Operating Instructions
for
Type 1109 Comparison Oscilloscope
Type 1106-A Frequency Transfer Units
Type 1107-A Interpolation Oscillator

PART VIII

TYPE 1109 COMPARISON OSCILLOSCOPE

This cathode ray oscilloscope unit is designed particularly for use as a frequency comparison device. The three-inch cathode-ray tube includes horizontal and vertical deflection plates, by means of which a circular sweep can be produced, and a radial deflection electrode, by means of which the voltage to be studied produces deflections radially inward and outward from the circular-sweep base. This type of display is particularly useful for frequency comparisons since the patterns are not distorted at the sides as in older systems.

The panel of the Type 1109 Comparison Oscilloscope is shown in the photograph of Figure 7. A schematic diagram is given in Figure 8 and a wiring diagram in Figure 9. At the left side is the x jack for introducing a frequency from an external source. Adjacent is the switch for selecting the frequency of the circular sweep; the five positions give LINE, 100 cycles, 1 kc, 10 kc and INTERPolation OSCillator. The LINE position gives the frequency of the power line supplying the unit; the INTERPolation OSCillator position gives a variable frequency circular sweep, the frequency being adjustable at the interpolation oscillator. The CRO tube face is in the center, with the SELECTOR switch to the right. The SELECTOR switch permits selection of the pairs of sources which are to be compared. These are x vs INTERPolator CIRCular SWeep; x vs STANdard CIRCular SWeep; DETector output vs STANdard CIRCular SWeep; INTERPolator vs STANdard CIRCular SWeep; and DETector output vs INTERPolator (Lissajous pattern). At the right is the power supply switch. Along the lower edge of the panel are the following controls: DIAMETER and SHAPING controls for circular sweep; HORizontal and VERTical CENTERING controls and FOCUS and BRILLIANCE controls for cathode ray tube.

Concentric jacks at the rear provide for connecting the unit to the 100-cycle, 1-kc, and 10-kc outputs of the frequency standard and to the outputs of the three 1106 Frequency Transfer Units and the 1107 Interpolation Oscillator. (These last are obtained at the rear of the 1108 Coupling Unit.)

Following is a brief description of the types of pattern obtained in the various cases:

With the SELECTOR on the DETector vs INTERPolation OSCillator position, a 1:1 Lissajous pattern is obtained when the interpolation oscillator is adjusted to match the beat-frequency output of the Type 1106 Frequency Transfer Units. The pattern appears as a circle or ellipse gradually closing to a straight line and then opening up again at a rate which is equal to the difference in frequency of the two frequencies being matched. (See Figure 10.) If a perfect match is obtained, the pattern does not change with time.

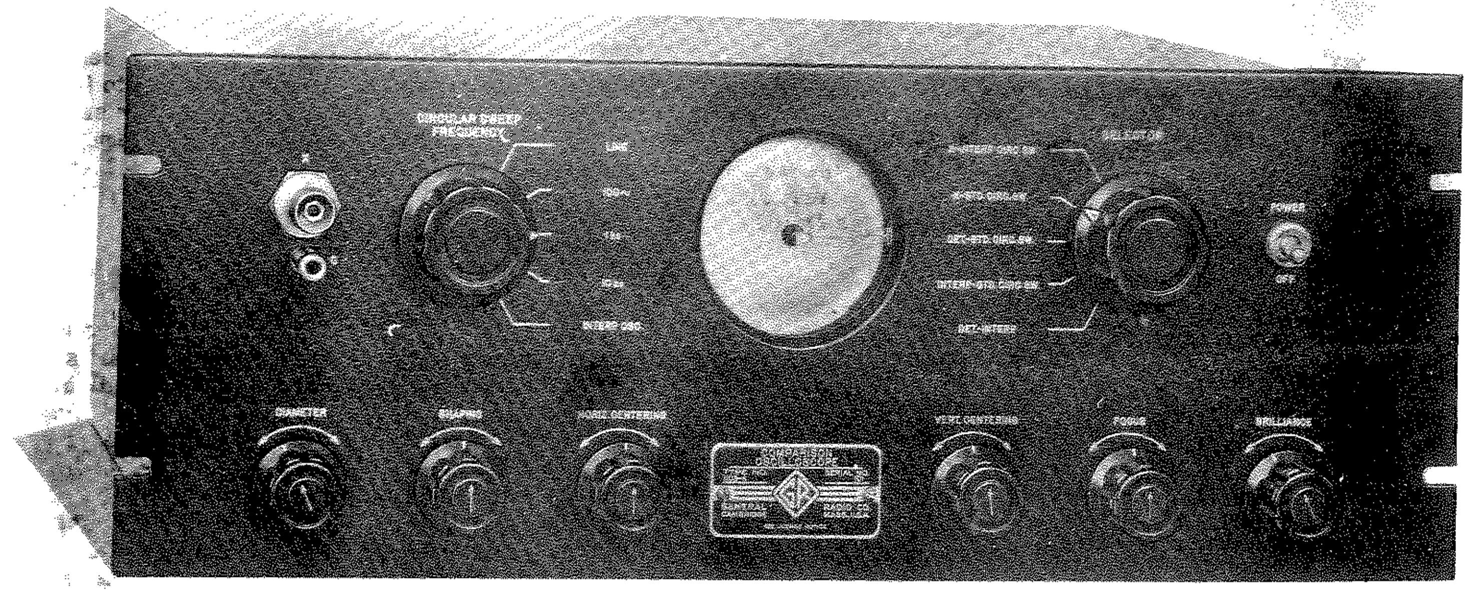


Figure 7. Panel View of the Type 1109-A Comparison Oscilloscope Showing All Controls.

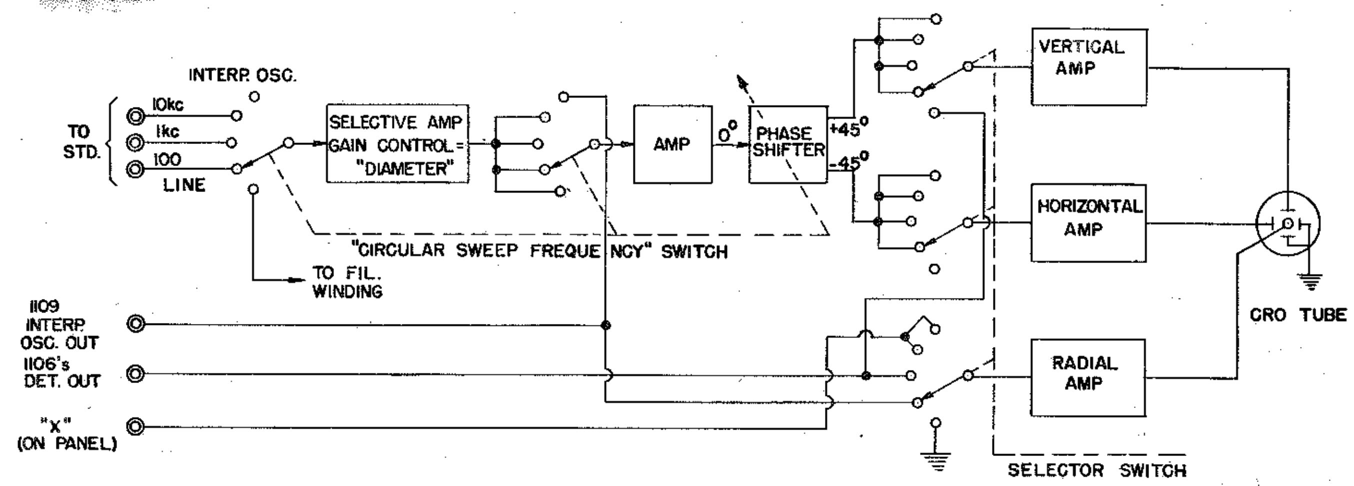


Figure 8. Functional Block Diagram of the Type 1109-A Comparison Oscilloscope.

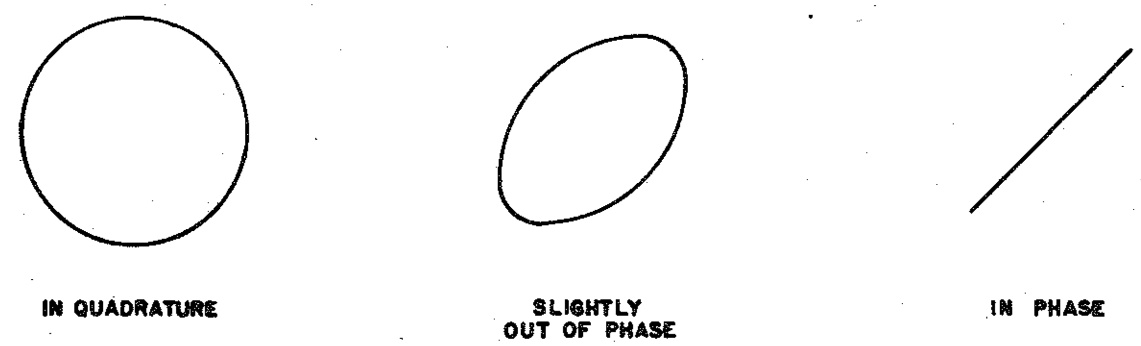


Figure 10. Lissajous Figures for a 1:1 Frequency Ratio.

CONDENSERS

C-1 =	0.2 μf (2 x 0.1 μf)	±10%		COLB-14
C-2 =	0.02 μf	±10%	Aerovox	1445
C-3 =	0.002 μf	±10%	Aerovox	1445
C-4 =	20 μf	450 w.v.		COEB-20
C-5 =	20 μf			
C-6 =	0.380 μf	±10%		*1
C-7 =	0.143 μf	±10%		*2
C-8 =	0.05 μf	±10%		*3
C-9 =	0.0038 μf	±10%		*4
C-10 =	0.05 μf	±10%	Aerovox	1445
C-11 =	2.0 μf	±10%		COL-15
C-12 =	0.5 μf	±10%		COL-13
C-13 =	0.30 μf	±10%		*5
C-14 =	0.03 μf	±10%	Aerovox	1445
C-15 =	0.003 μf	±10%	Aerovox	1445
C-16 =	0.007 μf	±10%		*6
C-17 =	0.5 μf	±10%		COL-13
C-18 =	0.3 μf	±10%		*7
C-19 =	0.03 μf	±10%	Aerovox	1445
C-20 =	0.003 μf	±10%	Aerovox	1445
C-21 =	0.007 μf	±10%		*8
C-22 =	0.05 μf	±10%	Aerovox	1445
C-23 =	0.05 μf	±10%	Aerovox	1445
C-24 =	0.05 μf	±10%	Aerovox	1445
C-25 =	0.05 μf	±10%	Aerovox	1445
C-26 =	0.05 μf	±10%	Aerovox	1445
C-27 =	0.05 μf	±10%	Aerovox	1445
C-28 =	0.05 μf	±10%	Aerovox	1445
C-29 =	1 μf	±10%		COL-45
C-30 =	0.25 μf	±10%		COL-36
C-31 =	20 μf			
C-32 =	20 μf	450 w.v.		COEB-25
C-33 =	20 μf			
C-34 =	20 μf			
C-35 =	0.01 μf	±10%	Aerovox	1441
C-36 =	0.01 μf	±10%	Aerovox	1441
C-37 =	0.05 μf	±10%	Aerovox	1445

