# DISTORTION AND NOISE METER

## TYPE 69-C

Manufactured by

**RCA VICTOR DIVISION**

of

**RADIO CORPORATION OF AMERICA**

**Camden, N. J., U. S. A.**

IB-32021-3

ADDENDA

January 1945

DISTORTION AND NOISE METER
TYPE 69C
IB-32021-3

Page 7 - MAINTENANCE -
Add a new paragraph at end of section to read: "In the event that R55A, C8 or T2 require replacement, it will be necessary to readjust R-55A so that the Low Audio response is flat within ± .5 db from 20 cycles to 40,000 cycles, and down not more than 1 db at 45,000 cycles. Potentiometer R-55A is located underneath the chassis, on the shield."

Page 8 - PARTS LIST-
Add in Column 2 after R-55.

| | | |
|---|---|---|
| R-55A | Potentiometer - 5,000 ohms, 1/2 watt | 44665 |

Page 16 - Figure 14 - For Revised Schematic, see end of book.

Figure 15 - For Revised Connections, see end of book.

ADDENDA

September 1944

DISTORTION AND NOISE METER

TYPE 69C

IB-32021-3

Page 3 - TECHNICAL SUMMARY - Electrical Characteristics
Change "Frequency Range - High or low - - - - - - - - at 30,000 cycles."
to read
"Frequency Response - High or low audio input within ±0.5 db. of 400 cycle response 30 - 40,000 cycles, may be down 1.0 db. at 45,000 cycles. Bridging input, within ±0.5 db. of 400 cycle response 30 - 15,000 cycles, may be down 1.5 db. at 30,000 cycles.

Page 5 - OPERATION - NOISE LEVEL MEASUREMENTS
1st Paragraph, 4th line.
Following "----"one milliwatt in a 600-ohm line."
INSERT - "The standardizing voltage in the 69-C is 0.775 volts (1 m.w. in a 600-ohm line) ±1.0 db."

# DISTORTION AND NOISE METER

## TYPE 69-C

| | | |
|---|---|---|
| MI-7512E | Finish 432 Black | Rack Mounting |
| MI-7512F | Finish 680 Gray | Rack Mounting |
| MI-7512G | Finish Black Panel | Blue Gray Cabinet |
| MI-7512H | Finish 685 Umber Gray | Rack Mounting |

## INSTRUCTIONS

Manufactured by

RCA Victor Division of Radio Corporation of America

Camden, N. J., U. S. A.

Printed in U. S. A.

