INSTRUCTION MANUAL

TYPE 1142-A

FREQUENCY METER AND DISCRIMINATOR

Form 1142-0100-E
ID B740
July, 1969

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

Condensed Operating Instructions

INTERPOLATION OFFSET FREQUENCY

Set this switch to the first digit of the meter indication. Then set the METER FUNCTION switch to INTERPOLATION. The meter indicates remaining digits.

METER FUNCTION

Selects DIRECT mode (frequency indicated on meter) or INTERPOLATION mode (frequency indicated by INTERPOLATION OFFSET FREQUENCY switch setting and meter, effectively increasing meter precision).

INTERP CAL

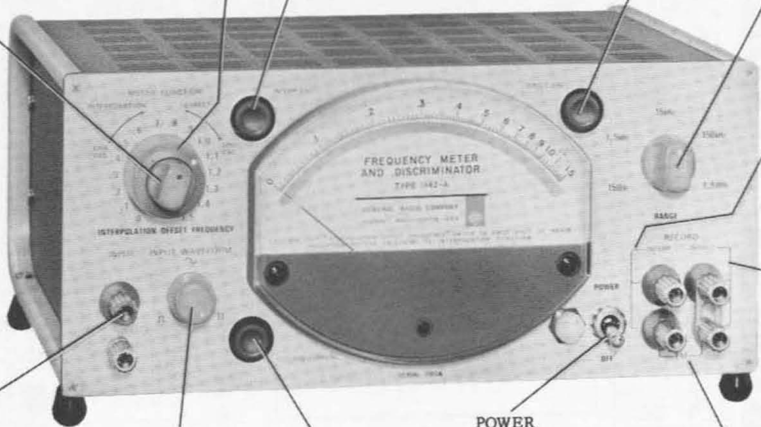
Calibrates frequency meter for INTERPOLATION mode. After DIRECT CAL is set, adjust for zero meter indication with the INTERPOLATION OFFSET FREQUENCY control set to 1.2 for 60-hertz lines or 1.0 for 50-hertz lines.

DIRECT CAL

Calibrates frequency meter for DIRECT mode. With no input signal and 150-hertz range, adjust for meter indication of twice the power-line frequency.

RANGE

Selects frequency range.



INTERP RECORD

Provides 0.64 volt behind 4800 Ω for full scale on interpolation ranges. Use a floating high-input-impedance recorder.

DIRECT RECORD

Provides 0 - 5 ma to operate a recorder. Remove the link, connect the recorder, and calibrate with the RECORD CURRENT control.

INPUT

Input signal may be of any waveform and should be between 30 mv and 300 v peak voltage (70 volts max above 150 kHz). For amplitude-modulated input signal, refer to paragraph 3.7.3.

POWER

Turns instrument on.

FM

Set the RANGE switch for a suitable deflection of the meter. Connect the ground link as shown. Use an ac voltmeter with a suitable low-pass filter to reject the carrier frequency. A 10-kHz low-pass, single-section RC filter is built in. The fm deviation in Hz is $\frac{V_{ac}}{15\ v}$ times the RANGE switch setting. If the external filter attenuates the ac voltage, the indicated fm deviation will be attenuated similarly. With a wave analyzer, individual components of fm can also be measured.

RECORD CURRENT

Adjusts the level of output current at the DIRECT RECORD terminals. Output current is proportional to frequency. A single-frequency calibration will serve all ranges. To calibrate the recorder from the power-line frequency, set the METER FUNCTION switch to DIRECT CAL, the RANGE switch to 150 Hz and set the RECORD CURRENT control for a suitable recorder deflection.

INPUT WAVEFORM

For maximum sensitivity, set according to input waveform. To check the input-signal level, turn a few degrees back and forth. If the meter deflection varies, the input level is too low.

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SPECIFICATIONS

INPUT:

Frequency: 3 cps to 1.5 Mc in 5 decade ranges, with full-scale values of 150 cps to 1.5 Mc.
Maximum Voltage: 300 V peak-to-peak up to 150 kc, 70 V peak-to-peak above 150 kc.
Sensitivity (rms/Impedance): 20 mv, 20 cps to 150 kc; rising to 200 mv at 3 cps and 1.5 Mc. Up to 5 V for narrow pulses (1 ns). 100-kΩ impedance dropping to minimum of 5 kΩ above 500 kc.

DISPLAY

Meter: A calibrated interpolation feature expands meter scale by a factor of 10 so that 1/10 of any range covers the full scale.

ACCURACY

General: Internal calibration at twice line frequency to standardize output current. Over-all accuracy is the sum of recorder output current accuracy and any of the following errors that are applicable.
Recorder Output Current Accuracy: Below 15 kc, 0.05% of full scale +0.05% of reading; above 15 kc, 0.1% of full scale +0.1% of reading.
Meter Accuracy: Direct reading, 1% of reading above 10% of full scale (0.1% of full scale below 10% of full scale). Interpolating, 0.1% of full scale (range switch setting).
Line-Voltage Effect: ±10% change produces approximately ±0.2% change in reading (±0.5% on 1.5-Mc range).
Warmup Drift: Less than 0.2% of reading after a few minutes, substantially complete within 30 minutes.
Ambient-Temperature Effect: Output current changes less than 0.01%/°C (0.02%/°C on 1.5-Mc range).

DISCRIMINATOR CHARACTERISTICS

Output Voltage: 15 V dc full scale (1.5) on all ranges.
Residual FM Noise: Below 1 Mc, noise is more than 100 db below full output. (With 400-cycle power, noise is 90 db down.) Narrow-band residual noise at frequencies other than 60 or 120 cps is more than 120 db down from full output.
Linearity: Below 15 kc, 0.05% of full scale (15 V) ±0.05% of output voltage; above 15 kc, 0.1% of full scale (15 V) ±0.1% of output voltage.

RECORDER OUTPUT

Direct: Output current adjustable to drive recorders from 1 mA (2.7 kΩ max) to 5 mA (190 Ω max).
Interpolate: Full scale, 0.64 V behind 4.8 kΩ.

POWER REQUIRED: 105 to 125 or 210 to 250 V, 50 to 400 cps, 85 w.
ACCESSORIES SUPPLIED: Type CAP-22 Power Cord, spare fuses.
ACCESSORIES AVAILABLE: Type 480-P312 Relay-Rack Adaptor Set, panel height 5¼ in.
DIMENSIONS: Width 12, height 5-7/8, depth 12 inches (305 by 150 by 305mm).
NET WEIGHT: 16 lb (7.5 kg).
SHIPPING WEIGHT: 23 lb (10.5 kg).
General Radio Experimenter reference: January 1961.

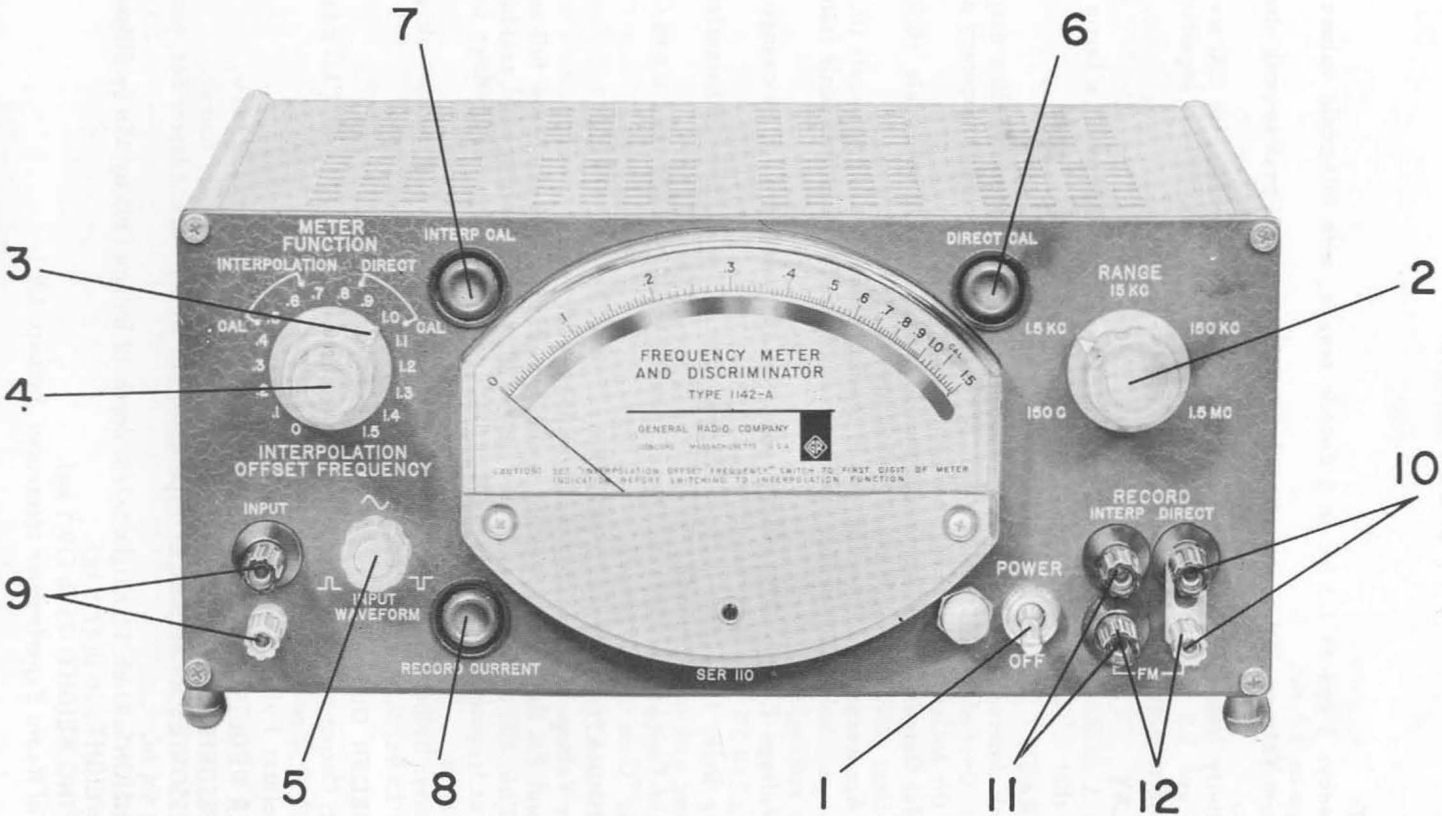


Figure 1. Type 1142-A Frequency Meter and Discriminator. (For legend, see page 2.)

TYPE 1142-A FREQUENCY METER AND DISCRIMINATOR

Section 1 INTRODUCTION

1.1 PURPOSE.

The Type 1142-A Frequency Meter and Discriminator directly measures the frequency of any signal (sine wave, square wave, or pulse) from 3 cps to 1.5 Mc. As a discriminator, the Type 1142-A can be used in combination with an ac voltmeter to measure fm deviation. With a wave analyzer, individual components of incidental fm in oscillators and multipliers can be measured. The usable frequency range, particularly for frequency-drift and incidental fm measurements, can be extended upward to thousands of megacycles if the frequency to be measured is heterodyned with a frequency standard. This gives a proportionate increase in resolution. With the addition of a recorder, such as the Type 1521-B Graphic Level Recorder, a recording of the measured frequency or of drift can be made.

1.2 DESCRIPTION.

1.2.1 GENERAL. The Type 1142-A Frequency Meter and Discriminator is basically a frequency-to-dc converter operating on the principles of a pulse-count discriminator. The input signal is fed to two stages of limiters and amplifiers and then to a Schmitt circuit, which generates a 0.1-μsec pulse for each input cycle. This pulse is amplified and used to trigger a monostable multivibrator, which generates a constant-duration pulse. The output of the monostable multivibrator is fed to an output stage, which supplies a constant-duration, constant-amplitude pulse to the meter circuit. The meter indicates the average current of the output stage, and thus the input frequency.

To ensure low-noise operation of the discriminator, each output pulse is generated at the positive-going zero crossings of the input signal. The pulse train is pulse-frequency-modulated (pfm) by an fm input signal. If the carrier frequency is filtered, the modulating signal can be recovered and measured by an ac voltmeter.

The residual noise level of the discriminator is 100 db below full scale for carrier frequencies below 1 Mc, consisting mainly of the fundamental and second harmonic of the power-line frequency. All other frequencies are down 120 db or more, permitting a resolution of one part per million of full scale (of the range in use).

Because the meter indicates the average current in the output stage, the Type 1142-A Frequency Meter and Discriminator measures the average frequency of an aperiodic or random input signal. Signals may be derived from photocell devices, tachometers, geiger tubes, magnetic pickups, or any other transducer that can supply a 30-mv-peak signal. While the maximum full-scale range is 1.5 Mc, the Type 1142-A responds to extremely short-duration pulses, e.g., 1 nsec or less, but requires an increase in input signal.

1.2.2 CONTROLS AND CONNECTORS. All controls and connectors except the power-cord receptacle are on the front panel of the Type 1142-A (see Figure 1). The functions of these controls and connectors are as follows (index numbers refer to Figure 1):

Fig. 1 Ref	Name	Type	Function (Paragraph Reference)
1	POWER	2-pos toggle switch	Turns instrument on (2.2).
2	RANGE	5-pos rotary selector switch	Selects frequency range (2.3b).
3	INTERPOLATION OFFSET FREQUENCY	16-pos rotary selector switch	With METER FUNCTION at DIRECT, frequency is indicated on meter scale. At INTERPOLATION, frequency is indicated by OFFSET FREQUENCY control setting and meter scale, effectively increasing meter precision [2.3c (1) and (2)].
4	METER FUNCTION	4-pos rotary selector switch (coaxial with INTERPOLATION OFFSET FREQUENCY)	
5	INPUT WAVEFORM	Continuous rotary control	Adjusts sensitivity as a function of input waveform (3.3).
6	DIRECT CAL	Thumbset adjustment	Calibrates frequency meter for DIRECT mode (2.6).

