5%	½ w	REC-20BF
	R40	10 M	±5%	½ w	REC-20BF

					GR No. (NOTE A)
RESISTORS (NOTE B)	R41	120 k	±5%	½ w	REC-20BF
	R42	100 k	±5%	½ w	REC-20BF
	R43	51	±5%	½ w	REC-20BF
	R44	1 M	±5%	½ w	REC-20BF
	R45A	36 k	±5%	2 w	REC-41BF
	R45B	36 k	±5%	2 w	REC-41BF
	R46	51 k	±5%	½ w	REC-20BF
	R47	2.7 k	±5%	½ w	REC-20BF
	R49	10 k	±5%	½ w	REC-20BF
CAPACITORS (NOTE C)	C1	10	±10%	500 dcwv	COM-20B
	C2	2.8-16			COA-28
	C3	150	±2%	500 dcwv	COM-5E
	C4	4-50			COA-2
	C5	150	±2%	500 dcwv	COM-5E
	C6	1-8			COT-26
	C7	10	±10%	500 dcwv	COC-21 (NPO)
	C8	0.01 μf	+100%-0	500 dcwv	COC-63
	C9	22	±10%	500 dcwv	COC-21 (NPO)
	C10	0.01 μf	+100%-0	500 dcwv	COC-63
	C11	0.002 μf	±5%	500 dcwv	COM-5D
	C12	47	±10%	500 dcwv	COC-21 (N750)
	C13	1-8			COT-26
	C14	10	±10%	500 dcwv	COC-21 (NPO)
	C15	30	±2%	500 dcwv	COM-5E
	C16	1-12			COT-26-2
	C17	30	±2%	500 dcwv	COM-5E
	C18	1-12			COT-26-2
	C19	0.01 μf	+100%-0	500 dcwv	COC-63
	C20	10	±10%	500 dcwv	COC-21 (NPO)
	C21	33	±2%	500 dcwv	COM-5E
	C22	1-12			COT-26-2
	C23	33	±2%	500 dcwv	COM-5E
	C24	1-12			COT-26-2
	C25	0.01 μf	+100%-0	500 dcwv	COC-63
	C26	3.3	±10%	500 dcwv	COC-1
	C27	3.3	±10%	500 dcwv	COC-1
	C28	47	±10%	500 dcwv	COC-21 (N750)
	C29	100	±2%	500 dcwv	COM-5E
	C30	1-12			COT-26-2
	C31	100	±2%	500 dcwv	COM-5E
	C32	1-12			COT-26-2

Parts List (cont.)

					GR No. (NOTE A)				GR No. (NOTE A)
CAPACITORS (NOTE C)	C33	0.01 μf	+100%-0	500 dcwv	COC-63	MISCELLANEOUS	D1	Diode	1N34A
	C34	3.3	±10%	500 dcwv	COC-1		D2	Diode	1N455A
	C35	3.3	±10%	500 dcwv	COC-1		D3	Diode	1N67A
	C36	10	±10%	500 dcwv	COC-21 (NPO)		D4	Diode	1N67A
	C37	39	±10%	500 dcwv	COC-21 (N750)		J1	Jack, Coaxial output	Part of 1213-202
	C38	0.1 μf	±10%	400 dcwv	COW-25				
	C39	0.0047 μf	±10%	200 dcwv	COW-16		J2	Jack	BP-5
	C40	25	±10%	500 dcwv	COC-21 (N750)		J3	Jack	BP-5
	C41	0.01 μf	+100%-0	500 dcwv	COC-63		L1	Inductor, 7 μf	ZCHA-52
	C42	0.0047 μf	+100%-0	500 dcwv	COC-62		L2	Inductor, Variable	1213-201
	C43	0.0047 μf	+100%-0	500 dcwv	COC-62		L3	Inductor, Variable	1213-41
	C44	0.01 μf	+100%-0	500 dcwv	COC-63		L4	Inductor, Variable	1213-40
	C45	0.001 μf	(GMV-0%)	500 dcwv	COC-3		PL1	Plug, Power	CDMP-11-4
	C46	0.0047 μf	+100%-0	500 dcwv	COC-62		Q1	Crystal, Quartz, 5000 kc	CRP-1
	C47	0.01 μf	+100%-0	500 dcwv	COC-63		S1	Switch, Rotary	SWRW-137
	C48	0.01 μf	+100%-0	500 dcwv	COC-63		S2	Switch, Rotary	SWRW-138
	C49	47	±10%	500 dcwv	COC-21 (N750)		V1	Tube	6BE6
	C50	100	±10%	500 dcwv	COC-21		V2	Tube	6AU6
	C51	2.2	±10%	500 dcwv	COC-1		V3	Tube	5687
	C52	20	±5%	500 dcwv	COM-20D		V4	Tube	5964
	C53	3.3	±5%	500 dcwv	COC-1		V5	Tube	5964
	C54	15	±10%	500 dcwv	COC-21 (NPO)		V6	Tube	6AN8
	C55	330	±10%	500 dcwv	COC-21		V7	Tube	6U8

