ELECTRONIC SWEEP OSCILLATOR

Stock No. 150	110-120 Volts	50-60 Cycles
Stock No. 150A	110-120 Volts	25-40 Cycles

CATHODE-RAY OSCILLOGRAPH

Stock No. 151	110-120 Volts	50-60 Cycles
Stock No. 151A	110-120 Volts	25-40 Cycles

OPERATING INSTRUCTIONS AND SERVICE NOTES

RCA PARTS DIVISION

RCA MANUFACTURING CO., INC. CAMDEN, NEW JERSEY, U. S. A.

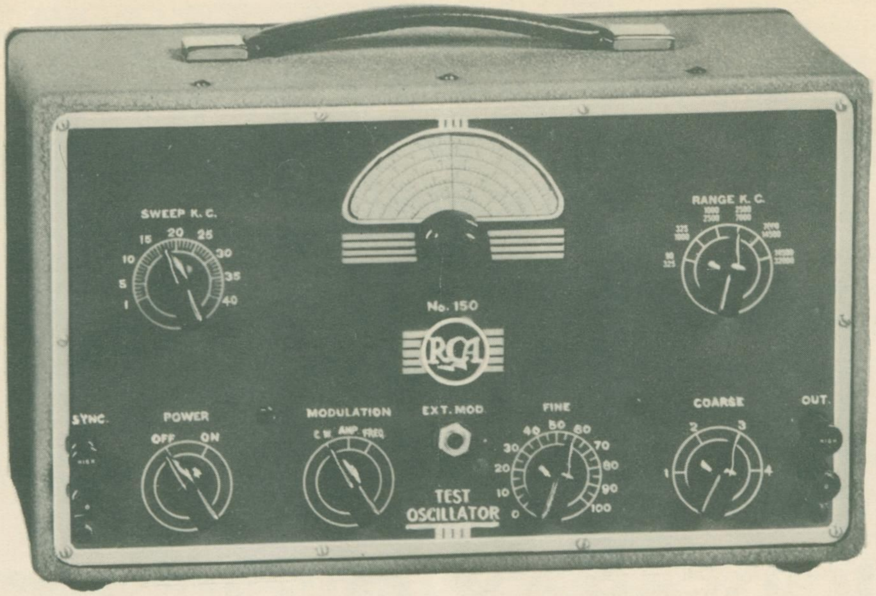


Figure 1—Electronic Sweep Oscillator

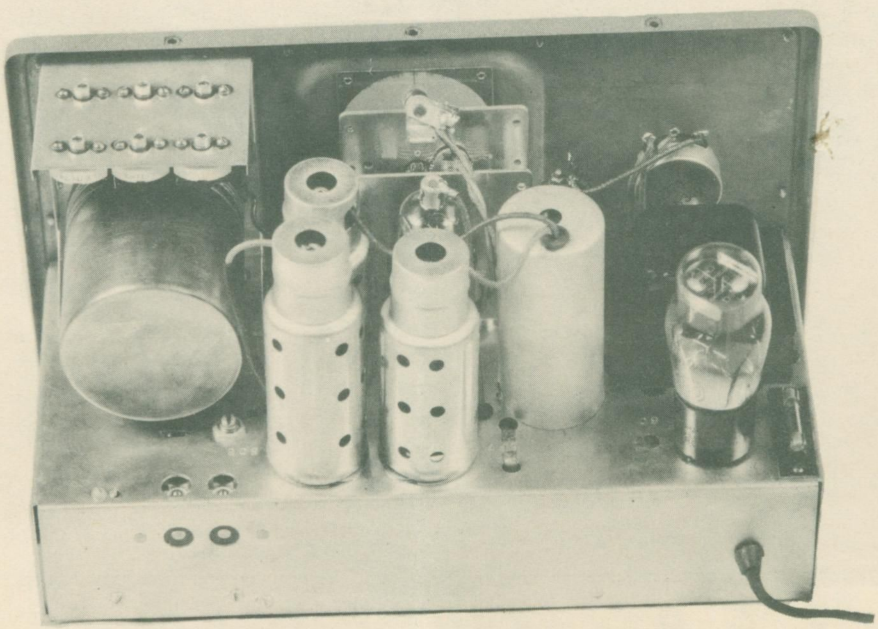


Figure 2—Electronic Sweep Oscillator (Rear View)

Electronic Sweep Oscillator

Stock No. 150 and 150A

IB-23357

Part I

OPERATING INSTRUCTIONS

WARNING — WHEN POWER IS ON, THERE IS A HIGH POTENTIAL THAT IS DANGEROUS TO HUMAN LIFE. 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 and 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.

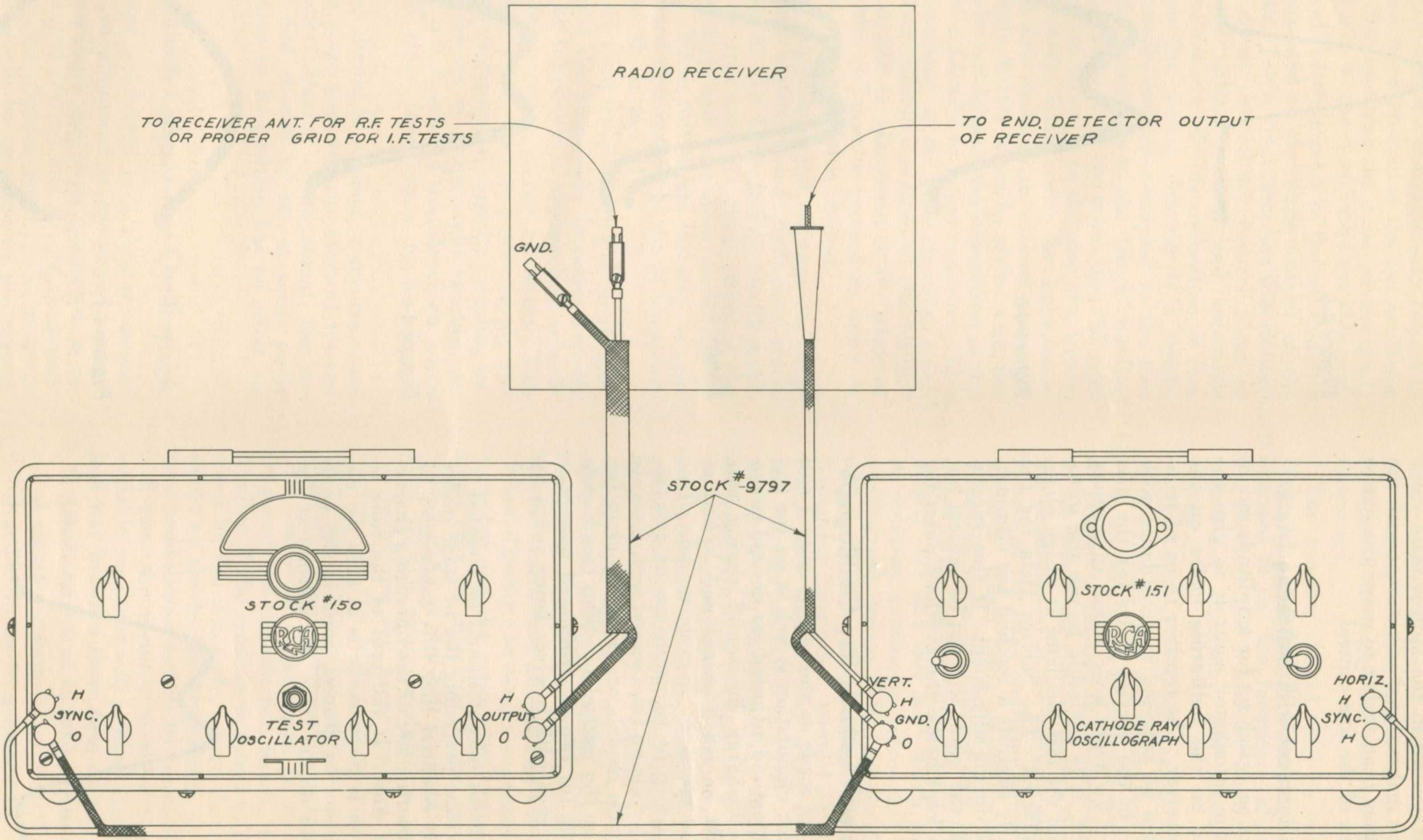


Figure 3—Connections for Receiver Test

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

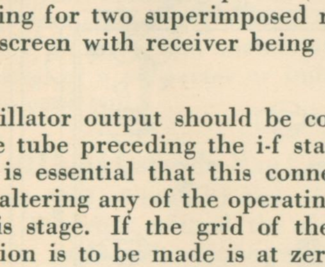


Figure 4-a

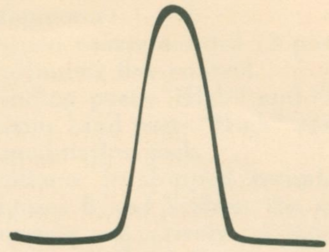


Figure 4-b

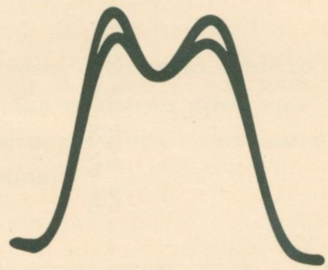


Figure 4-c

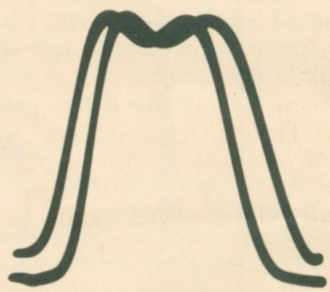


Figure 4-d

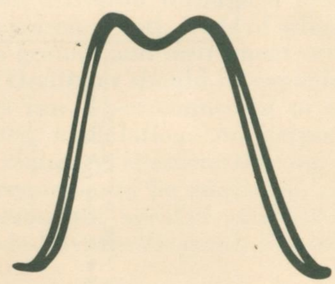


Figure 4-e

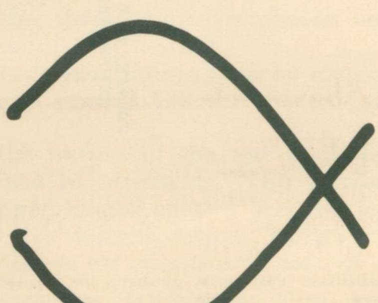


Figure 4-f

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 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. 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 ±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. 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 mc frequency.

1 at 19,200 kc unmodulated.

1 at 18,400 mc frequency modulated.

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.

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 ± 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.