*1 = Made up of:
- C-6A = 0.03 μf ±10% Aerovox 1445
- C-6B = 0.25 μf ±10% COL-12
- C-6C = 0.1 μf ±10% Part of COLB-14

*2 = Made up of:
- C-7A = 0.02 μf ±10% Aerovox 1445
- C-7B = 0.02 μf ±10% Aerovox 1445
- C-7C = 0.003 μf ±10% Aerovox 1445
- C-7D = 0.1 μf ±10% Part of COLB-14

*3 = Made up of:
- C-8A = 0.025 μf ±10% Aerovox 1445
- C-8B = 0.025 μf ±10% Aerovox 1445

*4 = Made up of:
- C9A = 0.003 μf ±10% Aerovox 1445
- C9B = 800 μμf ±10% Aerovox 1445

*5 = Made up of:
- C-13A = 0.25 μf ±10% COL-12
- C-13B = 0.05 μf ±10% COL-10

*6 = Made up of:
- C-16A = 0.005 μf ±10% Aerovox 1445
- C-16B = 0.002 μf ±10% Aerovox 1445

*7 = Made up of:
- C-18A = 0.25 μf ±10% COL-12
- C-18B = 0.05 μf ±10% COL-10

*8 = Made up of:
- C-21A = 0.005 μf ±10% Aerovox 1445
- C-21B = 0.002 μf ±10% Aerovox 1445

RESISTORS

RESISTORS				TYPE
R-1 =	10 K Ohms	±10%	IRC	BTA
R-2 =	10 K Ohms			POSC-12
R-3 =	1500 Ohms	±10%	IRC	BTA
R-4 =	100 K Ohms	±10%	IRC	BTA
R-5 =	100 K Ohms	±10%	IRC	BTA
R-6 =	560 Ohms	±10%	IRC	BTA
R-7 =	10 K Ohms	±10%	IRC	BTA
R-8 =	2200 Ohms	±10%	IRC	BTA
R-9 =	5 K Ohms			POSC-11
R-10 =	5 K Ohms			POSC-11
R-11 =	5 K Ohms			POSC-7
R-12 =	1 Megohm	±10%	IRC	BTA
R-13 =	560 Ohms	±10%	IRC	BTA
R-14 =	1 Megohm	±10%	IRC	BTA
R-15 =	560 Ohms	±10%	IRC	BTA
R-16 =	1 Megohm	±10%	IRC	BTA
R-17 =	560 Ohms	±10%	IRC	BTA
R-18 =	22 K Ohms	±10%	IRC	BTA
R-19 =	1 Megohm	±10%	IRC	BTA
R-20 =	560 Ohms	±10%	IRC	BTA
R-21 =	22 K Ohms	±10%	IRC	BTA
R-22 =	1 Megohm	±10%	IRC	BTA
R-23 =	1 Megohm	±10%	IRC	BTA
R-24 =	1 Megohm	±10%	IRC	BTA
R-25 =	2 Megohms			POSC-7
R-26 =	2 Megohms			POSC-7
R-27 =	2.2 Megohms	±10%	IRC	BTA
R-28 =	2.2 Megohms	±10%	IRC	BTA
R-29 =	3.9 Megohms	±10%	IRC	BTA
R-30 =	2 Megohms			POSC-7
R-31 =	1.5 Megohms	±10%	IRC	BTA
R-32 =	500 K Ohms			POSC-7
R-33 =	560 Ohms	±10%	IRC	BW-2
R-34 =	560 Ohms	±10%	IRC	BW-2
R-35 =	560 Ohms	±10%	IRC	BW-2
R-36 =	1 Megohm	±10%	IRC	BTA

MISCELLANEOUS

F-1 = 0.5 amp Slow Blow 3AG GR FUF-1 (115v)
F-2 = 0.5 amp Slow Blow 3AG GR FUF-1 (115v)
F-1 = 0.3 amp Slow Blow 3AG GR FUF-1 (230v)
F-2 = 0.3 amp Slow Blow 3AG GR FUF-1 (230v)

PL-1 = CDPP-562A
PL-2 = 774-G
PL-3 = 774-G
PL-4 = 774-G
PL-5 = 774-G
PL-6 = 774-G

J-1 = 774-P

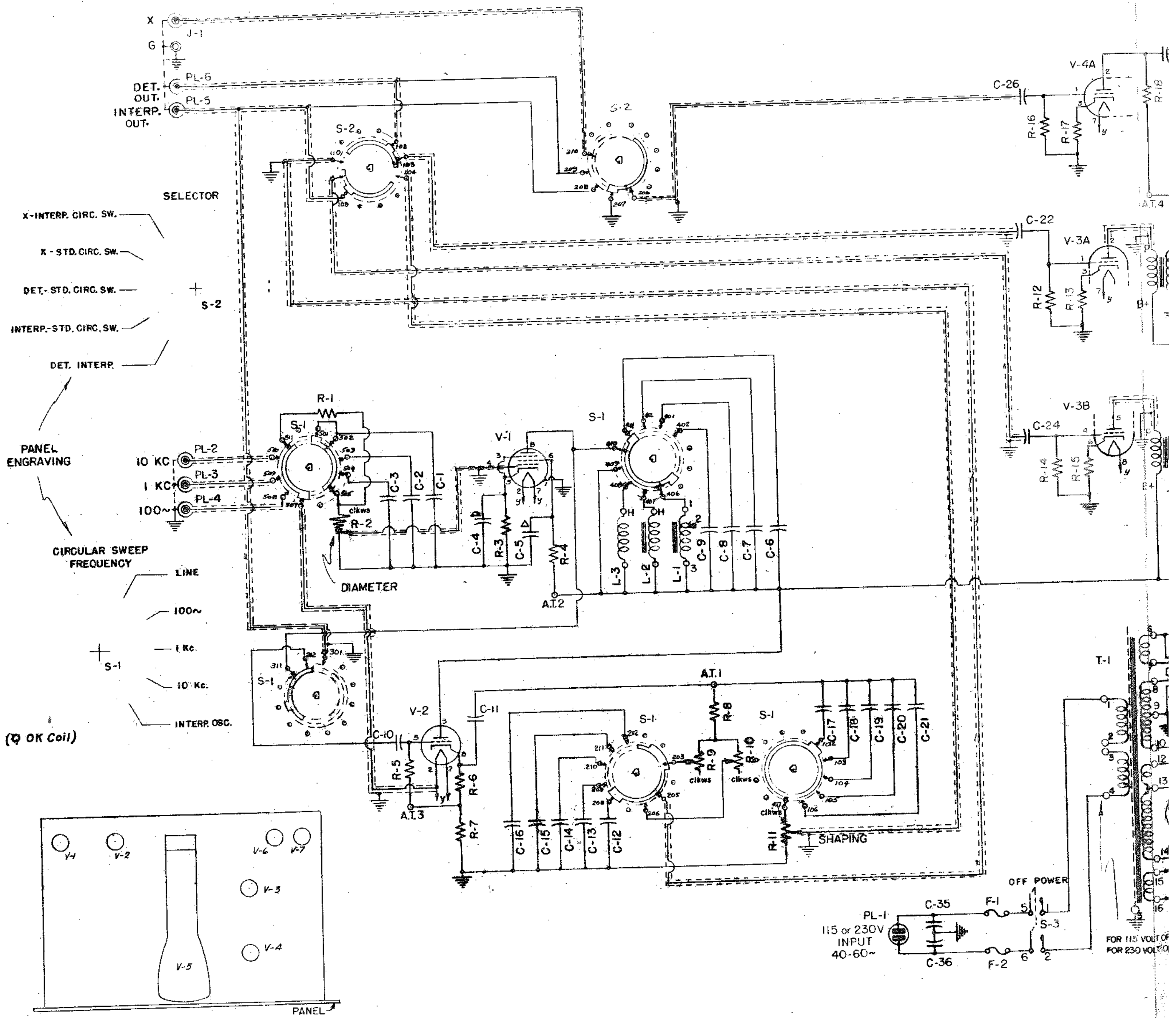
L-1 = 485-425-2
L-2 = 500 mh 119-B (Q OK Coil)
L-3 = 80 mh 379-R

T-1 = 365-468
T-2 = 345-452
T-3 = 345-452

S-1 = SWRW-34
S-2 = SWRW-35
S-3 = SWT-323

TUBES

V-1	RCA	6SJ7
V-2	RCA	6J5-GT/G
V-3	RCA	6SN7-GT
V-4	RCA	6SN7-GT
V-5	RCA	3DP1-A
V-6	RCA	2X2/879
V-7	RCA	6X5-GT/G



TOP VIEW OF INSTRUMENT

TUBE LAYOUT

Figure 9. Complete Wiring Diagram of the Type 1109-A Comparison Oscillosco

	RESISTORS				TYPE
COLB-14	R-1 =	10 K Ohms	±10%	IRC	BTA
1445	R-2 =	10 K Ohms			POSC-12
1445	R-3 =	1500 Ohms	±10%	IRC	BTA
COEB-20	R-4 =	100 K Ohms	±10%	IRC	BTA
	R-5 =	100 K Ohms	±10%	IRC	BTA
*1	R-6 =	560 Ohms	±10%	IRC	BTA
*2	R-7 =	10 K Ohms	±10%	IRC	BTA
*3	R-8 =	2200 Ohms	±10%	IRC	BTA
*4	R-9 =	5 K Ohms			POSC-11
1445	R-10 =	5 K Ohms			POSC-11
COL-15	R-11 =	5 K Ohms			POSC-7
COL-13	R-12 =	1 Megohm	±10%	IRC	BTA
*5	R-13 =	560 Ohms	±10%	IRC	BTA
1445	R-14 =	1 Megohm	±10%	IRC	BTA
1445	R-15 =	560 Ohms	±10%	IRC	BTA
*6	R-16 =	1 Megohm	±10%	IRC	BTA
COL-13	R-17 =	560 Ohms	±10%	IRC	BTA
*7	R-18 =	22 K Ohms	±10%	IRC	BTA
1445	R-19 =	1 Megohm	±10%	IRC	BTA
1445	R-20 =	560 Ohms	±10%	IRC	BTA
*8	R-21 =	22 K Ohms	±10%	IRC	BTA
1445	R-22 =	1 Megohm	±10%	IRC	BTA
1445	R-23 =	1 Megohm	±10%	IRC	BTA
1445	R-24 =	1 Megohm	±10%	IRC	BTA
1445	R-25 =	2 Megohms			POSC-7
1445	R-26 =	2 Megohms			POSC-7
1445	R-27 =	2.2 Megohms	±10%	IRC	BTA
1445	R-28 =	2.2 Megohms	±10%	IRC	BTA
COL-45	R-29 =	3.9 Megohms	±10%	IRC	BTA
COL-36	R-30 =	2 Megohms			POSC-7
	R-31 =	1.5 Megohms	±10%	IRC	BTA
COEB-25	R-32 =	500 K Ohms			POSC-7
	R-33 =	560 Ohms	±10%	IRC	BW-2
	R-34 =	560 Ohms	±10%	IRC	BW-2
1441	R-35 =	560 Ohms	±10%	IRC	BW-2
1441	R-36 =	1 Megohm	±10%	IRC	BTA
1445					

