# Electronic Sweep Oscillator

## Stock No. 150 and 150A

IB-23357

# Part I

# OPERATING INSTRUCTIONS

**WARNING** — WHEN POWER IS ON, THERE IS A HIGH POTENTIAL WHICH MAY CAUSE SEVERE SHOCK. DISCONNECT POWER CORD BEFORE WITHDRAWING CHASSIS.

## Introduction

The Stock No. 150 Test Oscillator is a compact, self-contained, a-c operated, portable instrument of high accuracy and stability designed especially for servicing and test purposes. The instrument supplies an r-f signal of approximately 0.25 volts over a frequency range of 90 to 32,000 kc in six (6) ranges. This r-f signal may be amplitude modulated approximately 30% at 400 cycles for alignment by meter or oscillograph or frequency modulated ±20 kc maximum at any frequency in the above range for use with the Cathode-Ray Oscillograph in visual alignment of i-f and r-f circuits. The sweep width of the frequency modulation is adjustable for any value between ±20 kc at maximum and ±0.5 kc at minimum. The Double Image Frequency Modulation is accomplished electronically (no moving parts) and is entirely free from amplitude modulation and requires no external parts, other than the Cathode-Ray Oscillograph, for visual work. A synchronizing voltage for locking the timing axis oscillator of the Cathode-Ray Oscillograph is supplied by the instrument. Each coil system (fixed and variable oscillator) is enclosed in individual compartments thus shielding them separately from the remainder of the oscillatory circuits and the output system.

From the earliest days of receiver measurements, the characteristics of selectivity and sensitivity were criterions by which receiver performance was judged.

One of the first methods of taking selectivity curves was to measure the input to the receiver necessary to give normal output at frequency intervals of 2 kc steps on each side of resonance up to frequencies where the required input was 10,000 times that required to give normal output at resonance. The curve was then plotted with carrier frequencies taken as the abscissa and the ordinate as a ratio of the required r-f input voltages at the respective measurement frequencies to the sensitivity limit of the receiver.

Another method used for taking selectivity data was to hold the r-f input constant and take output readings (of various frequencies covering the band width of the circuit) by means of a tube voltmeter. These readings when plotted versus frequency on each side of resonance, gave the selectivity curve of the circuit.

Various other methods have been developed in the laboratories to supplant these manual operations. These have taken the form of curve drawing equipments, in which the response of the circuit is traced on curve paper. This paper is moved in synchronism with the r-f frequency change and the variations in output tube voltmeter are followed with a pointer suitably connected with the pen tracing the curve.

Another method is the string galvanometer oscillograph commonly known as the visual. In this method the resonance trace is actually viewed on a screen.

A still later development is the Cathode-Ray method of viewing the resonance curves. This method, as does the oscillograph or visual method, requires an r-f oscillator whose frequency is varied by a rotating sweep condenser in shunt with the oscillator tuning capacitor. A commercial example of this type of equipment is the Test Oscillator, TMV-97-C and Frequency Modulator TMV-128 in conjunction with TMV-122 Cathode-Ray Oscillograph.

The outgrowth of these developments and various methods is the Frequency Modulated Oscillator Stock No. 150 in which all of the drawbacks associated with the mechanically operated systems have been overcome.

Figure 1 shows the general appearance of the instrument. The front panel carries the following controls:

1. Power switch.
2. Semi-full vision illuminated dial calibrated directly in kilocycles with high and low speed concentric knobs for tuning.

3. Three-position modulation control switch:
   1. No modulation (CW).
   2. Amplitude modulation (400 cycles).
   3. Frequency modulation.
4. Six-position range switch with following ranges:

| *Position* | *Range KC* |
|---|---|
| 1 | 90-325 |
| 2 | 325-1,000 |
| 3 | 1,000-2,500 |
| 4 | 2,500-7,000 |
| 5 | 7,000-14,500 |
| 6 | 14,500-32,000 |

5. Sweep width control with approximate calibration from 1 to 40 kc.
6. Output attenuator:
   (a) Stepped coarse control (3 positions).
   (b) Continuous fine control.
7. Output binding posts "High" and "Low."
8. Synchronizing bind posts "High" and "Low."
9. External modulation jack.

The test oscillator is shipped complete with Radiotrons. Figures 8 and 9 show the schematic and wiring diagrams respectively. A detailed description of the circuit and Radiotrons is given under Service Data.

# Installation

After unpacking the instrument remove the seven (7) screws holding the front panel to the case and withdraw chassis and front panel feeding power cord through hole in back of case. Check radiotrons, pilot light and fuse to see if all are firmly in place; also check grid leads to see that all four are on the radiotron grid caps. Replace the case and securing screws and instrument is ready for operation.

# Connections

## R-F and I-F Test

Connect the output from the Test Oscillator to the Receiver under test. Connect the "High" terminal to Receiver antenna terminal for r-f alignment through a proper dummy antenna or resistor as advised in the Receiver Service Data (200-ohm resistor will usually give correct alignment) or to proper i-f grid for i-f alignment. The "0" terminal of oscillator is connected to the receiver ground (chassis) in either case. Reference to the receiver Instruction Book will disclose the proper points for making the input connections for either tests. Connect the receiver to an output indicating meter or to a Cathode-Ray Oscillograph for visual alignment. The output indicating device may be a second detector plate current meter, a voltmeter on output plates, or a voltmeter or indicating device across the cone coil.

## I-F and R-F Test Using Cathode-Ray Oscillograph

The visual method of both i-f and r-f alignment is preferable. For this method the Cathode-Ray Oscillograph is preferably connected across the output of the second detector. Reference to Receiver Service Data will usually disclose the proper point of connection. The Oscillator, Receiver and Cathode-Ray are connected (preferably with low capacity shielded cable) as shown by Figure 3. If shielded cable is not available, standard flexible wire may be used if the various sets of leads are well separated from each other.

## Overall Response

Connect output from Oscillator to r-f input of receiver as in r-f connections above. Place the modulation switch on "c-w" position. Plug in a Beat Frequency Oscillator such as TMV-134-A or other external modulating source into the external modulation jack. The Beat Frequency Oscillator output should be delivered through a low resistance output transformer, both leads of which must be isolated from ground and instrument case. The Beat Frequency Oscillator should be capable of delivering 11 volts rms when connected to a 5,000-ohm load for 30% modulation. An output meter having a flat frequency characteristic up to the highest audio frequency to be employed may be connected across the speaker cone coil; however, the Cathode-Ray Oscillograph is preferable.

# Operation

## General

With proper connections established between units for test being made, turn test oscillator power switch to "on" position and proceed to adjust as follows:

(1) Adjust the six-point range switch and tuning dial for desired r-f frequency. The tuning dial is calibrated directly in kilocycles with six scales, one corresponding to each position of range switch. The concentric tuning knobs give a coarse and fine control for tuning.

(2) Adjust the three-point modulation switch for the type modulation desired.*

(3) If frequency modulation is to be employed, adjust the sweep control for the desired sweep width.

(4) Adjust the output of the test oscillator to the particular test requirements. This consists of setting the stepped coarse control and continuous fine control to give desired output. Both controls

* If, due to sub-normal 6F7 characteristics, 400-cycle modulation of the output is not present, when the instrument is operating with "Modulation" switch set on "Amp" position, the "Modulation" switch should be momentarily rotated to the "Freq" position, and back to "Amp." This procedure will start the audio oscillator unless the circuit is actually defective.