IB-32021-3

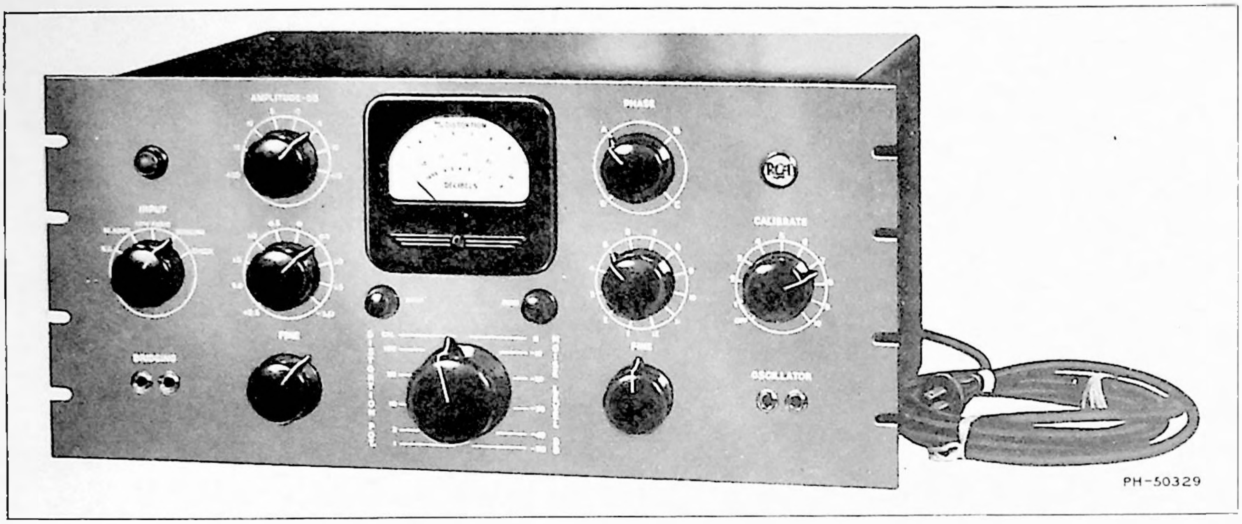


*Figure 1—Type 69-C Distortion and Noise Meter (Rack Model)*

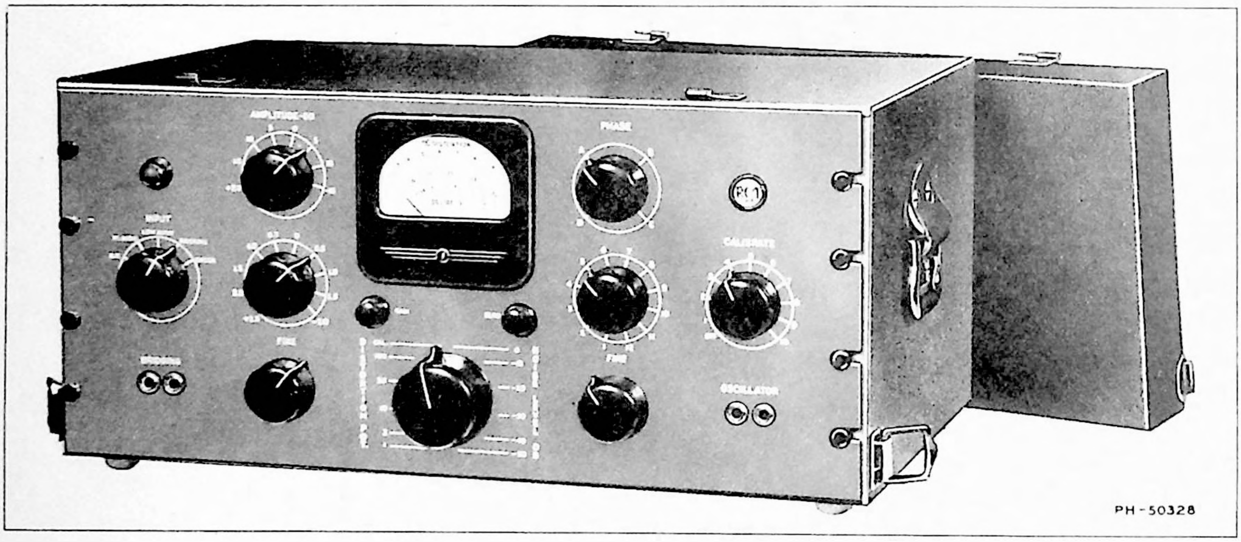


*Figure 2—Type 69-C Distortion and Noise Meter (Cabinet Model)*

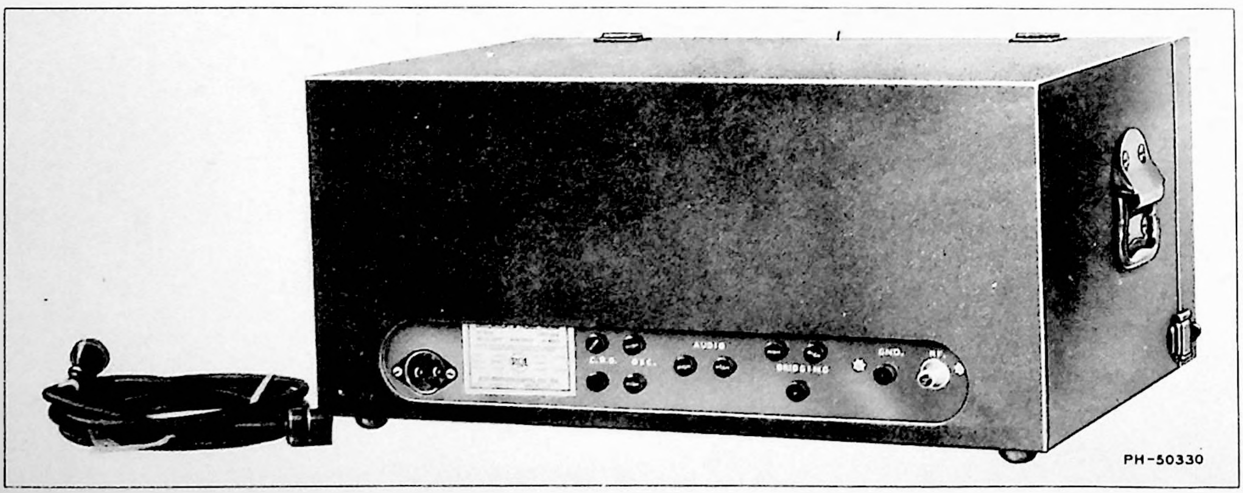


*Figure 3—Type 69-C Distortion and Noise Meter (Cabinet Model, Rear View)*

# DISTORTION AND NOISE METER

## TECHNICAL SUMMARY

### Electrical Characteristics

Frequency Range—High or low audio input, ±0.5 db 30-40,000 cycles, down 1.0 db at 45,000 cycles; Bridging input, ±0.5 db, 30-15,000 cycles, down 1.5 db at 30,000 cycles.

| | |
|---|---|
| Distortion Range | 0.3% to 100% r-m-s |
| Noise Level Range | 0 to −75 db |
| Line Rating | 110-120 volts, 25-60 cycles |
| Power Consumption | 50 watts |
| Fuse Protection | 1.5 amperes |

### Tube Complement

| | |
|---|---|
| Voltage Amplifiers | 1 RCA-6C5 |
| Voltage Amplifiers | 1 RCA-6C5G |
| Voltage Amplifiers | 2 RCA-6SJ7 |
| R-F Rectifier | 1 RCA-6X5G |
| Power Rectifier | 1 RCA-6X5G |
| Voltage Amplifier and Vacuum Tube Voltmeter | 1 RCA-6F8G |
| Voltage Regulator | 1 RCA-VR-150 |
| Voltage Regulator | 1 RCA-VR-105 |
| Ballast Tube | 1 Amperite 6-8 |

### Mechanical Specifications

| Dimensions | Rack Type | Cabinet Type |
|---|---|---|
| Height | 8¾ inches | 9 inches |
| Width | 19 inches | 19¼ inches |
| Depth | 13 inches | 14¾ inches |
| Weight (Net) | 44 pounds | 55 pounds |

## DESCRIPTION

The Type 69-C Distortion and Noise Meter was developed to supply an accurate and reliable instrument for measuring the harmonic distortion and noise level in the output of radio transmitters, audio amplifiers, or modulated radio frequency equipment of any type. Distortion or noise measurements are read directly from the meter scale, which is calibrated for several ranges. When used with the Type 68-A or 68-B Low Distortion Oscillator, distortion measurements may be made at any frequency from 50 to 8,500 cycles per second or higher with weighting of the harmonics as indicated in the TECHNICAL SUMMARY under Frequency Range. Reliable readings as low as 0.3 percent. may be made on any equipment having less than 180 degrees phase shift throughout its frequency range. Under these conditions, the inherent distortion in the oscillator approximates 0.1 percent. r-m-s, which will have a negligible effect upon the distortion meter readings. Under the worst possible phase conditions, a residual reading of approximately 0.2 percent. would be obtained.