MISCELLANEOUS

1445	F-1 = 0.5 amp Slow Blow 3AG GR FUF-1 (115v)	
COL-12	F-2 = 0.5 amp Slow Blow 3AG GR FUF-1 (115v)	
COLB-14	F-1 = 0.3 amp Slow Blow 3AG GR FUF-1 (230v)	
	F-2 = 0.3 amp Slow Blow 3AG GR FUF-1 (230v)	
1445	PL-1 = CDPP-562A	L-1 = 485-425-2
1445	PL-2 = 774-G	L-2 = 500 mh 119-B (Q OK Coil)
1445	PL-3 = 774-G	L-3 = 60 mh 379-R
COLB-14	PL-4 = 774-G	
	PL-5 = 774-G	T-1 = 365-458
1445	PL-6 = 774-G	T-2 = 345-452
1445	J-1 = 774-P	T-3 = 345-452
		S-1 = SWRW-34
1445		S-2 = SWRW-35
1445		S-3 = SWT-333

TUBES

	V-1	RCA	6SJ7
445	V-2	RCA	6J5-GT/G
445	V-3	RCA	6SN7-GT
	V-4	RCA	6SN7-GT
	V-5	RCA	3DP1-A
445	V-6	RCA	2X2/879
445	V-7	RCA	6X5-GT/G

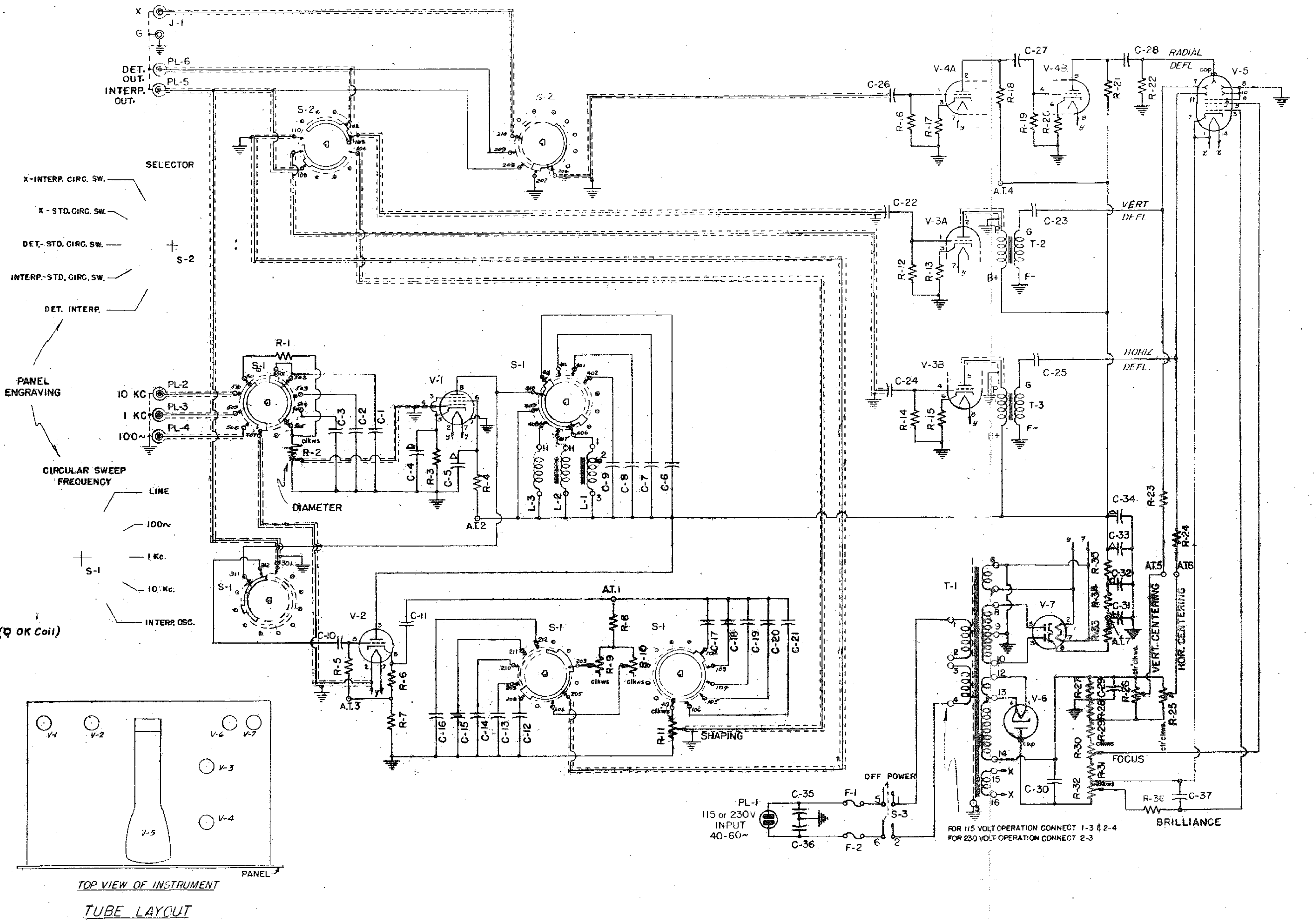


Figure 9. Complete Wiring Diagram of the Type 1109-A Comparison Oscilloscope.

When the radial deflection voltage is applied and is not large enough to overload the amplifier and when the frequency of the applied voltage is an exact multiple of the sweep frequency, the pattern appears as in Figure 12 for a ratio of 6:1. If the pattern rotates slowly clockwise, the radial deflection frequency is slightly higher than the circular sweep frequency; if counter clockwise, the radial deflection frequency is slightly lower than the circular sweep frequency.

This is a "single line" pattern. Similar patterns are obtained for every multiple of the circular sweep frequency, one more scallop appearing each time the ratio is increased by one. That is, a ratio of 10:1 gives 10 scallops; 11:1, eleven scallops, etc.

The circular sweep voltage available from the standard frequencies is much more than is required to produce a circle of the diameter of the screen. It is very convenient to make use of this feature in cases where very high multiples of the standard frequency are to be used. Using a circular sweep of about one-half the screen diameter, the pattern shows the scallops crowded very close together. By increasing the circular sweep voltage to obtain a circle of several screen diameters and then using the VERTical CENTERING control to bring the top or bottom portion of the large circle onto the screen, the pattern will be opened out so that the scallops are easily distinguished. In this manner, multiples of the standard frequency to a hundred or more are easily used. This method of operation is particularly useful in "filling in" a series of closely spaced calibration points, where widely separated key points have already been spotted by the use of the regular patterns.

If the radial deflection amplifier is overloaded, the scallops become sharp-sided and flat-topped, appearing somewhat as gear teeth. It is much easier to count the number of teeth than the number of scallops, particularly on multiple patterns. The advantages of overloading are considered further below.

If the radial deflection frequency is an odd multiple of one-half the circular sweep frequency, a "two-line" pattern is obtained as illustrated in Figure 12, for a ratio of 5:2. A similar pattern with two more loops in the chain is obtained for a ratio of 7:2, etc.

This leads to interpreting the patterns on the basis of the "number of lines" (not overloaded) and the "number of points", or teeth (overloaded). The number of lines is obtainable by not overloading the amplifier; count outward, radially, the number of lines composing the pattern. The number of lines indicates at once the number of intervals into which the interval between one multiple of the standard frequency and the next has been divided. This is summarized in Figure 13 for patterns up to "five-line". The use of five-line patterns, for example, is equivalent to having a standard frequency at one-fifth the value of the actual circular sweep frequency. In other words, five-line patterns provide a standard frequency within ±10 cycles of any audio frequency when using a 100-cycle circular sweep frequency. Another way of stating this is to say that the system shown in Figure 13 indicates known frequencies which can be inserted in each standard frequency interval between one multiple of the standard circular sweep frequency and the next. For a 100-cycle circular sweep this means that in each 100-cycle interval between two successive multiples, points at 20, 25, 33.3, 40, 50, 60, 66.7, 75, and 80 cycles can be readily filled in, using not more than "five-line" patterns. For a 1-kc circular sweep, multiply all these points by 10; for a 10-kc circular sweep, multiply all these points by 100.

In many applications, as in measuring frequencies, the oscillator calibration is fairly well known and it is desired simply to correct small errors. The advantage of the circular sweep method in such cases is that the frequency ratio does not have to be obtained by counting, (it is given at once by the oscillator calibration) and the multiple-line patterns provide a very large number of known calibrating frequencies at closely spaced intervals throughout the range of the oscillator. The oscillator scale can therefore be made to read correctly at any one of these points and the interpolation error for small ranges about these points is negligible.

An important feature of these multiple-line patterns is that the sequence represented in Figure 12 repeats in every interval between one multiple of the standard circular sweep frequency and the next. That is, exactly the same sequence is obtained in going from 500 to 600 cycles, and from 600 to 700 cycles, etc., when using a 100-cycle circular sweep frequency. If the standard frequency is multiplied by 10, the same patterns are again obtained at intervals 10 times as large, and so on.

On an undistorted multiple-line pattern, considerable difficulty is encountered in counting the number of scallops. If the radial deflection voltage is increased until the amplifier is overloaded, the pattern will have radial, or nearly radial lines, which divide the figure into the same number of parts as the number of scallops. The difference is made evident in Figure 12.

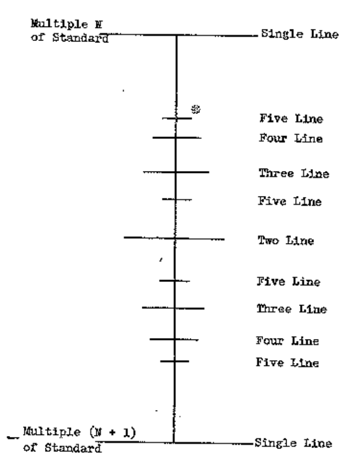


Figure 13. Division of a Standard-Frequency Interval by Multiple-Line Oscilloscope Patterns.