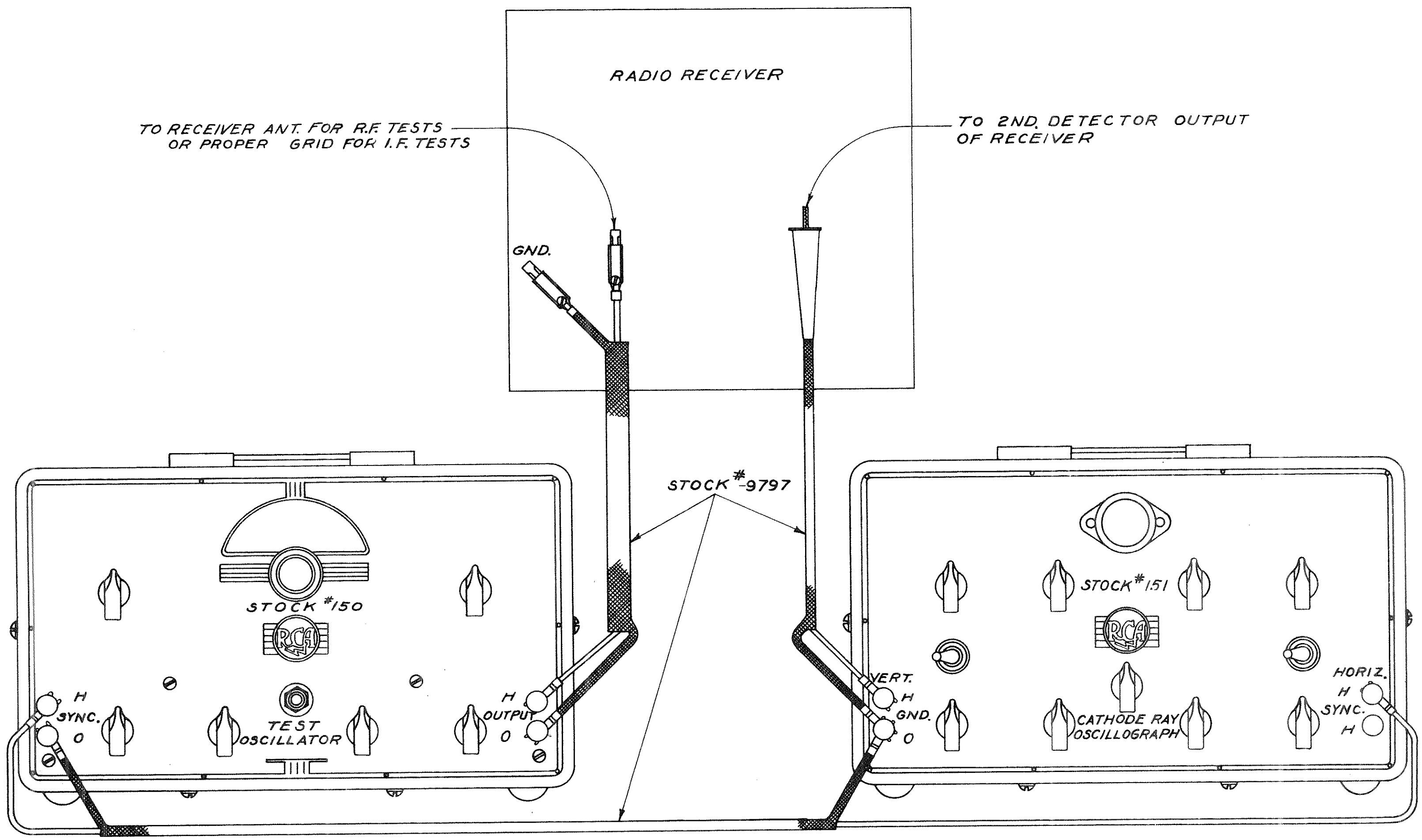



Figure 3—Connections for Receiver Test

at maximum gives approximately 0.25 volts. Lower signal output values should be obtained by reducing the stepped control to the approximate value desired and then making final adjustment with the fine control rather than trying to cover the entire reduction by use of the fine control.

## I-F and R-F Alignment with Indicating Meter

With modulation switch set for amplitude modulation, adjust the attenuator controls to give the desired reading on the indicating meter on the output of the receiver. The receiver i-f or r-f trimmers should then be adjusted in accordance with the instructions in the Service Notes for the particular receiver. To avoid a-v-c action in receiver on r-f alignment, it is advisable to use the minimum signal from the test oscillator at which alignment can be affected. The Service Data for the receiver generally suggests a method for eliminating a-v-c action during alignment. If this suggestion is followed, the input will not be critical but must always be kept below the overload point for the receiver.

## I-F Alignment with Cathode-Ray Oscillograph

Connections are made as shown in Figure 3 and the test oscillator modulation switch is set for frequency modulation and adjusted for desired sweep width. The cathode-ray horizontal timing axis oscillator should be synchronized and locked at 120 cycles or 50 cycles in 25-cycle models. This may be accomplished by adjusting timing axis frequency to give ½-cycle on tube screen with 60-cycle pickup for 60-cycle models or 25-cycle pickup for 25-cycle model on the vertical amplifier (see Figure 4-f), or adjusting for two superimposed resonance curves on the screen with receiver being swept by test oscillator.

The test oscillator output should be coupled to the grid of the tube preceding the i-f stage under alignment. It is essential that this connection be made without altering any of the operating characteristics of this stage. If the grid of the tube to which connection is to be made is at zero d-c potential with respect to ground, connect the oscillator to the grid of the tube and disconnect the

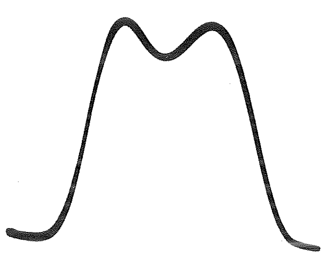


*Figure 4-a*

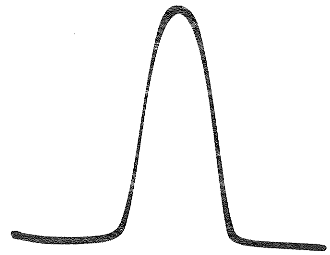


*Figure 4-b*

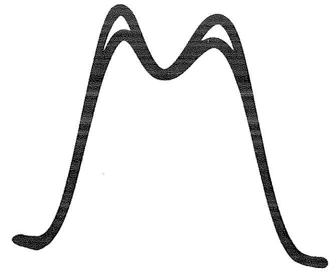


*Figure 4-c*

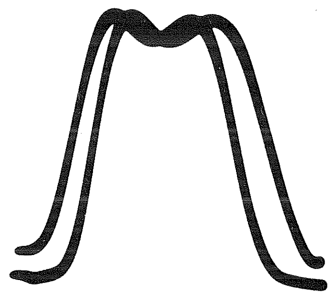


*Figure 4-d*

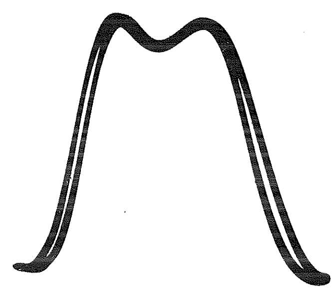


*Figure 4-e*

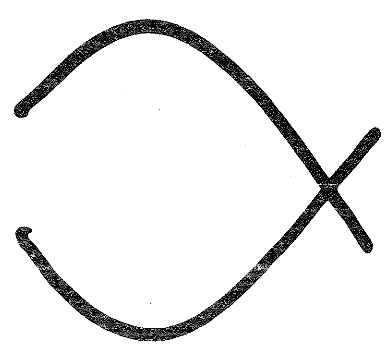


*Figure 4-f*

lead normally on the grid, the low side of the test oscillator output returning to chassis ground. If the grid is not at zero d-c potential with respect to ground, connect the high side of the test oscillator to the grid (disconnecting the lead on the grid) and the other side to the "—C" lead for this grid.

The "Vertical" binding posts of the oscillograph should be connected to the audio output of the second detector. For a diode detector this connection may be across the volume control alone or across both the volume control and automatic volume control resistor, if this connection is convenient. When the second detector is a triode, tetrode or pentode, resistance-coupled to the first audio stage, the connection to the "High" binding post may be to the plate of the tube. The "0" post being connected to ground. In the case of a triode, tetrode or pentode, transformer or impedance-coupled to the first audio stage, connect a resistor of approximately 20,000 ohms in series with the plate of the tube and by-pass the inductance in the plate circuit by a 1.0 mfd. or larger capacitor. This changes the impedance of the plate circuit to resistance rather than inductive reactance; the "High" binding post should be connected to the plate of the tube and the "0" post to ground in order to take the audio voltage off this resistor.