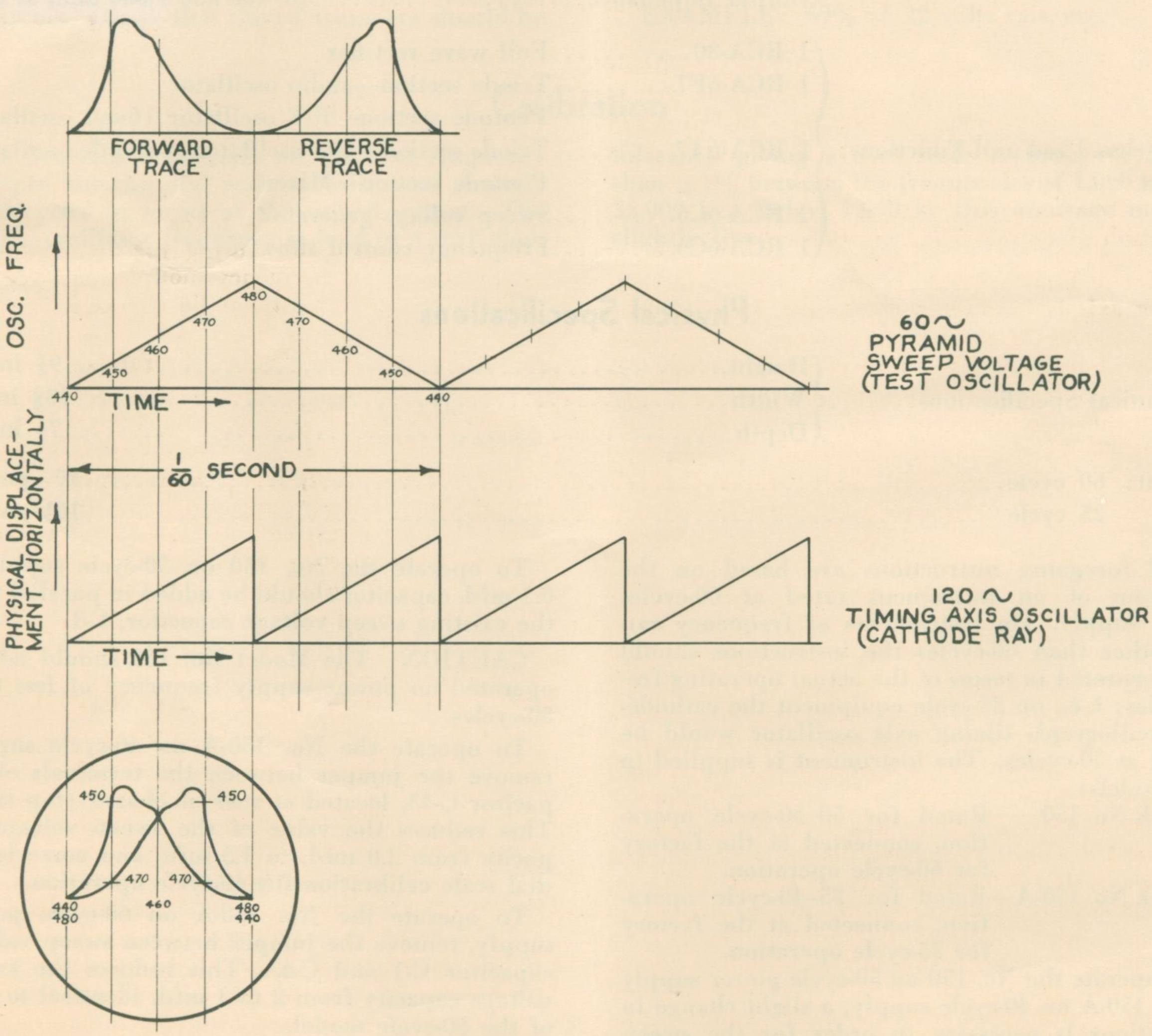


Figure 5—Resultant Curves on Cathode-Ray Screen

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 oscillator timing axis is located 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 and 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 ¼ 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 the 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 type 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.

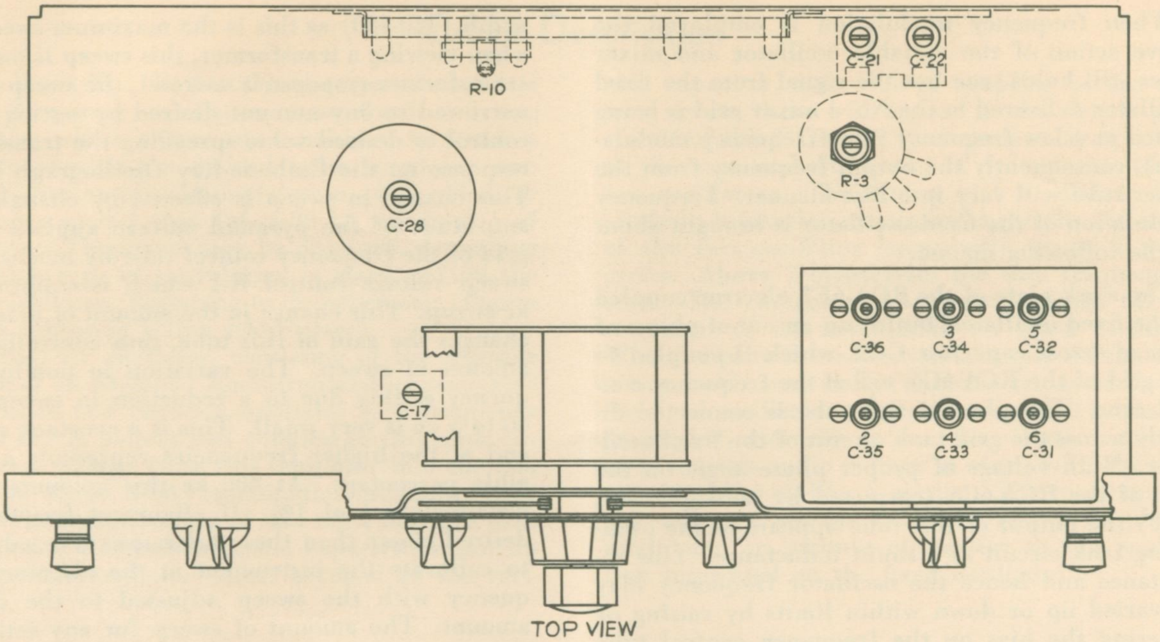


Figure 6—Test Oscillator Outline (Top View)

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, O-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 60-cycle 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

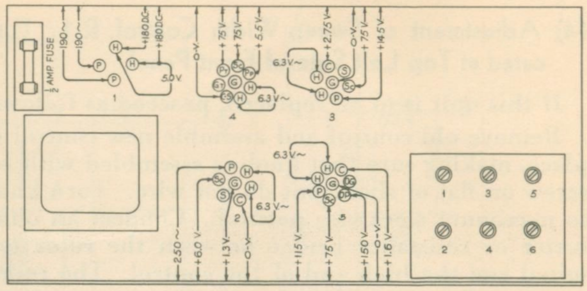


Figure 7—Tube Voltage Diagram

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.

To adjust R-3 proceed as follows: Align an over-coupled transformer so that the peaks coincide (see Figure 4e) (a), 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 replacement of the RCA-6C6 frequency control tube is made, the adjustment of R-1 should be performed as outlined under "Adjustment of Sweep Width Control," to obtain correct calibration of the sweep dial.

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.

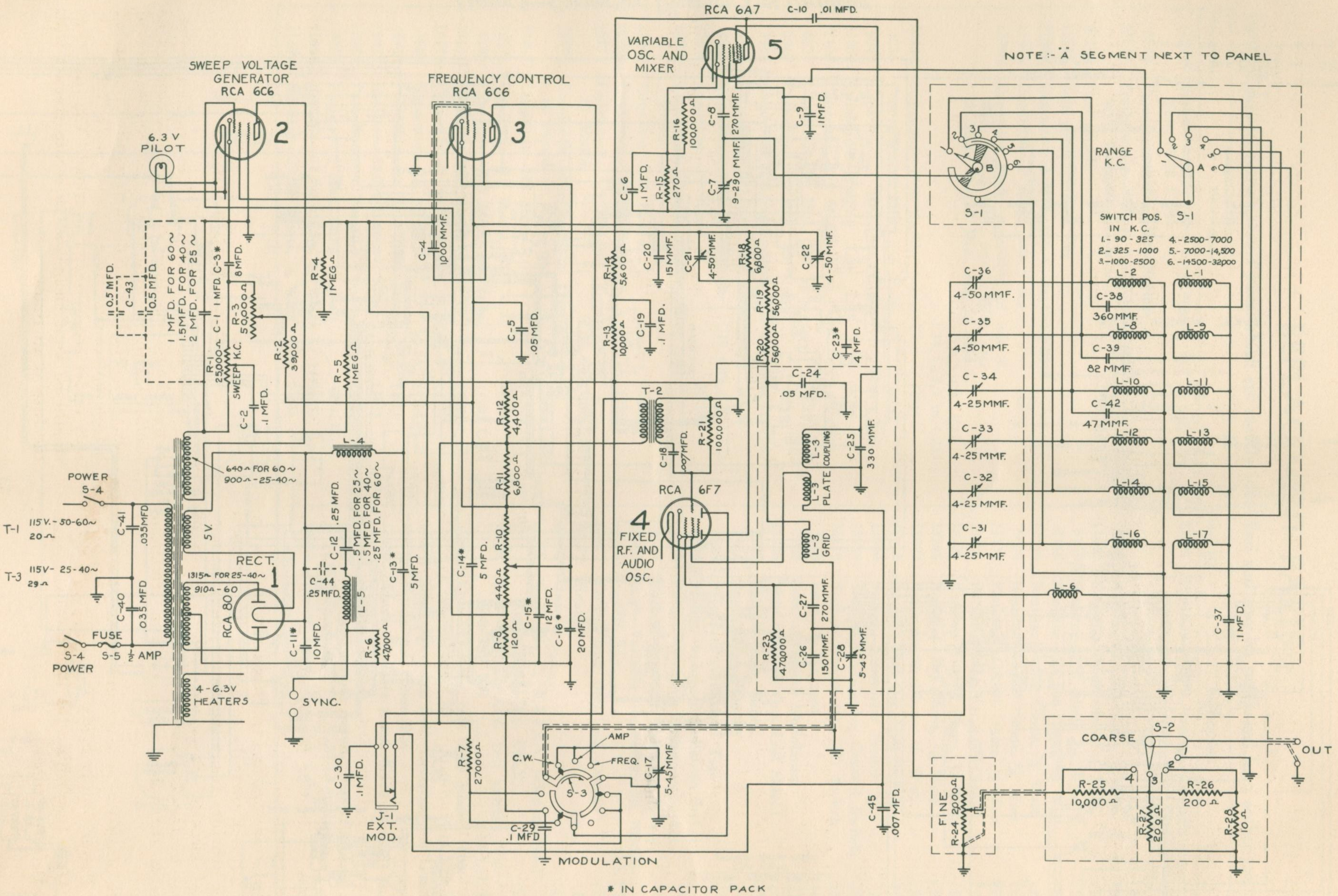


Figure 8—Schematic Diagram, Test Oscillator
T-611031

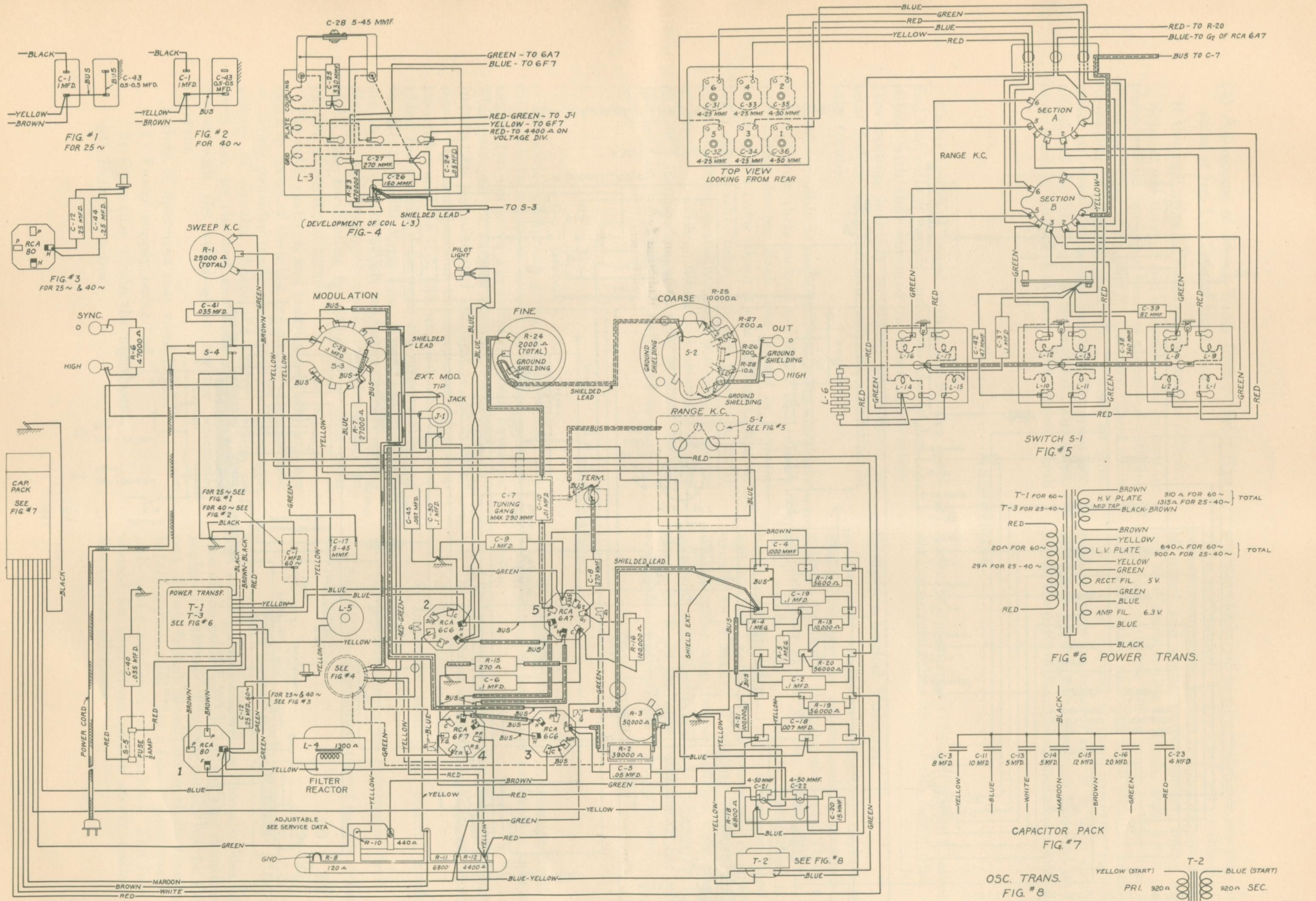


Figure 9—Connection Diagram, Test Oscillator
W-302137

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—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)
13987	Resistor—Fixed voltage divided, consisting of 120 Ohms, 140 Ohms, 300 Ohms, 4,400 Ohms, 6,800 Ohms	(R8, R9, 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. 900-325-1000 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. 1000-2500-7000 KC	(L10, L11, L12, L13)
13975	Coil—Variable Osc. coil assem. 7000-14,500-32,000 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	