If a low beat frequency is to be matched, it is sometimes helpful to use the detector in an oscillating condition. The output of the Type 1106 Frequency Transfer Unit then consists of an audio-frequency tone, waxing and waning at a rate equal to the low beat frequency. If the beat frequency is several cycles per second, or more, the waxing and waning is rapid and is better described as a flutter. This flutter can be matched with the interpolation oscillator set at the flutter frequency or at a multiple thereof. The pattern for a 1:1 match is indicated in Figure 11a, in various phases of rotation. If the matching frequency is a multiple of the flutter, the pattern at the ends of the figure is the Lissajous pattern for the multiple used. Figure 11b shows the pattern, when the interpolation oscillator is set at twice the flutter frequency, in various phases of rotation.

With the SELECTOR switch set on the other positions, circular sweep patterns are obtained. With the radial deflection voltage reduced to zero, a circle should be obtained. This can be changed in size by the DIAMETER control and in shape by the SHAPING control. The circle can be centered by the use of the HORizontal and VERTical CENTERING controls.

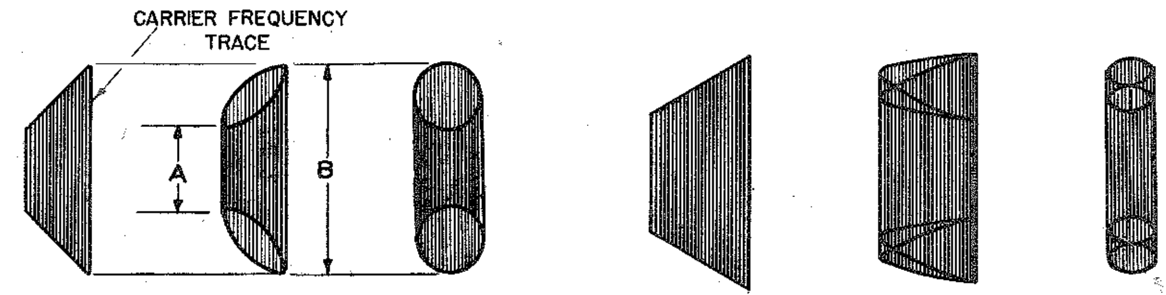


Figure 11. Modulated, or flutter, wave patterns. (a) The three patterns at the left show, for different phases of rotation, a 1:1 match where the interpolation oscillator frequency is the same as the flutter frequency. (b) The three patterns at the right show, for different phases, a match where the oscillator frequency is twice the flutter frequency.

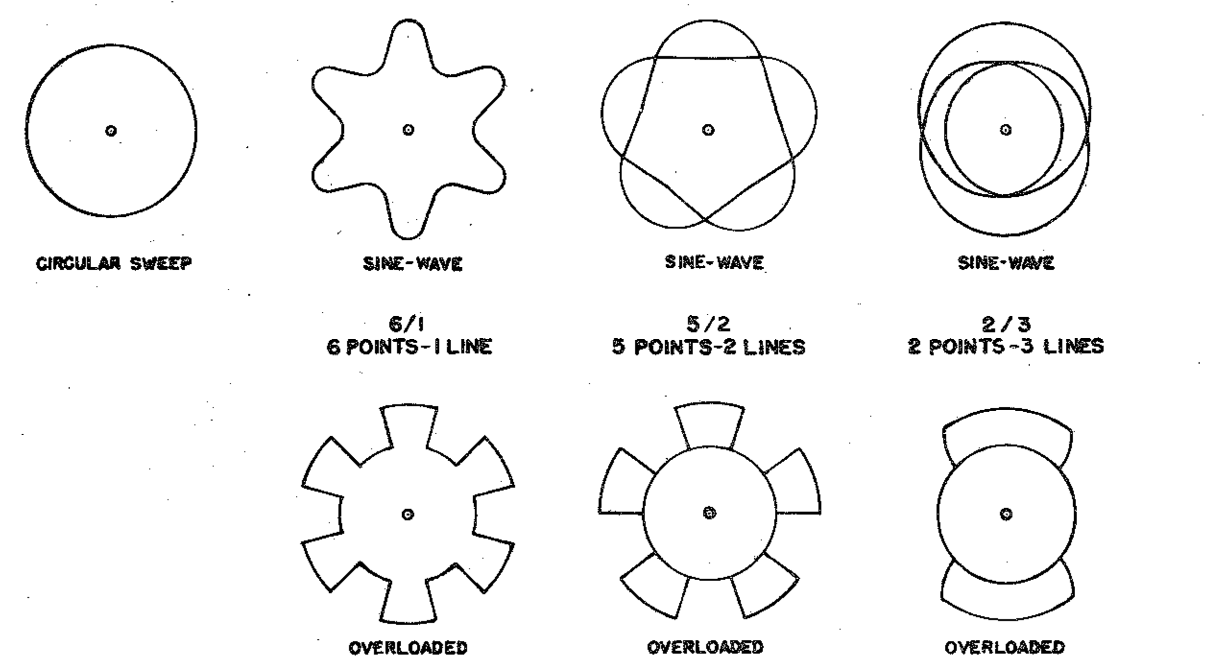


Figure 12.

Circular sweep pattern with radial deflection frequency equal to six times circular sweep frequency. SINGLE-LINE pattern. Note that with single-line patterns the inner and outer circles are not complete when the radial amplifier is overloaded.

Circular sweep pattern with radial deflection frequency equal to 5/2 times circular sweep frequency. TWO-LINE pattern. Note that with multiple-line patterns either the inner, or both inner and outer circles are complete, over-lapping the teeth of the wheel, when the radial amplifier is overloaded.

Circular sweep pattern with radial deflection frequency equal to 2/3 times circular sweep frequency. THREE-LINE pattern. The effect of nearly concentric circles is characteristic when the radial deflection frequency is below the circular sweep frequency.

The following simple rule then emerges for determining the frequency ratios. The number of points divided by the number of lines is the frequency ratio. This rule holds no matter whether the radial deflection is above or below the circular sweep frequency.

When the radial deflection frequency is below the standard circular sweep frequency, the pattern consists of nearly concentric circles when no overloading occurs and the frequency ratio is the ratio of small whole numbers. When overloading occurs, points similar to those previously described are obtained. This type of pattern is shown in Figure 12.

APPLICATIONS

In making frequency measurements, the various SELECTOR switch positions are used as follows:

1. DET. vs INTERP. For matching the beat-frequency output of the Type 1106 Frequency Transfer Units. Set the interpolation oscillator so that the 1:1 Lissajous figure stands still. Read the value of the beat frequency from the interpolation oscillator scales.

Suggestion: If the beat-frequency voltage is not great enough to produce a large pattern on the cathode ray tube, swing the pattern to one side of center by use of the centering control.

Suggestion: For the measurement of very low beat frequencies, the detector of the Type 1106 Frequency Transfer Units may be used in the oscillating condition. Adjust the levels of the standard and unknown frequencies to about the same value. The output of the detector then consists of an audio-frequency tone, waxing and waning in intensity at a rate equal to the difference of the standard and unknown frequencies. If this difference is several cycles per second, or more, the waxing and waning is better described as a flutter. This flutter can be matched with the interpolation oscillator set at the flutter frequency or a multiple thereof.

2. INTERP. vs STD. CIRC. SW. This position permits rapid checking of the calibration of the Type 1107 Interpolation Oscillator.

Suggestion: In making frequency measurements, make the approximate match in (1) above, then check the oscillator calibration and set for zero error at the check point nearest the approximate setting. Return to (1) and take the final reading. This operation can be done so quickly that it is well worthwhile in obtaining the most precise results.

3. DET. vs STD. CIRC. SW. This position is for the purpose of accurately setting the frequency of a radio-frequency source to values which are not multiples of the standard harmonic frequency.

Suggestion: A particular application of this position is in producing crystals for frequency monitors, where the crystal frequency must be off-set from the channel frequency by a specified amount such as 0.5 or 1.0 kc. Using a 1-kc standard circular sweep frequency, the above differences give simple patterns.

4. X vs STD. CIRC. SW. This position is for calibrating an external audio- or low-radio-frequency oscillator, or for standardizing such an oscillator at any one of the many known frequencies obtainable by the circular sweep patterns.

Suggestion: In calibrating an oscillator, which has no calibration at all, start with the highest circular sweep frequency appropriate to the oscillator range and identify principal points on the oscillator scale. Having established such known key points, the calibration can be continued using the same or a lower circular sweep frequency. For example, an oscillator covering a range of 48 to 68kc would give simple key patterns against a 10-kc circular sweep at 50, 55, 60, and 65 kc (one- and two-line patterns). Using a 1-kc sweep, points can be filled in at every 0.5 and 1.0 kc using only one- or two-line patterns.

Suggestion: Where a complete Type 1105 Frequency Measuring Equipment is being used, the oscillator to be calibrated can be connected to the INPUT terminals of the Type 1107 Interpolation Oscillator. Turn the interpolation OUTPUT control to zero. Throw the SELECTOR switch on the Type 1109 Comparison Oscilloscope to INTERP. vs STD. CIRC. SW. The INPUT control of the interpolation oscillator then serves as a volume control for the oscillator being calibrated. This method of operation does not permit as high a frequency range to be covered as that obtained by direct connection at the x jack on the Type 1109 Comparison Oscilloscope (see 5, below).

5. X vs INTERP. CIRC. SW. This position is primarily for measuring a frequency, introduced at the x jack, by means of the interpolation oscillator using the comparison oscilloscope as the comparison device. It is effective over the range from 5 kc to 100 kc or more.

Suggestion: Turn the interpolation oscillator to the DIRECT scale and set for 5000 cycles. Introduce the frequency to be measured. Gradually reduce the frequency of the interpolation oscillator until a one-line pattern is obtained. The number of points on this pattern gives the ratio of the unknown to the interpolation oscillator frequency. Multiply the oscillator frequency by the number of points to get the value of the unknown frequency.

In the measurement of fairly high frequencies the number of points becomes very large, for examply, measuring 100 kc gives a pattern with 20 points. If it is desired to avoid counting the number of points, proceed as directed above and obtain the first one-line pattern. Note the oscillator frequency reading, calling it f_1. Then continue to reduce the oscillator frequency until the next one-line pattern is obtained. Note the oscillator frequency reading, calling it f_2. Then $n_1 f_1 = n_2 f_2 = f_x$. But $n_2 = (n_1 + 1)$, so $(n_1 + 1)/n_1 = f_1/f_2$ and n_1 is easily

determined. Also $n_1 = (n_2 - 1)$, so $n_2/(n_2 - 1) = f_1/f_2$, giving n_2 and making it unnecessary to return to f_1 to complete the measurement.

Having found n_2, obtain the final value of f_2 by checking the interpolation oscillator against the standard at the nearest known frequency and resetting for zero error. Then take final setting of f_2 against the unknown frequency. Multiply this value of f_2 by n_2 to obtain the value of f_x.

TYPE 1106 FREQUENCY TRANSFER UNITS

SECTION 1
DESCRIPTION

PURPOSE

The Type 1106 Frequency Transfer Units are designed for use in frequency measurements, either as calibrated instruments or in conjunction with harmonic frequency standards.