With above connections and adjustments properly made, two superimposed resonance traces should appear on the Cathode-Ray Oscillograph screen. The i-f trimmers are then adjusted for complete symmetry and maximum amplitude of the two traces. When this occurs the stage is symmetrically aligned with respect to the i-f frequency (see Figures 4a, 4b, 4c and 4d).

In cases where complete symmetry of curves cannot be obtained the amplitude increases rapidly when alignment frequency is approached, trouble is apt to be regeneration in the i-f stages. This may be coupling in the common power supply due to an open by-pass capacitor, capacity coupling between stages, absence of proper tube shields, etc. In any event it is indicative of trouble which, when corrected, will allow transformer to be aligned symmetrically.

The i-f stages should be aligned in reverse order starting at last stage and working forward toward the first detector. During i-f alignment, the receiver tuning dial should be set at some point where a variation in its position has no effect on the i-f curves.

## R-F Alignment with Cathode-Ray Oscillograph

R-F alignment is effected in a similar manner and after the i-f alignment is completed, except that the test oscillator output is connected to receiver antenna and ground and the r-f frequency selected to suit the aligning points. The receiver alignment points will be specified in the Service Data for the set. The receiver oscillator trimmer should be adjusted first for correct frequency, then the first detector and r-f trimmers for symmetry and maximum height of the two curves. If the first detector and r-f trimmers shift the frequency (shift the resonance curves apart) the oscillator trimmer should be readjusted to bring the receiver back to proper frequency.

The receiver should then be tuned to the low frequency end of the band, the test oscillator changed to the low frequency aligning point and the receiver low frequency oscillator trimmer adjusted for symmetry and maximum height of curves.

Refer to detailed circuit description under Service Data and note that, due to the beat frequency principle on which this instrument operates, there will be present in the output, frequencies corresponding to the sum of the two oscillators, the difference and the fundamental of the variable oscillator, the harmonics of the fixed oscillator being effectively suppressed. On the higher frequencies the sum and difference frequencies will be present 1,600 kc apart with the variable oscillator half-way between. The dial scale is calibrated in terms of the sum frequency on the last two bands. In order to determine if the receiver is tuned to frequency indicated by the dial scale, where there may be some doubt on the higher frequencies, it is advisable to turn modulation switch to frequency modulation and tune the receiver to these two points. The variable oscillator will appear with no modulation half-way between these two, i. e.:

Oscillator set at 20 megacycles.
3 signals present.
1 at 20,000 kc frequency.
1 at 19,200 kc unmodulated.
1 at 18,400 kc frequency modulated.

When using amplitude modulation, the 400-cycle audio modulation will appear superimposed on the oscillographic image between approximately 799 and 801 kc. When using frequency modulation, extraneous traces may appear on the oscillograph screen if the test oscillator tuning is within the Sweep K.C. setting of the fixed oscillator. Example: Sweep K.C. control set at 20, extraneous traces may then appear when the test oscillator and receiver are tuned to a frequency between 780 and 820 kc. In the majority of cases, the selectivity of the i-f system of the receiver will govern the frequency limits at which these waves will appear and it will be possible to obtain an image on the oscillograph screen free from extraneous waves up to $\pm 10$ kc or less from 800 kc. These extraneous traces will appear, one on each side of the desired double-image trace as the test oscillator tuning approaches 800 kc, at which point the extraneous and desired traces coincide and give an audio beat-note pattern. When aligning, the extraneous traces should be disregarded and the main center traces used. Alignment may be affected, in the majority of cases, within 5 kc of the 800 kc fixed oscillator signal even though audio modulation pattern may be noticeable on the lower portion of the desired curves.

If receiver dial scale calibration is out so that these readings do not check, tune receiver to the highest of the three. The receiver will then be correctly tuned to the frequency indicated by test oscillator dial. On the four lower bands the 1,600 kc difference is far enough apart so as to not be confusing but it should be borne in mind that the dial scale is calibrated in terms of the difference frequency and the lowest of the three signals should be used if doubt exists.

If a frequency of exactly 800 kc is desired, the range selector should be placed to the highest frequency position (14,500—32,000 kc) and the test oscillator connected as previously outlined for the particular application. The output signal will then be from the fixed oscillator only. All controls function normally except the tuning control, which will have no effect at 800 kc when range selector is placed in position stated.

## R-F Alignment with Output Meter

The alignment procedure outlined above should be followed except that the r-f trimmers should be peaked, using an output meter across speaker voice coil, with 400 cycles amplitude modulated signal from the test oscillator.

## Overall Response Tests

With proper connections established between units, tune receiver to 1,000 kc. Adjust test oscillator controls for r-f frequency and output as required. Readings of receiver output may then be taken on the output meter or observed on a Cathode-Ray Oscillograph. The beat frequency oscillator output may be set at a value to give the desired percentage modulation. (A voltage of 11 volts rms will modulate the Stock No. 150 approximately 30 per cent.) Since the modulation characteristic of the oscillator is linear, any other percentage may be computed on the basis of 11 volts rms equals thirty per cent.

EXAMPLE: 60% = 22 volts rms, etc.

# Calibration

The instrument operates on the beat frequency principle but the dial scale is calibrated directly in kilocycles in terms of the mixed output. The variable oscillator frequency is held to a very close tolerance giving a dial scale accuracy of better than ±1% between the frequencies of 1,000 kc and 32,000 kc. Below 1,000 kc this accuracy may be slightly less.

# Part II
# SERVICE DATA

## Electrical Specifications

| | | |
|---|---|---|
| Power Supply Rating | Voltage | 110–120 volts AC |
| | Frequency (Stock No. 150) | 50–60 cycles* |
| | (Stock No. 150-A) | 25–40 cycles* |
| | Power Consumption | 30 watts |
| | Fuse Protection | ½-ampere |
| Range and Applications | R-F Frequency | 90-32,000 kc |
| | Sweep Frequency | ±20 kc max. |
| | Audio Modulation Frequency | 400 cycles |
| | Output | 0.25 volt |
| | Output Impedance | 10, 100 and 1,666 ohm at max. |

| | | |
|---|---|---|
| Radiotrons Used and Functions | 1 RCA-80 | Full wave rectifier |
| | 1 RCA-6F7 | Triode section—audio oscillator<br>Pentode section—R-F oscillator (fixed oscillator) |
| | 1 RCA-6A7 | Triode section—R-F oscillator (variable oscillator)<br>Pentode section—Mixer |
| | 1 RCA-6C6 | Sweep voltage generator |
| | 1 RCA-6C6 | Frequency control tube |

## Physical Specifications

| | | |
|---|---|---|
| Mechanical Specifications | Height | 9¼ inches |
| | Width | 13¾ inches |
| | Depth | 7½ inches |

| | | |
|---|---|---|
| Weight: | 60 cycle | 17 pounds |
| | 25 cycle | 18½ pounds |

*All foregoing instructions are based on the operation of an instrument rated at 60-cycles power supply. On instruments of frequency ratings other than 60-cycles the instructions should be interpreted in terms of the actual operating frequencies; i. e., on 25-cycle equipment the cathode-ray oscillograph timing axis oscillator would be locked at 50-cycles. The instrument is supplied in two models:

Stock No. 150 —Rated for 50–60-cycle operation, connected at the factory for 60-cycle operation.

Stock No. 150-A—Rated for 25–40-cycle operation, connected at the factory for 25-cycle operation.

To operate the No. 150 on 50-cycle power supply or the 150-A on 40-cycle supply, a slight change in connections is necessary in order for the sweep voltage dial scale calibration to be correct for these odd frequencies. These changes are as follows:

To operate the No. 150 on 50-cycle supply, a 0.1 mfd. capacitor should be added in parallel with the existing sweep voltage capacitor, C-1.