NOTES

(A) Type designations for resistors and capacitors are as follows:

COA – Capacitor, air	COW – Capacitor, wax
COC – Capacitor, ceramic	POSC – Potentiometer, composition
COM – Capacitor, mica	REC – Resistor, composition
COT – Capacitor, trimmer	REPO – Resistor, power

(B) All resistances are in ohms unless otherwise specified by k (kilohms) or M (megohms).

(C) All capacitances are in micromicrofarads unless other specified by μf (microfarads).

When ordering replacement components, be sure to include complete description as well as Part Number. (Example: R85, 51 k ±10%, ½ w, REC-20BF.)

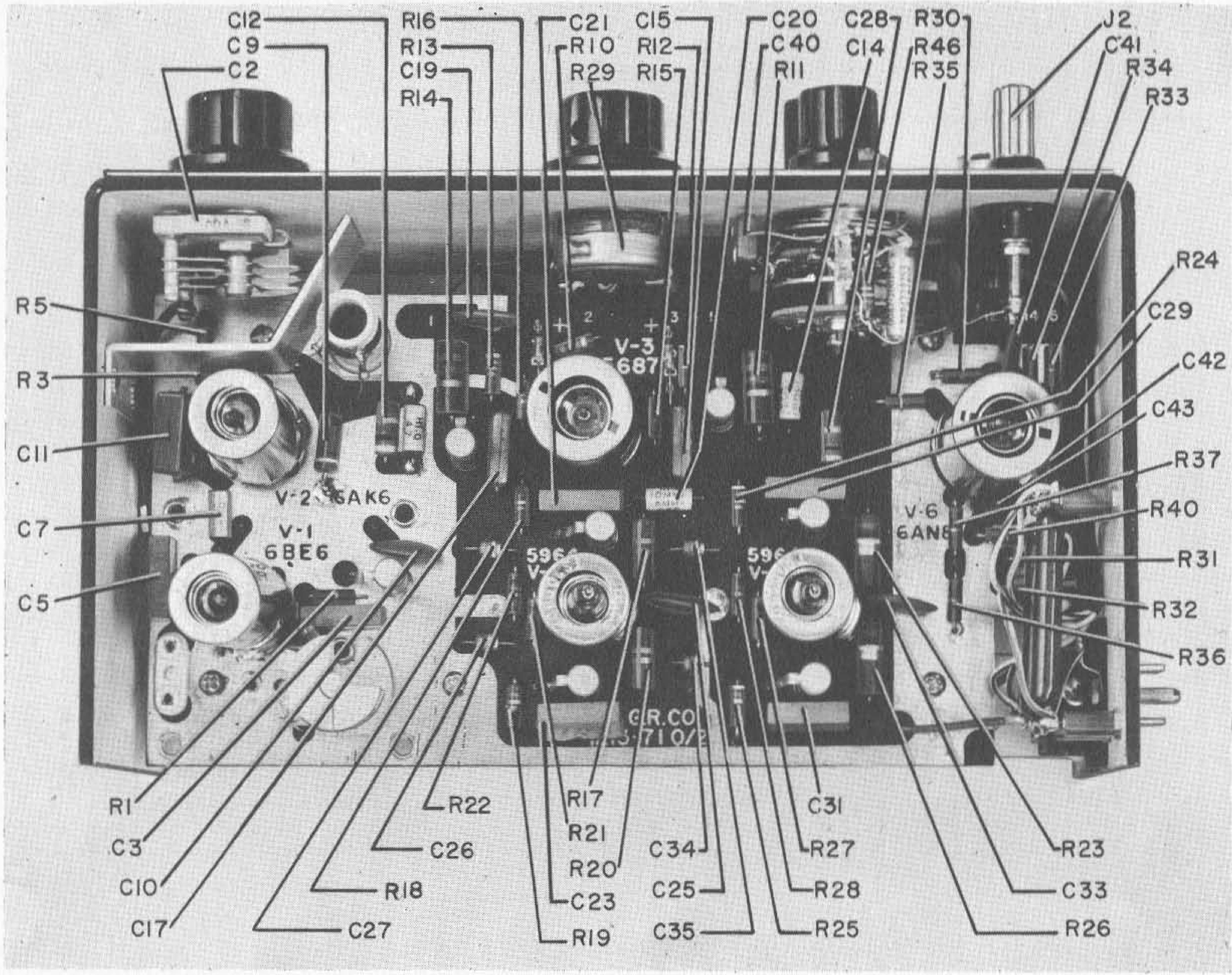

Figure 4. Top Interior View.

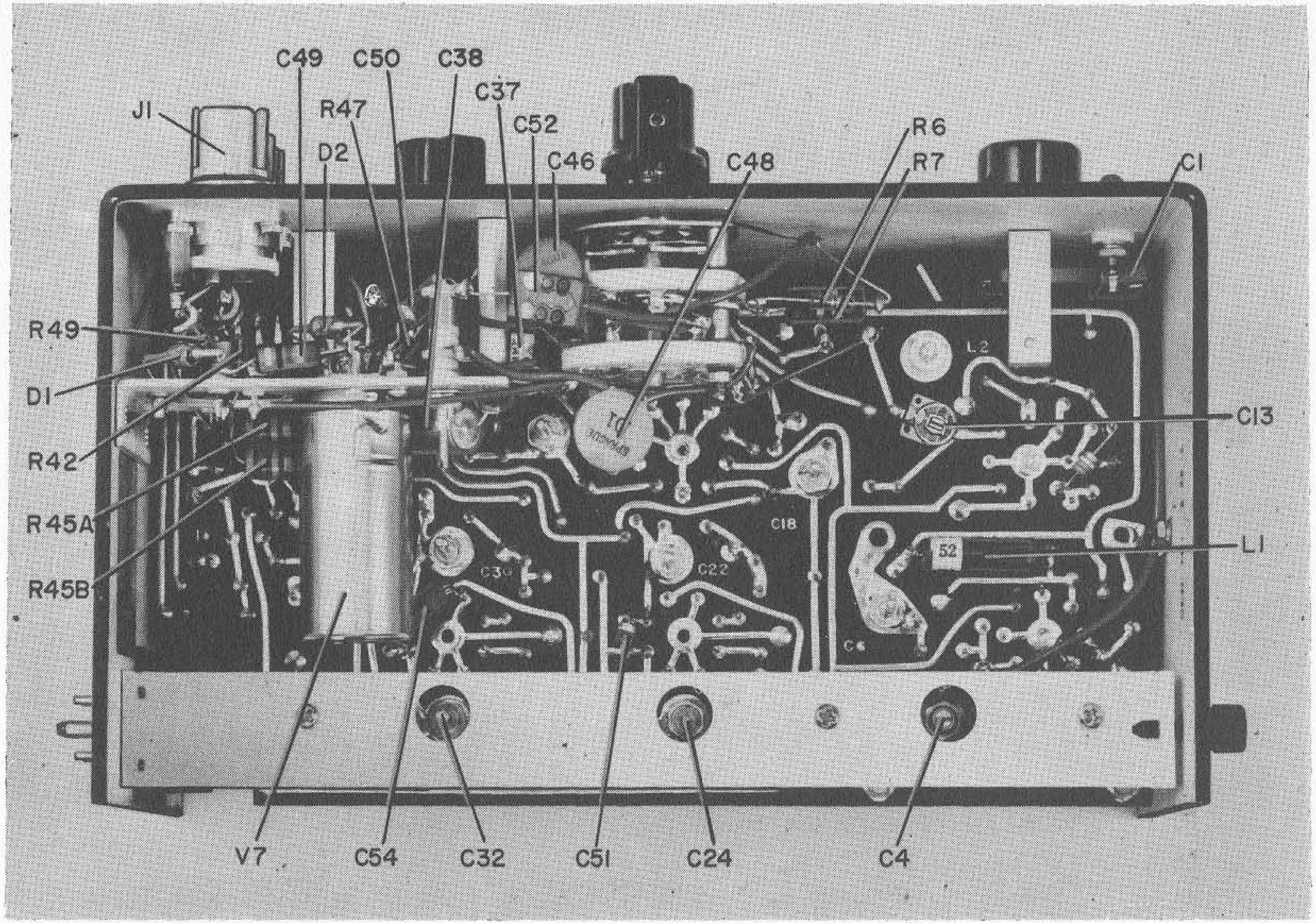

Figure 5. Bottom Interior View.