Distortion measurements may be made at frequencies down to 20 cycles per second with reasonable accuracy if the amount of distortion to be measured is not too small. Using one mw in a 600-ohm line as a zero reference level, distortion can be measured at volume levels as low as −17 db and noise levels may be measured as low as −75 db.

The essential elements of the 69-C Distortion and Noise Meter are as follows:

(1) An input circuit for the essentially sinusoidal signal from the 68-A or 68-B Beat Frequency Oscillator, including a level control, marked "CALIBRATE," and a phase-shift network comprising three controls—coarse, medium and fine, as shown in Figure 6.

(2) An input circuit for the distorted signal from the equipment under test. This includes a rectifier for demodulating an r-f signal when desired, a selector switch marked "INPUT," a source of voltage for standardizing the gain of a voltage amplifier, and three level controls—coarse, medium and fine, as shown in Figure 8.

(3) A push-pull amplifier stage which is used as a normal amplifier for noise level measurements, and as a cancellation stage for distortion measurements.

(4) A "DISTORTION-NOISE LEVEL" switch, which is used for circuit switching and for controlling the attenuation between the push-pull amplifier stage ((3) above) and the voltage amplifier.

(5) A three-tube voltage amplifier with negative feedback. The "GAIN" control determines the gain of this amplifier by controlling the amount of feedback.

(6) A detector and output meter, for measuring the r-m-s value of signal. A small amount of bucking current is fed through this meter to buck out the no-signal plate current of the detector. The amount of bucking current is controlled by the "ZERO" control. Figure 9 illustrates the distortion measurement circuit.

(7) A power supply furnishing heater, plate, and screen voltages, and the standardizing voltage mentioned in (2) above.

In making distortion measurements, the meter indicates the distortion factor—i. e., the ratio of r-m-s total distortion to the fundamental amplitude. This is accomplished by suppressing the fundamental frequency component of the wave in question and measuring the r-m-s total of the remaining components. Elimination of the fundamental frequency component is accomplished by adding to the distorted wave a sine wave of the same frequency, equal in amplitude to the fundamental component, but 180 degrees displaced in phase. This voltage is secured from the same oscillator which supplies the signal to the equipment under test and is adjusted in amplitude and phase by the use of the controls on the panel of the Distortion and Noise Meter. Distortion readings directly in percent. of the fundamental amplitude are obtained by first adjusting the meter to read full scale (100%) with only the sine wave input connected.

Measurements of noise levels are made by adjusting the meter for full scale deflection at the desired equipment output level and then removing the input signal from the equipment under test. The remaining noise and hum is amplified until a reliable meter deflection is obtained. The noise level is then read directly in decibels from the meter and attenuator scales.

## INSTALLATION

The Type 69-C Distortion and Noise Meter is supplied in two models, the rack model shown in Figure 1 and the cabinet model illustrated in Figure 2. The cabinet model is supplied in a substantial metal cabinet, while the rack model is supplied with a standard rack mounting panel and dust cover. In every other respect, both models are identical.

The power cable should be connected between the a-c receptacle of the meter and a power supply outlet furnishing 105-125 volts, 25-60 cycles and delivering 50 watts. The power line fuse on the chassis should be in the proper position corresponding to the applied line voltage. Terminals for connecting the Distortion and Noise Meter with the associated equipment are located on the rear of the chassis with parallel-connected jacks located on the front panel. These terminals are clearly identified on Figure 3.

The pickup circuit used for modulated r-f signals must provide a low resistance d-c path between the r-f and ground terminals of the distortion meter as well as low audio frequency impedance.

These conditions will be met by the use of a small pickup coil consisting of several turns. Capacitative coupling or an antenna may be used if a radio frequency choke or a parallel resonant circuit is connected across the r-f and ground terminals. A low resistance, untuned coil is the most desirable for this purpose, as it is least likely to introduce hum into the circuit or to cause frequency discrimination.

*The chassis of the Distortion and Noise Meter should be well grounded to minimize stray r-f pickup.* This can be accomplished by the use of a heavy strap or braid, as short as possible.

## OPERATION

Distortion and noise measurements are read from the same meter, which is calibrated to the following full scale readings:

| Distortion | Noise Level |
|---|---|
| 1% | –50 |
| 3% | –40 |
| 10% | –30 |
| 30% | –20 |
| 100% | –10 |
| | 0 |

The desired meter range is selected through the meter range switch, which is controlled by means of the large knob and scale. The desired distortion range may be selected by rotating the knobs over the left-half of the scale. The desired noise level range may be selected by rotating the knob over the right-half of the scale.

INPUT LEVELS—For accurate distortion or noise measurements, the input levels to the instrument should be adjusted to within the following limits:

Modulated r-f—10 volts to 80 volts.

To determine the proper r-f input level modulate the transmitter approximately 100 percent. and set the "DISTORTION-NOISE LEVEL" switch at "0." Adjust the input level until full-scale meter reading is obtained with the "AMPLITUDE" control set between "0" and "+16."

Audio frequency from 68-A or 68-B—2 volts to 4 volts.

Audio frequency from equipment under test—

1. Bridging input terminals or jacks (balanced)
   Minimum—0.14 volts or −15 db below 1 mw on 600-ohm line.
   Maximum—9.0 volts or ± 22 db above 1 mw on 600-ohm line.
2. Audio and ground input terminals
   (a) "Audio Low"—0.12 volts to 8.0 volts.
   (b) "Audio High"—1.2 volts to 80 volts.

COUPLING METHODS—Modulated radio frequency voltages to be measured are obtained through inductive coupling. The pickup coil should be designed with a low audio frequency impedance in order to eliminate any a-c hum component that may be picked up.