CAUTION: The Model No. 150 should not be operated on power supply frequency of less than 50-cycles.

To operate the No. 150-A on 40-cycle supply, remove the jumper between the terminals of capacitor C-43, located at rear of chassis (top side). This reduces the value of the sweep voltage capacity from 2.0 mfd. to 1.5 mfd. and corrects the dial scale calibration for 40-cycle operation.

To operate the No. 150-A on 60-cycle power supply, remove the jumper between sweep voltage capacitor C-1 and C-43. This reduces the sweep voltage capacity from 2 to 1 mfd. identical to that of the 60-cycle model.

To operate the No. 150-A on 50-cycles, it follows that C-1 should be 1.1 mfds.

# Circuit Description

The Stock No. 150 Test Oscillator consists of two radio frequency oscillators (one fixed and one variable) whose output are combined in a mixer tube to provide the desired radio frequency output. Either amplitude modulation (400 cycles) or frequency modulation (of $\pm 20$ kc maximum) of the output frequency may be obtained, depending on which type of modulation is employed on the fixed oscillator. Referring to the schematic (Figure 8) the following action takes place:

A fixed r-f oscillator, consisting of the pentode section of an RCA-6F7 Radiotron and its associated inductance and capacity oscillates at a frequency of 800 kc. A pickup coil coupled to this tank circuit feeds energy from this oscillator into the No. 4 grid of the RCA-6A7 combination oscillator mixer tube. The triode section of this tube, together with its associated inductances and capacities make up the variable oscillator which is tuned by the variable capacitor, C-7. Due to coupling in the electron stream there will appear in the output plate circuit of this RCA-6A7 frequencies corresponding to the sum and difference of frequencies of the two oscillators. The tuning dial is calibrated directly in kilocycles corresponding to the difference of the two oscillator frequencies up to 7 megacycles. Above 7 megacycles the sum frequency is used. The foregoing description applies for the condition of no modulation on fixed oscillator. When amplitude modulation is employed the same action holds true except that the triode section of the fixed oscillator tube oscillates at 400 cycles and is coupled externally to the r-f oscillator section so as to impress audio voltage in series with the plate supply of the oscillator section. The resultant output voltage from the RCA-6A7 tube is amplitude modulated an amount equivalent to the modulation impressed on the fixed oscillator.

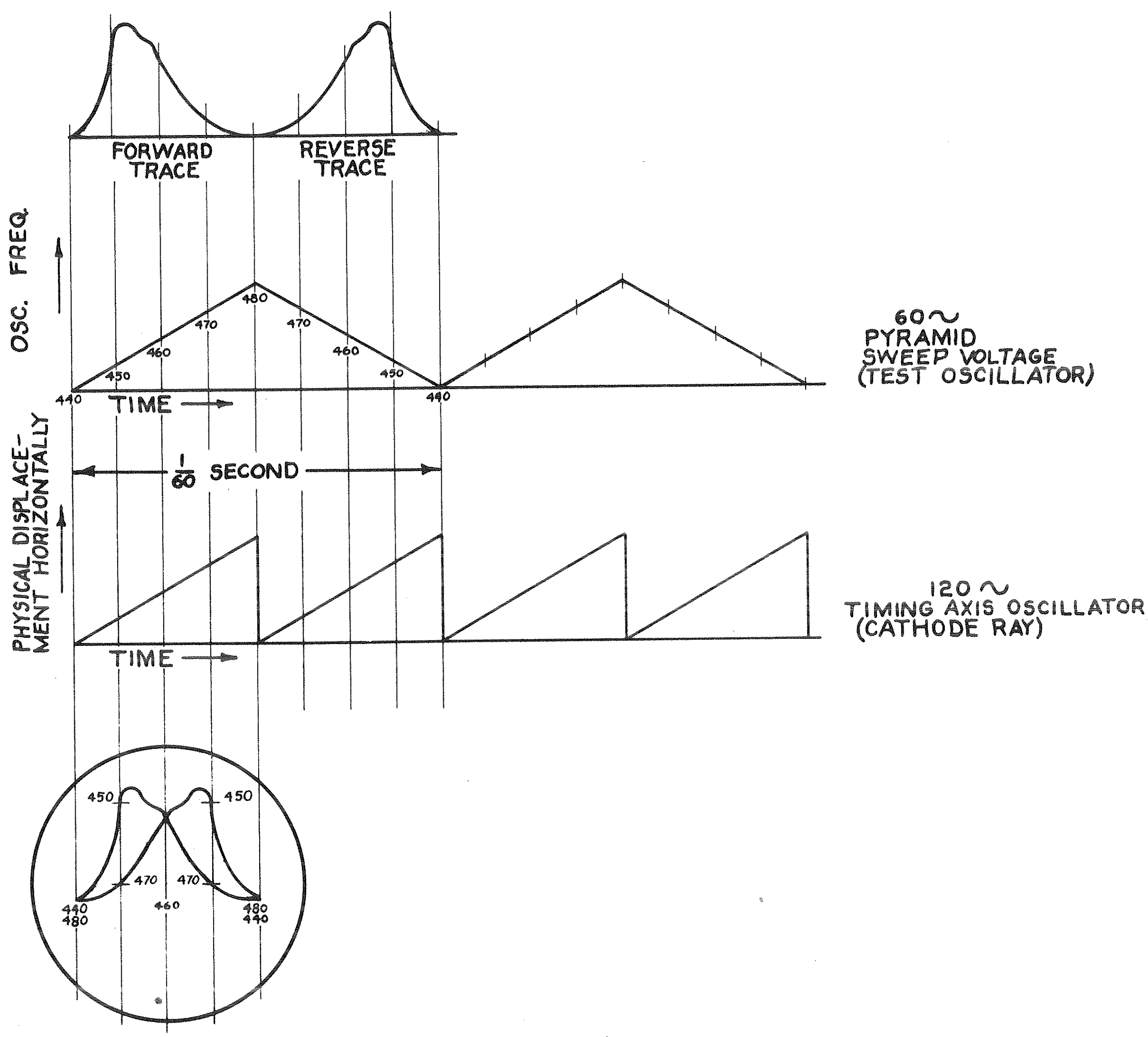



*Figure 5—Resultant Curves on Cathode-Ray Screen*

When frequency modulation is employed the above action of the variable oscillator and mixer tubes still holds true but the signal from the fixed oscillator delivered to the No. 4 mixer grid is being varied at a low frequency rate (frequency modulation), consequently the output frequency from the mixer tube will vary in a like manner. Frequency modulation of the fixed oscillator is brought about in the following manner:

The work plate of the RCA-6F7, electron coupled to the fixed oscillator, builds up an out-of-phase r-f voltage across capacitor C-22, which is coupled to the grid of the RCA-6C6, called the frequency control tube. The plate of this tube is connected directly across the grid tank circuit of the fixed oscillator. With voltage of proper phase angle on the grid of the RCA-6C6 (corrected by network C-21, R-18) the output of this tube appears to the oscillating tank circuit as a shunt inductance. This inductance and hence the oscillator frequency may be varied up or down within limits by raising or lowering the bias on the frequency control tube and so varying its gain. This is accomplished by varying the bias on this tube around a fixed point with a linear 60-cycle pyramid wave form generated by the second RCA-6C6 tube. The pyramid wave form is employed to obtain double image response or the folding back of the forward and reverse resonance traces of a circuit. A brief explanation of double image response follows:

Refer to Figure 5 and assume that the oscillograph timing axis oscillator is locked at 120 cycles, exactly twice the frequency of the pyramid sweep voltage, and that the horizontal deflection progresses from left to right on screen of the cathode ray. In 1/120-second the r-f oscillator frequency progresses from 440 to 480 kc, tracing the response curve on the screen from left to right, controlled horizontally by the timing axis oscillator. At the end of 1/120-second, the oscillator frequency starts decreasing and during the next 1/120-second changes from 480 to 440 kc. At the reversal point (peak of the pyramid voltage) the saw-tooth oscillator has caused the horizontal deflection to reach its maximum on tube screen, drops to zero and returns the beam to the left side of the screen. It then builds up again, tracing the reverse resonance curve (480-440) of the second half of the sweep cycle, thus giving the two superimposed curves, i.e., being the reverse of each other with respect to frequency except at the point corresponding to the alignment frequency. It will be noted that in the above figure the transformer is purposely shown misaligned so that both traces will be fully visible.