The units are used to pick-up and identify the frequency to be measured; to obtain the beat-frequency difference between a harmonic of a frequency standard and the frequency under measurement; to supply a substitute signal for measurement where the original signal is subject to fading, interference, or keying; to serve as a source of frequency of a desired value; to provide means for avoiding measurements involving very small beat-frequency differences between standard and unknown frequencies; and to provide means for accurately matching two radio frequencies.

PRINCIPLES OF OPERATION

There are three frequency transfer units, differing principally in the frequency ranges covered. These are

TYPE	RANGE
1106-A	100 - 2000 Kc
1106-B	1 - 10 Mc
1106-C	10 - 100 Mc

Each Type 1106 Frequency Transfer Unit consists of a heterodyne frequency meter and a regenerative detector with a two-stage audio-frequency amplifier. Both the frequency meter and the detector are provided with range switching and direct-reading frequency calibrated dials. The ranges of the frequency meter and detector are the same, at corresponding positions of the range switch. This feature is of considerable importance for easy operation. The frequency controls of both instruments give increasing frequency with right-handed rotation of the control knob.

While the detector has an actual fundamental range for each range switch position, the frequency meters have either two or three fundamental ranges (for the first two or three ranges) with the balance covered by selected harmonics. The fundamental ranges, the harmonic ranges, the frequency coverage of every range and the number of the harmonic used for coverage of a harmonic range are all indicated on the accompanying range chart. Further, the chart indicates which one of the fundamental ranges is involved in the coverage of each of the harmonic ranges. The harmonic ranges are all calibrated on the frequency dial, and in the normal use of the instrument, there is no noticeable difference in operation on either fundamental or harmonic ranges.

The use of harmonic frequency ranges in the frequency meter permits the use of fewer coils. The coils that are needed can, therefore, be made of much greater volume with a resulting higher Q, giving much improved performance.

The output circuit of the heterodyne frequency meter includes a buffer amplifier, a rectifier for harmonic generation, and a control for adjusting the level. The output connection is a concentric plug at the rear.

The radio-frequency input circuit to the detector is at a concentric plug at the rear. The input circuit is designed to work from an impedance level of about 50 ohms. The audio-frequency output is obtained at a concentric plug at the rear, and is at approximately 500-ohm impedance level. All of these connections are intended for use with the Type 1108 Coupling Unit.

The detector is supplied with a regeneration control so that the detector can be operated in either the oscillating or non-oscillating condition.

SECTION 2
INSTALLATION

(1) Install vacuum tubes, if not shipped in place, in accordance with the tube tags.

(2) Connect power supply by means of cord and plug supplied. Be certain that power corresponds in voltage and frequency with values given on plate at receptacle.

(3) For change from 105 - 125 volts to 210 - 250 volts,

or vice-versa, connect primary windings of transformer as shown in wiring diagram and change fuses as indicated in parts list.

(4) Input and output connections are made by concentric plugs at the rear.

(5) Throwing the POWER switch to ON supplies power to the whole instrument. The PLATE switch permits removing the plate voltage of the heterodyne frequency meter, so that its signal may be removed, during a measurement, without changing the dial setting.

SECTION 3
OPERATION

DETECTOR

The effective operation of a regenerative detector requires a certain amount of practice. The beginning of oscillations usually occurs with the regeneration control advanced about one-quarter to one-half from the minimum position. For any given frequency setting, the most sensitive condition for receiving continuous wave signals is just after oscillations have started. The most sensitive condition for modulated signals is just below where oscillations start. Careful adjustment of the regeneration control is therefore important. If the regeneration control is advanced too far, a squeal may be heard in the output, due to blocking of the detector.

Do not overload the detector tube with strong signals. The sensitivity is best at fairly low signal strength. When receiving continuous wave signals, too strong a signal applied may lock the detector into synchronization over an appreciable range on the frequency dial.

If difficulty is encountered in picking up a signal whose frequency is only approximately known, introduce a standard-harmonic signal such as multiples of 10 kc or 100 kc. Adjustment of the detector can then be made to the most sensitive oscillating condition. Removing the standard-harmonic signal then permits search over a small range with "preadjusted" detector.

The frequency calibration of the detector is somewhat affected by the setting of the regeneration control. It is most accurate when regeneration is adjusted where oscillations just start, that is, when adjusted for normal operation in the most sensitive condition.

HETERODYNE FREQUENCY METER

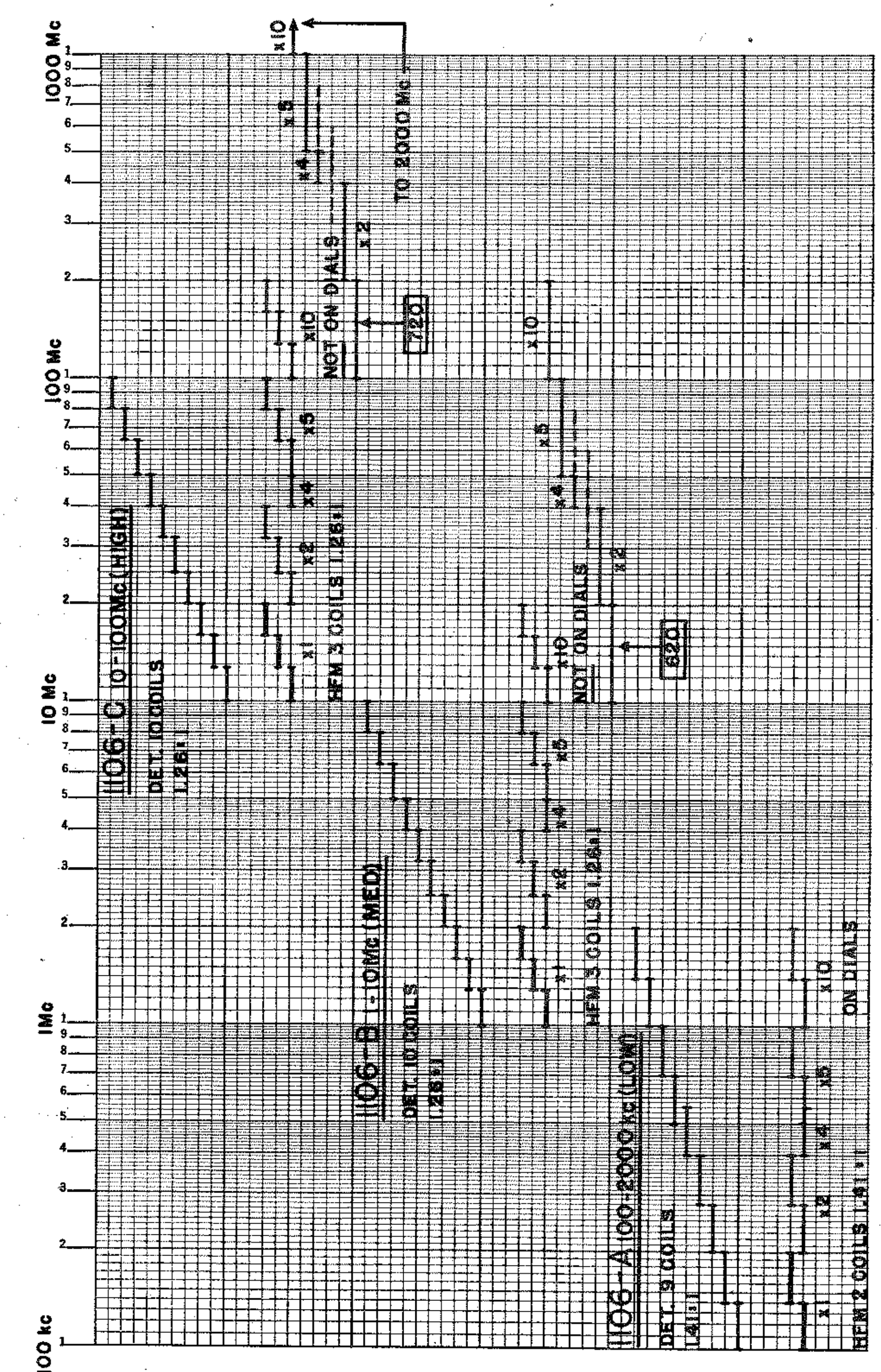
In measuring a frequency, or in identifying a harmonic of a frequency standard, the output of the frequency meter is combined with the unknown or standard frequency and both are applied to the input of the detector. Means are provided in the Type 1108 Coupling Panel for carrying out all the necessary switching, as well as regulation of the voltage levels of the standard frequency harmonics and unknown frequency. When the Type 1106 Frequency Transfer Unit is used independently, means must be provided externally for combining the voltages and for regulation of the amplitude of the frequency being measured.

Having picked up and identified the frequency to be measured in the oscillating detector, set the heterodyne frequency meter to the same range and dial setting. Then search in the vicinity of this dial setting until a beat note is heard. Adjust the frequency meter output so that beats of about equal intensity are obtained in the detector for the unknown and heterodyne frequency meter signals.

The heterodyne frequency meter can then be set accurately in agreement with the unknown frequency by the "three oscillator method". Detune the detector so that beat tones of a kilocycle or so are obtained with the frequencies of the unknown and the heterodyne frequency meter. This beat tone will wax and wane in intensity at a rate equal to the difference of the frequencies of the unknown and the heterodyne frequency meter. By careful adjustment of the frequency meter, the rate of waxing and waning can be reduced to a very small value, in which case the frequency meter is closely matched to the unknown frequency. The value of the unknown frequency is then read from the frequency meter dial.

Since the waxing and waning effect can be produced by matching any pair of the three frequencies, it is well to be certain that the correct pair has been matched, that is, the unknown and frequency meter frequencies. When the waxing and waning has been adjusted to a low value, change the detector tuning slightly. The pitch only of the beat tone heard should change but not the rate of waxing and waning. If either of the other two pairs of frequencies have been matched, in error, the rate of waxing and waning will change tremendously when the detector tuning is altered.

In using harmonics of the heterodyne frequency meter, it is evident, from the accompanying range chart, that when the detector is employed, the correlated ranges automatically insure the use of the correct harmonic. The same is true with an external calibrated receiver, if the heterodyne frequency meter is set so that the dial reading corresponds to the frequency of the receiver. With an external receiver it is easy to extend the range of the heterodyne frequency meter to include the use of the 10th harmonic (which is not on the calibrated dials of the 1106-B and 1106-C frequency meters). When the receiver is tuned to frequencies in the range from 10 to 20 Mc, or 100 to 200 Mc, the heterodyne frequency meter of the corresponding unit is set by using one of the fundamental frequency ranges (the first three range switch positions) and adjusting the frequency



Range Chart

This chart presents, on a logarithmic frequency scale, the limits of each range of the heterodyne detectors and heterodyne frequency meters of the Type 1106 Frequency Transfer Units. The 1106-A (Low) Unit covers 100 - 2000 kc; the 1106-B (Medium) Unit covers 1 - 10 Mc; the 1106-C (High) Unit covers 10 - 100 Mc.