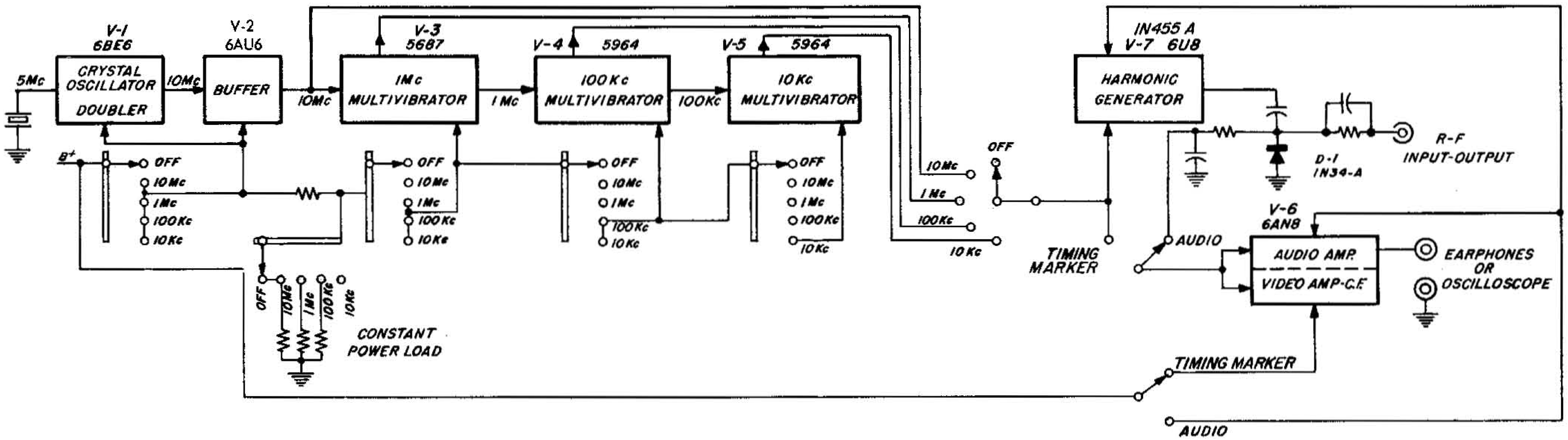

Figure 6. Block Diagram.

Figure 7. Schematic Diagram.

GENERAL RADIO COMPANY

275 MASSACHUSETTS AVENUE, CAMBRIDGE 39, MASS.

TRowbridge 6-4400

DISTRICT OFFICES

NEW YORK

Broad Ave. at Linden, Ridgefield, N. J.

Telephone N.Y. WOrth 4-2722
N.J. WHitney 3-3140

PHILADELPHIA

1150 York Rd., Abington, Penna.

Telephone HAncock 4-7419

WASHINGTON

8055 13th St., Silver Spring, Md.

Telephone JUniper 5-1088

CHICAGO

6605 West North Ave., Oak Park, Ill.

Telephone VIllage 8-9400

LOS ANGELES

1000 N. Seward St., Los Angeles 38, Calif.

Telephone HOllywood 9-6201

SAN FRANCISCO

1182 Los Altos Ave., Los Altos, Calif.

Telephone WHitecliff 8-8233

CANADA

99 Floral Pkwy., Toronto 15, Ont.

Telephone CHerry 6-2171

REPAIR SERVICES

EAST COAST

General Radio Company

Service Department

22 Baker Ave., W. Concord, Mass.

Telephone EMerson 9-4400

MIDWEST

General Radio Company

Service Department

6605 West North Ave., Oak Park, Ill.

Telephone VIllage 8-9400

WEST COAST

Western Instrument Co.

826 N. Victory Blvd., Burbank, Calif.

Telephone VIctoria 9-3013

CANADA

Bayly Engineering, Ltd.

First Street, Ajax, Ontario

Telephone Toronto EMpire 8-6866

Printed in USA