When the Distortion and Noise Meter is to be used in conjunction with a balanced audio line having an impedance of 600 ohms or less, a bridging transformer having an impedance of 20,000 ohms is provided. This impedance is sufficiently high to have no appreciable effect upon the low impedance line. The three transformer input connections terminate in three binding posts, marked "BRIDGING," located at the rear of the chassis, and a pair of parallel connected jacks located on the front panel. The center tap of the transformer winding is not grounded.

CONNECTIONS—Following are tabulated the correct connections to be made for distortion and noise measurements under various conditions:

For Modulated Radio Frequency Input—Connect the pickup coil between the "R-F" and "GROUND" terminals at the rear of the instrument and remove all connections from the audio terminal. Set the "INPUT" switch to "R-F" position.

For Audio Frequency Input Balanced Lines, Up to 600 Ohms—Connect the audio line either to the "BRIDGING" terminals at the rear or to the "BRIDGING" jacks on the front panel. The center tap connection may be connected, left open or grounded as desired. Set the "INPUT" switch to "BRIDGING" position.

For Unbalanced Audio Frequency Input—

(a) Below 4 volts
    Connect the audio line to "LOW AUDIO" and ground binding posts.
    Set the "INPUT" switch to "LOW AUDIO."
(b) Above 4 volts
    Connect the audio line to "HI. AUDIO" and ground binding posts.
    Set the "INPUT" switch to "HI. AUDIO."

For Distortion Measurements—Connect the 250- or 500-ohm 68-A or B terminals to the two terminals at the rear of the distortion meter marked "OSCILLATOR," or to the pair of jacks on the front panel marked "OSCILLATOR."

For Oscillograph Indication—When desired, a cathode-ray oscilloscope may be connected to the "CRO" binding posts to observe wave form of distortion or noise, or to assist in balancing out the fundamental. Any circuit connected across these binding posts should have an impedance of at least 100,000 ohms, and when an r-f field exists, such as around a transmitter, a shielded lead should be used.

CALIBRATION—Prior to making measurements, the instrument should be calibrated in the following manner:

1. Turn the power on by rotating the "CALIBRATE" control in a clockwise direction, and wait at least five minutes to allow voltages to stabilize.
2. With no input signal to the "OSC." binding posts or jacks and with the "DISTORTION-NOISE LEVEL" switch at the "CALIBRATE" position, adjust the "ZERO" control for a meter reading of zero percent. (not 0 db).
3. Set the coarse and medium "AMPLITUDE" controls to "0" positions and the "FINE" control with the pointer approximately vertical. Also set the "DISTORTION-NOISE LEVEL" switch to the "0" position, and the "INPUT" switch to the "CHECK" position. Adjust the "GAIN" control for full-scale meter reading (0 db).

NOISE LEVEL MEASUREMENTS—

Noise levels may be measured in either of two ways. One method gives a result in terms of the standard zero level of the 69-C, which is one milliwatt in a 600-ohm line. The other method gives a result in decibels below some arbitrary output level of the equipment under test. The first method is accomplished as follows:

(a) When using "LOW AUDIO" input, it is only necessary to remove input from equipment under test and adjust the "AMPLITUDE" controls and the "DISTORTION-NOISE LEVEL" switch until the meter reads on scale. The noise level (based on a 600-ohm line) is then read from the control settings and the meter readings.
(b) When using "HI. AUDIO" input, a close approximation can be obtained by using the above procedure and adding −20 db to the result.
(c) When using "BRIDGING" input, a close approximation can be obtained by using the above procedure and adding −1.5 db to the result.

The second method, which is the most accurate, is accomplished as follows:

1. Adjust the input to the device under test to obtain the output level below which it is desired to measure the noise level.
2. Adjust the "AMPLITUDE" and "DISTORTION-NOISE LEVEL" controls to obtain a meter reading of "0" db.

3. Remove the input signal from the device under test and move the "AMPLITUDE" and "DISTORTION-NOISE LEVEL" controls until the meter reads on the db scale. The sum of the amount that it was necessary to move the controls and the established meter reading denotes the noise level with respect to the original level.

DISTORTION MEASUREMENTS:

(a) Audio measurements—

1. Apply input signal from the low-distortion oscillator to the "OSCILLATOR" input of the Distortion and Noise Meter, place the "DISTORTION-NOISE LEVEL" switch on "CAL." and adjust the "CALIBRATE" control for a full-scale meter reading. This setting should remain unchanged.
2. Adjust the input to the equipment under test to the desired level, remembering that output must be within the limits specified in input levels above.
3. Place the "DISTORTION-NOISE LEVEL" switch on "0," the "INPUT" switch on appropriate position, and adjust the "AMPLITUDE" controls for full-scale deflection of the meter.
4. Place the "DISTORTION-NOISE LEVEL" switch on "100" and adjust the "PHASE" controls until meter reading is below the calibrated portion of its scale. Turn the "DISTORTION-NOISE LEVEL" switch to "30" and by further adjustment of the "PHASE" and "AMPLITUDE" controls, obtain a minimum meter reading, turning the "DISTORTION-NOISE LEVEL" switch for increased sensitivity as required.

With the selector switch placed on "CAL," during distortion measurements, the meter reading may vary with the position of the "PHASE" controls. This is a normal characteristic resulting in an error of not more than 10 percent. on the "% DISTORTION" scale indication. In order to eliminate this error, place the selector switch on "CAL," after adjusting the phase controls for a balanced condition and readjust the "CALIBRATE" control for a full scale meter indication. A slight readjustment of the "FINE" amplitude control will then be necessary for the final balance.

After obtaining an exact balance, the amount of total distortion is obtained by reading both the "meter" and "switch" scales. After a reading has been taken, the switch should be returned to the "CAL." position before making any adjustments to the equipment, in order to protect the meter.