A feature of the instrument which should be explained at this point is the variable band sweep. In the explanation and figures of double image response the sweep was referred to as being 40 kc in width (440-480) as this is the maximum sweep. If, when viewing a transformer, this sweep is too great (transformer response is narrow), the sweep can be narrowed to any amount desired by setting sweep control to desired value spreading the transformer response on the Cathode-Ray Oscillograph screen. This change in sweep is effected by changing the amplitude of the pyramid voltage applied to the grid of the frequency control tube by means of the sweep voltage control R-1 which is calibrated in kc sweep. This change in the amount of bias swing changes the gain of this tube, thus controlling the amount of sweep. The variation in nominal frequency setting due to a reduction in sweep from 40 to 5 kc is very small. This is a constant amount and at the higher frequencies represents a negligible percentage. At 400 kc this amounts to approximately $\frac{1}{4}$ of 1%. If alignment frequency is desired closer than these tolerances it is advisable to calibrate the instrument at the alignment frequency with the sweep adjusted to the desired amount. The amount of sweep for any setting of the sweep control remains constant for all r-f frequencies.

Another feature of the instrument is the absence of amplitude modulation when frequency modulation is employed.

Amplitude modulation takes place, to some extent, in test oscillators using rotating condenser, etc., as means of frequency modulation. This amplitude modulation cannot be checked by simply rotating condenser by hand and measuring output voltage as it occurs due to the rate of change of frequency (dynamic characteristic of circuit). It can only be found by comparing the visual picture with the alignment curve taken with laboratory curve drawing equipment. This amplitude modulation (output less at one end of sweep band than other) causes a properly aligned circuit to appear somewhat misaligned when viewed on the oscillograph. When frequency modulation is accomplished electronically it is possible to overcome this defect by proper compensating networks so that resonance curve as viewed on the oscillograph screen is an exact duplicate of one drawn by point to point test methods or one drawn by laboratory curve drawing equipment. Misalignment due to amplitude modulation as it occurs in the older systems of frequency modulation is quite noticeable in the older type of radio receivers using peaked i-f transformers and is extremely so in the newer flat topped i-f transformers. This misalignment may cause serious receiver interference from adjacent channel transmitters.

For a more detailed explanation of double image response and its advantages refer to Cathode-Ray Oscillograph Instruction Books, TMV-122-A.

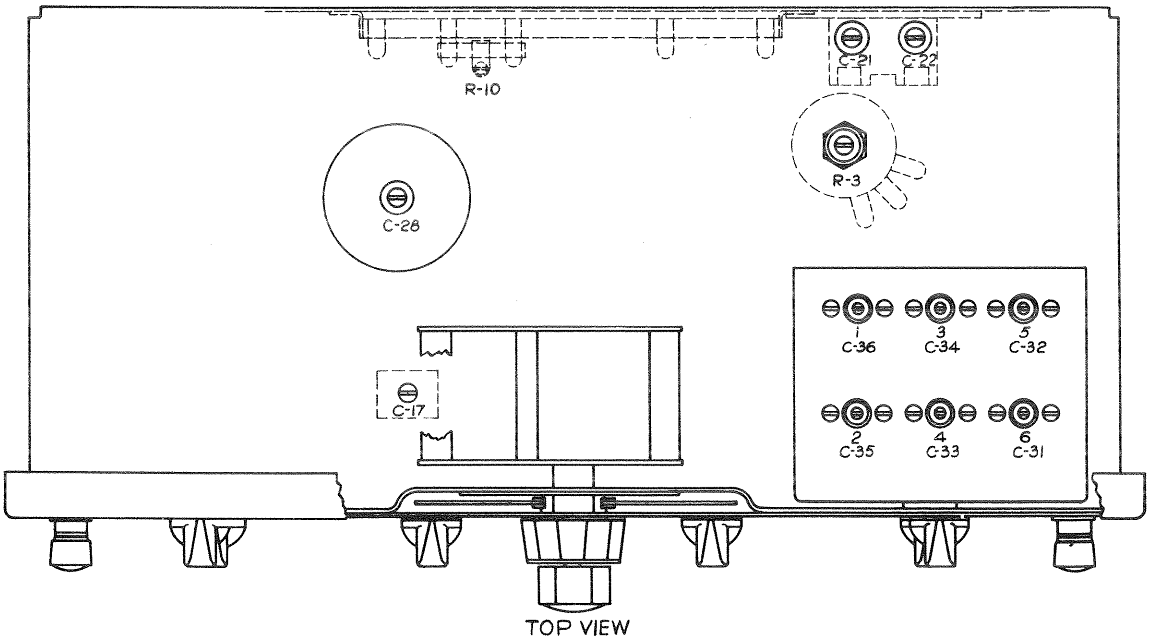



*Figure 6—Adjustment Locations (Top View)*

## Alignment

Correct alignment of both oscillators, correct adjustment of amount of d-c voltage on the plate of the sweep voltage generator tube and correct bias adjustment of frequency control tube bias are necessary for proper output and frequency calibration. These adjustments should be checked periodically and especially after replacing tubes, or making repairs or replacements. For a periodic check where no tubes, other than RCA-6A7 or 80 have been replaced, proceed as follows: Remove instrument from case and place bottom down on a metal bench or piece of sheet metal. Place the instrument in operation. Make connections to a radio receiving set and Cathode-Ray Oscillograph as for r-f alignment. Obtain a crystal calibrator or other accurate frequency source. If crystal calibrator is used it should be connected for d-c operation with the frequency switch set on "Low" position. Tune the receiver to 800 kc (8th harmonic of the calibrator). Set modulation switch on No. 150 Oscillator for frequency modulation and adjust cathode ray for double image sweep. The tuning dial on the 150 should be set at some point where a variation in tuning will not affect the resonance curve of the receiver being swept by the fixed oscillator. With these connections and adjustments properly made the two response curves of the receiver should appear on the cathode-ray screen with a visible beat note marker caused by the beat of the 150 and crystal calibrator. Next, adjust the fixed oscillator trimmer, C-28, located in the top of the fixed oscillator shield can, so that the two traces, on cathode-ray screen, coincide at their peaks. The visible beat note from the crystal calibrator should occur at the peaks of the curves. Change modulation switch to C-W position and adjust trimmer C-17, located on bottom side of chassis with hole for trimming (at left side of tuning condenser facing front of instrument), for zero beat with the crystal calibrator, observing beat on Cathode-Ray Oscillograph. The fixed oscillator frequency is then properly adjusted and compensated for the three positions of the modulation switch. To adjust dial scale calibration only the receiver and crystal calibrator are required. The dial scale should be checked to see that the mark for maximum capacity is on the indicating line with the capacitor plates fully in mesh. Connect output of the 150 to the input of the receiver together with a lead coupled to the crystal calibrator. There are six air trimmers, one for each band, with the following alignment points:

| | |
|---|---|
| 1— 330 kc (C-36) | 4— 7,000 kc (C-33) |
| 2—1,000 kc (C-35) | 5—14,500 kc (C-32) |
| 3—2,500 kc (C-34) | 6—32,000 kc (C-31) |

For the first band tune receiver to 3,300 kc (33rd harmonic of calibrator) on low output and adjust trimmer for zero beat, using 10th harmonic of 330. For the third band, set receiver to 5 mc and use calibrator on high output, using the 5th harmonic of calibrator and 2nd harmonic of 150, and adjust trimmer for zero beat.