(Continued)

(Continued)

Fig. 1 Ref	Name	Type	Function (Paragraph Reference)
7	INTERP CAL	Thumbset adjustment	Calibrates frequency meter for INTERPOLATION mode (2.6).
8	RECORD CURRENT	Thumbset adjustment	Adjusts level of output at DIRECT RECORD terminals (2.5).
9	INPUT	Jack top binding post pair	Input terminals (2.3).
	RECORD		
10	DIRECT	Jack top binding post pair	Output terminals for recorder (2.5.2 and 2.5.3).
11	INTERP	Jack top binding post pair	
12	FM	Jack top binding post pair (two of RECORD terminals)	Discriminator output (2.4.2).

Section 2
OPERATING PROCEDURE

2.1 POWER REQUIREMENTS AND INSTALLATION.

The Type 1142-A Frequency Meter and Discriminator can be operated from either a 115- or 230-volt, 50- to 60- or 400-cycle line. The instrument can be adapted from 115-volt to 230-volt operation or vice versa by a minor wiring modification (refer to Figure 25).

Provisions have been incorporated for adequate cooling of the instrument, but the ventilation holes at the top and bottom of the cover should not be obstructed.

The Type 1142-A can be rack-mounted by the use of the Type 480-P 312 Panel Extensions.

To remove the front rubber feet, unscrew them from the extension legs.

The instrument should not be operated in ambient temperatures above 50 °C, and thus must not be placed directly above a high-dissipation instrument without adequate spacing between units.

2.2 INITIAL CONTROL SETTINGS.

Before using the instrument, it is desirable to check the calibration and recalibrate, if necessary. For calibration procedure, refer to paragraph 2.6.

Before applying power to the instrument, make sure that the power-line frequency and voltage are as indicated on the nameplate adjacent to the power-input connector. Then proceed as follows:

a. Connect the instrument to the power line using the power cable supplied. The cable is for three-wire service.

b. Set the METER FUNCTION switch to DIRECT.

c. Set the RANGE switch to 1.5 Mc.

d. Snap the POWER switch on. The pilot lamp should light.

It is best to allow the instrument to warm up for about 30 minutes before checking or setting calibration

2.3 OPERATION AS A FREQUENCY METER.

a. With controls set as described in paragraph 2.2, connect the signal whose frequency is to be measured to the INPUT terminals. Note that the lower INPUT terminal is grounded. The input signal may be of any waveform and should be between 30 mv and 300 v peak voltage.

b. Set the RANGE switch for the highest on-scale deflection of the meter. To check that the input-signal level is adequate, turn the INPUT WAVEFORM control a few degrees back and forth. If the meter deflection varies, the input level is too low.

c. Read the frequency on the meter scale, taking into account the position of the RANGE switch. The accuracy of this reading is ±1% of reading. If greater precision is desired, use the following INTERPOLATION procedure.

(1) Set the INTERPOLATION OFFSET FREQUENCY switch (the outer of the two coaxial switches) to the digit corresponding to the first digit (or first two digits of numbers between 1.0 and 1.5) of the meter indication. (For example, if the meter indication is 0.38, the switch should be set to 0.3. If the indication is 1.26, the switch should be set to 1.2.)

(2) Set the METER FUNCTION switch to INTERPOLATION. The position of the INTERPOLATION OFFSET FREQUENCY switch now indicates the first digit (or digits) of the frequency, and the meter indicates the following digits. For instance, if the INTERPOLATION OFFSET FREQUENCY switch is at 0.3 and the meter indication is 0.79, the significant figures of the frequency are 379. If the switch is at 1.2 and the meter indication is 0.61, the significant figures are 1261. (The actual frequency in each case depends, of course, on the position of the RANGE switch. With the RANGE switch at 1.5 kc, the frequencies in the above examples would be 379 cps and 1.261 kc, respectively.)

d. For use with a recorder, refer to paragraph 2.4.

2.4 USE OF THE FREQUENCY METER WITH A RECORDER.

2.4.1 GENERAL. Frequency measurements made with the Type 1142-A can be displayed on most standard 1- and 5-ma recorders, such as the General Radio Type 1521-B Graphic Level Recorder. The meter on the Type 1142-A will continue to indicate the frequency being measured during recording, and can thus be used in the calibration of the recorder. In addition to conventional DIRECT recorder output terminals, the Type 1142-A includes separate output connections for recording in the interpolation mode of operation. Refer to paragraph 2.4.3.

2.4.2 DIRECT RECORD OPERATION. Before making recordings, it will be necessary to calibrate the recorder. A simple method of calibrating is as follows:

a. Set controls for normal frequency-meter operation, as described in paragraph 2.2.

b. Set the METER FUNCTION switch to DIRECT CAL and the RANGE switch to 150 C.

c. Disconnect the ground link from the DIRECT RECORD terminals and connect the recorder to these binding posts.

d. Adjust the RECORD CURRENT control to place the calibrating frequency (120 cps) as desired on the recorder paper. If the 120-cycle point is set at 4/5 of full scale, full scale on the recorder will thereafter correspond to full scale on the meter. This calibration will hold for all positions of the RANGE switch. If the recorder pen vibrates excessively, because of its attempt to follow the pulsating dc signal at these RECORD terminals (refer to paragraph 3.6), a low-pass filter will be required. This may simply consist of a capacitor (e.g., 1-4μf) across these terminals; or if additional filtering is necessary, a more complex filter, such as the one shown in Figure 2, can be used. The values of R and C depend upon the sensitivity of the particular recorder being used and can therefore be determined experimentally.

The recorder can be calibrated by use of a known frequency supplied by an oscillator or signal generator. Any signal, including that to be recorded, can be measured first on the Type 1142-A and then used to calibrate the recorder. A single-frequency calibration will serve for all ranges of the Type 1142-A.

2.4.3 INTERPOLATION RECORD OPERATION. To make recordings using the interpolation feature, a high-impedance (about 100 kilohms or higher) recorder is required.

Operation of the Type 1142-A with a recorder is the same as normal operation of the frequency meter (refer to paragraph 2.3).

Since both INTERP RECORD terminals are above ground, both input terminals of the recorder must be ungrounded. If it is more convenient, the Type 1142-A may be ungrounded, in which case one terminal of the recorder may be grounded.

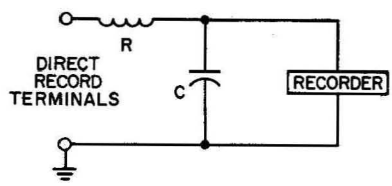


Figure 2. Low-pass filter to be used with a recorder.

The recorder must be calibrated before use with the frequency meter. The calibration procedure is as follows:

a. Set the controls for normal frequency-meter operation, as described in paragraph 2.2.

b. Connect a variable-frequency oscillator, with the same frequency range as the Type 1142-A, to the INPUT terminals.

c. Measure this frequency as described in paragraph 2.3, using the interpolation feature.

d. At the conclusion of the interpolation measurement (step c (2) of paragraph 2.3), adjust the frequency of the variable-frequency oscillator so that the meter of the Type 1142-A indicates 0.

e. Connect the recorder to the INTERP RECORD terminals and set the recorder pen to the desired zero position on paper. If the recorder pen vibrates excessively, because of its attempt to follow the pulsating dc signal at these INTERP RECORD terminals (refer to paragraph 3.6) a low-pass filter will be required. This may simply consist of a capacitor (1-4 μf) across these terminals; or, if additional filtering is necessary, a more complex filter, such as the one shown in Figure 2, may be used, except that the DIRECT RECORD terminals are replaced by the INTERP RECORD terminals.

Disconnect the recorder from the Type 1142-A.

f. Increase the frequency of the variable-frequency oscillator by an amount equal to the desired full-scale indication on the recorder. If the oscillator does not cover the frequencies to be recorded, increase the frequency by an amount equal to

$$f_r \frac{R_c}{R_r}$$

where f_r = frequency spread to be recorded

R_c = RANGE setting for calibration

R_r = RANGE setting for recording.

This amount can be read directly from the meter of the Type 1142-A. Reconnect the recorder to the frequency meter.

g. Adjust the sensitivity control on the recorder so that the pen is at full scale.

The recorder calibration is now constant in percentage of RANGE switch setting for any position of the RANGE switch. For any one position of the switch, therefore, the frequency coverage of the recorder is constant for any position of the INTERPOLATION OFFSET FREQUENCY switch.

Suppose we wish to record the drift of an oscillator whose frequency varies between 1.000 and 1.007 Mc. Choose a frequency scale of 1.00 to 1.01 Mc on the recorder, to allow for some overlap. Note that the frequencies will be recorded on the 1.5 MC RANGE setting and the desired frequency spread (1.00 to 1.01 Mc) is 10 kc.

Use a variable-frequency oscillator to supply a signal of unknown frequency to the INPUT terminals of the Type 1142-A. Measure this frequency in the direct mode; suppose the meter indicates that it is 5.1 kc on the 15 KC range. Therefore, set the INTERPOLATION OFFSET FREQUENCY switch to 0.5 (the first digit) and the METER FUNCTION switch to INTERPOLATION. The meter will now indicate on scale, say at 0.12. Decrease the frequency of the oscillator until the meter on the Type 1142-A indicates 0. The output voltage at the INTERP RECORD terminals is now 0. Attach the recorder to these terminals and set the pen at zero by means of the recorder zero-set control. Then disconnect the recorder from the INTERP RECORD terminals.

Increase the oscillator frequency by an amount given by the formula in paragraph 2.4.3,f. In this case it is 10 kc $\times \frac{15 \text{ kc}}{1.5 \text{ Mc}}$ or 100 cps. This 100 cps is indicated by a meter reading of 0.10 on the Type 1142-A. Then reconnect the recorder and adjust its sensitivity for full-scale indication. The recorder coverage is now 100 cps with the Type 1142-A RANGE switch at 15 KC. If the RANGE switch setting is changed to 150 C, 1.5 KC, 150 KC, or 1.5 MC, the recorder coverage becomes 1 cps, 10 cps, 1 kc, or 10 kc, respectively.

Returning to the example, set the RANGE switch to 1.5 MC and the INTERPOLATION OFFSET FREQUENCY switch to 1.0. The recorder now has a frequency coverage of 1.00 to 1.01 Mc.

2.5 OPERATION AS A DISCRIMINATOR.

2.5.1 GENERAL. The Type 1142-A always operates as both frequency meter and discriminator, and during measurement of fm deviation will continue to indicate the carrier frequency on its meter. The operation of the controls is as described in paragraph 2.3, except that the INTERPOLATION mode of operation is not used in fm deviation measurements. Therefore, the METER FUNCTION switch is left at DIRECT.

2.5.2 MEASUREMENT OF FM DEVIATION.

a. With the controls set as described in paragraph 2.2, connect the signal whose fm deviation is to be measured to the INPUT terminals. Note that the lower INPUT terminal is grounded. The input signal may be of any waveform and should be between 30 mv and 300 v peak voltage.

b. Set the RANGE switch for the highest on-scale deflection of the meter. If the meter does not indicate at any position of the RANGE switch, adjust the INPUT WAVEFORM control as necessary, to obtain a deflection.

c. To check that the input signal level is adequate, turn the INPUT WAVEFORM control a few degrees back and forth. If the meter deflection varies, the input level is too low.

d. Connect the ground link between the DIRECT RECORD terminals as shown in Figure 3.

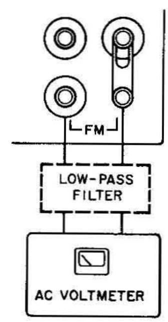
e. Connect an ac voltmeter between the FM terminals, as shown in Figure 3. A low-pass filter is usually required to filter out the carrier while passing the modulating frequency (refer to paragraph 3.6). If the ac voltmeter used is a wave analyzer, it will be possible to determine the individual components of the modulation.

f. Convert the voltage indicated on the voltmeter to frequency deviation by using the following simple equation:

$$\text{fm deviation} = \frac{V_{ac}}{V_{dc}} \text{(RANGE switch setting).}$$

If there is no dc attenuation in the low-pass filter, V_{dc} equals 15 volts; otherwise, with a high-impedance dc voltmeter, measure V_{dc} when the frequency meter indicates full scale on any range. In the equation, fm deviation will be in the units of the RANGE switch setting, and will be either rms or peak, depending upon whether an rms- or peak-reading voltmeter is used.

Figure 3. Connection Diagram for FM Deviation Measurement.



For example, using a low-pass filter with no dc attenuation and with a voltmeter indication of 1 mv and the RANGE switch at 150 kc, the rms fm deviation is determined as follows:

$$\text{fm deviation} = \frac{0.001}{15}(150 \text{ kc}) = 0.01 \text{ kc} = 10 \text{ cps}$$

2.5.3 MEASUREMENT OF FM DEVIATION AT HIGH MODULATING FREQUENCIES.

To facilitate use of the discriminator with conventional ac voltmeters, the fm output circuit includes a low-pass 10-kc single-section RC filter. In fm deviation measurements at modulating frequencies above 10 kc, it may be desirable to bypass this filter. This is very easily accomplished; the output is simply taken from the DIRECT RECORD terminals rather than from the FM terminals. This connection not only bypasses the low-pass filter, but also, since it is a lower impedance, effectively raises the maximum modulating frequency that can be measured. With this connection, however, the output voltage is reduced and is uncalibrated. †

The procedure for measuring fm deviation using the output at the DIRECT RECORD terminals is as follows:

a. Move the ground link from the DIRECT RECORD to the FM terminals. If a wide-band ac voltmeter is to be used, a low-pass filter should be connected between the DIRECT RECORD terminals and the voltmeter, to filter out the carrier while passing the modulating frequency (refer to paragraph 3.6).

b. Connect a 3- or 5-volt dc voltmeter, whose input impedance is high compared with the filter resistance, across the filter output, or across the DIRECT RECORD terminals if no filter is used.

c. It will now be necessary to calibrate the dc output voltage against a known frequency. The known frequency may be the 120-cycle internal calibrating signal or an external signal applied at the INPUT terminals. (The frequency of the external signal may have been measured as described in paragraph 2.3.) If the internal 120-cycle calibrating signal is to be used, set the METER FUNCTION switch to DIRECT CAL and the RANGE switch to 150 C. If an external calibrating signal is to be used, set the METER FUNCTION switch to DIRECT and the RANGE switch to produce an on-scale meter deflection.

d. Adjust the RECORD CURRENT control for any convenient dc output voltage. (The maximum available dc output is about 3 volts.) Note the dc voltage, calibrating frequency, and RANGE switch setting for later use in fm deviation calculation.

e. Disconnect the dc voltmeter.

f. Follow the procedure outlined in steps a through c of paragraph 2.5.2.

g. Connect an ac voltmeter to the DIRECT RECORD terminals. Note the ac voltmeter reading.

h. Convert the voltage indicated on the voltmeter to frequency deviation by means of the following equation:

$$\text{fm deviation} = \frac{f_{cal} V_{ac} R_m}{V_{dc} R_{cal}}$$

where f_{cal} = calibrating frequency noted in step d

V_{ac} = ac voltage measured in step g

R_m = position of RANGE switch during fm deviation measurement

V_{dc} = dc voltage noted in step d

R_{cal} = position of RANGE switch noted in step d.