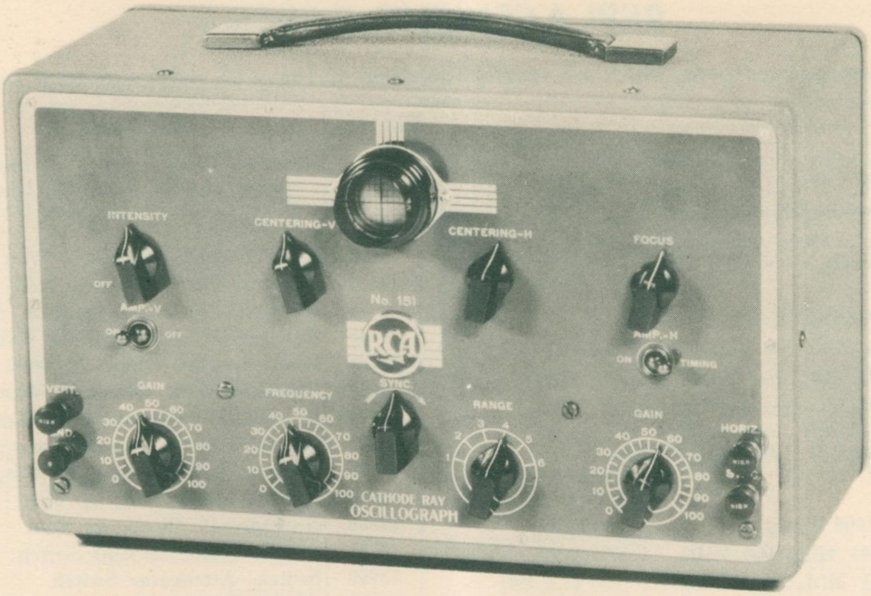


Figure 1—Front View of Cathode-Ray Oscillograph No. 151 and 151A

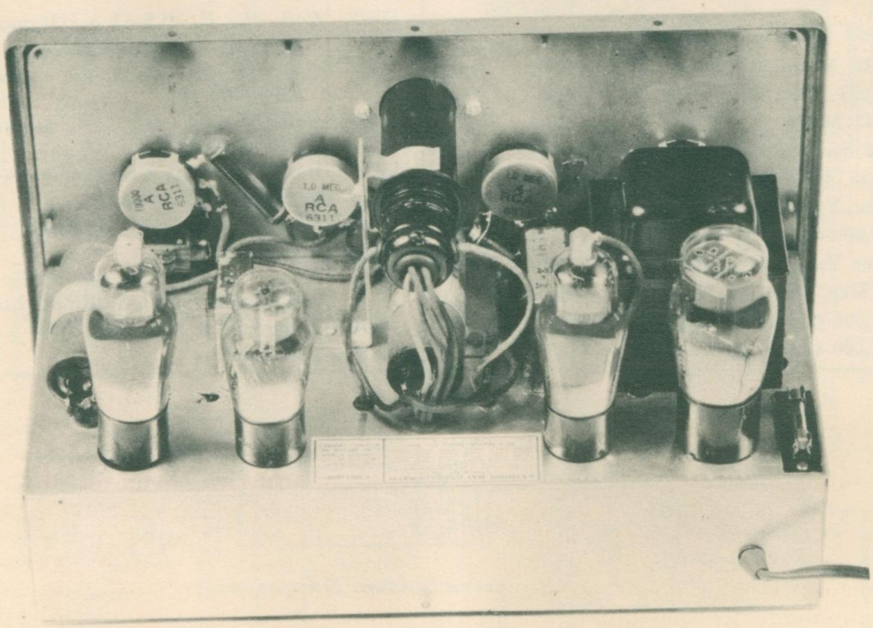


Figure 2—Rear View of Cathode-Ray Oscillograph No. 151 and 151A

Cathode-Ray Oscillograph

Stock No. 151 and 151A

IB-23357

Part III
OPERATING INSTRUCTIONS

WARNING — WHEN POWER IS ON, THERE IS A POTENTIAL OF 400 VOLTS FROM THE AMPLIFIER TUBE GRIDS TO GROUND. DISCONNECT POWER CORD BEFORE WITHDRAWING CHASSIS.

Introduction

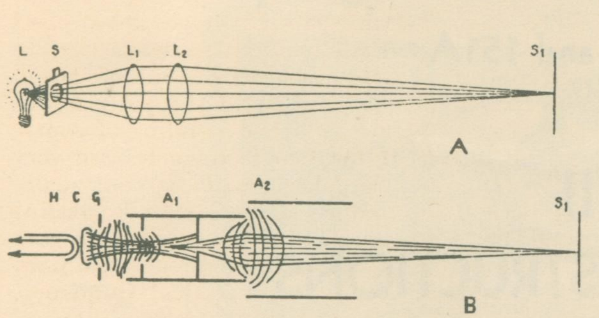
These instructions cover the installation, operation, maintenance and servicing of the No. 151 Cathode-Ray Oscillograph, designed especially for high-quality servicing of radio receiving sets and other communication devices. This Oscillograph provides a reliable instrument for the study of wave shapes, measurement of modulation, adjustment of radio receivers and transmitters, determination of peak voltages, and other similar applications. Its chief (although not the only) advantage over older types of measuring instruments is its freedom from inertia, allowing the observation of very rapid changes of current or voltage without appreciable distortion. The unit is entirely portable, the dimensions are approximately 9¼ inches high by 13¾ inches wide by 7¾ inches deep, and the weight is approximately 15 pounds. The illustration on the opposite page shows the general appearance of the instrument and the operating controls. It operates entirely from an a-c source of 110 volts, an integral power unit supplying all operating voltages required for operation of the equipment.

The purpose of these instructions is to give the fundamentals of operation. As the use of cathode-ray apparatus becomes more widespread many new applications will be found for this equipment so that a thorough understanding of these fundamentals will enable the operator to readily adapt the equipment to his particular use. Since the equipment is built around the cathode-ray tube, a discussion of cathode-ray tubes and images obtained follows, which serves to explain the operation of the equipment and aids in analyzing figures which appear on the screen. The operator is urged to read this section thoroughly so that the numerous applications of the equipment may be readily understood and also that optimum performance may be obtained at all times.

General Discussion of Cathode-Ray Tube

Fundamentally, a cathode-ray tube consists of (1) an electron-beam source, (2) provision for deflecting the beam, (3) provision for focusing the beam on a screen, and (4) a fluorescent screen for visibly indicating the position of the beam.

In the RCA-913 tube the electron source is a substantial cathode, indirectly heated. The cathode, control electrode (grid), and focusing electrodes constitute an electron gun, used to project a beam of electrons (Function 1). Two sets of electrostatic plates at right-angles to each other provide for deflection of the electron beam (Function 2). Focusing (Function 3) is accomplished by adjusting the ratio between the voltages on anodes No. 2 and No. 1. This ratio is in the neighborhood of 5:1. In practice, the anode No. 2 voltage is generally held constant and the anode No. 1 voltage is varied, since it is the smaller potential to control. The screen (Function 4) forms one end of the tube. It is one inch in diameter, and the inside is coated with material which emits light when struck by the electron beam. The control electrode (grid) constitutes a means of controlling the quantity of electrons admitted into the stream, and thus allows control of spot intensity (also called "brilliancy") —the more negatively the grid is biased, the fewer electrons in the beam, the smaller the spot, and the less the intensity.



"A"—Optical Analogy
"B"—Three Element Cathode Rays

Figure 3—Focusing Cathode Rays

The "Electron Gun" in the cathode-ray tube may be compared to a simple optical system as shown in Figure 3-A. In this diagram the light emitted from the lamp, "L," is focused on the screen, "S_1," by means of a double lens system, "L_1," "L_2," and the amount of light is controlled by the shutter, "S," which, when closed, shuts off the light completely. The brilliancy of the image on the screen depends on the size of opening in the shutter, "S," and the candle power or wattage of the lamp, "L." If the candle power of the lamp is fixed (that is if we select a lamp of a given wattage) then the brilliancy is solely controlled by the shutter, "S." The size or definition of the image on the screen, "S," is controlled by adjusting the position of the lenses, "L_1" and "L_2," to the correct distance, which is called focusing. If the position of the lens, "L_1," is fixed, then the focus will depend solely on the adjustment of the position of lens, "L_2." Furthermore, with both lenses, "L_1 and L_2," adjusted correctly, it would be possible to change the focus by actually substituting for the lens, "L_2," various lenses until the one having the correct index of refraction is obtained. This is essentially the method of controlling the focus in the cathode-ray tube.

Figure 3-B shows the elements constituting the "electron gun" previously mentioned. "C" is the cathode which radiates electrons when warmed by the heater, "H." The bias voltage of the grid "G" controls the number of electrons allowed to pass through it. The distance from the "gun" at which the electrons converge to a point, or "focus," is determined by the ratio of the voltages on the two anodes, "A_1 and A_2." Obviously, then, there is a particular ratio of these two voltages which will cause the beam to focus at the screen distance.

Figure 4 shows the addition of one pair of deflecting plates, "D_3 and D_4," to the previous figure. If these two plates are at the same potential, that is if no voltage difference exists between them, the electron stream is unaffected by their presence. However, if a difference of potential does exist between "D_3 and D_4" the electron stream will be deflected toward the plate which is more positive ("D_3" in the figure). (A positive charge attracts electrons, which are negative, while a negative charge repels. Both plates therefore bend the electron beam up as shown.) A similar pair of plates at right angles to the first pair would effect a deflection at right angles to the first deflection. By applying voltages of the proper value and polarity to each pair of plates the spot may be moved to any point on the screen. If an alternating voltage is applied to one pair of plates the spot will move in response thereto, the location of the spot at any instant of time resulting from the value of the voltage at that instant. If the voltage alternates more rapidly than about ten cycles per second, the retentivity of the screen and the observer's eye cause the spot to blend into a continuous line.

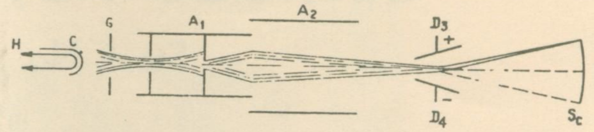


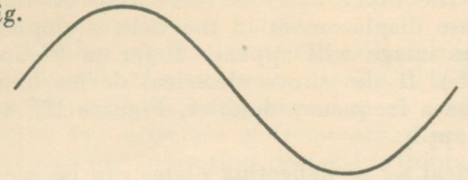
Figure 4—Deflection in One Direction

In the No. 151 Oscillograph there are controls (centering—V and H) for effecting permanent displacement of the spot by applying a direct voltage to the deflecting plates. They are intended to correct any accidental eccentricity of the cathode-ray spot itself, or as a means for centering those patterns (such as that obtained in I.F. amplifier alignment) having a greater deflection in one direction than in the other. These controls move the axis, or zero point about which the alternating voltage deflects the spot. Moving these controls simply transfers the whole pattern's physical position relative to the dimensions of the screen, and introduces no distortion, change in sensitivity, or other harmful effect.