CIRCUIT LOADING—The output of the Type 68-A Beat Frequency Oscillator should terminate in the correct impedance in order to secure minimum distortion of the oscillator signal. The correct terminating impedance is indicated at each pair of output terminals. To illustrate, an impedance of 500 ohms should be connected between the two terminals marked 500, or an impedance of 250 ohms between each terminal marked 500 and the center tap terminal. The Type 89-A Attenuator Panel will provide proper impedance loading.

EFFECT OF NOISE ON DISTORTION MEASUREMENTS—The Type 69-C Distortion and Noise Meter indicates the r-m-s total of all components of the input signal which fall within the limits of the frequency range. The exception is the fundamental frequency component, which is cancelled by the voltage taken directly from the oscillator. The reading of the meter will therefore include the following components:

| Component | Frequencies for 1,000 cycle modulation (60-cycle power supply) |
|---|---|
| (1) Harmonics ... | 2,000, 3,000, 4,000..20,000, etc. |
| (2) Modulation cross products between hum and fundamental ...... | 1,000 + 60 = 1,060 |
| | 1,000 — 60 = 940 |
| | 1,000 + 120 = 1,120 |
| | 1,000 — 120 = 880 |
| | 1,000 ± 180 = etc. |
| (3) Modulation cross products between hum and harmonics | 2,000 ± 60 = 2,060 and 1,940 |
| | 2,000 ± 120 = 2,120 and 1,880 |
| | 2,000 ± etc. |
| | 3,000 ± 60 = 3,060 and 2,940 |
| | 3,000 ± 120 = |
| | 3,000 ± etc. |
| | 4,000 ± etc. |
| (4) Hum components ......... | 60, 120, 180, etc. |
| (5) Noise components ......... | All frequencies |

The Distortion and Noise Meter sums all these quantities and thus indicates, as percent. distortion, the ratio of the sum of all undesired components to the fundamental frequency component. If it is desired to determine the distortion due to the harmonic and cross product components alone, either of two methods may be used.

One method is to operate the equipment under test at a high output level, which results in making the hum and noise components negligible compared to the other components. Another method is as follows:

1. Measure distortion in the normal manner at the desired output level.
2. Measure the noise level in decibels, using the same output level as a reference level.
3. Convert the reading in decibels to percent.; for example, −40 db = 1%, − 60 db = 0.1%.
4. These values may then be substituted in the following equation:

$$H = \sqrt{D^2 - N^2}$$

Where H = total harmonic and cross section distortion in percent.

D = distortion percent. obtained as per (1).

N = noise (in percent.) obtained as per (2) and (3).

When making distortion measurements, it should be kept in mind that the noise level in the output of the beat frequency oscillator approximates 50 db below 1 milliwatt and is substantially independent of the actual oscillator output voltage. While the design of the distortion meter is such that the effects of noise and distortion present in the oscillator output tend to be cancelled out, in most cases the cancellation will be more complete for the distortion than for the noise components.

Therefore, it is desirable to operate the oscillator at as high an output as practicable, thus improving the signal to noise ratio to the point where the noise output of the oscillator (expressed in percent. of signal) is small compared to the percent. distortion being measured. High oscillator output may not always be consistent with the input voltage requirements of the meter, but this difficulty can readily be overcome by the use of one or two attenuator pads or the 89-B attenuator panel.

When operating the Noise and Distortion Meter at a point remote from the oscillator, the effects of noise and distortion in the line may be great enough to seriously affect the accuracy of the measurements. Hence this type of operation is not recommended.

Normally, when taking measurements near 0 or 180 degrees phase shift, a balance cannot be obtained at frequencies which are transmitted through the equipment under test with phase shifts which fall within these narrow limits. This, however, can be overcome by inserting a capacitor in series with one of the two outside terminal connections (not the center tap) between the distortion meter and oscillator. The value of the capacitor and the choice of which connection to use is best decided by trial.

# MAINTENANCE

Service generally consists of replacing tubes which have become defective through usage. All tubes should be tested at regular intervals in a tube tester.

The Distortion and Noise Meter is protected by a 1.5-ampere fuse. Should the clips holding this fuse become unduly heated through improper contact, the fuse will blow. Hence the holding contacts should be free from foreign matter and hold the fuse firmly in place.

Figures 4 and 5 show respectively the top and bottom view of the chassis, with the components comprising the circuit identified by numerals corresponding to like values on the list of spare parts. This facilitates replacement of circuit elements which have developed a breakdown. Schematic circuit and connection diagrams are shown in Figures 6 and 7.

Resistance elements through constant usage, sometimes become altered in value. This change, if sufficiently great, will affect operation in that portion of the circuit in which the resistance element is located.

Check tube socket voltages against the values in the table below. In event that the check on the tubes does not remove the cause of fault, disconnect the Distortion and Noise Meter from its source of power. With an ohmmeter, check through the entire equipment for continuity.

If such procedure shows the circuit to be intact, then check each element therein with the ohmmeter and compare the resistance readings of the resistors against the corresponding resistor given in the spare parts list.

In testing capacitors for open, short and leaky circuits, it is necessary to remove one side of the capacitor under test from the circuit in which it is connected. The probes of the ohmmeter are then placed across the terminals of the capacitor under inspection and from the nature of the ohmmeter deflection, the condition of the capacitor can readily be ascertained.