2.6 CALIBRATION.

At periodic intervals, the frequency calibration of the Type 1142-A should be checked and reset if necessary. The procedure is as follows:

a. Turn the instrument on and let it warm up for at least 30 minutes. Make sure no signal is connected to the INPUT terminals.

b. Connect the ground link between the DIRECT RECORD terminals.

c. Set the RANGE switch to 150 C and the METER FUNCTION switch to DIRECT CAL.

d. The meter should now indicate exactly twice the power-line frequency (i.e., 120 cps with a 60-cycle line). If it does not, adjust the DIRECT CAL thumbset, a dual potentiometer with a single panel control. This arrangement makes possible a more precise setting of the meter. To adjust it, turn the thumbset until the meter indicates beyond the desired reading; then reverse the direction of adjustment, to set the meter precisely.

e. Set the INTERPOLATION OFFSET FREQUENCY to 1.2 for 60-cycle lines, 1.0 for 50-cycle lines.

f. Set the METER FUNCTION switch to INTERPOLATION CAL.

g. The meter should now indicate 0. If it does not, adjust the INTERP CAL control as necessary. This control functions in the same manner as the DIRECT CAL control (refer to step d, above).

If a source of standard frequency, such as 100 cps, is available, it may be connected to the INPUT terminals and used to calibrate the Type 1142-A. The procedure is as described above, except that the meter should indicate the standard frequency in step d, and the INTERPOLATION OFFSET FREQUENCY switch should be set at 1.0 (for 100 cps) in step e.

After tube replacement or in abnormal ambient temperatures, ranges may have to be calibrated individually (refer to paragraph 5.2).

Section 3

PRINCIPLES OF OPERATION

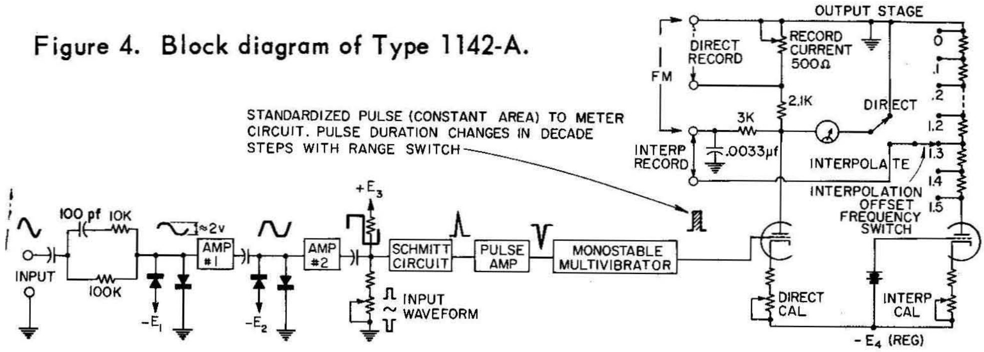
3.1 GENERAL.

General principles of operation are described in paragraph 1.2.1. This section will describe operation in greater detail and will discuss sources of error in fm deviation measurements. (Refer to the block diagram, Figure 4, as well as the complete circuit diagram, Figure 25).

3.2 LIMITERS AND AMPLIFIERS.

The input circuit is a shunt diode limiter. Its input impedance, and hence that of the Type 1142-A, varies from 100 kilohms at low frequencies to a minimum of 5 kilohms at frequencies above 500 kc. The diodes are biased to limit signals to approximately a 2-v peak-to-peak amplitude, a level

Figure 4. Block diagram of Type 1142-A.



sufficient to drive the first amplifier from saturation to cutoff. A low-impedance biasing circuit is used, so that the limiter is symmetrical even under conditions of very large input of amplitude-modulated signals. Thus, the limiter ensures that the output of the first amplifier is an amplified replica of the input signal near its zero crossings. This would not be true if the input signal were directly applied to the first amplifier, because of grid current flow and the attendant grid bias change at high input levels.

Amplifier No. 1 is a conventional pentode amplifier (the pentode section of a Type 6AW8 tube), whose bias signal is derived from a combination of fixed grid bias and cathode bias. The output of this amplifier feeds a second limiter, which clips excessive drive signals at the second amplifier and thereby minimizes zero-crossing shifts. Amplifier No. 2 is a conventional triode amplifier (the triode section of the Type 6AW8 tube), whose output, because of the high gain (approximately 60 db) and limiting of the two amplifiers and limiters, is a square wave for sine-wave inputs, with zero crossings coinciding in time with the zero crossing of the input signal.

3.3 SCHMITT CIRCUIT AND PULSE AMPLIFIER.

The output of Amplifier No. 2 is fed to a Schmitt circuit or cathode-coupled binary. An inductive load on one plate differentiates the signal. The inclusion of a diode across this inductor clips the negative-going pulse, leaving a 0.1-μsec positive pulse for each positive-going zero crossing of the input signal. This positive pulse is amplified and inverted by the pulse amplifier, a Type 6AN5 tube.

The INPUT WAVEFORM control positions the input signal with reference to the Schmitt circuit hysteresis loop so that the circuit operates at a given peak-to-peak amplitude of the input signal regardless of waveform. To understand the function of the INPUT WAVEFORM control, consider the drawings of Figure 5.. In Figure 5a, with the grid-bias level set midway between the Schmitt triggering levels by the INPUT WAVEFORM control, the

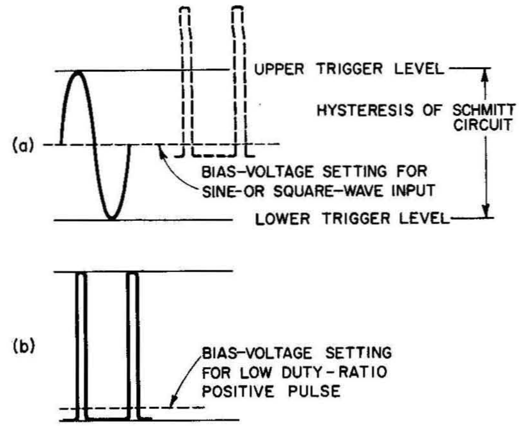


Figure 5. Diagram Showing Function of INPUT WAVEFORM Control.

sine wave shown triggers the Schmitt circuit, while the positive pulse, though of equal peak-to-peak amplitude, does not reach both triggering levels. In Figure 5b, the grid bias is reduced by means of the INPUT WAVEFORM control, so that the positive pulse spans the range between triggering levels.

3.4 MONOSTABLE MULTIVIBRATOR.

The output of the pulse amplifier is applied to a monostable multivibrator, a twin-triode, Type 5965. This stage produces an output pulse of constant amplitude and duration for each input pulse. The pulse duration is determined by resistor-capacitors, with accuracy and stability ensured by the use of precision, temperature-compensated capacitors and General Radio wire-wound resistors. Range switching changes the timing resistors and capacitors to produce decade changes in pulse duration.

Resistors R204, R236, R205, and R232 (see Figure 25) are included in the multivibrator circuit to minimize the effects of line-voltage variation.

3.5 OUTPUT STAGE.

The output of the multivibrator is applied to the grid of one section of a Type 5965 twin-triode (V5A), turning this section on for precisely the duration of the pulse. The current during conduction is a function of the regulated voltage E_4 and the cathode resistor (R214), a stable, wire-wound resistor in series with the DIRECT CAL potentiometer. The average current through the plate load resistor is directly proportional to the number of input pulses per second, and thus to the input frequency. A meter across this load resistor indicates this frequency, full-scale meter deflection corresponding to a voltage drop of 15 volts across the plate-load resistor R212. The other section of the twin-triode, V5B, is a constant-current source with a plate load consisting of 0.1-percent wire-wound resistors that are switched to provide constant voltages from 0 to 15 volts in 1-volt steps. Its plate current is adjusted by the INTERP CAL control so that the total voltage drop across these resistors is 15 volts. In the interpolation mode of operation, the meter is switched between the plate load of V5B and the plate of V5A. The meter then indicates the difference between the plate voltage of V5A, which corresponds to the frequency of the input signal, and the voltage from the voltage divider, which depends upon the setting of the INTERPOLATION OFFSET FREQUENCY switch. Thus, the input frequency is indicated by the sum of the setting of the INTERPOLATION OFFSET FREQUENCY switch and the reading on the meter.

A maximum current of 7 ma is available at the DIRECT RECORD terminals, so that most 1-ma and 5-ma recorders can be used. The RECORD CURRENT potentiometer is a convenient sensitivity control for these recorders, and has no visible interaction on the meter indication.

A second set of recorder output terminals (INTERP RECORD) makes available the interpolation signal from the meter circuit. Full-scale voltage is 0.64 volt behind 4800 ohms. Use of a high-impedance recorder eliminates any interaction on the meter indication.

3.6 OPERATION AS A DISCRIMINATOR.

3.6.1 GENERAL. The frequency meter operates by generating a constant-amplitude, constant-duration pulse for each cycle of the input signal. These standardized pulses have a fixed time relation with respect to the incoming signal, thus making possible the operation of the frequency meter as a pulse-count discriminator.

3.6.2 FM TERMINALS. With a constant-frequency input signal (Figure 6a), the standard pulses are uniformly spaced (Figure 6b). If a low-pass filter is used to attenuate the carrier-frequency components, a dc signal results (Figure 6c). If the input frequency varies, i.e., is frequency modulated, as in Figure 6d, the standardized pulses are no longer uniformly spaced (Figure

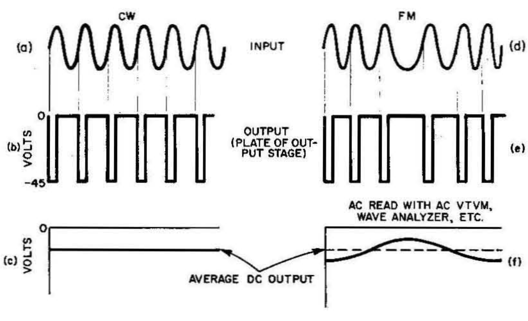


Figure 6. Diagram Showing Operation of the Pulse-Count Discriminator for (left) Constant Input Frequency and (right) Frequency-Modulated Input.

6e). If a low-pass filter is used to attenuate the carrier-frequency components of the pulse train, an ac signal identical to the original modulating signal results (Figure 6f).

The output at the FM terminals is in the form of pulses with a peak value of -45 volts and an average value, at full scale on all ranges, of -15 volts dc.

In order to measure the ac output voltage corresponding to the modulating signal, the voltmeter must be able to distinguish between this voltage and the 45-volt output pulses of the carrier frequency. A single-section RC low-pass filter with a break frequency of 10 kc is incorporated at the FM terminals of the instrument to help serve this purpose, Figure 7. (In this equivalent circuit, the voltage source, E, is the voltage at the plate of the output stage, as in Figure 6b and 6e.) At low carrier frequencies, additional filtering may be necessary, depending upon the characteristics of the voltmeter in use. If the standard 75-μsec de-emphasis network is desired, an additional capacitance of 0.011 μf should be placed across the FM terminals.

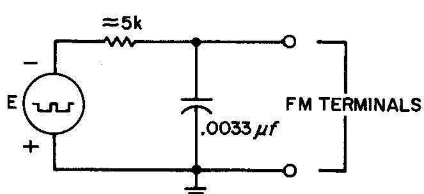


Figure 7. Equivalent circuit at FM terminals.

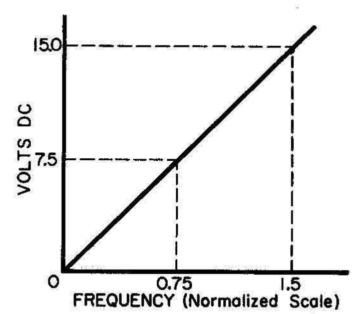


Figure 8. Output voltage as a function of frequency.

As shown in Figure 8, the output voltage at the FM terminals is directly proportional to the input frequency. On any frequency range, the output is 15 volts at full-scale on the frequency meter. Referring to Figure 8, an input frequency of 75 kc produces an output voltage of 7.5 volts at the FM terminals (assuming that the 150-kc range is used). A variation in input frequency will produce a corresponding change in output voltage; when such changes are repetitive, as with fm signals, the changing output voltage constitutes an ac signal whose amplitude is proportional to the change in frequency and whose frequency equals the modulating frequency. For instance, if the peak-to-peak deviation of the 75-kc carrier in Figure 8 is 150 kc (i.e., the peak-to-peak deviation equals the RANGE in use – 150 kc), the peak-to-peak output voltage is 15 volts. This deviation-voltage relationship holds throughout any range, so that, for instance, a 15-μv change in output voltage (peak, peak-to-peak, or rms) would indicate a 1-ppm change in input frequency (peak, peak-to-peak, or rms).

The narrow-band noise is more than 120 db down from full output; therefore, peak deviation as small as 1.5 cps on the 1.5-Mc range or 0.0015 cps on the 1.5-kc range can be measured.

3.6.3 DIRECT RECORD TERMINALS. The signal at the DIRECT RECORD terminals is similar to that at the FM terminals (paragraph 3.6.2) except that the maximum output voltage is 3.5 volts dc instead of 15 volts at full scale on any range, the maximum output impedance is 500 ohms instead of 5000 ohms, and the 10-kc low-pass filter is not used. The equivalent circuit at the DIRECT RECORD terminals is shown in Figure 9.