Successive fundamental frequency ranges are presented at successively higher levels giving a stair-type figure. Harmonic ranges are presented horizontally to the right of the fundamental range which produces them and are marked with the number of the harmonic. These harmonic ranges, except where noted, are given calibrations on the dials of the heterodyne frequency meters.

meter for 1/10th of the receiver frequency. This use is clearly indicated in the range chart, as associated with the Type 620 and 720 Heterodyne Frequency Meters.

At times, when the output of the heterodyne frequency meter is taken to external equipment, situations arise where the harmonic of the frequency meter is not identified by the method of use. In such cases considerable confusion can result if the range settings corresponding to the harmonic ranges, shown in the range chart, are used.

If the unknown frequency is above the fundamental range of the frequency meter, first establish which harmonic is being used, by utilizing the fundamental scales only. With the heterodyne frequency meter set at the highest fundamental frequency, gradually reduce the frequency until a beat is obtained against the unknown frequency. Note the frequency meter reading for zero beat. Then continue to reduce the frequency of the frequency meter until the next beat is obtained against the unknown frequency. Note the frequency meter reading for zero beat. Then, if f_1 is the first reading and f_2 the second, we have:

$$nf_1 = (n + 1)f_2 = f_x$$

$$\text{and } n = \frac{f_2}{f_1 - f_2}$$

The harmonic number n should be an integer; if the calculated result does not give an integral value, it is evident what the nearest integral value is, and this value should be used.

If this integer corresponds to one of the harmonic numbers appearing on the range chart, the range switch of the frequency meter can be set for the corresponding range, giving a direct-reading scale. If the integer is not one appearing on the range chart, it is a simple matter to choose another value of n, by taking successively lower settings on the fundamental frequency meter scales.

If the unknown frequency is below the fundamental frequency range of the heterodyne frequency meter, any beat which is obtained is due to a harmonic of the unknown frequency beating with the fundamental (or a harmonic) frequency of the frequency meter. The harmonic can be identified most easily by use of the detector. Starting with the lowest frequency, gradually raise the detector frequency until a beat is obtained. Note the frequency reading for zero beat. Raise the detector frequency until the next beat is obtained and note the frequency reading for zero beat. Then if f_1 is the first and f_2 is the second frequency reading, we have:

$$nf_x = f_1$$

$$(n + 1)f_x = f_2$$

$$f_2 - f_1 = f_x$$

The difference of the two frequency readings gives an approximate value for f_x, which, when substituted in either of the first two equations permits identification of n, since n must be an integer.

TYPE 1107-A INTERPOLATION OSCILLATOR

SECTION 1
DESCRIPTION

PURPOSE

The Type 1107-A Interpolation Oscillator is designed particularly for use in conjunction with standard-frequency equipment to measure the audio-frequency difference between the unknown frequency and a harmonic of 10 kc from the standard. This difference ranges from 0 to 5000 cycles, for all such measurements.

ADVANTAGES

The Type 1107-A Interpolation Oscillator is of the beat-frequency type, with a direct-reading linear scale; each division of the scale corresponds to an increment of one cycle. A special feature is the use of "direct" and "reverse" scales, permitting frequency measurements to be made by addition only. This feature is described in detail below.

Provision is made for readily introducing a standard frequency for checking the calibration of the interpolation oscillator, utilizing the output voltmeter as a beat indicating meter. In a similar manner, an audio frequency, the value of which is to be determined, can be introduced. Separate volume controls are provided for adjustment of the levels of the interpolation oscillator output and the input signal from either the frequency standard or the source under measurement.

Separate incremental-frequency dials, covering a range of plus or minus 10 cycles, are provided for both "direct" and "reverse" scales. These are also used as zero adjustments.

PRINCIPLES OF OPERATION

The audio frequency output (0 - 5000 cycles) is derived from the difference in frequency of two radio frequency oscillators operating at 42 or 47 kc and 42 to 47 kc. The fixed frequency of 42 or 47 kc is selected by the "direct" and "reverse" switch positions respectively. In the "direct" position, as the dial is moved over the 0 - 5000 divisions scale, the output frequency varies from 0 upward to 5000 cycles. In the "reverse" position, as the dial is moved over the 0 - 5000 division scale, the output frequency varies from 5000 cycles downward to zero. The "reverse" scale is separate from the "direct" scale and is marked to be read from 5000 to 10000 cycles. The scale in use is marked by an illuminated index, the illumination changing from one index to the other, when the "direct-reverse" switch is operated.

The accompanying figures indicate the manner of use for measuring frequencies in conjunction with a 10-kc harmonic standard frequency.

In Figure A, the unknown frequency is less than 5000 cycles above the 10-kc standard frequency harmonic f_1. Using the "direct" scale, the difference in frequency $f_x - f_1 = f_b$ is matched by using the interpolation oscillator. The value of f_x is then given by $f_x = f_1 + f_b$.

In Figure B, the unknown frequency is more than 5000 cycles above the 10-kc standard frequency harmonic f_1. Using the "direct" scale, the difference in frequency $f_2 - f_x = f_b$ is matched by using the interpolation oscillator. The value of f_x is then given by $f_x = f_2 - f_b$. It will be noted that the "direct" scale corresponds to the usual interpolation oscillator having but one scale. It will also be noted that, in effect, the scale divisions are laid off to the left of f_2, that is, in a negative direction, corresponding to the subtraction of f_b from f_2.

In Figure C, the use of the "reverse" scale is indicated. On throwing the switch to the "reverse" position, the fixed oscillator frequency is shifted by 5000 cycles. The output frequency then varies from 5000 cycles at zero divisions on the original scale to zero at 5000 divisions on the original scale. In other words, the sense of the frequency change with dial reading has been reversed. Using the original vernier dial, a new main scale is provided which is marked to read 5000 divisions (at zero of the original scale) to 10,000 divisions (at 5000 divisions of the original scale). For the same value of $f_2 - f_x = f_b$ as in Figure B, the actual interpolation oscillator output frequency must, of course, be the same as before to obtain a match. Referred to the initial 10-kc standard frequency harmonic, f_1, we can write for $f_x = f_2 - f_b$, $f_x = f_1 + (f_2 - f_1 - f_b)$. The difference $f_2 - f_1$ is of course equal to 10 kc, the base standard frequency. The quantity in parenthesis is then equal to 10 kc minus the beat frequency f_b. This quantity is evidently the same as f_b', read in a positive sense from f_1, the initial 10-kc standard frequency harmonic, and $f_x = f_1 + f_b'$, where f_b' is read from the scale provided for the "reverse" switch position.

In Figure D, the frequency and dial divisions of the interpolation oscillator are shown, for use of the "direct" and "reverse" scales, as required for covering a complete interval from one 10-kc standard frequency harmonic, f_1, to the next higher, f_2. Figure D, in effect, combines Figures A and C.

SECTION 2
INSTALLATION

(1) Install vacuum tubes, if not shipped in place, in accordance with the tube tags.

(2) Connect the line plug to the power line. Be sure that voltage and frequency correspond to values given on nameplate beside power socket.

(3) For change from 105 - 125 volts to 210 - 250 volts or vice-versa, connect primary windings of transformer as shown in wiring diagram and change fuses as indicated in parts list.

(4) When the power switch is thrown to ON, a bright disc of light should appear at the index of the scale, on the lower scale for the DIRECT-REVERSE switch in the DIRECT position, and on the upper scale for the switch in the REVERSE position. The disc of light thus serves as a "pilot" as well as indicating the scale in use.

(5) Separate input and output terminals are supplied both on the panel and at the rear. The output voltage of the oscillator is available at the output terminals; the output level is controlled by adjustment of the OUTPUT volume control. The INPUT terminals are provided for introduction of the audio frequency to be matched on the oscillator. The level is controlled by adjustment of the INPUT control.

(6) The panel terminals for input and output are arranged for use with either Type 274 Plugs or 774 Concentric Connectors; the rear terminals are arranged for use with Type 774 Concentric Connectors only, which are supplied on the patch cords for connecting Type 1105 Measuring Equipment.

SECTION 3
OPERATION

CALIBRATION

The instrument is adjusted at the factory so that the scale is direct-reading within ± 2 cycles.

STANDARDIZATION

As the instrument is normally used as an interpolation oscillator, in conjunction with a frequency standard, provision has been made in the Type 1105 Frequency Measuring Equipment for the rapid and convenient checking of the oscillator calibration against 100- or 1000-cycle standard frequency, using a cathode ray oscilloscope. This method provides a tremendous number of known frequencies, so that the oscillator can be checked at points within 10 cycles of any frequency in the range from 0 to 5000 cycles. In use it is more convenient to bring the scale error to zero, by adjustment of the "Δf" dial, as a "zero set", than it is to determine the value of the error.

ALTERNATIVE METHOD

When the interpolation oscillator is not being used with a frequency standard, a few volts derived from the a-c power line can be used as a standardizing source.

USE

Beat Indication: In matching an unknown frequency with the interpolation oscillator, it is generally most convenient to use telephones or loudspeaker while watching the beats on the output meter. If the source being measured provides ample signal, adjust the INPUT volume control (with the OUTPUT control at minimum) until a deflection of roughly one-half scale is obtained on the meter. Then advance the OUTPUT control to obtain the maximum swing on the meter, when the oscillator frequency has been adjusted nearly to the frequency being measured. Under these conditions, the meter needle will swing from nearly zero to nearly full scale. Accurate matching is then obtained when the oscillator frequency is adjusted to stop the motion of the needle at mid-swing.

Weak Signals: If the source being measured provides only a weak signal, advance the INPUT control to maximum. Advance the OUTPUT control only far enough to cause the meter needle to swing near to zero on the scale. This adjustment gives the greatest possible swing, which, however, may be over only the first few divisions of the meter scale.

If the oscillator has been set to one-half or twice the frequency being measured, although a small swing of the meter needle may be observed, it is not possible to obtain the pronounced swings, down to zero, as described above.

Beat Matching with the CRO: In matching a very low frequency, it is difficult to tell by ear whether or not the oscillator is equal to the frequency being measured. Frequently, it is found that the oscillator has been set to one-half or twice the low frequency. With the precautions previously outlined it is usually possible to get a match by use of the output voltmeter. It is much more reliable and generally much quicker to use a cathode ray oscilloscope, since the form of the pattern leaves no doubt as to the frequency ratio. A further advantage is that the oscillator can be set to a known multiple of the frequency being measured and a more accurate result is obtained.

Small Changes in Frequency: The "Δf" dials are provided with scales covering ±10 cycles, in 0.5 cycle divisions. In measuring small changes in frequency, set the Δf dial at zero and adjust the main frequency control to the reference frequency. The small changes in frequency are then matched by use of the Δf dial, the + portion indicating an increase and the - portion a decrease in frequency from the reference value.