# TUBE SOCKET VOLTAGES

**(120-volt line, fuse in 120-volt position)**

All voltages except filament are d-c to ground, measured with a 20,000-ohm-per-volt voltmeter.

| Tube | $E_f$ a-c | $E_p$ | $E_{sg}$ | $E_k$ | $E_p$ #2 | $E_k$ #2 |
|---|---|---|---|---|---|---|
| 6X5G R-F Diode | 6.3 | | | | | |
| 6C5 | 6.3 | 120 | — | 3.7 | — | — |
| 6C5 | 6.3 | 120 | — | 3.5 | — | — |
| 6SJ7 | 6.3 | 152 | 112 | 3.8 | — | — |
| 6SJ7 | 6.3 | 152 | 112 | 3.8 | — | — |
| 6F8-G | 6.0 | 105 | — | 3.6 | 250 | 11.5 |
| 6X5-G | 6.3 | d-c out = 357, a-c pl. to pl. 600 volts r-m-s | | | | |
| VR105/30 | | 105 | | | | |
| VR150/30 | | 255 | | | | |
| Amperite 6-8 | 12.0 | | | | | |

# PARTS LIST

| ITEM | DESCRIPTION | Stock No. |
|---|---|---|
| C-1 | Omitted | |
| C-2 | Capacitor—47 mmfd. | 13141 |
| C-3 | Capacitor—56 mmfd. | 12723 |
| C-4 | Capacitor—0.25 mfd. | 30849 |
| C-5, C-6 | Capacitor—2 sections 15 mfd., 1 section 40 mfd. | 34150 |
| C-7 | Capacitor—2 sections 10 mfd., 1 section 40 mfd. | 33865 |
| C-8 | Capacitor—560 mmfd. | 39646 |
| C-9, C-10 | Capacitor—Same as C-4 | |
| C-11, C-12, C-13 | Capacitor—Same as C-7 | |
| C-14 | Capacitor—Same as C-4 | |
| C-15 | Capacitor—Same as C-7 | |
| C-16 | Capacitor—Same as C-4 | |
| C-17 | Capacitor—Same as C-7 | |
| C-18 | Capacitor—0.025 mfd. | 30859 |
| C-19, C-20 | Capacitor—Same as C-7 | |
| C-21 | Capacitor—3 sections 40 mfd. each | 19805 |
| C-22 | Capacitor—Same as C-4, 2 req. | |
| C-23 | Capacitor—0.01 mfd. | 19801 |
| C-24 | Capacitor—0.05 mfd. | 19802 |
| C-25 | Capacitor—0.25 mfd. | 19803 |
| C-26 | Capacitor—1.0 mfd. | 19804 |
| C-27, C-28, C-29 | Capacitor—2 sections 15 mfd., 1 section 5 mfd. | 19806 |
| C-30 | Capacitor—Same as C-5 | |
| C-31 | Capacitor—1 section 40 mfd. | 19807 |
| C-32 | Capacitor—Same as C-7 | |
| C-33 | Capacitor—100 mfd. | 12720 |
| C-34, C-35 | Capacitor—3,900 mmfd. | 13763 |
| C-36 | Capacitor—3,300 mmfd. | 4881 |
| C-37 | Same as C-36 | |
| L-1 | Omitted | |
| L-2, L-3 | Filter Reactor | 19812 |
| M-1 | Meter | 44311 |
| R-1 | Resistor—180,000 ohms, 2 watts | 19734 |
| R-2 | Resistor—10,000 ohms | 13097 |
| R-3 | Resistor—1.29 ohms | 19778 |
| R-4 | Resistor—3,300 ohms | 30150 |
| R-5 | Resistor—18,000 ohms | 19779 |
| R-6 | Resistor—8,750 ohms | 19757 |
| R-7 | Resistor—2,270 ohms | 19755 |
| R-8 | Resistor—2,165 ohms | 19754 |
| R-9 | Resistor—544 ohms | 19751 |
| R-10 | Resistor—170 ohms | 19747 |
| R-11 | Resistor—10,800 ohms | 19758 |
| R-12 | Resistor—4,930 ohms | 19756 |
| R-13 | Resistor—2,100 ohms | 19753 |
| R-14 | Resistor—1,030 ohms | 19752 |
| R-15 | Resistor—538 ohms | 19750 |
| R-16 | Resistor—290 ohms | 19748 |
| R-17 | Resistor—360 ohms | 19749 |
| R-18 | Resistor—1,120 ohms | 19759 |
| R-19 | Resistor—1,700 ohms | 19760 |
| R-20 | Resistor—Same as R-8 | |
| R-21 | Resistor—1,600 ohms | 19761 |
| R-22 | Resistor—1,500 ohms | 19762 |
| R-23 | Resistor—Same as R-17 | |
| R-24 | Resistor—412 ohms | 19763 |
| R-25 | Resistor—260 ohms | 19764 |
| R-26 | Resistor—308 ohms | 19765 |
| R-27 | Resistor—154 ohms | 19766 |
| R-28 | Resistor—Same as R-16 | |
| R-29 | Resistor—1,390 ohms | 19767 |
| R-30, R-31 | Resistor—1,300 ohms | 19768 |
| R-32, R-33 | Resistor—1,100 ohms | 19769 |
| R-34 | Resistor—900 ohms | 19770 |
| R-35 | Resistor—1,000 ohms | 19771 |
| R-36 | Resistor—13,500 ohms, ½ watt | 19735 |
| R-37 | Resistor—100,000 ohms, ½ watt | 19736 |
| R-38 | Resistor—91,000 ohms, ½ watt | 19737 |
| R-39 | Resistor—11,000 ohms, ½ watt | 19738 |
| R-40 | Potentiometer | 19798 |
| R-41, R-42 | Resistor—1,000 ohms, ½ watt | 19739 |
| R-43, R-44 | Resistor—10,000 ohms, 2 watts | 19740 |
| R-45 | Resistor—47.5 ohms, ½ watt | 19741 |
| R-46 | Resistor—103 ohms | 19772 |
| R-47 | Resistor—8.1 ohms | 19773 |
| R-48 | Resistor—316 ohms | 19774 |
| R-49 | Resistor—Same as R-14 | |
| R-50 | Resistor—81 ohms | 19775 |
| R-51 | Resistor—3,160 ohms | 19776 |
| R-52 | Resistor—10,300 ohms | 19777 |
| R-53 | Resistor—100,000 ohms, ½ watt | 3252 |
| R-54 | Resistor—470,000 ohms, ½ watt | 30648 |
| R-55 | Potentiometer—2,000 ohms | 19799 |
| R-56 | Resistor—1,000 ohms | 4687 |
| R-57 | Resistor—120,000 ohms | 30180 |
| R-58 | Resistor—22,000 ohms, ½ watt | 30492 |
| R-59, R-60 | Resistor—6,800 ohms | 14659 |
| R-61 | Resistor—220,000 ohms, ½ watt | 14583 |
| R-62 | Resistor—Same as R-56 | |
| R-63 | Resistor—Same as R-57 | |
| R-64 | Resistor—22,000 ohms, 1 watt | 30736 |
| R-65, R-66 | Resistor—Same as R-59 | |
| R-67 | Resistor—Same as R-61 | |
| R-68 | Resistor—1,800 ohms, ½ watt | 30930 |
| R-69 | Resistor—27,000 ohms, 1 watt | 13477 |
| R-70, R-71 | Resistor—27,000 ohms | 30409 |
| R-72 | Resistor—470,000 ohms, ½ watt | 30648 |
| R-73 | Resistor—1,800 ohms | 19742 |
| R-74 | Potentiometer—12,000 ohms | 19800 |
| R-75 | Resistor—40,000 ohms | 44313 |
| R-76 | Resistor—1,000 ohms | 19744 |
| R-77 | Resistor—3,700 ohms | 19745 |
| R-78 | Resistor—1,500 ohms, 2 watts | 19746 |
| R-79 | Resistor—3,300 ohms, 1 watt | 30150 |
| R-80 & S-7 | Potentiometer | 19796 |
| R-81, R-82 | Resistor—Same as R-58 | |
| R-83 | Resistor—430 ohms, ½ watt | 19781 |
| R-84 | Resistor—470 ohms, ½ watt | 19782 |
| R-85 | Resistor—560 ohms, ½ watt | 19783 |
| R-86 | Resistor—620 ohms, ½ watt | 19784 |
| R-87 | Resistor—910 ohms, ½ watt | 19787 |
| R-88 | Resistor—1,300 ohms, ½ watt | 19790 |
| R-89 | Resistor—680 ohms, ½ watt | 31024 |
| R-90 | Resistor—300 ohms, ½ watt | 19780 |
| R-91 | Resistor—Same as R-84 | |
| R-92 | Resistor—Same as R-85 | |
| R-93 | Resistor—Same as R-41 | |
| R-94 | Resistor—1,200 ohms, ½ watt | 19789 |
| R-95 | Resistor—1,800 ohms, ½ watt | 19792 |
| R-96 | Resistor—Same as R-83 | |
| R-97 | Resistor—Same as R-87 | |
| R-98 | Resistor—750 ohms, ½ watt | 19785 |
| R-99 | Resistor—820 ohms, ½ watt | 19786 |
| R-100 | Resistor—Same as R-94 | |
| R-101 | Resistor—Same as R-95 | |
| R-102 | Resistor—2,700 ohms, ½ watt | 19793 |
| R-103 | Resistor—Same as R-99 | |
| R-104 | Resistor—1,600 ohms, ½ watt | 3560 |
| R-105 | Resistor—1,100 ohms, ½ watt | 19788 |
| R-106 | Resistor—1,600 ohms, ½ watt | 19791 |
| R-107 | Resistor—3,000 ohms, ½ watt | 19794 |
| R-108 | Resistor—9,100 ohms, ½ watt | 19795 |
| R-109 | Potentiometer | 19797 |
| R-110 | Resistor—82,000 ohms, ½ watt | 8064 |
| R-111 | Omitted | |
| R-112, R-113 | Resistor—68 ohms, ½ watt | 32808 |
| R-114 | Resistor—330 ohms, ¼ watt | 30538 |
| R-115 | Resistor—56,000 ohms, ½ watt | 30650 |