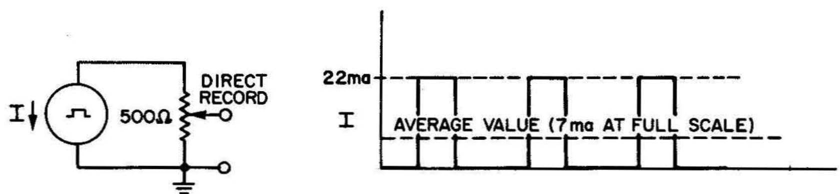


Figure 9. Equivalent circuit at the DIRECT RECORD terminals (a) and corresponding current-source waveform (b).

3.6.4 INTERP RECORD TERMINALS. When zero suppression is desirable such as for frequency-drift measurements using a recorder, the INTERP RECORD terminals should be used. The output at these terminals is shown in Figure 10. The position of the base line A-A varies with respect to ground potential as the setting of the INTERPOLATION OFFSET FREQUENCY switch is changed. Furthermore, the position of the pulse train with respect to base line A-A varies with the input frequency. Accordingly, a useful equivalent circuit for the INTERP RECORD terminals is not reasonable.

If excessive vibration of the recorder pen occurs because of this pulse train, insert a capacitor of one or more microfarads across the INTERP RECORD terminals.

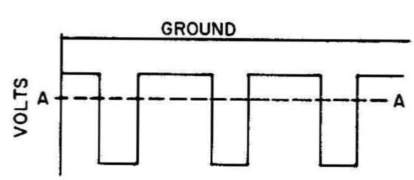


Figure 10. Voltage across the INTERP terminals.

3.7 PRECAUTIONS IN USE OF DISCRIMINATOR.

3.7.1 GENERAL. While the use of the discriminator poses no problems peculiar to this instrument, certain precautions should be taken to ensure accurate measurement of low values of fm deviation. Obviously, sufficient signal must be available. Furthermore, measurements cannot be made if noise generates extraneous zero crossings.

3.7.2 EFFECTS OF ADDITIVE NOISE. A more subtle error in incidental fm measurements can be caused by a low-frequency noise signal superimposed on the input signal. The generated pulse does not start precisely at the zero crossing of the input signal but at a time when the input signal reaches some fixed voltage (usually less than 10 mv). Noise introduced with the signal will result in some variation in the time relationship between the input signal and the output pulses and will be measured as fm. The amount of this fm is a function of the frequency of the noise as well as of the signal-to-noise ratio. The peak deviation of the extraneous fm is approximately:

$$\Delta f_{cps} = f_{noise} \times \frac{A_{noise}}{A_{signal}}$$

where A = amplitude of noise and input signals.

For example, a 1-volt, 100-kc carrier, with a noise signal of 1 mv at 100 cps, would give an equivalent fm output of 0.1 cycle or 1 ppm deviation. A simple RC high-pass filter can be used to reduce the low-frequency noise signal and usually is adequate to eliminate this problem. This filter should be used (1) to remove the recovered amplitude modulation in the measurement of incidental fm on an amplitude-modulated signal that has been heterodyned in a diode mixer or (2) to remove 60-cycle hum pickup in the input.

3.7.3 EFFECTS OF AMPLITUDE MODULATION. The presence of high levels of amplitude modulation on the input signal can also produce errors. Obviously, as the modulation approaches 100%, the input carrier is near zero amplitude during a considerable number of carrier-frequency cycles, and the input level may be too low for proper operation of the Type 1142-A. Even with sufficient signal a difficulty exists, as shown in Figure 11. The start time of the output pulses is determined by the time at which the input signal reaches a given instantaneous value; therefore, any change in the slope of the input signal affects the time of these pulses with respect to the zero crossing of the input signal. The fm deviation produced by amplitude modulation is approximately:

$$\Delta f = f_{mod} M \frac{S}{A_{car}}$$

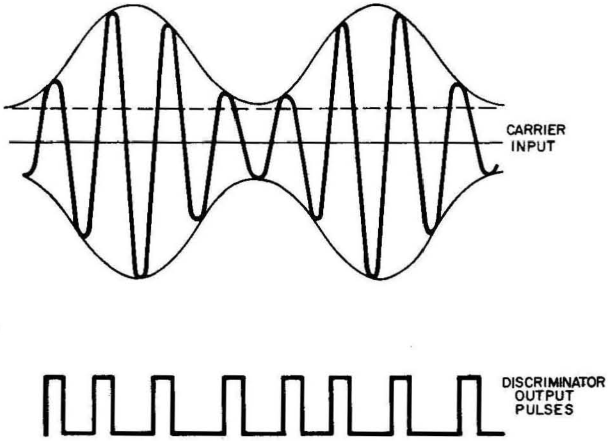


Figure 11. Apparent FM produced by AM wave.

where f_{mod} = modulation frequency (in same units as Δf)

M = modulation index

S = sensitivity of the meter at the carrier frequency (no modulation)

A_{car} = amplitude of the carrier

To determine the sensitivity (in same units as A_{car}), the signal is reduced to the point where the instrument fails. As an example, assume that, at 100 kc, S is 10 mv. A 1-volt, 100-kc carrier, modulated 25% at 400 cps, will produce an fm output of approximately:

$$\Delta f = 400 \times 0.25 \times \frac{0.01}{1} = 1 \text{ cycle (or 10 ppm)}$$

This am-generated fm may be minimized by an increase in the input level or by a reduction in the percentage modulation. The input signal cannot be increased indefinitely, however. Because of the nature of limiters, whether they are internal or are added externally to aid in eliminating the am, some demodulation of the am signal will occur. This demodulated signal reacts upon the input stages in the same manner as additive noise, and results in a discriminator output as previously described.

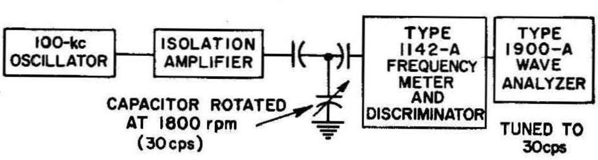
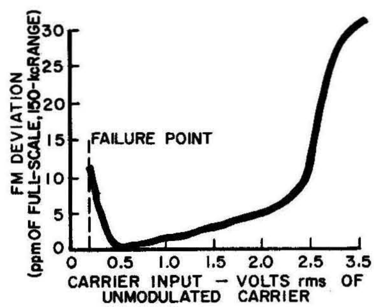


Figure 12. Setup Used to Determine FM Deviation in an AM Wave as a Function of Input Level.

It is difficult, if not impossible, to measure this effect with available amplitude-modulated oscillators or signal generators because of the difficulty of separating the fm generated in the source from that of the discriminator.

To measure this effect, a motor-driven capacitive voltage divider (Figure 12) was used to generate an amplitude-modulated wave relatively free of any fm or phase-modulation effects. A plot of effective fm as a function of

Figure 13. Results of measurements of Figure 12.



input carrier level is shown in Figure 13. It is apparent that an input level between approximately 0.5 volt and 2.0 volts is optimum. On either side of this range there is an increase in measured fm. At low voltages there is insufficient signal for accurate measurement, and above 2.0 volts the limiters produce some demodulation.

A knowledge of these sources of error in measurements with the discriminator should be helpful in explaining the functions of the various filters used in the measurements of fm, flutter, and wow, described in Section 4.

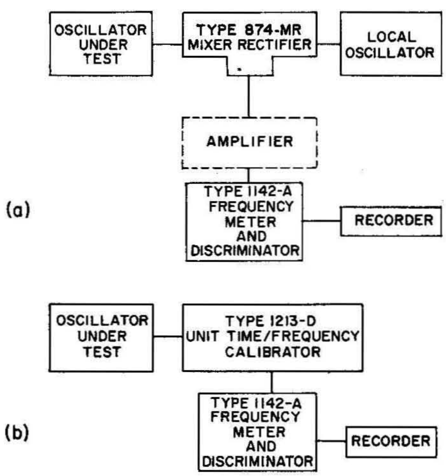
Section 4
APPLICATIONS

4.1 GENERAL.

The Type 1142-A Frequency Meter and Discriminator can be used to measure and to record frequency and frequency changes, or used as an extremely linear and low-noise discriminator for fm demodulation and incidental-fm measurements. There are, however, many additional applications utilizing this meter as the main element in a measurement system, which greatly extend its range and utility.

4.2 FREQUENCY AND DRIFT MEASUREMENTS

To extend the range of frequencies over which measurements can be made, the signal under measurement can be heterodyned with a local oscillator to bring their difference frequency within the range of the frequency meter. Thus, with the arrangement shown in Figure 14a, frequencies can be measured and recorded through the kilomegacycle range. The measurement accuracy is essentially that of the local oscillator. For example, if the local oscillator is a precision standard oscillator operating at 1000 Mc and the frequency of the oscillator under test is within 150 cps of the local oscillator, then frequency changes of 0.1 cps or approximately 1 part in 10^{10} can be read directly on the frequency meter. Since a frequency difference as high as 1.5 Mc is also readable on the meter, measurements of warm-up drift on high-frequency oscillators are conveniently made with the same equipment (Figure 14a).



Figures 14a, 14b. Setups Used to Heterodyne High Frequencies Down to Range of Frequency Meter.

Frequency measurements near integral multiples of 100 kc, 1 Mc, and 10 Mc are readily measured with the Unit Time/Frequency Calibrator, Type 1213-D[1]. This instrument includes a crystal-controlled source of these frequencies together with a heterodyne detector and audio-beat amplifier. As shown in Figure 14b, the local oscillator, mixer, and amplifier are replaced by the calibrator unit.

[1] R. W. Frank, "A Time/Frequency Calibrator of Improved Stability," *General Radio Experimenter,* Volume 33, Number 10, October, 1959.

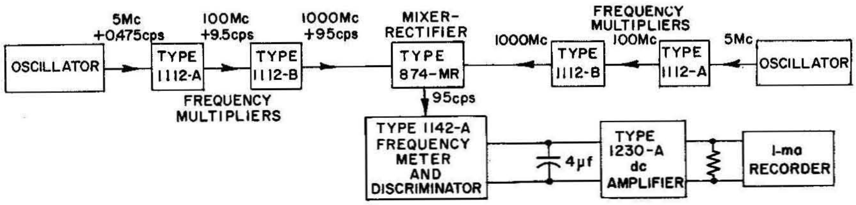


Figure 15. Setup Used to Measure Relative Drift of Two 5-Mc Oscillators. The 5-Mc frequencies were multiplied up to 1000 Mc to magnify frequency drift.

The arrangement shown in Figure 15 was used to obtain the record (Figure 16) of the relative drift of two 5-Mc crystal oscillators. The 4-μf capacitor on the interpolation recorder output provides sufficient filtering to prevent the recorder pen from responding to the pulse frequency in the frequency-meter output. The shunt resistor was used to adjust the full-scale sensitivity of the recorder, in this instance to one part in 10^8.

4.3 FREQUENCY-MODULATION MEASUREMENTS.

Fm deviation measurements are made by substitution of an ac voltmeter for the dc recorder shown in Figure 14a. The use of heterodyne techniques not only extends the frequency range but also increases the resolution.

As an example, incidental-fm measurements of a 50-Mc oscillator were made with the use of a battery-powered 49.5-Mc local oscillator; battery power was used to eliminate incidental-fm components of the ac power-supply frequencies from the local oscillator, because these were the primary fm components of interest in the oscillator under measurement. The results, however, showed that, while 60- and 120-cycle fm components of a normal level did exist, even larger peak deviations at 25- and 45-cycle rates were also present. These fm components were finally traced to microphonics in the

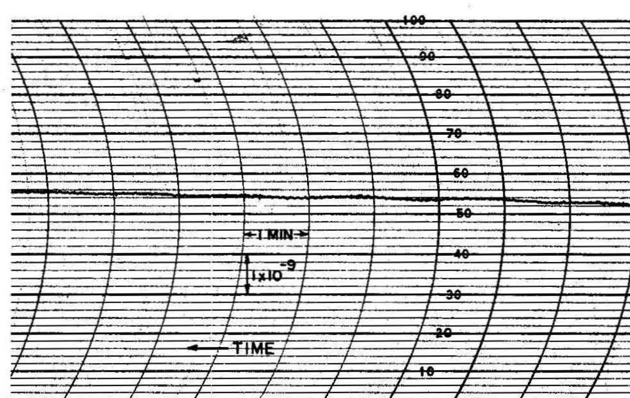


Figure 16. Recording of the Measurement of Figure 15.

oscillator under test. The sources of the vibrations were a blower-cooled oscilloscope and power supply resting on the same bench as the 50-Mc oscillator, with fan speeds of 1500 and 2700 rpm respectively.

A measurement that demanded the full utilization of the techniques and precautions previously discussed was the determination of the fm noise level of the Type 1112-A Standard-Frequency Multiplier[2]. A block diagram of the measuring setup is shown in Figure 17. Inasmuch as the predominant fm components were expected to be harmonics of the power-line frequency, the multiplier was powered by a variable-frequency power supply set to approximately 70 cps, so as to permit separation of the multiplier's fm noise level from that of the rest of the system. The low output level of the 9.9988-Mc

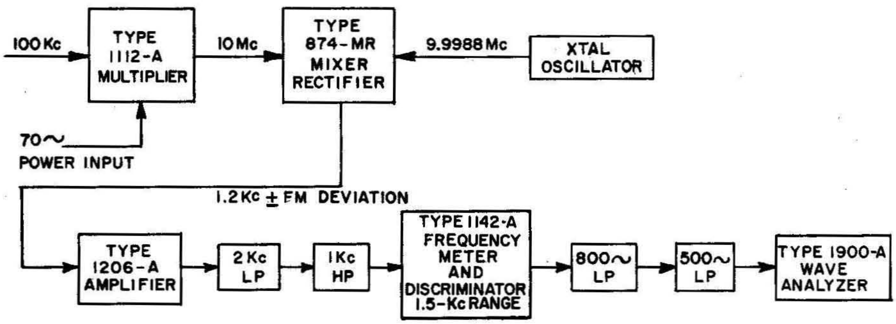


Figure 17. Setup Used to Measure FM Noise Level of Type 1112-A Standard-Frequency Multiplier.

local oscillator necessitated the use of an amplifier (Type 1206-B) to drive the frequency meter. A band-pass filter consisting of a 2-kc, low-pass, RC, section together with a 1-kc, high-pass, RC, section attenuated extraneous signals (60- and 70-cycle hum as well as high-frequency carrier noise) while passing the 1.2-kc carrier and sidebands. The 800-cycle and 500-cycle filters shown in Figure 17 prevent the 45-volt, 1.2-kc pulses from overloading the wave analyzer.