In order to study the wave shape of any voltage causing a vertical deflection, it is necessary to move the spot horizontally too, so that the pattern may be spread out. Since a curve of voltage vs. time is usually desired, a circuit is incorporated giving a voltage having the unusual characteristic of a constant, steady rise to a maximum value and then a sudden drop to its starting value (a "saw tooth" shape). Under influence of this voltage the spot moves horizontally from one side of the tube to the other at a constant speed and then snaps back suddenly to its starting position. By this means the pattern on the end of the tube is made exactly the same as a curve of the unknown voltage vs. time, and the oscillograph operating in this manner may be considered an automatic plotting machine wherein the scales may be changed by merely setting the control knob. Examples of such curves are shown in Figure 5-11, wherein the unknown voltage (vertical) is a sine wave. The ratios shown

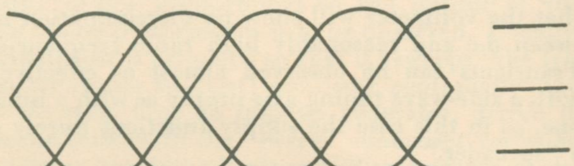
Fig.

5



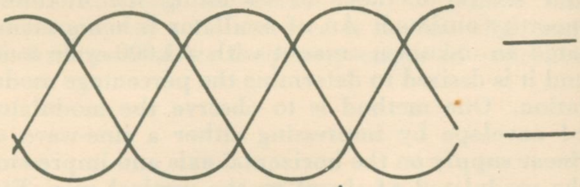
1:1

6



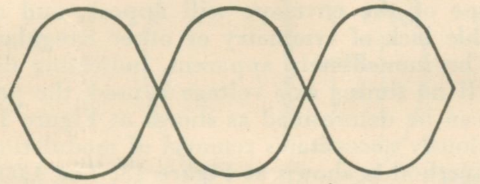
5.4 $1\frac{1}{4}:1$

7



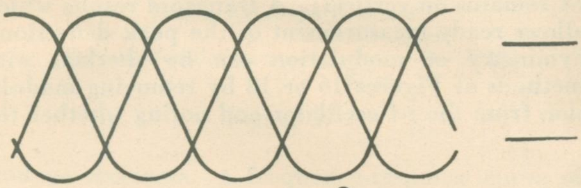
4:3 $1\frac{1}{3}:1$

8



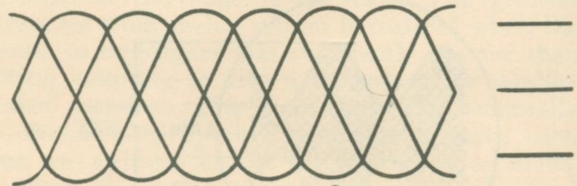
3:2 $1\frac{1}{2}:1$

9



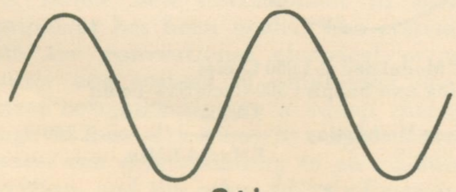
5:3 $1\frac{2}{3}:1$

10



7:4 $1\frac{3}{4}:1$

11



2:1

are the ratio of unknown voltage frequency to "saw tooth" oscillator frequency.

When sinusoidal alternating voltages are applied to both deflection axes, the resultant patterns are closed continuous lines known as Lissajous Figures. If the two frequencies are equal the pattern will be as shown in Figure 12 A-E depending of course upon the phase. If the two frequencies are very slightly different, the phase angle is continually changing and the pattern changes with it, passing through the whole series of shapes shown. Figure 12 F-J shows the patterns obtained when the horizontal frequency is twice the vertical frequency. Figures 13, 14, and 15 show the patterns obtained with the marked frequency ratios, the vertical frequency being the higher in each case. Whenever such a figure stands still, the two frequencies are in an exact ratio, any slight variation from such ratio being indicated by motion of the pattern.

In thinking of any of these patterns it must be remembered that the electrons strike only one point at a time, the apparent line being caused entirely by the retentivity or "holding over" of the screen and the human eye.

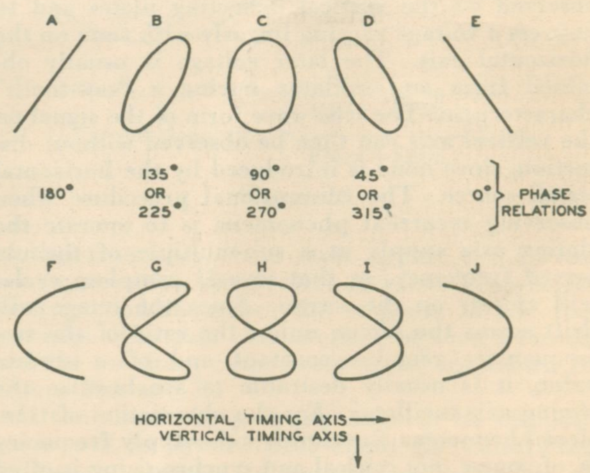


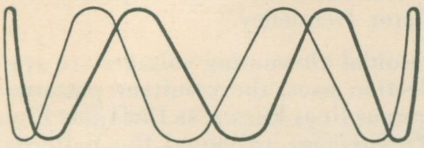
Figure 12

***Figures 5-11, inclusive, adapted from "The Cathode Ray Oscillograph in Radio Research," R. A. Watson Watt. Published by His Majesty's Stationery Office, London, England.**

***Figures 12 to 15, inclusive, adapted from "Frequency Measurements with the Cathode Ray Oscillograph," Frederick J. Rasmussen, A. I. E. E. Transactions, November, 1926, Vol. XLV., Pages 1256-65.**

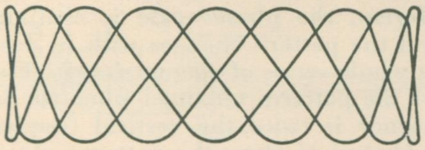
Fig.

13



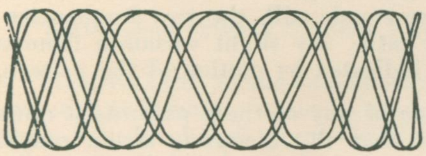
6 : 1

14



9 : 2 $4\frac{1}{2}$: 1

15



16 : 3 $5\frac{1}{3}$: 1

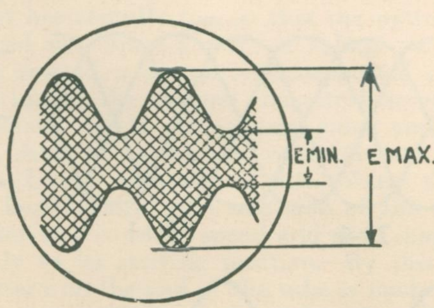
General Applications

The most universal method of employing a cathode-ray tube is to impress the voltage to be observed on the vertical deflecting plates and to impress a voltage varying linearly with time on the horizontal axis. The later voltage is usually obtained from an oscillator having a "saw-tooth" characteristic. The true wave form of the signal on the vertical axis can then be observed without distortion, since none is introduced by the horizontal signal source. The conventional procedure when observing recurrent phenomena is to operate the timing axis supply at a sub-multiple of the observed frequency, so that several complete cycles will appear on the screen. Since the image will drift across the screen unless the ratio of the two frequencies remains constant and of a certain value, it is usually desirable to synchronize the timing axis oscillator. For the observation of transient phenomena the timing axis supply frequency is, of course, not critical and synchronizing is often useless. In some cases, however, it is desirable to synchronize the start of the phenomenon with a timing axis impulse.

Although use of a linear timing axis is fairly general, there are quite a few applications of the tube which do not employ one. From the information on Lissajous Figures it can be seen that if a sine-wave source of known frequency is impressed on one axis, a variable-frequency source can be impressed on the other axis and calibrated at a number of points other than the known frequency. The phase shift in an electrical device can be observed by impressing the input on one axis and the output on the other axis. If there is 0 or 180-degree phase displacement in the unit, a sloping straight-line image will appear. Refer to Figure 12 (A to E). If the above electrical device happened to be a frequency doubler, Figures 12F to 12J would apply.

The vertical set of deflecting plates can be used as a peak voltmeter. The impedance can be made very high, and the input capacitance very low, so that the voltmeter will show no discrimination between d-c and reasonably high radio frequencies. Transients can be observed almost as effectively with a sine-wave timing axis supply as with a linear one, as in this case the supply functions purely as a "spreader."

In order to illustrate the flexibility of such apparatus, a desired measurement will be assumed and several methods of obtaining the unknown quantity outlined. An r-f oscillator is being modulated an unknown amount with a 1,000-cycle tone, and it is desired to determine the percentage modulation. One method is to observe the modulated r-f envelope by impressing either a sine-wave or linear supply on the horizontal axis and impressing the modulated r-f signal on the vertical axis. Figure 16 shows this method graphically. Incidentally, if a linear timing axis is used, as shown, the true wave-shape of the envelope will appear, and an appreciable lack of symmetry or other irregularities will be immediately apparent, indicating distortion. If no timing axis voltage is used, the percentage can be determined as shown at Figure 17. This obviously necessitates removal of modulation. A third method is shown at Figure 18. The 1,000-cycle audio voltage which is modulating the r-f signal is impressed on the horizontal axis (modulated r-f remains on vertical). A trapezoid results which allows ready measurement of the peak deflections. Symmetry of modulation can be checked with methods of Figures 16 or 18 by removing modulation from the r-f oscillator and noting whether the



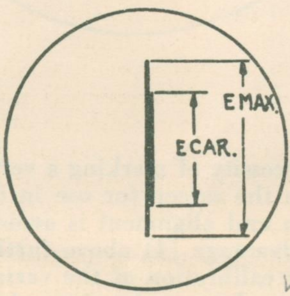
R. F. Modulated at 1,000 Cycles
Timing Axis Supply: 500-Cycle Saw-Tooth

$$\text{Percent Modulation} = \frac{\text{EMax.} - \text{EMin.}}{\text{EMax.} + \text{EMin.}} \times 100$$

Figure 16

carrier height is mid-way between the positive and negative modulated heights.

Another application of the cathode-ray tube is as a "visual" or curve-tracing device. This consists of an r-f oscillator being varied at an audio rate between two extremes of frequency, a means of displacing the indicating device horizontally in synchronism with the change of radio frequency, and a means of obtaining vertical deflection of the indicating device proportional to the output of the unit whose performance is to be observed. Usually, a condenser is arranged so that it "sweeps" the frequency of the r-f (test) oscillator continually, and at the same time an impulse generator, driven in synchronism with the "sweep" condenser varies an oscillator providing horizontal displacement of the indicating device in synchronism with the "sweep" condenser. (The No. 150 Oscillator performs all these functions simultaneously.) Perhaps the greatest use of such a device is for the alignment of the intermediate frequency stages of superhet-



Timing Axis Supply—None

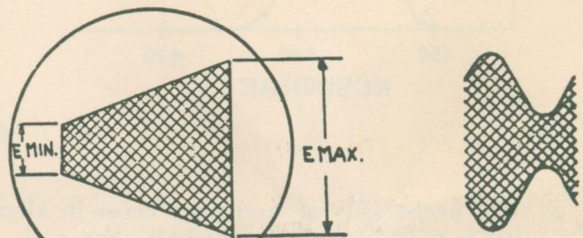
$$\text{Percent Modulation} = \frac{\text{EMax.} - \text{ECar.}}{\text{ECar.}} \times 100$$

Figure 17

erodyne receivers. A frequency-response curve of the circuit under test is continually before the aligner, which allows rapid and very accurate adjustment of the stage in question. The greatest advantage from such a system is realized when the circuit to be aligned has sufficiently greater than critical coupling to give a flat-topped or double-peaked response. The same result can eventually be obtained by manually plotting a curve each time an adjustment on the unknown is made. However, this latter method is very laborious and requires considerable time.