On all other bands the fundamentals of the 150 are used together with the proper harmonic of the calibrator set on low or high output as required. Care must be exercised at the higher frequencies to tune the receiver to the proper harmonic of the crystal calibrator since the image from the 1,000-kc step above the point desired is very close, in some instances, to the step desired, i. e., in a receiver using 460-kc i-f transformers, fundamentals from the calibrator will be present at 23,000, 24,000, 25,000, etc. Images will be present at 23,080, 24,080, 25,080, etc., and in sets with low r-f selectivity these images may appear as strong as the true signals. Another point to watch is the two responses from the test oscillator which are 1,600 kc apart. The last two bands are calibrated in terms of the sum frequency so the highest response should be used on these two bands.

When tubes other than RCA-6A7's or RCA-80's have been replaced, the following adjustment should first be made and then the calibration checks made as previously outlined.

### (1) Frequency Control Bias Adjustment, R-10

This following adjustment must be made in the event of tube replacement:

Place Oscillator in operation on frequency modulation with Sweep Width Control at maximum. Make connections between the Oscillator, Receiver and Cathode-Ray Oscillograph as for r-f alignment. Set oscillator frequency at some point at which receiver dial scale has 5 kc graduation in frequency. Example: 200 kc on "X" band of most all wave receivers.

Tune receiver to resonance with oscillator, that is, until the two traces coincide at their peak. The oscillator frequency may be shifted slightly to make the traces coincide at some exact frequency, 200 kc for example. Now tune the receiver to the extremes of the r-f sweep. This may be 190 kc on the low frequency side and 230 kc on the high frequency side. The bias resistor, R-10, is now adjusted so that the extremes of the sweep are symmetrical above and below the nominal frequency. The receiver dial scale is generally accurate enough for this work; however, if increased accuracy is desired, an external oscillator should be used to beat the frequency extremes. The frequency extremes referred to above are represented on the cathode-ray screen when the receiver is tuned so that one-half of the resonance trace of the receiver appears at each end of the line of horizontal deflection.

### (2) Adjustment of DC on Sweep Voltage Generator, R-3. Screwdriver Adjustment on Top of Chassis. (Located Near Variable Oscillator Shield Can Assembly.)

This adjustment should be checked immediately after replacement of a tube or any part associated with this circuit. Any mis-adjustment of this circuit will be evident only on over-coupled circuits (double peaked i-f transformers, see Figure 4e) and causes one trace to be slightly inside the other, depending on the amount of mis-adjustment.

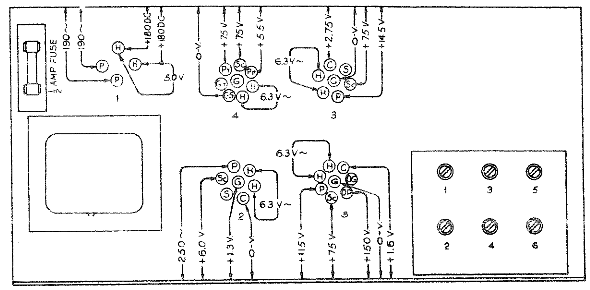


*Figure 7—Tube Voltage Diagram*

To adjust R-3 proceed as follows: Align an over-coupled transformer so that the peaks coincide (see Figure 4e), then adjust R-3 until the sides of two traces coincide (see Figure 4a).

### (3) Adjustment of Phase Angle Compensation and R-F Feedback Voltage, Capacitors C-21 and C-22, respectively. (Located at Right Rear Top of Chassis.)

These two adjustments are not affected by tube replacements. They are accurately adjusted at the factory and under no condition (except failure of C-21, C-22 or R-18) should their adjustment be disturbed. If, due to failure, either of these three parts require replacement, the following procedure is given for the proper alignment of this network:

(A) Adjust fixed oscillator on frequency modulation for correct band-width and frequency and compensate for pure frequency modulation. (Two trimmer adjustments.)
The following equipment will be required:
- (a) A double peaked i-f transformer at some convenient frequency, 460 kc for example, working out of a mixer tube and into a diode.
- (b) A variable r-f signal source such as a RCA TMV-97-C Test Oscillator capable of being operated 460 kc above and below the 800 kc fixed oscillator to produce the i-f signal. Compensation for pure frequency modulation is brought about as follows: With the i-f transformer properly tuned, adjust compensation trimmer so that response of the transformer is identical when the 460 kc signal is produced in the mixer tube by a 340 kc signal or a 1,260 kc signal from the signal source beating with the 800 kc fixed oscillator.

### (4) Adjustment of Sweep Width Control, R-1. (Located at Top Left Side of Front Panel.

If this unit is to be replaced, proceed as follows:

Remove old control and assemble new control in place, making sure that knob is assembled with set screw on flat of shaft, but do not wire. Turn knob to maximum clockwise position. Connect an ohmmeter or resistance bridge between the rotor terminal and the high end of the control. The resistance reading should be zero. Now rotate knob counter-clockwise until a resistance reading of 120 ohms is obtained. Leave knob set at this position, remove ohmmeter, loosen locking nut on back side of panel and rotate potentiometer, being careful not to disturb setting of knob, until knob pointer coincides with the 40 kc mark on the dial scale. Tighten locking nut with knob pointer in this position. The control is then correctly calibrated. replace wires on control and it is then ready for operation. If a control becomes loosened on front panel, the calibration is corrected as outlined above.

# Radiotrons

Under ordinary usage, within the ratings specified for voltage supply, tube life should be consistent with that obtained in other applications. Low output, inability to obtain modulation, or total failure of operation may be indicative of tube trouble.

If tube trouble is suspected, the tubes should be removed from their sockets and tested in a reliable tube-testing device. Each tube should be replaced in the socket from which it was removed. Replacing a questionable tube, with one known to be in good condition, is another sure and definite means of tracing trouble. When replacements of the tubes are made, the adjustments of controls should be performed as outlined previously.

### Radiotron Socket Voltages.

Operating conditions of the basic circuits of this instrument may be determined by measuring the voltages applied to the tube elements. These values are shown by Figure 7. The values shown should hold within ±20% when the instrument is normally operative with all tubes intact and rated voltage applied. Variations in excess of this limit will usually be indicative of trouble. To fulfill the conditions under which these voltages were measured required a 1,000-ohm/volt AC/DC meter having ranges of 3, 30 and 300 volts, using the nearest range above the voltage to be measured.

# Maintenance

The various diagrams given in this booklet contain such information as will be needed to locate causes for defective operation if such develops. The values of the various resistors, capacitors, and inductances are indicated adjacent to the symbols signifying these parts on the diagrams. Identification titles, such as R-3, L-2, and C-1, etc., are provided for reference between the illustrations and the Replacement Parts List. These identifications are in a sequence which begins at the left of the diagram and increases numerically from left to right, thus facilitating the location of such parts on the schematic diagram.

The coils, reactors, and transformer windings are rated in terms of their d-c resistance. This method of rating provides ready means for checking continuity of circuits. Suspected faulty circuits or parts may be checked and their resistances compared with the value given on the schematic diagram.

Failure of operation may result from:

(1) Power supply being "off."

(2) Open fuse within the instrument.

(3) Defective tubes.

(4) Defects within the instrument itself.

Low output or improper calibration may result from:

(1) Improper alignment of the various circuits.

(2) Oscillator coil shields loose or removed.

(3) Defective tubes.