In the above setup, i.e., with a 10-Mc carrier and a 1.2-kc beat, a 7 μv reading on the wave analyzer corresponds to a peak deviation of approximately one part in 10^{10}. The total noise level of the Type 1112-A Standard-Frequency Multiplier was found to be approximately 5 parts in 10^{10}.

While the previous examples have been concerned primarily with small peak deviations at low modulation rates, there are occasions when the measurement of large frequency deviations or high modulation frequencies is desired. The sum of the peak deviations above the carrier frequency and the

[2] F. D. Lewis, "New Standard-Frequency Multipliers," *General Radio Experimenter,* Volume 32, Number 14, July, 1958.

carrier frequency must not exceed 1.5 Mc. The peak deviation below the carrier frequency cannot enter the pass band of the filter, which must pass the highest modulation frequency. For modulating frequencies above 10 kc, the output is decreased because of the internal 10-kc filter. If a higher roll-off frequency is desired, it is necessary either to remove this filter or to use DIRECT RECORD terminals (paragraph 2.5.3). The roll-off frequency now depends upon the capacitive load of the external voltmeter or filter. However, with a total shunt capacitance of 500 pf, it is possible to maintain the response within 1 db out to a 200-kc modulation frequency.

4.4 FLUTTER AND WOW MEASUREMENTS.

The measurement of flutter and wow of tape recorders, both audio and data, or of turntables is possible with the setup shown in Figure 18. The oscillator frequency is usually an industry standard, e.g., 3 kc for audio recorders. The high- and low-pass filters preceding the Type 1142-A Frequency Meter and Discriminator may or may not be necessary. The function of the high-pass filter is to attenuate the low-frequency hum components from the recorder amplifiers so that they will not generate any fm in the frequency meter; the low-pass filter is included to attenuate the bias signal often present at the output terminals of a three-head tape recorder when recording and playback are occurring simultaneously. The low-pass filter following the

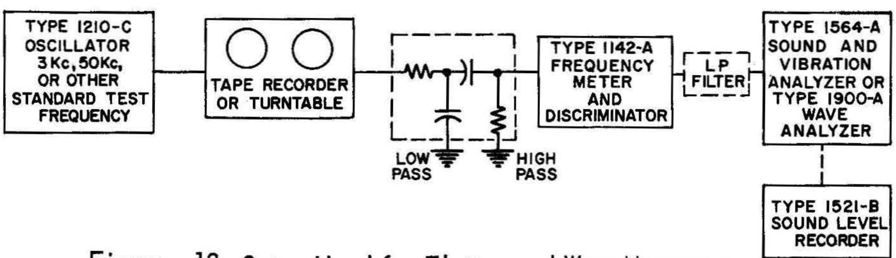


Figure 18. Setup Used for Flutter and Wow Measurements.

frequency meter may not be necessary when data recorders are being tested, since the internal 10-kc filter of the frequency meter is usually adequate when a carrier of 50 kc or 100 kc is used.

While a wide-band rms voltmeter with the appropriate low-pass filter (300 cps for audio recorders, 5 kc or 10 kc for data recorders) will give the total flutter and wow level, a wave analyzer indicates specific frequency components, pinpointing the source of the major flutter components. For example, Figure 19 is an automatic plot of flutter of an audio tape recorder made with the use of the Type 1554-A Sound and Vibration Analyzer (tunable from 2.5 cps to 25 kc) coupled to the Type 1521-B Graphic Level Recorder. Peak flutter components are produced not only at power supply frequencies

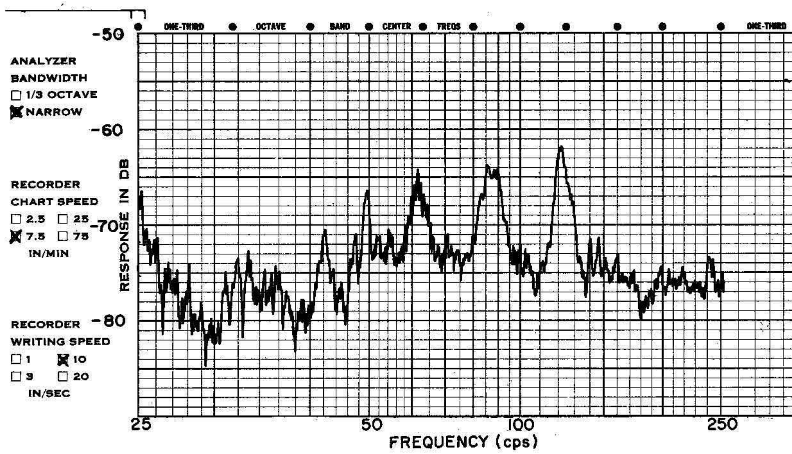


Figure 19. Recording of Flutter in an Audio Tape Recorder, Made with Setup Shown in Figure 14. A response of -60 db corresponds to a frequency deviation of 0.1% of the test frequency.

but also at frequencies directly related to motor speed, capstan speed, idler speed, etc.

Automatic plots like that of Figure 19 can be made over a frequency range of 20 cps to 25 kc. The response of the Graphic Level Recorder drops off below 20 cps so that hand-plotting is necessary at lower frequencies.

4.5 PRODUCTION APPLICATIONS.

Since the frequency meter generates a standardized pulse for each input cycle, it follows that it will measure the average of a frequency that is changing, even if it is aperiodic or random. This fact is made use of in production testing of the Type 1300-A Beat-Frequency Video Generator. To calibrate the sweep-frequency circuits, the peak deviation with sine wave sweep is set to 1 Mc by measurement of the average output frequency. Since the average of a sine wave is 0.636 of peak, the frequency is adjusted for a frequency-meter indication of 636 kc.

It is also apparent that signals to be counted may be derived from simple photocell devices, tachometers, geiger tubes, magnetic pickups, or any other transducers capable of supplying a 30-mv peak signal.

Section 5
SERVICE AND MAINTENANCE

5.1 GENERAL.

The two-year warranty given with every General Radio instrument attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible.

In case of difficulties that cannot be eliminated by the use of these service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office (see back cover), requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.2 FREQUENCY ALIGNMENT.

The frequency calibration of individual frequency ranges can be adjusted easily without removal of the instrument cover. Such alignment may be required under the following conditions:

a. after replacement of tubes, especially of V4 and V5,

b. under conditions of extreme ambient temperatures,

c. if, after calibration in accordance with paragraph 2.6, the upper ranges do not appear to be calibrated.

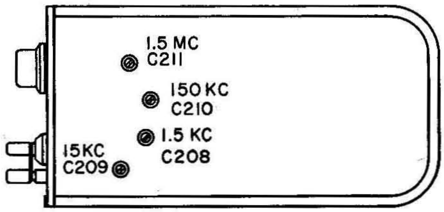
Before making the following adjustments, calibrate the lowest range against a 100-cycle standard as described in paragraph 2.6. Then proceed as follows:

a. Connect the standard 1-Mc signal to the INPUT terminals. Measure the frequency of this signal, using the INTERPOLATION mode of operation (paragraph 2.3).

b. With the INTERPOLATION OFFSET FREQUENCY switch at 1.0, the meter should indicate 0. If it does not, adjust trimmer capacitor C211 (see Figure 20) as necessary to zero the meter.

c. Align the remaining three ranges in a similar manner, using standard frequencies of 1, 10, and 100 kc as appropriate. Adjust trimmer capacitors C208, C209, and C210 for the 1.5-, 15-, and 150-kc ranges, respectively. Locations of these adjustments are shown in Figure 20.

Figure 20. Location of Frequency Adjustments.



5.3 REMOVAL OF COVER.

To open the instrument for access to tubes and components, loosen the two fluted captive screws at the rear of the instrument and slide the U-shaped dust cover away from the panel. All tubes and adjustments and most components are now accessible. Occasionally, it may be necessary to remove the side panels of the instrument. To do this, remove the four screws from the corners of the front panel and the two screws at the rear of each side panel.

5.4 RECONNECTION OF POWER TRANSFORMER FOR DIFFERENT LINE VOLTAGE.

Unless otherwise ordered, the Type 1142-A Frequency Meter and Discriminator is shipped with its power transformer wired for 115-volt, 50-60-cycle input. A simple wiring change at the transformer primary is all that is required to convert the instrument for 230-volt operation, or to convert a 230-volt model for 115-volt service. Refer to the schematic diagram, Figure 25, for proper connections. When rewiring the transformer primary for a different line voltage, be sure to change the input plate adjacent to the power-input connector so that the legend indicates the appropriate input voltage and frequency. The instrument is normally supplied for 115-volt operation, with a corresponding plate (Type LAP-166E). A 230-volt plate (Type LAP-166E2) is supplied with a 230-volt instrument. When the line voltage is changed, the appropriate plate may be ordered from General Radio. Also install fuses appropriate to the line voltage used, as indicated in the parts list.

5.5 TROUBLE-SHOOTING PROCEDURE.

If the instrument is inoperative and the pilot light is not on, look through the ventilation holes in the top of the dust cover to see if the tube filaments are lit. If the filaments are lit, the pilot light is defective and must be replaced (refer to parts list). If neither the tube filaments nor the pilot light are lit, check to see that the instrument is connected to a source of proper voltage. Then remove the dust cover (refer to paragraph 5.3) and check the two fuses mounted on the power transformer at the rear of the instrument. If either fuse is defective, insert a replacement of the proper rating (refer to parts list).

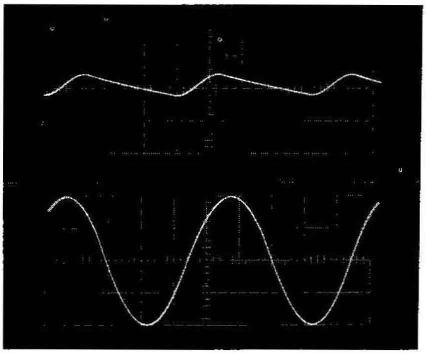
If, after the above checks have been made, the instrument does not respond to an input signal, check the following power-supply voltages, using either a vacuum-tube voltmeter or a 20,000-ohm-per-volt multimeter. Voltages in the following table are from the anchor terminals indicated to ground and may vary ±10%.

Anchor Terminal No.	DC volts to ground
12	+220
15 or 25	-300
34	-370

After checking the above voltages, measure the voltage between anchor terminals 25 and 34. With no input signal applied, this voltage should be - 69 volts. If it is not, adjust potentiometer R226 (see Figure 22) so that this voltage is - 69 volts ± 0.25 volt. If unable to adjust this voltage to - 69 volts, check tubes V7 and V8 and associated components. If the dc voltages are as indicated above and the instrument is still inoperative, conventional signal-tracing techniques may be applied to isolate the fault to one stage. Turn the instrument on, set the METER FUNCTION switch to DIRECT CAL, and set the RANGE switch to 150 CPS. Trace the signal with an oscilloscope, comparing the presentations with those shown in the oscillograms below. If the voltage at any point is not as indicated in the oscillogram, check the tube indicated and refer to the table of voltages to isolate defective components.

Inability to calibrate the instrument in the DIRECT CAL position may be due to the presence of a large signal at the INPUT terminals. For best results, remove any such signal from the INPUT terminals before calibrating the instrument.

Rubbing the face of the meter may produce a static charge (especially in dry atmosphere) and the presence of such a charge may make the instrument appear inoperative. Wiping the face of the meter with a damp cloth will usually eliminate this difficulty.

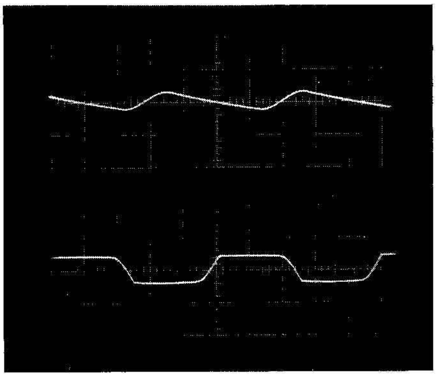


A. ANCHOR TERMINAL NO. 1

Top: Frequency 120 cps (DIR CAL)
Vertical scale 0.5 v/cm
Sweep 2 msec/cm

Bottom: Frequency 100 kc
Vertical scale 5v/cm
Sweep 2μsec/cm

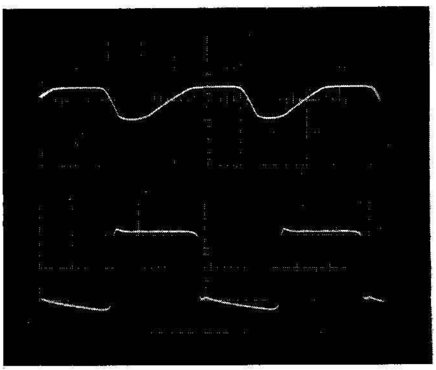
Figure 21. Oscillograms.