A rather new development in such "visual" equipment has been made. The system dispenses with the conventional electrical or mechanical shutter and instead of employing one series of curves corresponding to a sweep through the r-f range in one direction, it employs two series of curves, one corresponding to an r-f sweep in one direction, and the other to an r-f sweep in the reverse direction. In other words, two curves (except in one case to be described later), appear on the screen, and the side of the screen which represents high frequency on one curve represents low frequency on the other. If on the first, third, fifth, ..."saw-tooth" pulses the left side of the screen represents low frequency, then on the second, fourth, sixth ....pulses the left side represents high frequency. There is only one point on the screen which represents the same frequency on every "saw-tooth" pulse. This point is the calibration point. All other points on the screen represent two frequencies, one above and one below the calibrating frequency.

When a circuit is incorrectly aligned it is not symmetrical about the calibrating frequency; that is, its response at 1 KC. above the calibrating frequency is not the same as the response at 1 KC. below. Since any point on the cathode-ray screen (except the calibrating point) represents two frequencies equally spaced above and below the cali-



Timing Axis Supply—The Modulating Signal

$$\text{Percent Modulation} = \frac{\text{EMax.} - \text{EMin.}}{\text{EMax.} + \text{EMin.}} \times 100$$

Figure 18

brating frequency, there must appear two curves, one representing the circuit's response to high frequencies and the other the response to low frequencies. The gain characteristic of such a circuit and the resultant cathode-ray trace are shown in Figure 19A and B.

If the circuit be properly aligned, its response curve will be symmetrical about the calibrating frequency; that is, its response at a number of kilocycles above the calibrating frequency is the same as its response at the same number of kilocycles below. Since the responses are equal the heights of the two curves will be equal, the curves will be superimposed and appear as one. The circuit of Figure 19, after being properly aligned, gives the response curve and cathode-ray trace shown in Figure 20A and B.

The chief advantages of the "double-image" over the conventional method are:

1. The superposition or "folding back" of the high- and low-frequency sides makes symmetrical adjustments easy and very accurate.

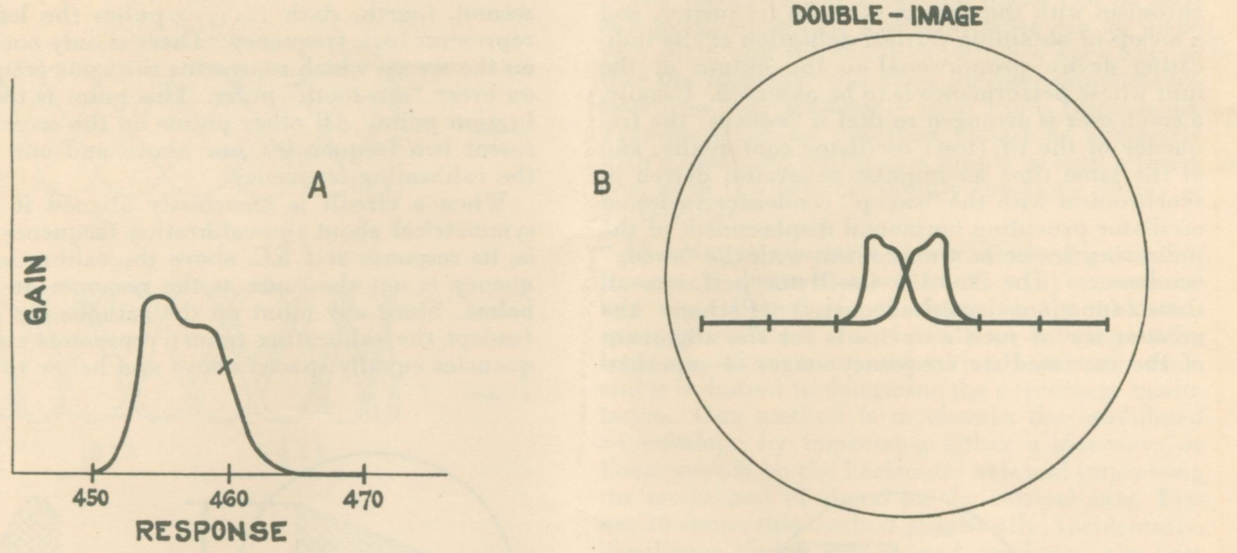


Figure 19

2. The probability of frequency error in aligning is reduced to less than half. For a given frequency error the separation between the two curves of the "double-image" method is twice the displacement of the one curve of the conventional method. Also any small error is much more obvious with two images on the screen.
3. The necessity of employing an electrical or mechanical shutter is eliminated.
4. Distortion in the detector or audio amplifier does not cause error in aligning. If appreciable audio distortion is present, the images on the screen will not be true response curves of the tuned circuit. Nevertheless, the actual response is still truly symmetrical when the two curves are made to completely coincide.
5. The necessity of marking a vertical reference line on the screen for use in frequency calibration and alignment is avoided.
6. The advantage (4) above further allows frequency calibration of the variable frequency oscillator by zero-beating with a standard-frequency oscillator, *without* regard to displacement of the curve by any audio distortion.

Alignment of the radio frequency stages of receivers can be made using the same method discussed above for i-f alignment. The single-frequency source and output meter method may be used, if desired, but from the standpoint of demonstrating the performance of the r-f stages or explaining their operation, the oscillographic method is preferable.

Installation

Unpack the instrument from the shipping container and remove the screws securing the front panel to the case. Withdraw the chassis from the case, supporting the panel at the bottom, and feeding the power cable through the hole in the back. Make certain that all tubes are firmly in their sockets and all grid cap connections are in place. Should the deflecting plates in the cathode-ray tube not be in the proper plane it will be necessary to twist the tube to its proper position. However, do not correct its position with the set in operation. Next replace the chassis in the case and replace the securing screws. With "Intensity" control in extreme counter-clockwise position ("Off"), plug the power supply cable into an electrical outlet supplying 110-120 volt, AC supply. The instrument is then ready for operation.

NOTE: DO NOT ATTEMPT TO OPERATE THE EQUIPMENT WHEN WITHDRAWN FROM THE CASE AS THE HIGH POTENTIALS USED ARE DANGEROUS.

CATHODE-RAY OS

No. 151 and

POSITION OF CONTROLS FOR

No.	APPLICATION OR DEMONSTRATION	SWITCH POSITIONS			CONTROLS			
		Ampl. V	Ampl. H	Range	Intensity	Focus	Ampl. V Gain	Ampl. H Gain
1	FIRST OBTAINING SPOT	Off	*	*	First clockwise rotation closes power switch. Adjust for desired brilliancy of image. Remember tube screen can be burned	Adjust for maximum concentration of electron beam (smallest line or spot) after setting for desired intensity	*	0
2	LOCATING TUBE POSITION	Off	Timing	*			*	Set for line about $\frac{3}{4}$-in. long
3	APPLYING VERTICAL DEFLECTING VOLTAGE	On	*	*			Vary	0
4	APPLYING HORIZONTAL DEFLECTING VOLTAGE	Off	On	*			0	Vary
5	APPLYING DEFLECTING VOLTAGE ON BOTH AXES	On	On	*			Vary	Vary
6	AC VOLTMETER WITHOUT AMPLIFIER	Off	*	*			*	*
7	AC VOLTMETER WITH AMPLIFIER	On	*	*			Max. or other calibrated point	*
8	OBSERVING WAVE-SHAPE OF AUDIO VOLTAGE	On	Timing	Depends on freq. of observed audio			For desired amplitude	For desired spread
9	MEASURING PERCENTAGE OF MODULATION	Off	Timing	Depends on freq. of modulating audio			*	For desired spread
10	MEASURING PERCENTAGE OF MODULATION	Off	On	*			*	For desired spread at 100% mod.
11	"VISUAL" RF CURVE TRACING	On	Timing	Tap "1" or "2"			For desired amplitude	For desired spread
12	CHECKING PHASE SHIFT OF AMPLIFIER	On	On	*			For desired vertical deflection	For desired horizontal deflection
13	FREQUENCY MEASUREMENT	On	Timing or On	Depends on freq. desired			For desired vertical deflection	For desired horizontal deflection

*Denotes position immaterial.

SCILLOGRAPH

151A

VARIOUS APPLICATIONS

		APPLIED VOLTAGES			REMARKS	
Freq.	Sync.	"Vert." Bdg. Post	"Horiz." Bdg. Post	"Sync." Bdg. Post		
*	*	None	None	None	Do not burn screen; adjust the two beam centering to center spot on screen.	
*	*	None	None	None	Rotate cathode-ray tube so line is exactly horizontal.	
*	*	60 cycle supply between 2 and 150 volts	None	None	Elementary Demonstration.	Pre-liminary Adjust-ments
*	*	None	60 cycle supply between 2 and 150 volts	None	Elementary Demonstration.	
*	*	60 cycle as above	60 cycle supply as above	None		
*	*	Voltage to be measured	None	None	Set up is same for calibrating; use substitution method.	
*	*	Voltage to be measured	None	None	Set up is same for calibrating; use substitution method.	
epends on freq. of observed audio	Just enough to lock image	Voltage to be observed	Jumper to Sync.	Jumper to "Horiz."	Probably greatest application.	
epends on freq. of odulating audio	Just enough to lock image	RF Voltage to be observed	1 volt or more of audio from modulator	None	Wave-shape method.	
*	*	RF Voltage to be observed	2 volts or more of audio from the modulator	None	Trapezoid method.	
or double trace	Just enough to lock image	Audio output of chassis 2nd detector	Bdg. posts on Freq. Mod.	None	Output of oscillator impressed in grid circuit of tube preceding stage to be aligned. Center pattern with "Centering V."	
*	*	2 volts or more of audio output of amp.	2 volts or more of audio input to amp.	None		
		2 volts or	1 volt or			

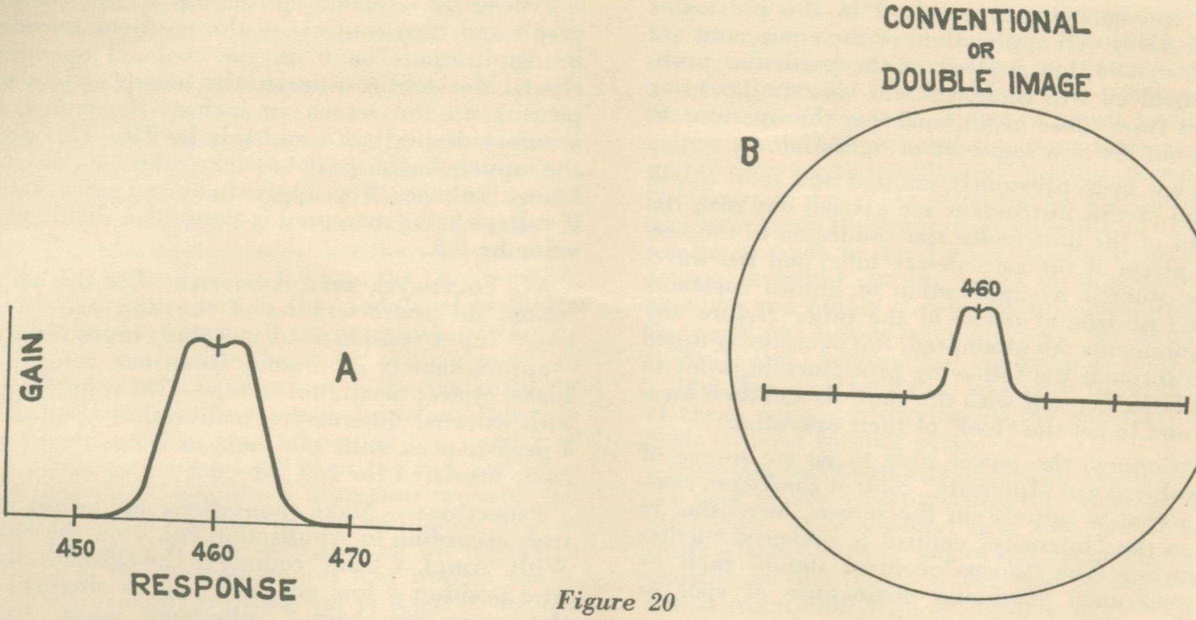


Figure 20

Operation

Controls

(Refer to the Schematic and Wiring Diagrams, Figures 21 and 22, for location of circuit units designated by symbols.)