## PARTS LIST—Continued

| ITEM | DESCRIPTION | Stock No. | ITEM | DESCRIPTION | Stock No. |
|---|---|---|---|---|---|
| S-1 | Switch—1 section, 5 positions | 19818 | | Binding Post (marked "HIGH") | 4857 and 4605 |
| S-2 | Switch—2 sections, 8 positions | 19813 | | Cover—Insulating for capacitor | 28451 |
| S-3 | Switch—2 sections, 10 positions | 19814 | | Fuse Mounting | 4774 |
| S-4 | Switch—3 sections, 12 positions | 19815 | | Fuse—2 amperes | 3883 |
| S-5 | Switch—2 sections, 4 positions | 19817 | | Grid Cap | 30314 |
| S-6 | Switch—6 sections, 12 positions | 19816 | | Insulator | 16531 |
| S-7 | Included in R-80 | | | Jack Assembly | 30079 |
| T-1 | Bridging Transformer, XT-3100 | 19809 | | Knob (small size) | 4323 |
| T-2 | Balancing Transformer, XT-3103 | 19810 | | Knob Assembly (medium size) | 17268 |
| T-3 | | | | Knob Assembly (large size) | 17269 |
| T-4 | Input Transformer, XT-3118 | 19811 | | Lamp | 11891 |
| T-5 | Power Transformer, XT-3150 | 19808 | | Motor Connector Base | 23225 |
| | MISCELLANEOUS | | | Mounting Plate | 19820 |
| | Binding Post (marked "O") | 4860 | | Mounting Plate | 28452 |
| | Binding Post (marked "LOW") | 4606 | | Pilot Light | 34258 |
| | | | | Scale—Dial for meter No. 44311 | 44312 |
| | | | | Tube Socket | 18467 |
| | | | | Tube Socket | 31769 |
| | | | | Tube Shield Top | 4629 |
| | | | | Tube Shield | 3682 |
| | | | | Tube Shield | 3950 |