B. V1, PIN 7

Top: Frequency 120 cps
Vertical scale 0.5v/cm
Sweep 2 msec/cm

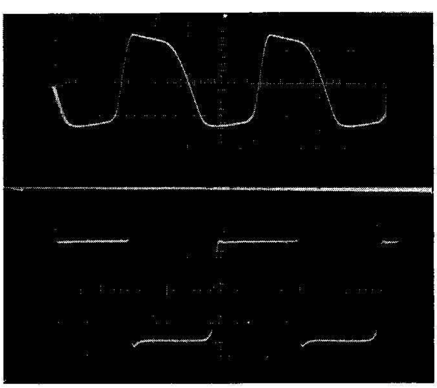
Bottom: Frequency 100 kc
Vertical scale 5v/cm
Sweep 2 μsec/cm



C. V1, PIN 2

Top: Frequency 120 cps
Vertical scale 5v/cm
Sweep 2 msec/cm

Bottom: Frequency 100 kc
Vertical scale 5v/cm
Sweep 2 μsec/cm

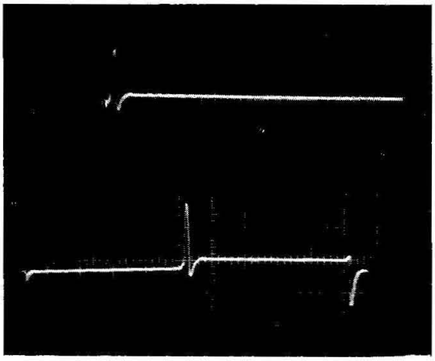


D. V2, PIN 2

Top: Frequency 120 cps
Vertical scale 20v/cm
Sweep 2 msec/cm

Bottom: Frequency 100 kc
Vertical scale 20v/cm
Sweep 2 μsec/cm

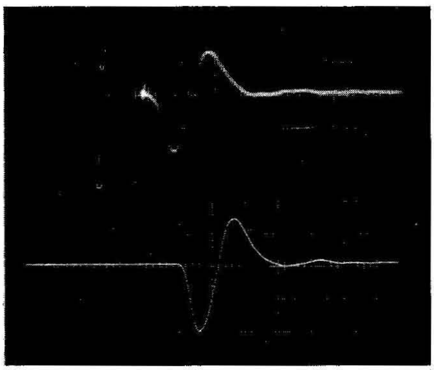
Figure 21. Oscillograms (Continued).



E. V3, PIN 1

Top: Frequency 120 cps
Vertical scale 10v/cm
Sweep 1 μsec/cm

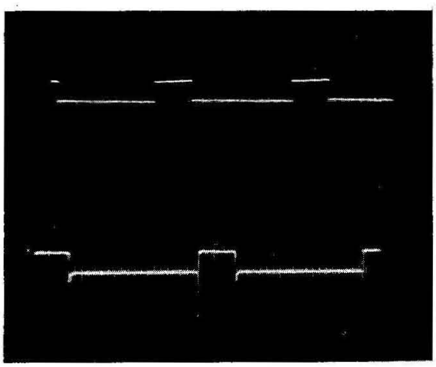
Bottom: Frequency 100 kc
Vertical scale 10v/cm
Sweep 1 μsec/cm



F. ANCHOR TERMINAL NO. 6 or 24

Top: Frequency 120 cps
Vertical scale 20v/cm
Sweep 0.1 μsec/cm

Bottom: Frequency 100 kc
Vertical scale 20v/cm
Sweep 0.1 μsec/cm

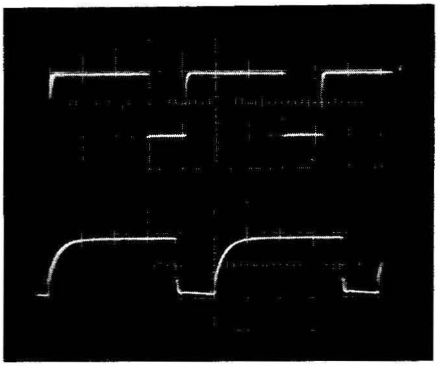


G. V4, PIN 8

Top: Frequency 120 cps
Vertical scale 10v/cm
Sweep 2 msec/cm

Bottom: Frequency 100 kc
Vertical scale 10v/cm
Sweep 2 μsec/cm

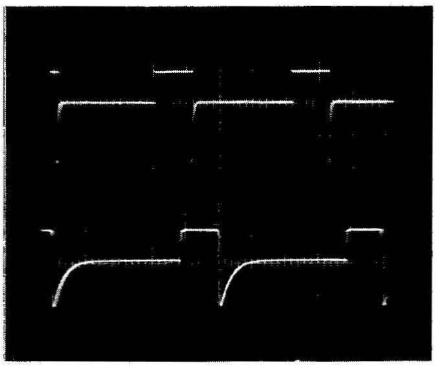
Figure 21. Oscillograms (Continued).



H. V4, PIN 6

Top: Frequency 120 cps
Vertical scale 20v/cm
Sweep 2 msec/cm

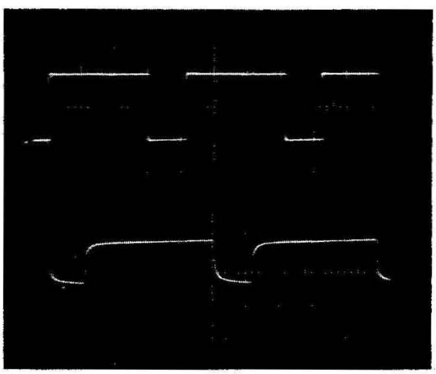
Bottom: Frequency 100 kc
Vertical scale 20v/cm
Sweep 2 μsec/cm



I. V4, PIN 1

Top: Frequency 120 cps
Vertical scale 20v/cm
Sweep 2 msec/cm

Bottom: Frequency 100 kc
Vertical scale 20v/cm
Sweep 2 μsec/cm



J. ANCHOR TERMINAL NO. 45

Top: Frequency 120 cps
Vertical scale 20v/cm
Sweep 2 msec/cm

Bottom: Frequency 100 kc
Vertical scale 20v/cm
Sweep 2 μsec/cm

Figure 21. Oscillograms (Continued).

5.6 TABLE OF VOLTAGES

TUBE (TYPE)	PIN	DC VOLTS
V1 (6AW8)	1	0
	2	-2.2
	3	205
	4	f
	5	0
	6	1.1
	7	-1.5
	8	140
	9	147
V2 (5687)	1	215
	2	35
	3	70
	4	0
	5	f
	6	70
	7	64
	8	0
	9	220
V3 (6AN5)	1	-320
	2	-300

TUBE (TYPE)	PIN	DC VOLTS
V3 (6AN5) (Cont)	3	-370f
	4	-370f
	5	-0.2v
	6	-185
	7	-300
V4 (5965)	1	-330
	2	-370
	3	-368
	4	-370f
	5	-370f
	6	0
	7	-330
	8	-305
	9	-370f
V5 (5965)	1	-0
	2	-330
	3	-305
	4	-370f
	5	-370f
	6	-81

TUBE (TYPE)	PIN	DC VOLTS
V5 (5965) (Cont)	7	-300
	8	-295
	9	-370f
V6 (6AV5GA)	1	-318
	2	-370f
	3	-300
	4	—
	5	-200
	6	—
	7	-370f
	8	-175
V7 (5965)	1	-265
	2	-370
	3	-368
	4	-370
	5	-370
	6	-195
	7	-268
	8	-265
	9	-370
V8 (5651)	2	-385
	5	-304

f indicates filaments elevated above ground

DC Supplies to Ground	
AT	DC Volts
12	220
25	-300[1]
34	-370[1]
33	-535

[1] Voltage without input signal

Transformer Voltages	
Terminals	Volts ac
5 - 6	103
7 - 8	130
11 - 9	125
11 - 10	125
12 - 13	6.3
14 - 15	6.3

Conditions of Measurement: 1. Set panel controls as follows:

METER FUNCTION - DIRECT
INTERPOLATION OFFSET FREQ - 0
INPUT WAVEFORM - CCW
RANGE - 150 C

2. Measure voltages with no input signal.

PARTS LIST

Ref. No.	*Description*	*Part No.*
Capacitors		
C1A	60 μF	
C1B	Electrolytic, 50 μF 300 V	4450-2650
C1C	50 μF	
C2A	50 μF	
C2B	Electrolytic, 25 μF 450 V	4450-0800
C2C	25 μF	
C3A	50 μF	
C3B	Electrolytic, 25 μF 450 V	4450-0800
C3C	25 μF	
C4A, C4B	Electrolytic, 30 μF 150 V	4450-1700
C5A, C5B	Electrolytic, 25 μF 200 V	4450-3300
C6A, C6B	Electrolytic, 25 μF 200 V	4450-3300
C7	Ceramic, 0.0033 μF ±5% 500 V	4409-2335
C8	Electrolytic, 650 μF 350 V	4450-5599
C9	Electrolytic, 33 μF ±20% 10 V	4450-5400
C10	Ceramic, 0.022 μF +80-20% 500 V	4407-3229
C100	Plastic, 0.1 μF ±10% 400 V	4860-9300
C101	Mica, 100 pF ±10% 500 V	4570-0900
C102	Ceramic, 0.01 uF +80-20% 500 V	4406-3109
C103	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C104	Electrolytic, 10 μF +100-10% 250 V	4450-2100
C105	Plastic, 0.1 μF +10% 400 V	4860-9300
C106	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C107	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C108	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C109	Mica, 220 pF ±10% 500 V	4570-1100
C110	Mica, 470 pF ±10% 500 V	4570-1150
C111	Oil, 0.047 μF ±10% 600 V	4510-4200
C112	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C113	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C114	Ceramic, 0.022 μF +80-20% 500 V	4407-3229
C115	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C200	Plastic, 0.22 μF ±10% 400 V	4860-9501
C201	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C202	Plastic, 0.47 μF ±10% 200 V	4860-8247
C203	Electrolytic, 10 μF +100-10% 250 V	4450-2100
C204	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C205	Electrolytic, 10 μF +100-10% 250 V	4450-2100
C206	Electrolytic, 10 μF +100-10% 250 V	4450-2100
C207	Plastic, 0.33 μF ±10% 400 V	4860-9700
C208	Air, 3.9 - 7.5 pF	4380-3300
C209	Air, 2.7 - 19.6 pF	4380-3700
C210	Air, 2.7 - 19.6 pF	4380-3700
C211	Air, 1.7 - 8.7 pF	4380-3600
C212A	Mica, 2000 pF ±1/2% 500 V	4600-1198
C212B	Ceramic, 180 pF ±5% 500 V	4417-1805
C213	Ceramic, 182 pF ±1% 500 V	4411-1821
C214	Ceramic, 168 pF ±1% 500 V	4411-1681
C215	Ceramic, 22 pF ±5% 500 V	4422-0225
C216	Electrolytic, 4 pF +100-10% 300 V	4450-3200
C217	Ceramic, 0.047 μF +80-20% 250 V	4409-3479
C219A	Mica, 0.022 μF ±1/2% 500 V	4565-9223
C219B	Ceramic, 600 pF ±5% 500 V N1500	4418-1605
C220	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C221	Ceramic, 0.05 μF ±20% 500 V	4408-3509
C222	Ceramic, 0.01 μF +80-20% 500 V	4406-3109

Ref. No.	Description	Part No.
Resistors		
R1	Wire-wound, 6.8 Ω ±10% 1/2 W	6760-9689
R2	Power, 680 Ω ±5% 5 W	6660-1685
R3	Composition, 150 Ω ±5% 2 W	6120-1155
R4	Power, 680 Ω ±5% 5 W	6660-1685
R6	Potentiometer, composition 1 MΩ±20%	6040-1900
R7A R7B	Potentiometer, 50 Ω 500 Ω	1142-0410
R8A R8B	Potentiometer, 100 Ω 1 kΩ	1142-0420
R9	Wire-wound, 500 Ω ±10%	6050-1100
R10	Wire-wound, 2.5 kΩ ±10%	6050-1500
R11	Wire-wound, 25 kΩ ±10%	6050-1910
R12	Film, 147 Ω ±1% 1/2 W	6450-0147
R13	Precision, 146.7 Ω ±0.1%	6690-6230
R14	Film, 294 Ω ±1% 1/2 W	6450-0294
R15	Precision, 293.4 Ω ±0.1%	6690-6227
R16	Film, 1.76 kΩ ±1% 1/2 W	6450-1176
R17	Precision, 586.8 Ω ±0.1%	6690-6228
R18	Film, 1.18 kΩ ±1% 1/2 W	6450-1118
R19	Precision, 586.8 Ω ±0.1 %	6690-6228
R20	Film 590 Ω ±1% 1/2 W	6450-0590
R21	Precision, 586.8 Ω ±0.1%	6690-6228
R22	Composition, 300 Ω ±5% 1/2 W	6100-1305
R23	Composition, 150 Ω ±5% 1/2 W	6100-1155
R42	Composition, 750 Ω ±5% 1/2 W	6100-1755
R43	Precision, 64.9 kΩ ±1/2%	6730-2649
R44	Power, 18 kΩ ±5% 5 W	6660-3185
R45	Power, 11 kΩ ±5% 5 W	6660-3115
R46	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R47	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R48	Power, 680 Ω ±5% 5 W	6660-1685
R49	Power, 680 Ω ±5% 5 W	6660-1685
R100	Composition, 220 kΩ ±5% 1 W	6110-4225
R101	Composition, 10 kΩ ±5% 1/2 W	6100-3105
R102	Composition, 10 kΩ ±5% 1/2 W	6100-3105
R103	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R104	Composition, 220 kΩ ±5% 1 W	6110-4225
R105	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225
R106	Composition, 82 Ω ±5% 1/2 W	6100-0825
R107	Composition, 6.8 kΩ ±10% 2 W	6120-2689
R108	Composition, 20 kΩ ±5% 1 W	6110-3205
R109	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R110	Composition, 1.5 kΩ ±5% 1/2 W	6100-2155
R111	Composition, 100 kΩ ±5% 2 W	6120-4105
R112	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R113	Composition, 4.7 kΩ ±5% 1 W	6110-2475
R114	Composition, 2.7 MΩ ±5% 1/2 W	6100-5275
R115	Composition, 1.5 kΩ±5% 1 W	6110-2155
R116	Composition, 33 kΩ ±5% 1 W	6110-3335
R117	Composition, 510 kΩ ±5% 1/2 W	6100-4515
R118	Power, 3.3 kΩ ±5% 5 W	6660-2335
R119	Composition, 82 kΩ ±5% 2 W	6120-3825
R120	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R121	Composition, 27 kΩ ±5% 1/2 W	6100-3275
R122	Composition, 510 Ω ±5% 1/2 W	6100-1515
R126	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R127	Composition, 1 MΩ ±5% 1/2 W	6100-5105
R128	Composition, 1 MΩ ±5% 1/2 W	6100-5105