Audio Source: To use the interpolation oscillator as an audio-frequency source, use the DIRECT scale. Turn the INPUT control to minimum. The output voltage is controlled by adjustment of the OUTPUT control. The meter indicates the voltage applied to the load connected to the "output" terminals.

SECTION 4
MAINTENANCE

If it is found that, over a period of time, the settings of the Δf dials have drifted from zero when the main scale is set to correct reading against a standard frequency, realignment is readily made as follows: Set the main dial to the correct reading for the frequency of the standard. Adjust the Δf dial for zero beat. Adjust the trimmer capacitor corresponding with the Δf dial in use (under snap covers just below the DIRECT-REVERSE switch) until zero beat is again obtained at zero on the Δf dial.

If it is found that the number of divisions on the main scale, to cover the range from 1 to 5 kc is greater (or less) than the correct number, it indicates that the variable capacitance is too small (too large) relative to the fixed capacitance, in the variable oscillator circuit. The initial capacitance of the circuit should therefore be reduced (increased) slightly. This is done by removing the snap cover, to the right of the main frequency control, and adjusting the trimmer capacitance.

Having made a change in the setting of the trimmer, reset the oscillator to 1 kc, readjusting the Δf capacitor as necessary; then check the scale reading obtained at 5 kc. Repeat the trimmer adjustment as necessary to obtain correct alignment.

RESISTORS

					TYPE
R1	=	1 Megohm	±10%	IRC	BTS
R2	=	47 K Ohms	±10%	IRC	BTA
R3	=	20 K Ohms	± 5%		301-462
R4	=	1 Megohm	±10%	IRC	BTS
R5	=	5 K Ohms	±10%		POSW-862
R6	=	56 K Ohms	±10%	IRC	BTA
R7	=	560 Ohms	±10%	IRC	BTS
R8	=	5 K Ohms	±10%		POSW-862
R9	=	22 K Ohms	±10%	IRC	BTA
R10	=	560 Ohms	±10%	IRC	BTS
R11	=	2700 Ohms	±10%	IRC	BTA
R12	=	1 Megohm	±10%	IRC	BTS
R13	=	1 Megohm	±10%	IRC	BTS
R14	=	47 K Ohms	±10%	IRC	BTA
R15	=	20 K Ohms	± 5%		301-462
R16	=	3 K Ohms	± 5%		REPO-1068
R17	=	47 K Ohms	±10%	IRC	BTA
R18	=	100 K Ohms	±10%	IRC	BTS
R19	=	12 K Ohms	±10%	IRC	BTA
R20	=	33 K Ohms	±10%	IRC	BTA
R21	=	47 K Ohms	±10%	IRC	BTA
R22	=	30 K Ohms	±10%		POSC-12
R23	=	56 K Ohms	±10%	IRC	BTS
R24	=	560 Ohms	±10%	IRC	BTA
R25	=	22 K Ohms	±10%	IRC	BTA
R26	=	22 K Ohms	±10%	IRC	BTA
R27	=	1 Megohm	±10%	IRC	BTS
R28	=	560 Ohms	±10%	IRC	BTA
R29	=	22 K Ohms	±10%	IRC	BTA
R30	=	22 K Ohms	±10%	IRC	BTA
R31	=	1 Megohm	±10%	IRC	BTS
R32	=	560 Ohms	±10%	IRC	BTA
R33	=	3300 Ohms	±10%	IRC	BTA
R34	=	50 K Ohms	±10%		POSC-12
R35	=	1 Megohm	±10%	IRC	BTS
R36	=	560 Ohms	±10%	IRC	BTS
R37	=	3300 Ohms	±10%	IRC	BTA
R38	=	22 K Ohms	±10%	IRC	BTA
R39	=	270 Chms	±10%	IRC	BW-2
R40	=	270 Ohms	±10%	IRC	BW-2
R41	=	270 Ohms	±10%	IRC	BW-2
R42	=	5.6 Ohms	±10%	IRC	BW-1/2

CONDENSERS

				TYPE
C1	=	0.001 µf	±10%	COM-45B
C2	=	0.04 µf	± 1%	505-462
C3	=	0.04 µf	± 1%	505-462
C4	=	890 µµf		1107-25
C5	=	0.05 µf	±10%	COM-50B
C6	=	1 µf	±10%	COL-45
C7	=			
C8	=	140 µµf		COA-5
C9	=			368-412-3
C10	=	140 µµf		COA-5
C11	=	325 µµf		COA-6
C12	=			368-412-2
C13	=	500 µµf	±10%	COM-45B
C14	=	0.25 µf	±10%	COL-3
C15	=	500 µµf	±10%	COM-45B
C16	=	0.001 µf	±10%	COM-45B
C17	=	0.04 µf	± 1%	505-462
C18	=	0.04 µf	± 1%	505-462
C19	=			} 622-401
C20	=			
C21	=	140 µµf		COA-5
C22	=	25 µµf		COA-1
C23	=	0.05 µf	±10%	COM-50B
C24	=	1 µf	±10%	COL-45
C25	=	100 µµf	±10%	COM-45B
C26	=	0.002 µf	±10%	COM-45B
C27	=	100 µµf		COA-4
C28	=	0.002 µf	±10%	COM-45B
C29	=	20 µf	450 volts	Part of COEB-25
C30	=	0.05 µf	±10%	COM-50B
C31	=	20 µf	450 volts	Part of COEB-25
C32	=	0.05 µf	±10%	COM-50B
C33	=	20 µf	450 volts	Part of COEB-25
C34	=	0.05 µf	±10%	COM-50B
C35	=	16 µf	150 volts	COE-4
C36	=	0.05 µf	±10%	COM-50B
C37	=	0.05 µf	±10%	COM-50B
C38	=	16 µf	150 volts	COE-4
C39	=	20 µf	450 volts	Part of COEB-25
C40	=	0.01 µf	±10%	COM-41B
C41	=	0.01 µf	±10%	COM-41B
C42	=	100 µf	500 volts	COE-10
C43	=	100 µf	500 volts	COE-10
C44	=	100 µf	500 volts	COE-10

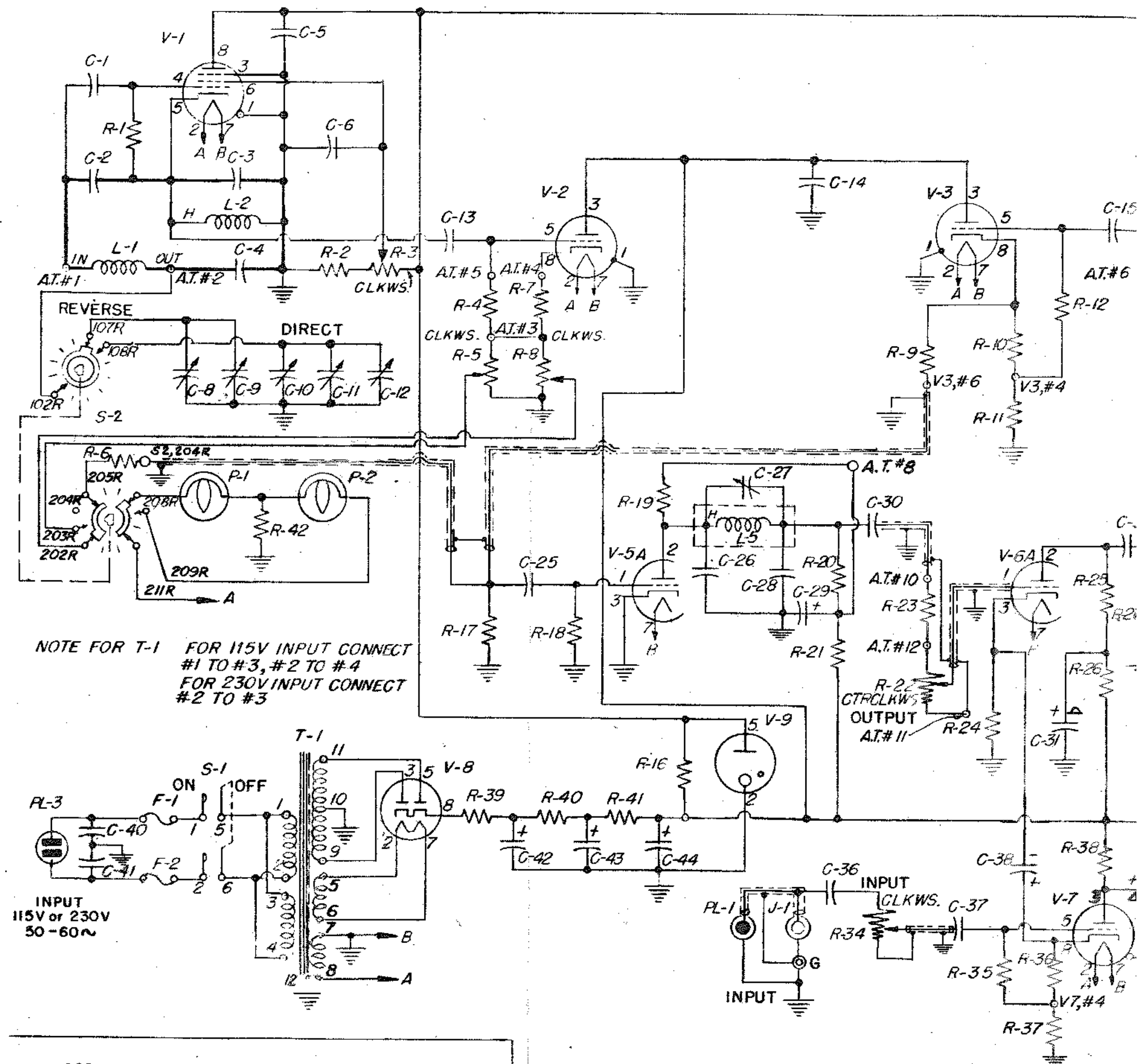
INDUCTORS

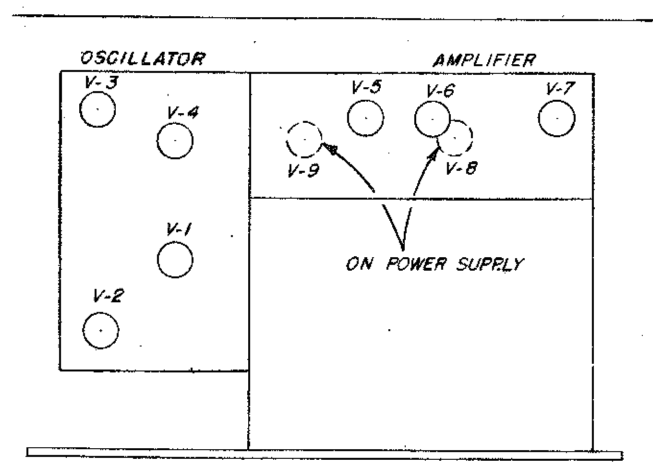
L1	=	11.4 mh	1107-26
L2	=	60 mh	379-R
L3	=	11.4 mh	1107-26
L4	=	60 mh	379-R
L5	=	250 mh	119-A (Q OK. COIL)