1. "Intensity" control, R-23, is a potentiometer in the high side of the bleeder. Its position controls the bias on the grid of the cathode-ray tube, which in turn determines the quantity of electrons emanating from the "gun," thus controlling spot size. The power switch S_4 is located on this potentiometer. Initial clockwise rotation of this control turns on the power; additional rotation increases the spot intensity.

2. "Focus" control, R-21, is a potentiometer in the bleeder. Its position controls the anode No. 1 voltage, which (with constant A_2 voltage) determines the distance at which the electron beam focuses. In general, for a given "Intensity" setting, the "Focus" control should be set for maximum distinctness of spot or image.

3. "Ampl. V" switch, S_1, connects the "Vertical" binding posts either straight through to the vertical deflecting plates on the cathode-ray tube or through an amplifier to these deflecting plates. In either case there is a condenser in the input circuit.

4. "Ampl. H" switch, S_2, has two positions: "Timing" and "On." On "Timing" the "saw-tooth" or timing axis oscillator feeds through an amplifier to the horizontal deflecting plates on the cathode-ray tube and the "Horizontal" binding post is the synchronizing input terminal. When "On" the "Horizontal" binding post is connected through an amplifier to these deflecting plates.

5. "Ampl. V Gain" control, R_1, is a potentiometer on the input circuit of the vertical amplifier. With "Amplifier V" switch "On," this potentiometer controls the vertical deflection.

6. "Ampl. H Gain" control, R_7, is a potentiometer on the input circuit of the horizontal amplifier. With "Amplifier H" switch on "Timing" or "On" this potentiometer controls the horizontal deflection. Due to the capacity load on this input potentiometer, when operating on "Timing" at the higher audio frequencies, linear sweep will not be obtained at all settings of this control.

7. "Range" switch, S_3, selects one of six timing capacitor values. It thus changes the timing axis oscillator frequency in steps giving six ranges approximately as follows: No. 1, 20-130; No. 2, 50-300; No. 3, 100-900; No. 4, 350-3,000; No. 5, 1,100-10,000, and No. 6, 3,000-12,000 cycles.

8. "Freq." control, R_{13}, is a rheostat in series with the timing condenser. It changes the timing axis oscillator frequency gradually as it is rotated, and in conjunction with "Range" switch above gives continuous range between the extremes of frequency.

9. "Sync." control, R_{11}, is a potentiometer controlling the amount of synchronizing voltage fed to the grid of the RCA-885 tube. In general it should be set as far counterclockwise as is consistent with a locked image, as over-synchronization causes poor wave-form from the timing axis oscillator.

10. "Centering V and H" are potentiometers to control the amount of d-c potential between the two deflecting plates of each pair, and thereby allow adjustment of the position of the spot or image.

11. There are two pairs of binding posts labeled "Vert. High," "Gnd. 0," "Horiz. High," and "Sync. High." As indicated by the word "High" on the posts, the Vert., Horiz., and Sync. posts all connect to internal circuits, the only ground posts being marked "Gnd. 0." To connect to the vertical amplifier, connect to Vert. and Gnd. To connect to the horizontal amplifier, connect to Horiz. and Gnd. To connect to the synchronizing circuit, connect to Horiz. and Gnd. The Horiz. binding post is controlled by the "Amp.-H" switch so that when the switch is "On" the post connects to the amplifier input and when the switch is on "Timing" the post connects to the synchronizing circuit. The Sync. post carries a fraction of the amplified vertical voltage and is to be connected to the "Horiz." post whenever it is desired to synchronize on the signal being examined.

Applications

General. The following procedures are included in order to familiarize the operator with the operations and connections involved in the particular applications. All applications of the equipment are not described, but analysis of the particular problem involved will show wherein it is similar to or differs from those given, enabling the operator to work out his own sequence of operation.

As has been previously pointed out, most applications of this instrument are carried out with the output of the unit under test connected to the vertical plates of the cathode-ray tube, and the waveshape studied by application of known constants on the horizontal plates of the tube. Before any measurements are attempted, the operator is urged to go through the following procedure in order to familiarize himself with the controls and their location and to get the "feel" of their operation:

1. Connect the power plug to an a-c source of 110 volts. Turn "Intensity" control clockwise, causing a spot to appear on the screen, increasing in size as the "Intensity" control is advanced further clockwise. The "Focus" control should then be adjusted until maximum distinctness of spot or image occurs.

CAUTION. DO NOT ALLOW A SMALL SPOT OF HIGH BRILLIANCY TO REMAIN STATIONARY ON THE SCREEN FOR ANY LENGTH OF TIME, AS DISCOLORATION OR BURNING OF THE SCREEN WILL RESULT.

With the spot on the screen and with the "Intensity" control retarded so that the spot is not too brilliant, adjust the position of the spot to the center of the screen by rotation of the two centering controls.

To turn the equipment off, turn "Intensity" control to its extreme counter-clockwise position, until a distinct "snap" is heard.

2. Apply a source of 60-cycle current to the "Vertical" binding posts. To adjust the length of the resultant line appearing on the screen turn "Ampl. V" switch "On" and adjust "Ampl. V Gain" control until the length is as desired. Application of the same 60-cycle source to the "Horizontal" binding posts with "Ampl. H" switch "On" will similarly show a horizontal line on the screen, the length of which may be varied by manipulation of "Ampl. H Gain" control.

3. To expand (2) further, have 60 cycles available at both "Horizontal" and "Vertical" terminals.

Apply the horizontal 60-cycle supply on the screen through "Ampl. H" and its gain control, then apply the 60-cycle vertical supply through "Ampl. V" and its gain control. The result will be a straight line. (See Figure 12.)

AC Voltmeter without Amplifier—For this application, the characteristics of the unit are as follows: Input resistance—2 megohms; input capacity—approximately 40 mmf.; voltage range—85 r-m-s volts (higher with external attenuator); calibration—approximately 250 peak-to-peak volts per inch or 85 r-m-s volts per inch. Insulated for 200 volts d.c.

Procedure — Make connections to the Oscillograph and turn controls to the positions specified in Application No. 6 on the enclosed operating chart. Measure or estimate the length of line appearing on the screen in inches (depending on accuracy desired) and multiply by 250. This gives the approximate peak-to-peak value of the unknown voltage. For approximate effective value, if voltage being measured is sinusoidal, divide peak value by 2.8.

AC Voltmeter with Amplifier—For this application, the characteristics of the unit are as follows: Input resistance—1 megohm; input capacity—approximately 30 mmf.; frequency range—20-10,000 cycles; maximum voltage—500 volts (higher with external attenuator); calibration—(roughly) 5 peak-to-peak volts per inch, or 2 r-m-s volts per inch. Insulated for 100 volts d.c.

Procedure — Make connections and adjust controls according to Application No. 7 on the chart. With "Ampl. V Gain" control in the extreme clockwise position a line one inch long is obtained on the screen for about 2 volts r-m-s input. Intermediate positions of the gain control give different calibrations, of course, and if considerable use is made of this feature it may be advisable to plot a curve of the inputs required to give a one-inch deflection at various intermediate positions of the gain control.

A particular application of operation as an a-c voltmeter is in making hum measurements in a power supply unit. In this case the "O" binding post ("Vertical") is connected to the common lead of the filter circuit of the unit under test and a clip lead, connected to the "High" binding post, is used to check the a-c ripple present at the various circuit component terminals. When the direct potential exceeds 100 volts it will be necessary to add a capacitor of .1 to .5 mfd. in series, and a 1 megohm leak across the input terminals, to prevent damage due to high direct potentials on the input condenser.

Audio Quality Measurements — Use of the "saw-tooth oscillator" feature of the Oscillograph provides a check which cannot be made with an ordinary voltmeter. This is extremely helpful in discovering the audio quality of a receiver or similar instrument and also in locating causes of audio distortion.

Procedure — Apply the output from a constant frequency record or audio oscillator to the "Vertical" binding posts, with controls set as in Application No. 8. Turn "Range" switch to that tap giving a range including the frequency of the input signal and adjust "Freq." control until the saw-tooth oscillator frequency is near that of the input signal. If the two frequencies are identical, one cycle of the input signal will be observed on the screen; if the saw-tooth oscillator frequency is one-half that of the input signal, two cycles of the latter will appear; if one-third, three cycles; etc. Next, connect this constant frequency record or audio oscillator output to the audio input of the unit under test and connect the output of the unit under test to the "Vertical" binding posts of the Oscillograph, all adjustments of which are as previously set. If the resultant wave does not correspond to that obtained when the input was direct to the Oscillograph, audio distortion is present.

If it is desired to measure the overall audio fidelity of a receiver, for instance, the procedure is similar to that above except that the voltage modulating an r-f oscillator is fed into the Oscillograph, adjusted as above. Then the modulated oscillator is connected to the r-f input terminals of the receiver and the loudspeaker voice coil connected to the Oscillograph. Comparison of the two resultant waves will indicate how much distortion occurs in the receiver under test. Observing the quality of the input to the receiver from the test oscillator will also show how much distortion is being fed into the receiver from the test oscillator. This is desirable, since it may show that all the distortion present in the receiver output may not be due to the receiver characteristics, but to those of the test oscillator.

Modulation Indicator — (1) One method of measuring the modulation of a transmitter is to place the modulated r-f output of the transmitter into the vertical plates of the cathode-ray tube and the audio input signal to the transmitter on the horizontal plates of the tube through the synchronizing circuit.

Procedure — Connect a constant frequency input to the transmitter and connect a small pickup coil, located near the transmitter tank coil, to the "Vertical" binding posts. The pickup on this coil should be from 50-75 volts. Connect the "Horiz." binding post of the Oscillograph to transmitter audio amplifier at a point providing a 2–4-volt signal at low impedance. Turn controls to positions given in Application No. 9 on the chart. Turn "Range" switch to tap including the frequency of the input signal and adjust "Freq." control until the saw-tooth oscillator interlocks with the signal on the vertical plates. Adjustment of the "Sync." control provides control of the voltage to the grid of the RCA-885 tube. Adjustment of "Ampl. H Gain" control varies the horizontal deflection.

(2) Another, somewhat similar, method of modulation measurement is to connect the pickup coil to the "Vertical" binding posts as before, and connect the audio signal (from the transmitter audio amplifier) to the "Horizontal" binding posts. Turn controls to positions given in the chart for Application No. 10. Adjust "Ampl. H Gain" control until desired horizontal deflection is obtained. The percentage modulation can then be readily determined. (See Figure 18.)

Alignment of Intermediate Frequency Stages —For alignment of the intermediate frequency stages of a receiver it is essential that an auxiliary apparatus be available to sweep the intermediate frequency for which the receiver is designed. The Type TMV-128-A Frequency Modulator is designed for this use. It consists of sweep condenser and a synchronizing generator rotated in synchronism by a driving motor. The condenser is arranged to "sweep" the frequency of the r-f input to the receiver (or i-f stages) and the synchronizing generator connects to the "Horiz." binding post of the Oscillograph so as to synchronize the saw-tooth oscillator with the frequency variation of the test oscillator (such as the TMV-97-C) input to the receiver. A switch on the panel of the Modulator provides two ranges of capacity for "sweeping" the test oscillator output frequency; on "Hi" the range is 20-65 mmf., and on "Lo" the range is 15-35 mmf.

The No. 150 Oscillator takes the place of both of these units, performing all the necessary functions without moving parts.

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 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 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 "O" 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 "O" post to ground in order to take the audio voltage off this resistor.

Procedure —Connect the test oscillator output to the grid of the tube preceding the i-f transformer being aligned, and connect the "Vertical" binding posts in the second detector as previously explained. The test oscillator should be set at the i-f alignment frequency with modulation "On."

Turn Intensity-control "On," adjust "Focus" properly, turn "Ampl. V" switch "On" and adjust the gain control. Turn "Ampl. H" switch on "Timing." Adjust the i-f transformer trimmers for maximum output; *i. e.*, peak them as much as possible. Remove the modulation on the test oscillator, connect the sweep condenser to the r-f oscillator and connect the synchronizing generator to the "Horiz." binding post. Turn motor "On" and readjust the frequency of the test oscillator until the forward and reverse waves show on the screen of the tube. Raise the frequency of the test oscillator until the highest points of the two waves coincide. (This readjustment is necessary to compensate for the added capacity of the cable and one-half of the sweep condenser capacity when the TMV-97C Test Oscillator, TMV-128 Frequency Modulator are used. This whole preliminary adjustment is unnecessary with the No. 150 Frequency Modulated Oscillator.) Record the dial setting of the oscillator for future reference. Adjust the trimmer condensers of the primary and secondary of the i-f transformer until the two curves coincide throughout their entire length. When this occurs, the stage is symmetrical with respect to the i-f frequency. During i-f alignment, the receiver tuning dial should be set at a point where variation of its position has no effect on the resultant curve. If this point cannot be found, short-circuit the grid or plate coil of the receiver r-f oscillator. The i-f stages should be aligned in order, starting at the last stage and working toward the first detector.