Ref. No.	Description	Part No.
Resistors (cont)		
R129	Composition, 1 MΩ ±5% 1/2 W	6100-5105
R130	Composition, 1 MΩ ±5% 1/2 W	6100-5105
R131	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R132	Composition, 360 Ω ±5% 1/2 W	6100-1365
R201	Composition, 150 Ω ±5% 1/2 W	6100-1155
R202	Precision, 2.2 kΩ ±0.05%	6690-4230
R203	Precision, 3.6 kΩ ±0.05%	6690-4250
R204	Composition, 3 MΩ ±5% 1/2 W	6100-5305
R205	Composition, 560 kΩ ±5% 1/2 W	6100-4565
R206	Precision, 30 kΩ ±0.05%	6690-4270
R207	Precision, 105 kΩ ±0.05%	6690-5290
R208	Composition, 180 Ω ±5% 1/2 W	6100-1185
R209	Composition, 1.5 kΩ ±5% 1 W	6110-2155
R210	Composition, 1.5 kΩ ±5% 1 W	6110-2155
R211	Composition, 1.3 kΩ ±5% 1/2 W	6100-2135
R212	Precision, 2.1 kΩ ±0.05%	6690-4229
R213	Composition, 1.6 kΩ ±5% 1/2 W	6100-2165
R214	Precision, 3 kΩ ±0.05%	6690-4240
R215	Composition, 10 kΩ ±5% 1 W	6110-3105
R216	Precision, 9.75 kΩ ±0.05%	6690-4260
R217	Composition, 680 kΩ ±5% 1/2 W	6100-4685
R218	Composition, 270 kΩ ±5% 1/2 W	6100-4275
R219	Composition, 12 kΩ ±5% 1/2 W	6100-3125
R220	Composition, 33 kΩ ±5% 1/2 W	6100-3335
R221	Power, 18 kΩ ±5% 5 W	6660-3185
R222	Composition, 12 kΩ ±5% 1/2 W	6100-3125
R223	Composition, 12 kΩ ±5% 1/2 W	6100-3125
R224	Composition, 200 kΩ ±5% 1/2 W	6100-4205
R225	Film, 60.4 kΩ ±1% 1/2 W	6450-2604
R226	Wire-wound 10 kΩ ±10%	6050-1800
R227	Composition, 27 kΩ ±5% 1/2 W	6100-3275
R228	Composition, 9.1 MΩ ±5% 1/2 W	6100-5915
R229	Precision, 105 kΩ ±0.05%	6690-5290
R230	Composition, 30 kΩ ±5% 1/2 W	6100-3305
R231	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R232	Film, 200 kΩ ±1% 1/2 W	6450-3200
R233	Composition, 3 kΩ ±5% 1/2 W	6100-2305
R234	Composition, 10 MΩ ±5% 1/2 W	6100-6105
R235	Composition, 10 MΩ ±5% 1/2 W	6100-6105
R236	Composition, 10 MΩ ±5% 1/2 W	6100-6105
Miscellaneous		
D1 thru D3	DIODE, Type 1N3253	6081-1001
D100 thru D103	DIODE, Type 1N625	6082-1012
D104	DIODE, Type 1N191	6082-1008
D200	DIODE, Type 1N191	6082-1008
D201	DIODE, Type 1N3604	6082-1001
D202	DIODE, Type 1N3604	6082-1001
J1	JACK, Binding post	0938-3002
J2 thru J6	JACK, Binding post	0938-3000

Ref. No.	*Description*	*Part No.*
Miscellaneous (cont)		
L100	INDUCTOR, 330 μH ±10%	4300-4300
L101	INDUCTOR, 68 μH ±10%	4300-3300
L200	INDUCTOR, 22 μH ±10%	4300-2600
L201	INDUCTOR, 56 μH ±10%	4300-3200
F1	FUSE, (115 V) 1.25 amp 3AG Slo-Blo	5330-1600
F2	FUSE, (115 V) 1.25 amp 3AG Slo-Blo	5330-1600
F1	FUSE, (230 V) 0.6 amp 3AG Slo-Blo	5330-1100
F2	FUSE, (230 V) 0.6 amp 3AG Slo-Blo	5330-1100
M1	METER	5730-0930
P1	PILOT LAMP	5600-0300
PL1	PLUG, Power	4240-0600
RX1 thru RX7	RECTIFIER, Type 1N3254	6081-1002
S1	SWITCH, Coaxial	7890-4000
S2	SWITCH, Coaxial	7890-4000
S3	SWITCH	7890-1940
S4	SWITCH	7910-1300
T1	TRANSFORMER	0365-4900
T100	TRANSFORMER	5000-6000
V1	TUBE, Type 6AW8	8360-2550
V2	TUBE, Type 5687	8380-5687
V3	TUBE, Type 6AN5	8360-1200
V4	TUBE, Type 5965	8380-5965
V5	TUBE, Type 5965	8380-5965
V6	TUBE, Type 6AV5GA	8360-2390
V7	TUBE, Type 5965	8380-5965
V8	TUBE, Type 5651	8380-5651
V9 thru V11	TUBE, Type NE-2	8390-0200

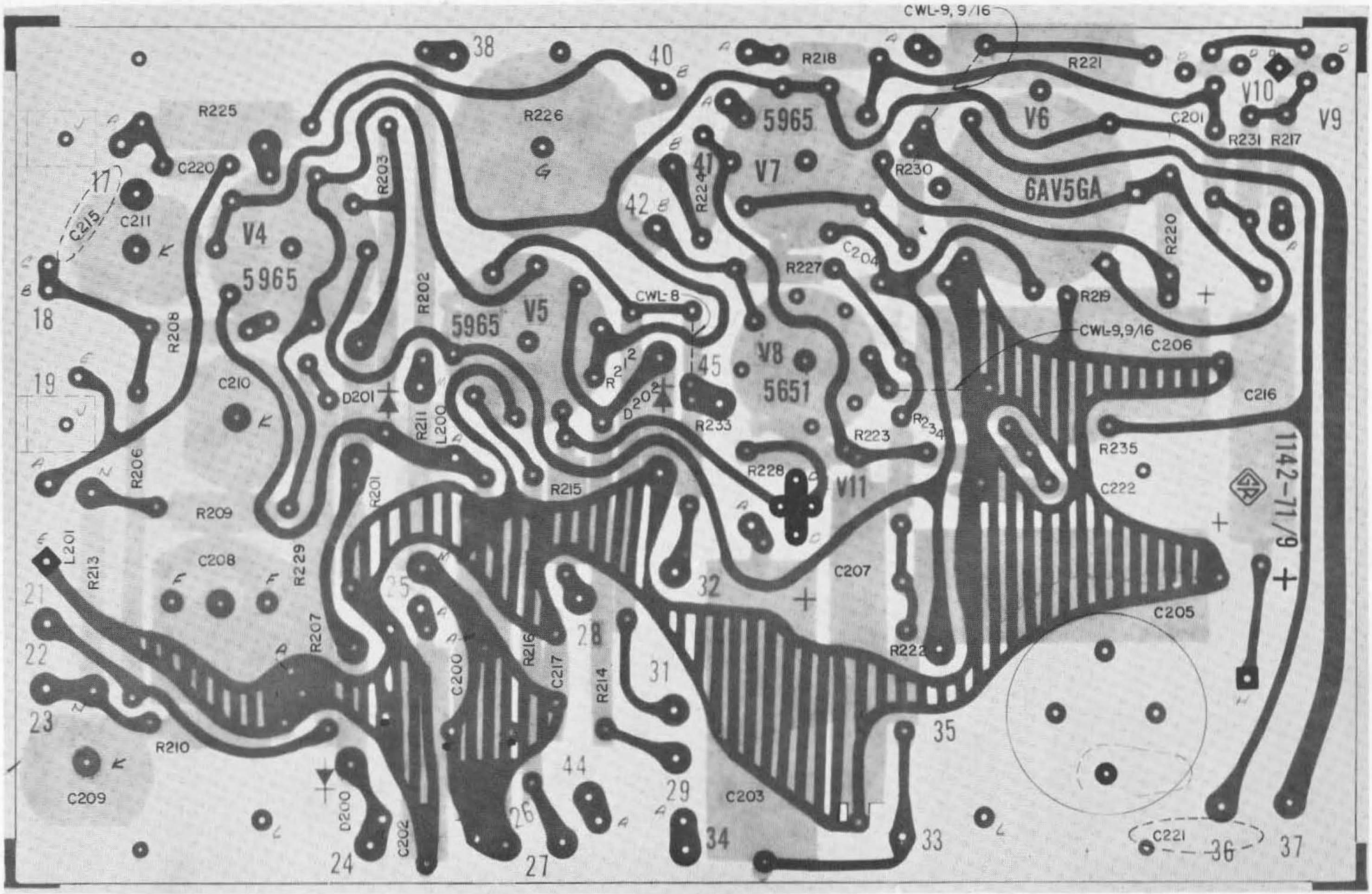
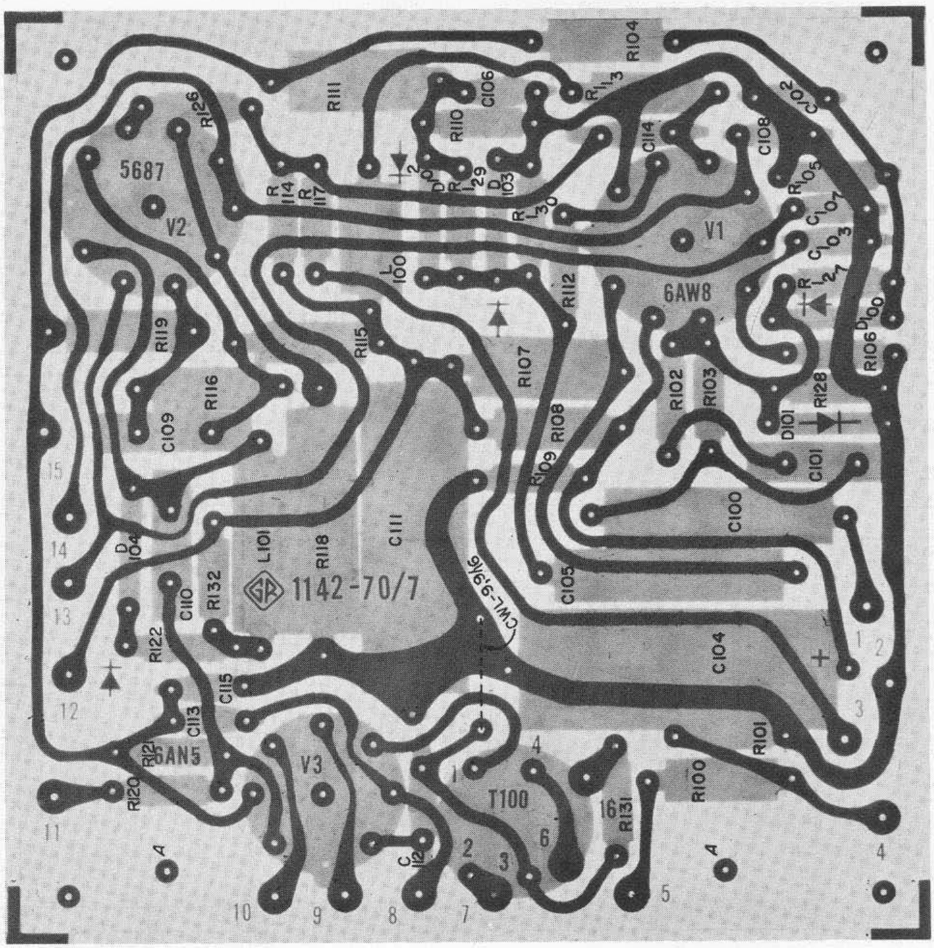


Figure 24. Etched circuit boards.


5687
V2
V1
6AW8
6AN5
V3
T100
1142-70/7
C111
C100
C104
C105
R104
R111
R112
R107
R108
L101
R118

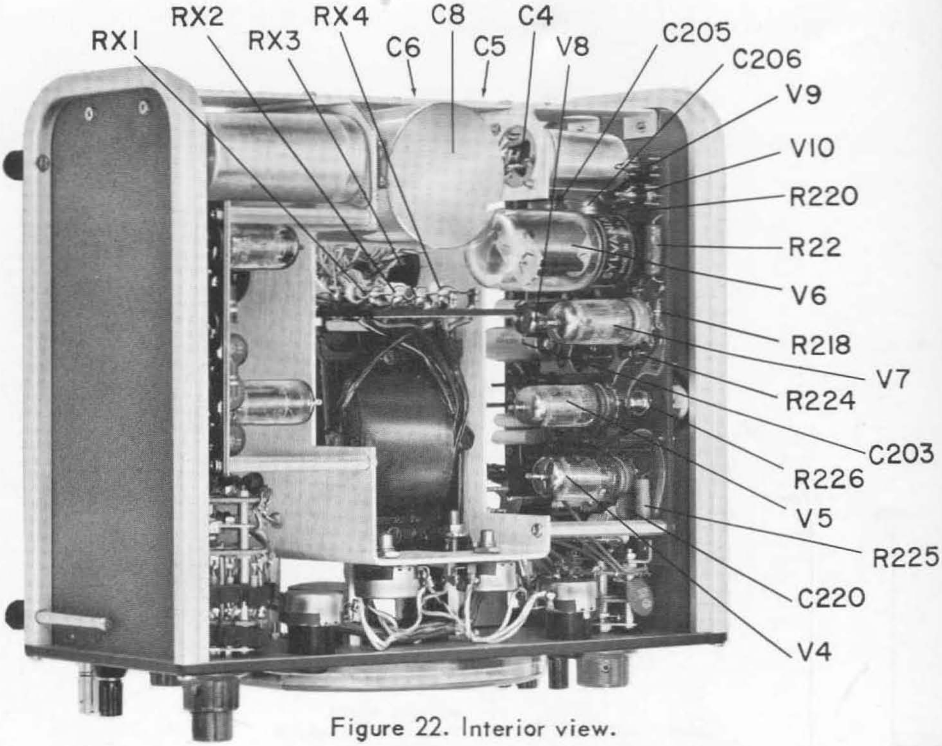


Figure 22. Interior view.