MISCELLANEOUS

T1	=	Transformer 485-439-2	
S1	=	Switch DPST SWT-333	
S2	=	Switch SWRW-46	
F1	=	Fuse 1 amp Bussmann 8AG	115 volts
F2	=	Fuse 1 amp Bussmann 8AG	115 volts
F1	=	Fuse 0.5 amp Bussmann 8AG	230 volts
F2	=	Fuse 0.5 amp Bussmann 8AG	230 volts
PL1	=	Plug 774-G	
PL2	=	Plug 774-G	
PL3	=	Plug CDPP-562A	
J1	=	Jack 774-P	
J2	=	Jack 774-P	
P1	=	6.3 volt Pilot Light 2LAP-939	
P2	=	6.3 volt Pilot Light 2LAP-939	
M1	=	Weston Model 301 (3-1/2 BD case) 10 volt, 2000 ohm/volt, 20 K ohms Rectifier type (GR No. MER-2)	

WIRING DIAGRAM FOR 1107-A INTERPOLA

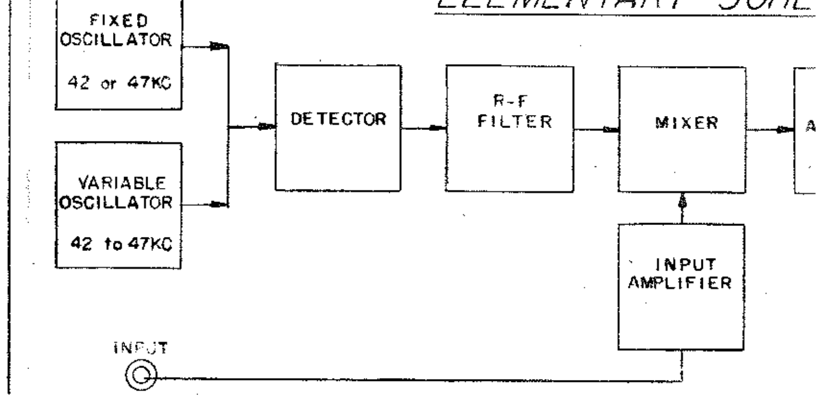




TUBE LAYOUT

TOP VIEW

ELEMENTARY SCHE



		TYPE
±10%	IRC	BTS
±10%	IRC	BTA
± 5%		301-462
±10%	IRC	BTS
±10%		POSW-862
±10%	IRC	BTA
±10%	IRC	BTS
±10%		POSW-862
±10%	IRC	BTA
±10%	IRC	BTS
±10%	IRC	BTA
±10%	IRC	BTS
±10%	IRC	BTS
±10%	IRC	BTA
± 5%		301-462
± 5%		REPO-1068
±10%	IRC	BTA
±10%	IRC	BTS
±10%	IRC	BTA
±10%	IRC	BTA
±10%	IRC	BTA
±10%		POSC-12
±10%	IRC	BTS
±10%	IRC	BTA
±10%	IRC	BTA
±10%	IRC	BTA
±10%	IRC	BTS
±10%	IRC	BTA
±10%	IRC	BTA
±10%	IRC	BTS
±10%	IRC	BTA
±10%	IRC	BTA
±10%		POSC-12
±10%	IRC	BTS
±10%	IRC	BTS
±10%	IRC	BTA
±10%	IRC	BTA
±10%	IRC	BW-2
±10%	IRC	BW-2
±10%	IRC	BW-2
±10%	IRC	BW-1/2

-26
R
-26
R
A (Q OK COIL)

S

5-439-2

T-333

smann 8AG) 115 volts
smann 8AG)
ussmann 8AG) 230 volts
ussmann 8AG)

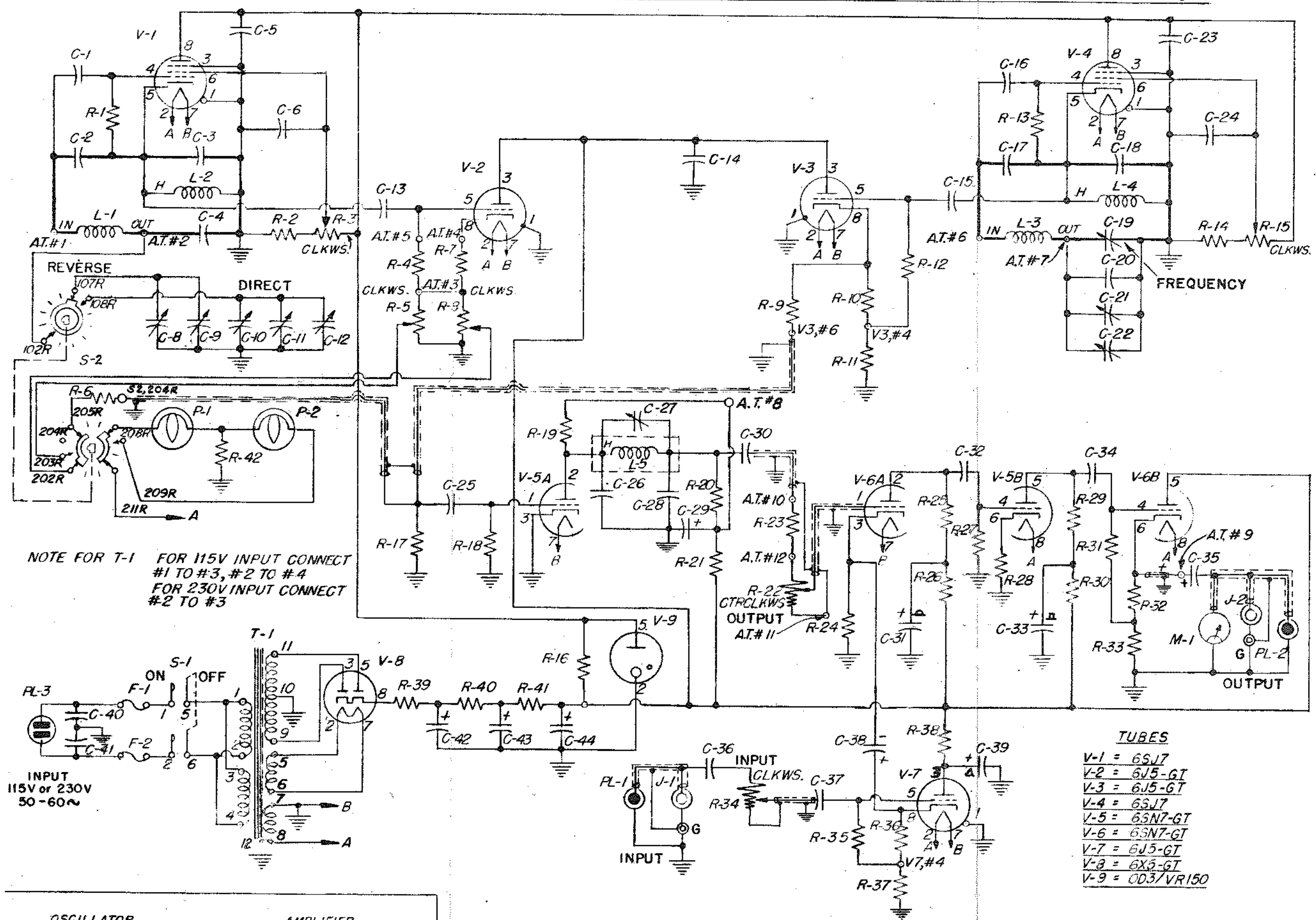
Light 2LAP-939
Light 2LAP-939

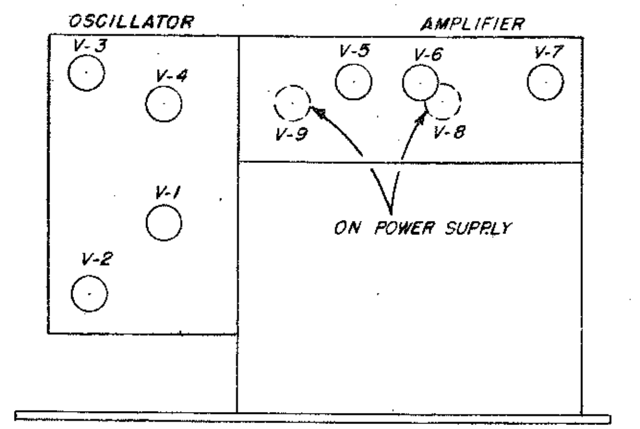
l (3-1/2 BD case)
hm/volt, 20 K ohms
(GR No. MER-2)

CONDENSERS

				TYPE
C1	=	0.001 µf	±10%	COM-45B
C2	=	0.04 µf	± 1%	505-462
C3	=	0.04 µf	± 1%	505-462
C4	=	890 µµf		1107-25
C5	=	0.05 µf	±10%	COM-50B
C6	=	1 µf	±10%	COL-45
C7	=			
C8	=	140 µµf		COA-5
C9	=			368-412-3
C10	=	140 µµf		COA-5
C11	=	325 µµf		COA-6
C12	=			368-412-2
C13	=	500 µµf	±10%	COM-45B
C14	=	0.25 µf	±10%	COL-3
C15	=	500 µµf	±10%	COM-45B
C16	=	0.001 µf	±10%	COM-45B
C17	=	0.04 µf	± 1%	505-462
C18	=	0.04 µf	± 1%	505-462
C19	=			} 622-401
C20	=			
C21	=	140 µµf		COA-5
C22	=	25 µµf		COA-1
C23	=	0.05 µf	±10%	COM-50B
C24	=	1 µf	±10%	COL-45
C25	=	100 µµf	±10%	COM-45B
C26	=	0.002 µf	±10%	COM-45B
C27	=	100 µµf		COA-4
C28	=	0.002 µf	±10%	COM-45B
C29	=	20 µf	450 volts	Part of COEB-25
C30	=	0.05 µf	±10%	COM-50B
C31	=	20 µf	450 volts	Part of COEB-25
C32	=	0.05 µf	±10%	COM-50B
C33	=	20 µf	450 volts	Part of COEB-25
C34	=	0.05 µf	±10%	COM-50B
C35	=	16 µf	150 volts	COE-4
C36	=	0.05 µf	±10%	COM-50B
C37	=	0.05 µf	±10%	COM-50B
C38	=	16 µf	150 volts	COE-4
C39	=	20 µf	450 volts	Part of COEB-25
C40	=	0.01 µf	±10%	COM-41B
C41	=	0.01 µf	±10%	COM-41B
C42	=	100 µf	500 volts	COE-10
C43	=	100 µf	500 volts	COE-10
C44	=	100 µf	500 volts	COE-10

WIRING DIAGRAM FOR 1107-A INTERPOLATION OSCILLATOR





TUBE LAYOUT
TOP VIEW

ELEMENTARY SCHEMATIC DIAGRAM