Frequency Measurements—In using the Oscillograph for frequency measurement, either Lissajou figures (sine waves on both axes) may be used, or the linear timing axis may be employed on the horizontal axis. The frequency stability of the saw-tooth oscillator running free is not good enough to depend on for accurate measurements, but when this oscillator is synchronized with a standard-frequency voltage its frequency stability is the same as that of the standard, and it can be synchronized at any sub-multiple of the standard frequency down to about one tenth. This allows convenient calibration of a device at many points between one-hundredth of—and ten times a single standard-frequency source, and every point is as accurate as the standard. If a 1,000-cycle standard source is used, calibration points between 10 and 10,000 cycles are easily obtained. Using Lissajou figures, calibration points between 100 and 10,000 cycles can be obtained. A frequency standard which is almost universally available is the 60-cycle a-c supply. Since the advent and rapid spread of electric clocks the frequency of nearly all commercial power is held to a very close tolerance. When synchronizing on 60 cycles, the saw-tooth oscillator can be locked at 30 or 60 cycles, as desired. This allows accurate calibration at frequencies up to about 600 cycles. Refer to Application No. 13 on the chart.

Checking Phase Shift—To check phase shift of a device with the Oscillograph, set controls as shown on Application No. 12 on enclosed chart, observing the screen pattern with input to device on "Horizontal" binding posts and output from device on "Vertical." If no phase shift exists, a sloping straight-line image will appear.

Part IV
SERVICE DATA

Electrical Specifications

Power Supply Rating	Voltage	110–120 Volts AC
	Frequency (Stock No. 151)	50–60 Cycles
	(Stock No. 151A)	25–60 Cycles
	Wattage Consumption	35 Watts
	Fuse Protection	1 Amp.
Operating Limits	Deflection sensitivity at amplifier inputs	5 peak-to-peak volts per inch (max. "gain.")
	Deflection sensitivity at cathode-ray tube inputs	250 peak-to-peak volts per inch
	Input Characteristics:	
	(1) Through either amplifier	1 megohm, approximately 30 mmfd.
	(2) Without either amplifier	2 megohms, approximately 40 mmfd.
	Frequency response range of amplifiers	20–15,000 Cycles
	Maximum signal input (with amplifier)	500 Volts (RMS)
	Frequency range of timing axis	30–10,000 Cycles
	Maximum d-c voltage across input binding posts	100 Volts with amplifiers; 200 Volts direct
Radiotrons Used and Functions	1 RCA-6C6	Signal amplifier for vertical deflection
	1 RCA-6C6	Signal amplifier for horizontal deflection
	1 RCA-885	"Saw-tooth" oscillator
	1 RCA-913	Cathode-ray tube (1-inch)
	1 RCA-80	Full-wave rectifier

Physical Specifications

Overall Dimensions	Height (including carrying-handle)	9¼ inches
	Width	13¾ inches
	Depth	7¾ inches
Weight:	60 cycle	14½ pounds
	25 cycle	16 pounds

Circuit Description

The schematic arrangement of the entire circuit is shown in Figure 21.

There is one usual feature to this circuit that causes surprising voltage distributions but doesn't affect the operating theory. Since the shell of the cathode-ray tube is connected to the second anode, which must be at a positive potential from the cathode, and since the shell must be grounded for safety, the positive side of the power supply has been connected to ground. This is common practice in Cathode-Ray Oscillographs, but in this case the power supply is common to the oscillograph and amplifier tubes, so the cathode, grid, suppressor and screen grids of the amplifiers are all at a high potential to ground and the plate is nearly at ground. It may be argued that no improvement has been made since the grid clips are at high voltage, but the grid clips cannot be reached when the equipment is in the case, and the resistance of the circuit is sufficiently high to limit the current to safe values at all but very low settings of the gain control.

While the voltage distribution, as shown in Figure 24 is quite unusual, the method of operating the amplifier tubes has not been affected. The grids are maintained about two volts negative from the cathode, the suppressor is connected to the cathode, the screen grid is about 35 volts positive from the cathode and the plate still more positive.

An amplifier consisting of a single RCA-6C6 constitutes the means of obtaining "gain" for the signal applied to the vertical deflecting system. The input to this stage is a high-resistance potentiometer connected to provide "gain" control. An isolation capacitor is made a part of the input circuit to exclude any d-c which may be associated

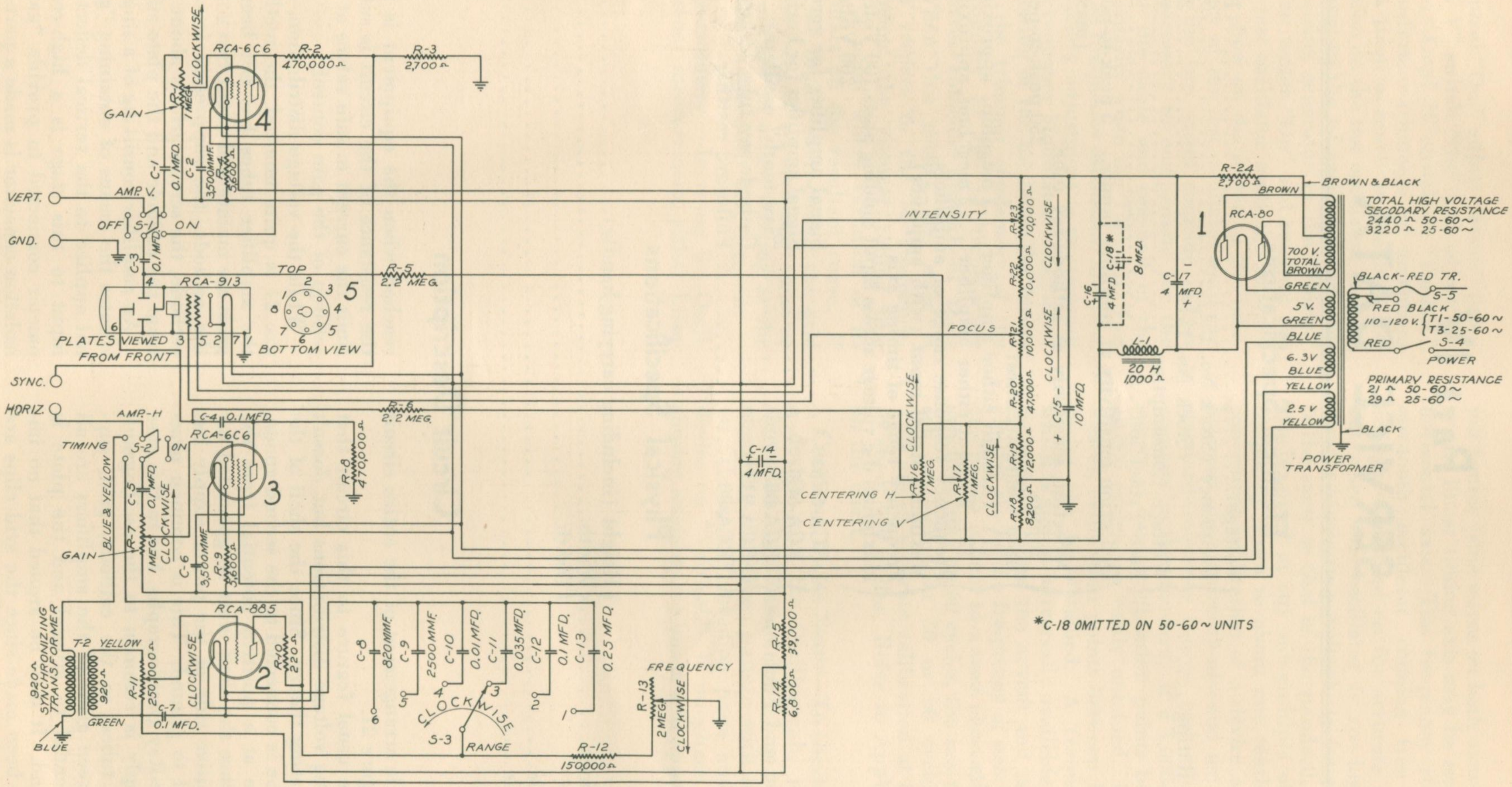


Figure 21—Schematic Diagram (Stock No. 151 and 151A) T-611032

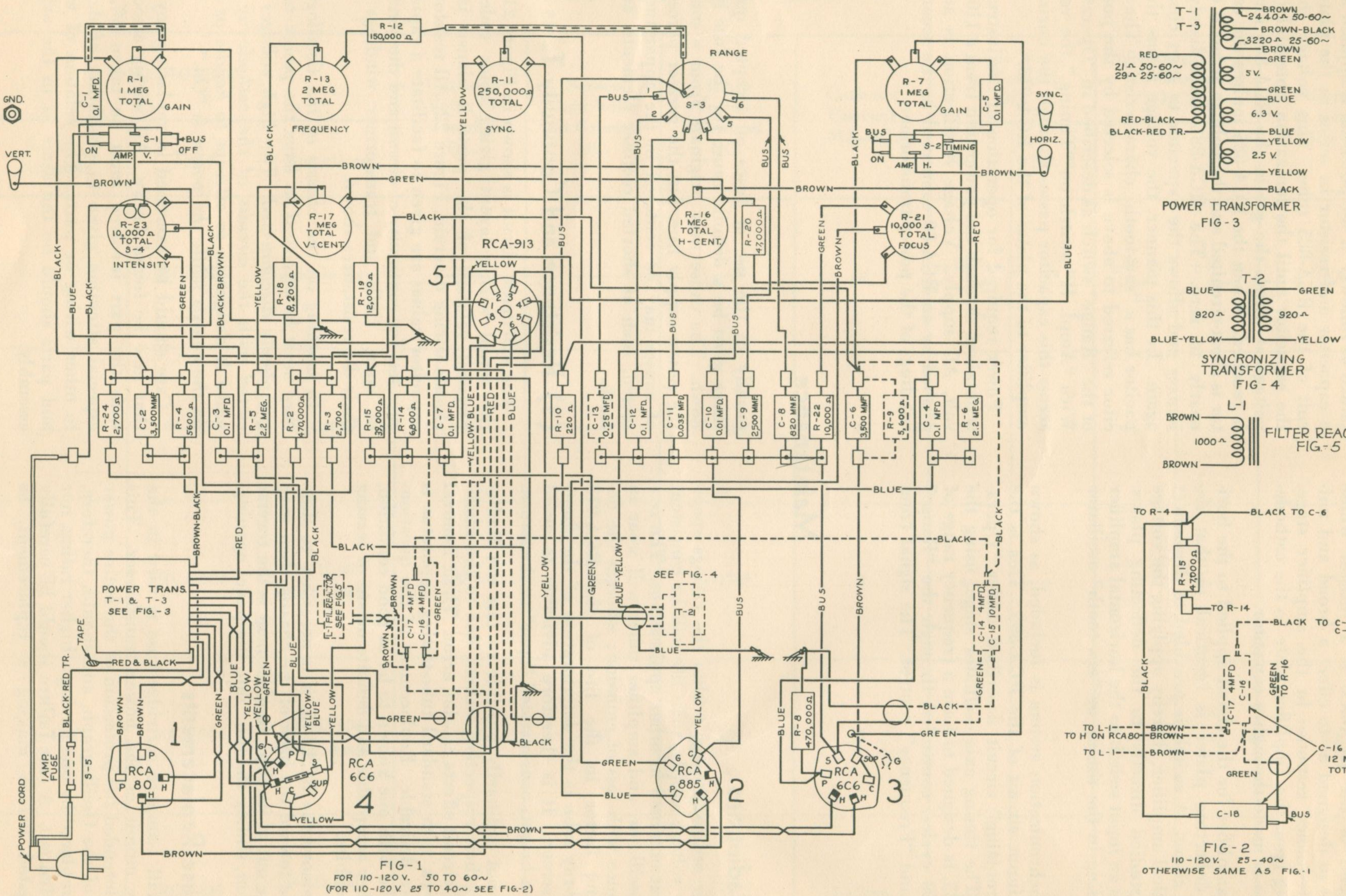


Figure 22—Connection Diagram (Stock No. 151 and 151A) T-611033

with the circuit being observed. The plate, or output circuit of the RCA-6C6 is a resistor whose value is so designed as to effect a broad and uniform frequency response in the amplifier stage. Coupling from the amplifier plate to the cathode-ray tube is made through a capacitor.