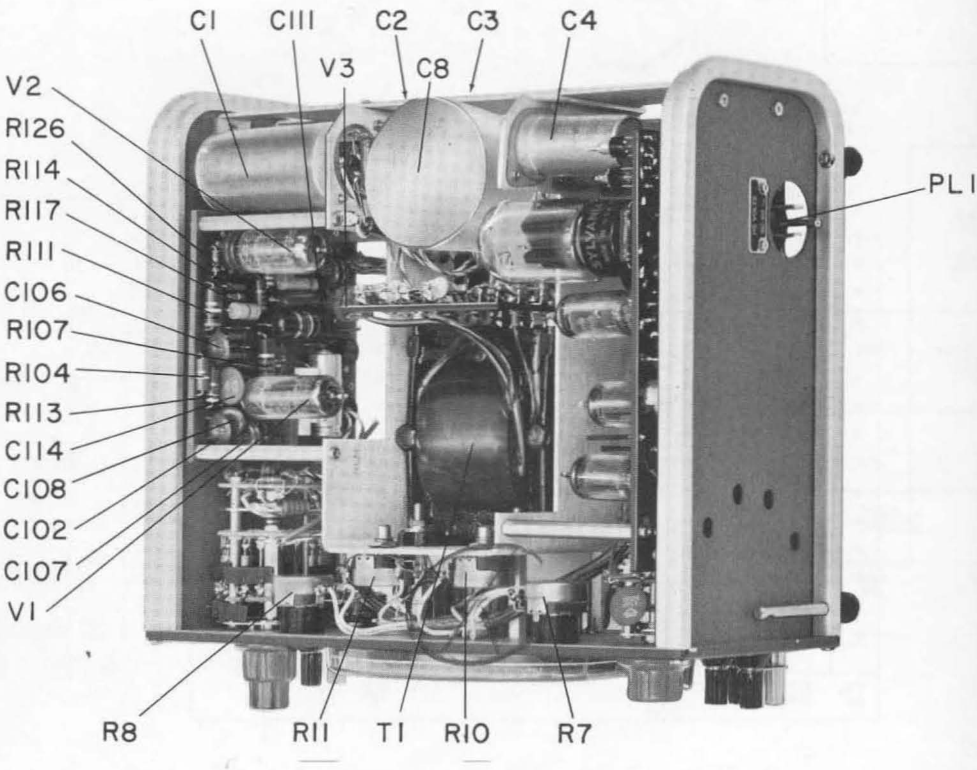


Figure 23. Interior view.

RESISTORS 1/2 WATT, UNLESS OTHERWISE SPECIFIED

RESISTANCE IN OHMS, UNLESS OTHERWISE SPECIFIED
K= 1000 M = 1 MEGOHM

CAPACITANCE VALUES ONE AND OVER IN PICOFARADS
LESS THAN ONE IN MICROFARADS, UNLESS OTHERWISE SPECIFIED.

⊘ SCREWDRIVER ADJUSTMENT

○ KNOB CONTROL

NOTE FOR T1
FOR 115V OPERATION, CONNECT #1 to #3 & #2 TO #4
FOR 230V OPERATION, CONNECT #2 TO #3

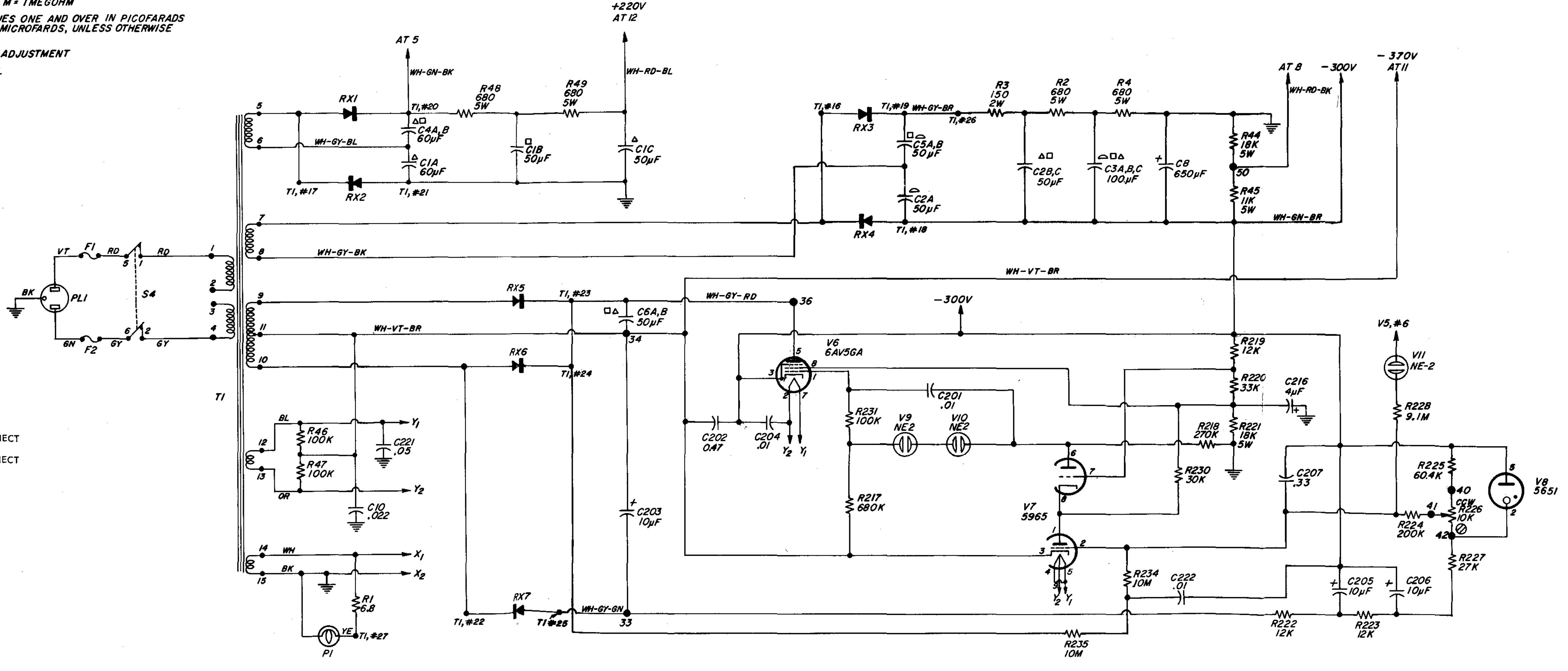


Figure 25a. Schematic diagram. (See also Figure 25b)

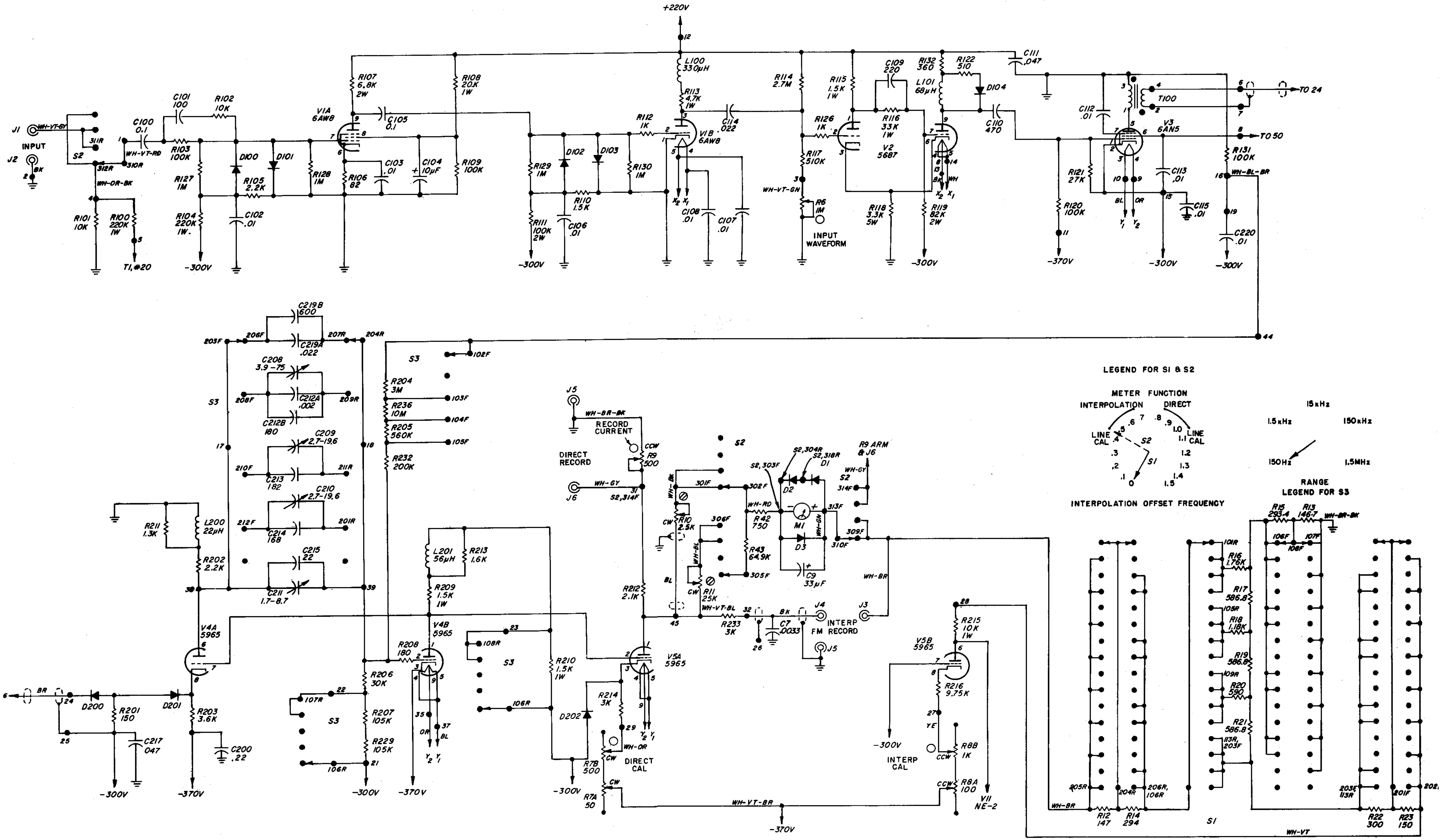


Figure 25b. Schematic diagram. (See also Figure 25a.)

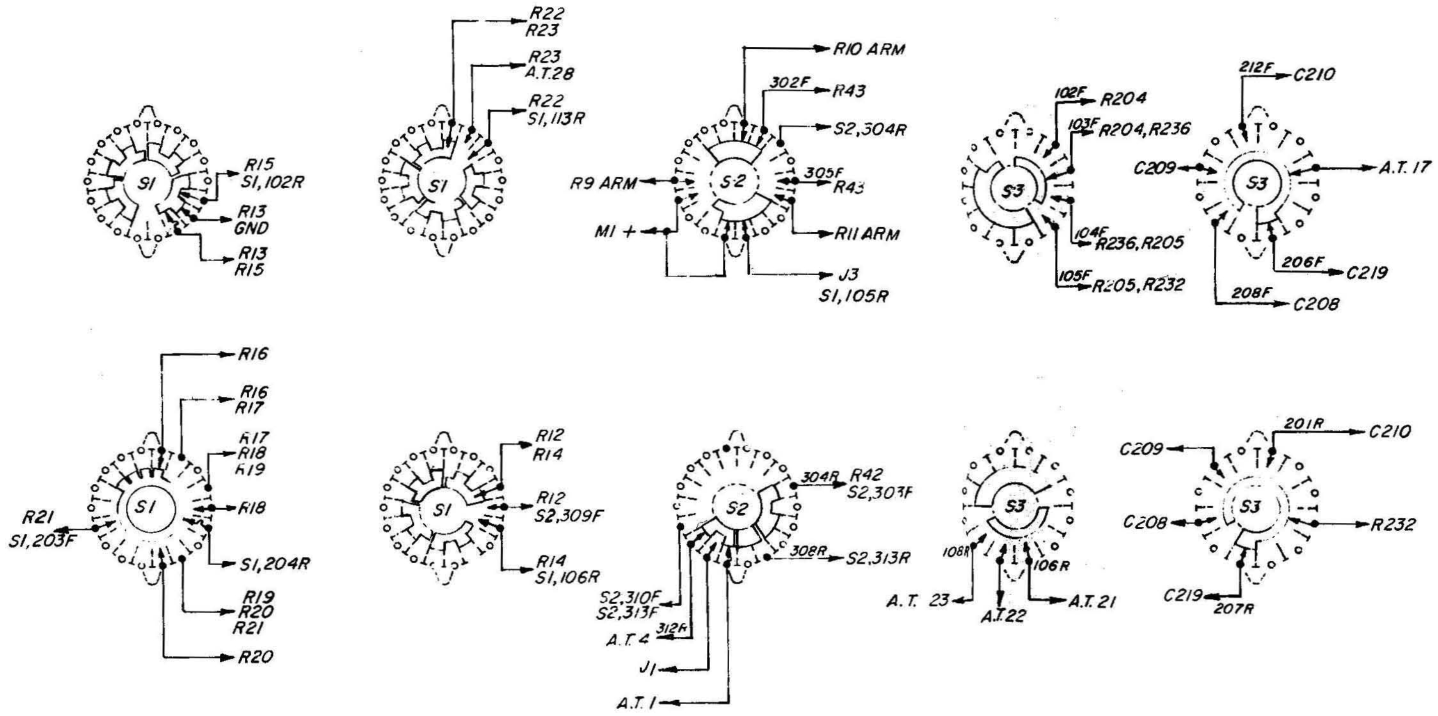


Figure 26. Switching diagram for Type 1142-A Frequency Meter and Discrimnator.

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