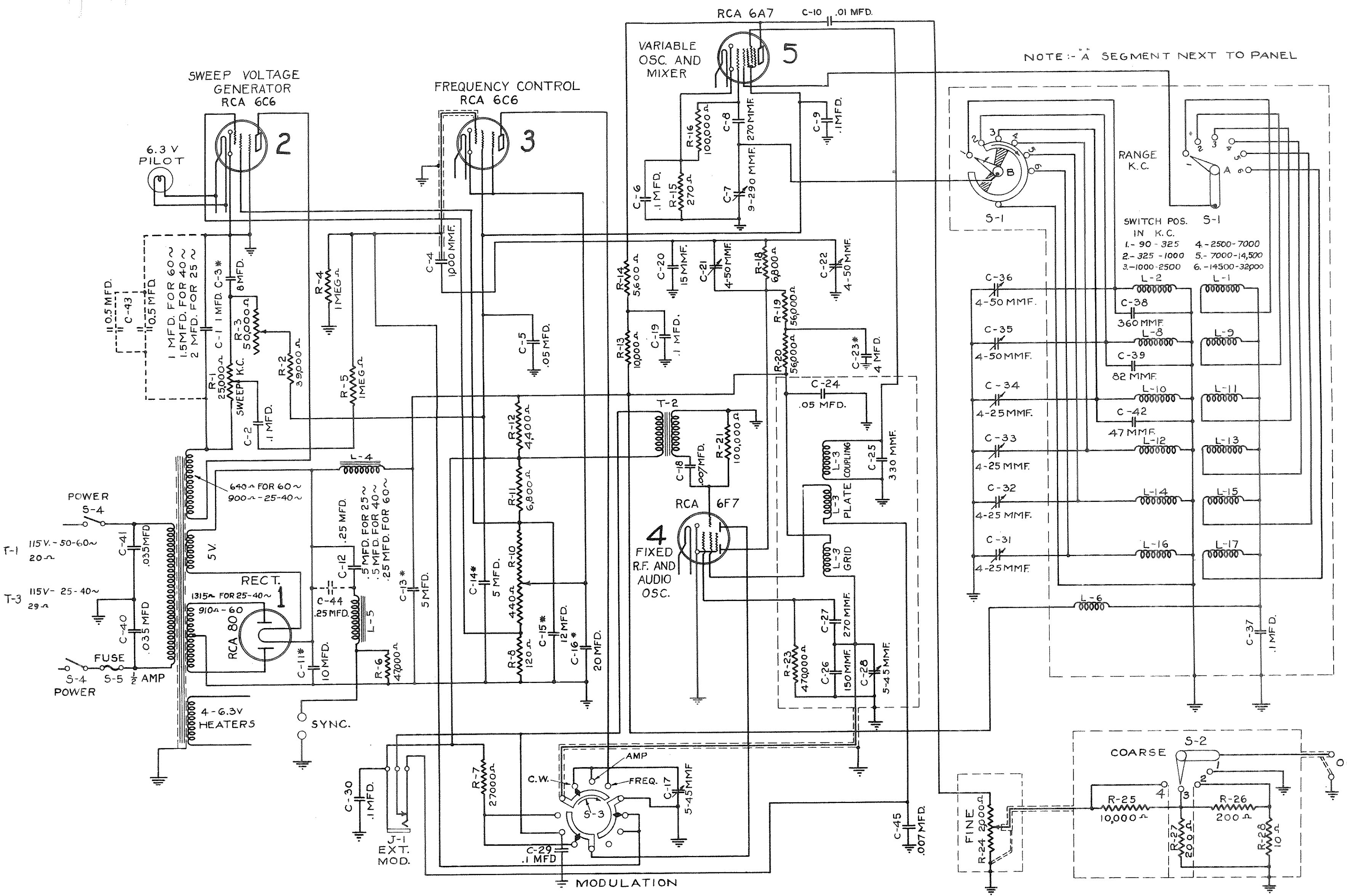
(4) Improper setting of control knobs on shafts.

(5) Defects within the instrument itself.

CAUTION.—Disconnect power supply before removing case.

# Fuse Replacement

A small ½-ampere cartridge fuse provides protection of the power-supply system, and should not be replaced with one of higher rating, nor be shorted out. A fuse failure should be carefully investigated before replacement since a fuse of good quality fails only under conditions of overload. The fuse clips should be kept clean and in secure contact with the fuse at all times.