The amplifier for the signal applied to the horizontal deflecting plates is identical to that described above. A switch is provided to disconnect the vertical amplifier, thereby applying the voltage to be studied directly to the deflecting plates. There is an input switch to the horizontal amplifier for feeding in the timing or "saw-tooth" oscillator signal.

A synchronization system is included, as shown in the input circuit of the RCA-885. This is the "Synchronizing" circuit described under "Operation." The timing axis oscillator stage, using the RCA-885, is designed to have a frequency range of 30-10,000 cycles, controlled through the "Range" switch and "Frequency" control. The signal from this oscillator has a "saw-tooth" wave-shape, obtained as follows: A d-c potential is applied across a capacitor and resistor in series in the plate circuit of the RCA-885 tube. This voltage charges the capacitor until the ionization potential (plate voltage at which the gas in the RCA-885 ionizes) is reached. When the RCA-885 ionizes the capacitor is short-circuited and the voltage across it drops nearly to zero. The RCA-885 immediately deionizes and allows the capacitor to start charging again. In this manner, the voltage across the capacitor has a "saw-tooth" characteristic. The capacitor referred to above is selected by the position of the "Range" switch as described in "Operation." With "Ampl. H" switch on "Timing," the voltage across this capacitor passes through the horizontal amplifier to the plates of the RCA-913.

Power required for operation of the instrument is obtained through the power unit from a 110–120-volt, AC supply. Voltage rectification is accomplished by an RCA-80 connected in the secondary windings of the power transformer.

Maintenance

(1) Radiotrons

Under ordinary usage within the ratings specified for voltage supply, tube life will be consistent with that obtained in other applications. The rectifier, oscillator, and amplifier tubes will wear in accordance with loss of emission; whereas the determining factor in the life of the RCA-913 cathode-ray tube is the deterioration of the fluorescent screen. It is therefore advisable to avoid leaving a bright, concentrated "spot" on the screen.

It is not ordinarily possible to test the Radiotrons in their respective sockets, due to the likelihood of circuit effects causing error. Their removal and check with standard tube-testing apparatus is therefore desirable. Replacement of the questionable tube with one known to be in good condition, is another acceptable and definite means of tracing tube troubles.

To remove the RCA-913, it is necessary to slide the tube toward the back of the chassis, then snap the tube out of its clip. Replacement is the reverse operation, sliding the tube into the panel opening.

(2) Fuse Replacements

A small 1-ampere cartridge fuse is used in the primary circuit of the power transformer. This fuse is intended for protection of the entire power system of the Oscillograph, and should, therefore, not be replaced by one having a higher rating, nor be shorted out. A fuse failure should be carefully investigated before making a replacement, as usually in the use of fuses of accepted quality, there must be a definite cause for the fuse breakdown. The cause may originate from a surge in the power-supply line, but the greater percentage of causes may be centered in the apparatus protected, such as shorted rectifier elements, and so forth.

(3) Resistance and Continuity Tests

The schematic circuit is shown in Figure 21, and the actual wiring layout giving color code and physical relation of the parts is shown in the chassis wiring diagram, Figure 22. All resistor and capacitor values are given to facilitate a rapid and sure test for continuity of circuit and the condition of same. Coils and transformer windings have their d-c resistances shown.

In working on the chassis of the Oscillograph, care must be observed to have the power supply completely disconnected. The high voltages associated with the circuits of the cathode-ray tube make it dangerous to attempt to handle or work on the chassis while the power is "On."

Care should be exercised in replacing any part that may be found faulty. All wiring associated with the part involved must be taken off, and especial attention given to possibility of damage to other wiring or parts. The relation of wiring and parts should be the same as in the original assembly.

RADIOTRON SOCKET VOLTAGE TABLE

120-Volt, Supply Line

RADIOTRON			Cathode Volts to Ground DC.	Screen Grid Volts To Ground DC.	Plate Volts to Ground DC.	Cathode Current MA-DC.	Anode Volts to Ground DC.		Deflecting Plates to Ground DC.		Filament or Heater Volts AC.
Socket Number	Type	Function					No. 1	No. 2	D_1	D_3	
5	RCA-913	Cathode Ray	—350	——	——	.06	—265 to —300	O	+30 to —50*	+30 to —50*	6.3
1	RCA-80	Rectifier	+35	——	—380	6	—	—	—	—	5.0
3	RCA-6C6	20—15,000 Cycle Amp.	—380	—350	—150*	.3	—	—	—	—	6.3
4	RCA-6C6	20—15,000 Cycle Amp.	—380	—350	—150*	.3	—	—	—	—	6.3
2	RCA-885	30—10,000 Cycle Osc.	—350	——	O	.2—2ma.	—	—	—	—	2.5

* Cannot be correctly measured with ordinary voltmeter.

Figure 23

(4) Voltage Measurements

One means of learning the condition of operation and tracing the circuit faults of the Oscillograph is by checking the correctness of the voltages and currents at the Radiotron sockets. The normal values, which can be expected to be found when the instrument is working properly under the specified power ratings, are indicated adjacent to the socket positions in Figure 24, and also given by the Radiotron Socket Voltage Table. In general, the values shown are measured from the socket contacts to ground; however, the heater or filament voltages are a-c and appear between the F-F or H-H clips. All readings given are actual operating values, and do not allow for any errors likely to be caused by current drain of the measuring instrument. Some of the voltages are not measurable with ordinary test equipment; these have been asterisked (*) in the table.

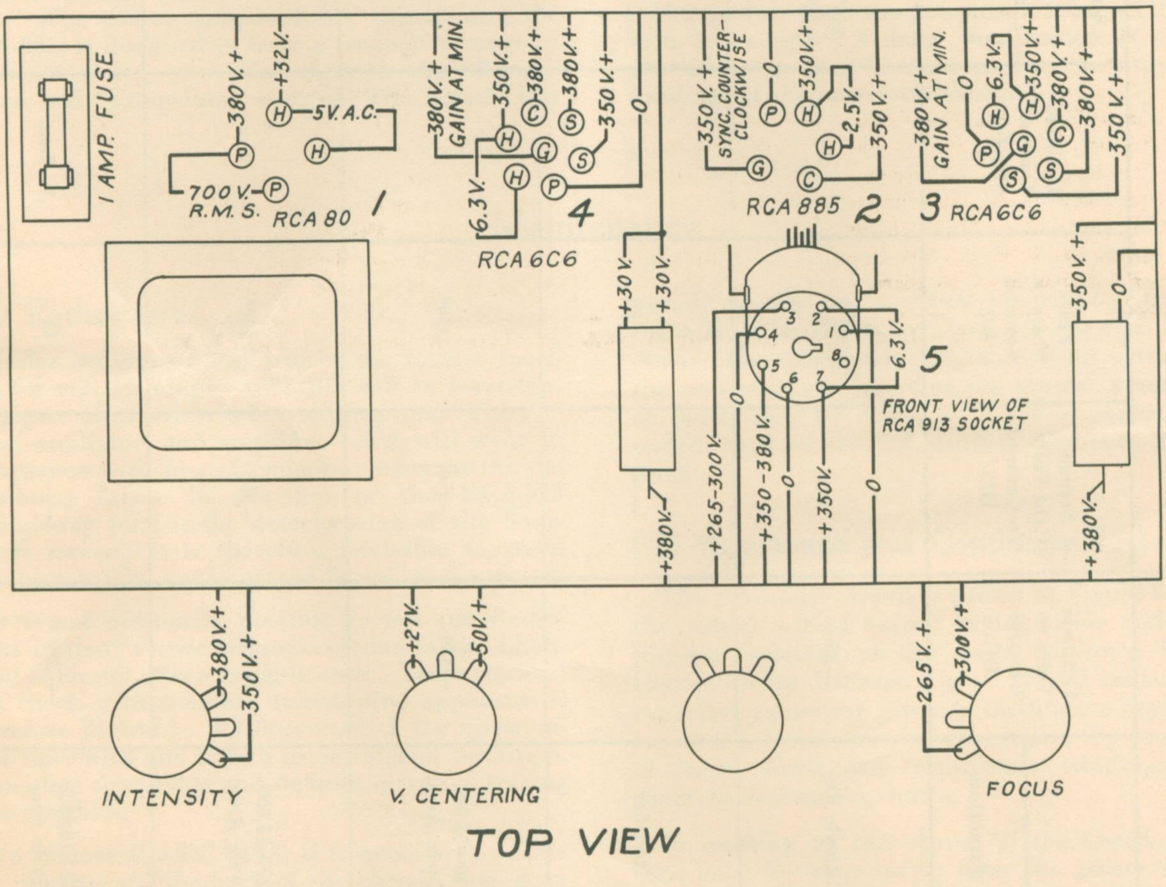


Figure 24—Radiotron Socket Voltage Diagram (Stock No. 151 and 151A)

REPLACEMENT PARTS

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

Stock No.	Description		Stock No.	Description	
14118	Power Transformer—110-120 V., 50-60 cyc.	(T-1)	11726	Resistor—6800 Ohms	(R-14)
14119	Synchronizing Transformer	(T-2)	11322	Resistor—¼ W., 39,000 Ohms	(R-15)
14139	Power Transformer—110-120 V., 25-60 cyc.	(T-3)	14250	Resistor—½ W., 8200 Ohms	(R-18)
6552	Filter Reactor	(L-1)	13915	Resistor—½ W., 12,000 Ohms	(R-19)
4839	Capacitor—0.1 Mfd. 400 V.	(C-1, C-5)	13596	Resistor—2 W., 47,000 Ohms	(R-20)
5005	Capacitor—0.0035 Mfd.	(C-2, C-6)	14126	Potentiometer—10,000 Ohms with Switch	(R-21, S-4)
4841	Capacitor—0.1 Mfd. 200 V.	(C-7, C-3, C-4)	3078	Resistor—½ W., 10,000 Ohms	(R-22)
12536	Capacitor—820 Mmfd.	(C-8)	14125	Potentiometer—10,000 Ohms	(R-23)
5107	Capacitor—0.0025 Mfd.	(C-9)	4750	Switch—D.P.D.T. Toggle	(S-1, S-2)
4858	Capacitor—0.01 Mfd.	(C-10)	14127	Switch—Single Gang 6 Position	(S-3)
5196	Capacitor—0.035 Mfd.	(C-11)	14133	Fuse—1 Amp.	(S-5)
11414	Capacitor—0.1 Mfd.	(C-12)	4794	Tube Socket—4 Prong	
5170	Capacitor—0.25 Mfd.	(C-13)	4814	Tube Socket—5 Prong	
14121	Bypass Condenser—4-10 Mfd.	(C14, C15)	4786	Tube Socket—6 Prong	
14120	Filter Condenser—4-4 Mfd. 475 V.	(C-18, C-16, C-17)	14128	Tube Plug—Octal Base	
14123	Potentiometer—1 Megohm	(R-1, R-7, R-16, R-17)	14129	Tube Support Bracket Ass'y	
11172	Resistor—¼ W., 470,000 Ohms	(R-2, R-8)	14130	Eye Piece	
5144	Resistor—¼ W., 2700 Ohms	(R-3, R-24)	14131	Eye Piece Base	
11647	Resistor—¼ W., 5600 Ohms	(R-4, R-9)	14137	Screen	
11626	Resistor—¼ W., 2.2 Megohms	(R-5, R-6)	4857	Binding Post (High)	
11174	Resistor—¼ W., 220 Ohms	(R-10)	4607	Binding Post (0)	
14124	Potentiometer—250,000 Ohms	(R-11)	7960	Bar Pointer Knob	
14132	Resistor—1 W., 150,000 Ohms	(R-12)	13210	Fuse Term.—Bd. Ass'y	
14122	Potentiometer—2 Megohms	(R-13)			

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