* IN CAPACITOR PACK

*Figure 8—Schematic Diagram, Test Oscillator T-611031*

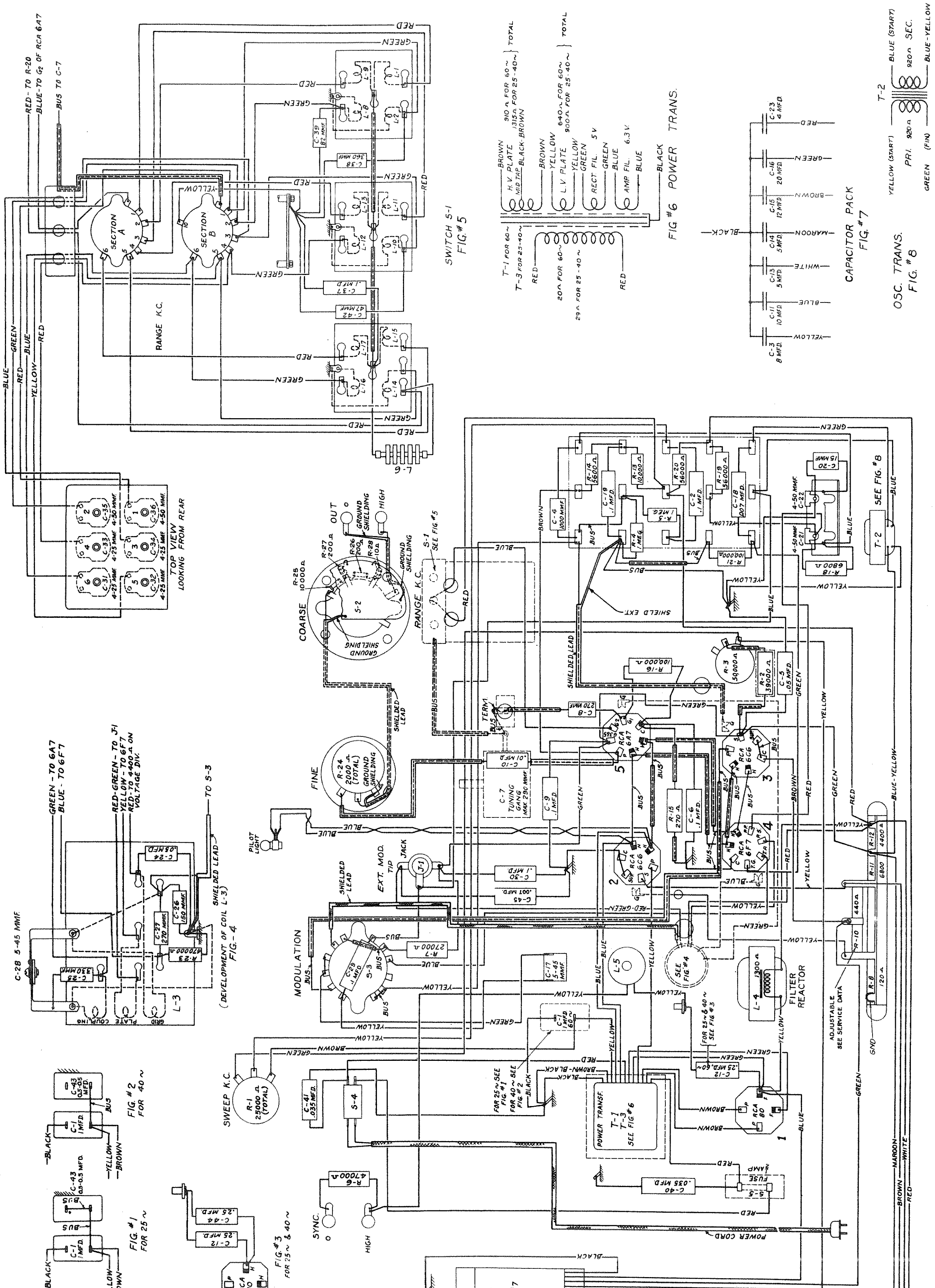


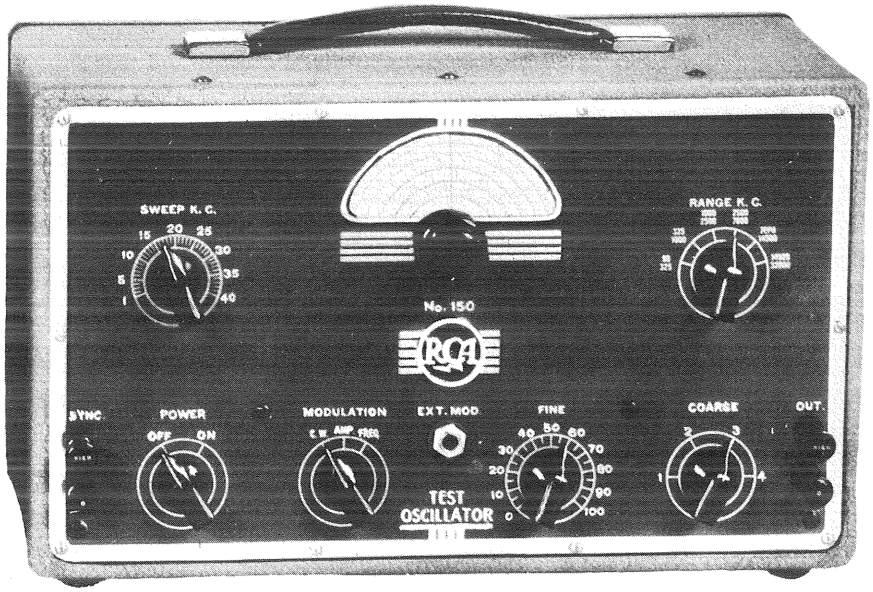

*Figure 9—Connection Diagram, Test Oscillator W-302137*

# REPLACEMENT PARTS

**Insist on genuine factory tested parts, which are readily identified and may be purchased from authorized dealers.**

| Stock No. | Description | |
|---|---|---|
| 13991 | Transformer—Power transformer 110 Volt, 50-60 Cycle | (T1) |
| 3979 | Transformer—Osc. Transformer | (T2) |
| 14144 | Transformer—Power transformer 110 Volt, 25 Cycle | (T3) |
| 13210 | Fuse Block | |
| 12118 | Cap—Grid Contact Cap | |
| 11897 | Capacitor—1 Mfd., 250 Volts, Oil Filled | (C1) |
| 11414 | Capacitor—0.1 Mfd., 300 Volts | (C2) |
| 13966 | Capacitor Pack—consisting of one 4 Mfd., two 5 Mfd., one 8 Mfd., one 10 Mfd., one 12 Mfd., one 20 Mfd. | (C3, C11, C13, C14, C15, C16, C23) |
| 13434 | Capacitor—1000 Mmfd. | (C4) |
| 4836 | Capacitor—.05 Mfd., 150 Volts | (C5) |
| 4841 | Capacitor—.1 Mfd., 150 Volts | (C6, C9) |
| 13968 | Condenser—Tuning | (C7) |
| 12488 | Capacitor—270 Mmfd. | (C8, C27) |
| 4858 | Capacitor—.01 Mfd., 200 Volts | (C10) |
| 4840 | Capacitor—.25 Mfd., 200 Volts | (C12) |
| 13969 | Condenser, Trimmer—Mica. 5-45 Mmfd. | (C17, C28) |
| 5148 | Capacitor—.007 Mfd., 400 Volts | (C18) |
| 4841 | Capacitor—.1 Mfd., 200 Volts | (C19, C29, C30, C37) |
| 12896 | Capacitor—15 Mmfd. | (C20) |
| 13970 | Condenser—Double trimmer Mica. 5-45 Mmfd. | (C21, C22) |
| 12952 | Capacitor—330 Mmfd. | (C25) |
| 12725 | Capacitor—150 Mmfd. | (C26) |
| 13971 | Condenser—Air Padding Trimmer—4-25 Mmfd. | (C31, C32, C33, C34) |
| 13972 | Condenser—Air Padding Trimmer—4-50 Mmfd. | (C35, C36) |
| 13967 | Capacitor—360 Mmfd. | (C38) |
| 12813 | Capacitor—82 Mmfd. | (C39) |
| 5196 | Capacitor—.035 Mfd., 400 Volts | (C40, C41) |
| 13141 | Capacitor—47 Mmfd. | (C42) |
| 16420 | Capacitor—2 Sections each .5 Mfd. | (C43) |
| 4840 | Capacitor—.25 Mfd. | (C44) |
| 13986 | Potentiometer, Var. 25,000 Ohms | (R1) |
| 11322 | Resistor—39,000 Ohms, ¼ Watt | (R2) |
| 13984 | Potentiometer, Var. 50,000 Ohms | (R3) |
| 3033 | Resistor—1 Meg. Ohm, ¼ Watt | (R4, R5) |
| 11646 | Resistor—47,000 Ohms, ¼ Watt | (R6) |
| 11400 | Resistor—27,000 Ohms, ¼ Watt | (R7) |

| Stock No. | Description | |
|---|---|---|
| 13987 | Resistor—Voltage divider, consisting of 120 ohms, 440 ohms adjustable, 6,800 ohms, 4,400 ohms | (R8, R10, R11, R12) |
| 3381 | Resistor—10,000 Ohms, ¼ Watt | (R13) |
| 11647 | Resistor—5,600 Ohms, ¼ Watt | (R14) |
| 6135 | Resistor—270 Ohms, ¼ Watt | (R15) |
| 5145 | Resistor—100,000 Ohms, ¼ Watt | (R16, R21) |
| 11726 | Resistor—6,800 Ohms, ¼ Watt | (R18) |
| 5029 | Resistor—56,000 Ohms, ¼ Watt | (R19, R20) |
| 11172 | Resistor—470,000 Ohms, ¼ Watt | (R23) |
| 13985 | Potentiometer, Var. 2,000 Ohms | (R24) |
| 13736 | Resistor—10,000 Ohms, ¼ Watt | (R25) |
| 13248 | Resistor—200 Ohms, ¼ Watt | (R26, R27) |
| 13988 | Resistor—10 Ohms, ¼ Watt | (R28) |
| 13938 | Switch—Var. Osc. Coil Switch | (S1) |
| 13990 | Switch—Attenuator Switch | (S2) |
| 13939 | Switch—Modulation Control Switch | (S3) |
| 13513 | Switch—Power (On-Off) Switch | (S4) |
| 3748 | Fuse—½ Ampere | (S5) |
| 7903 | Jack—External Modulation | (J1) |
| 13989 | Shield—Fixed Osc. Coil Shield | |
| 2682 | Shield—Tube Shield | |
| 3950 | Shield—Tube Shield | |
| 4629 | Shield—Tube Shield Top | |
| 4794 | Socket—4-contact Radiotron Socket | |
| 4786 | Socket—6-contact Radiotron Socket | |
| 4787 | Socket—7-contact Radiotron Socket | |
| 13973 | Coil—Variable Osc. coil assem. 90-325—325-1000 KC | (L1, L2, L8, L9) |
| 13977 | Coil—Fixed Osc. Coil Assem. | (L3) |
| 12477 | Reactor | (L4) |
| 13983 | Reactor | (L5) |
| 13978 | Coil—R. F. Choke (Hammerlund Midget Code No. CH-X) | (L6) |
| 13974 | Coil—Variable Osc. coil assem. 1000-2500—2500-7000 KC | (L10, L11, L12, L13) |
| 13975 | Coil—Variable Osc. coil assem. 7000-14,500—14,500-32,000 KC | (L14, L15, L16, L17) |
| 13976 | Coil—Mounting Base Complete | |
| 13979 | Escutcheon Nameplate | |
| 13980 | Knob—Variable Cond. Knob | |
| 7960 | Knob—Controls | |
| 13981 | Knob—Variable cond. knob (Kurz-Kasch Cat. No. S-281-7AA-Black) | |
| 4991 | Lamp—Pilot lamp, 6.3 Volts | |
| 3529 | Lamp Socket | |




*Electronic Sweep Oscillator*


*Front View of Cathode-Ray Oscillograph No. 151 and 151A*