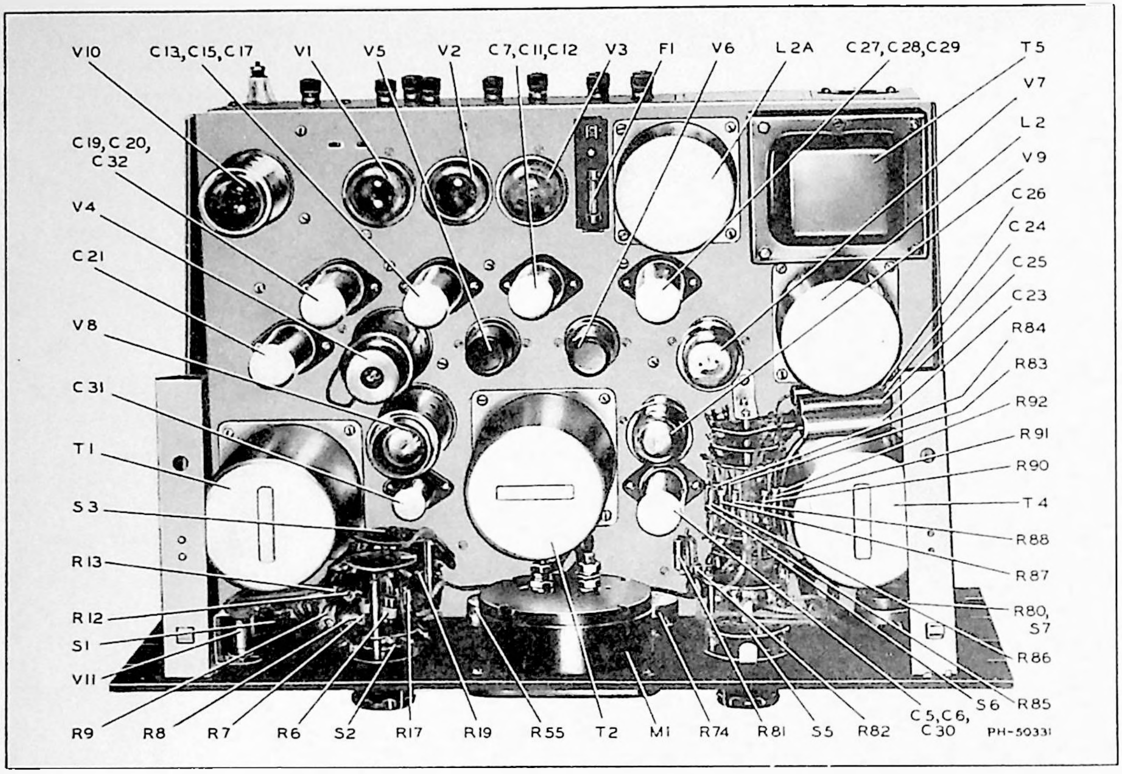


*Figure 4—Chassis and Panel Assembly, Top View*

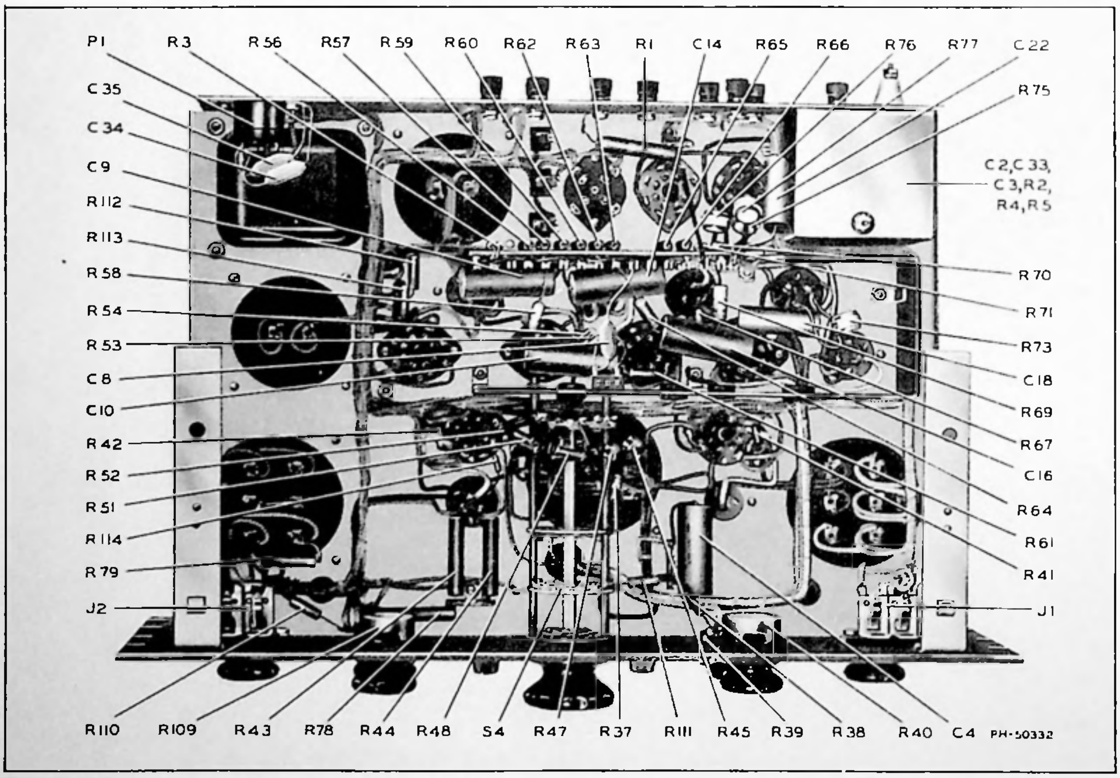


*Figure 5—Chassis and Panel Assembly, Bottom View*

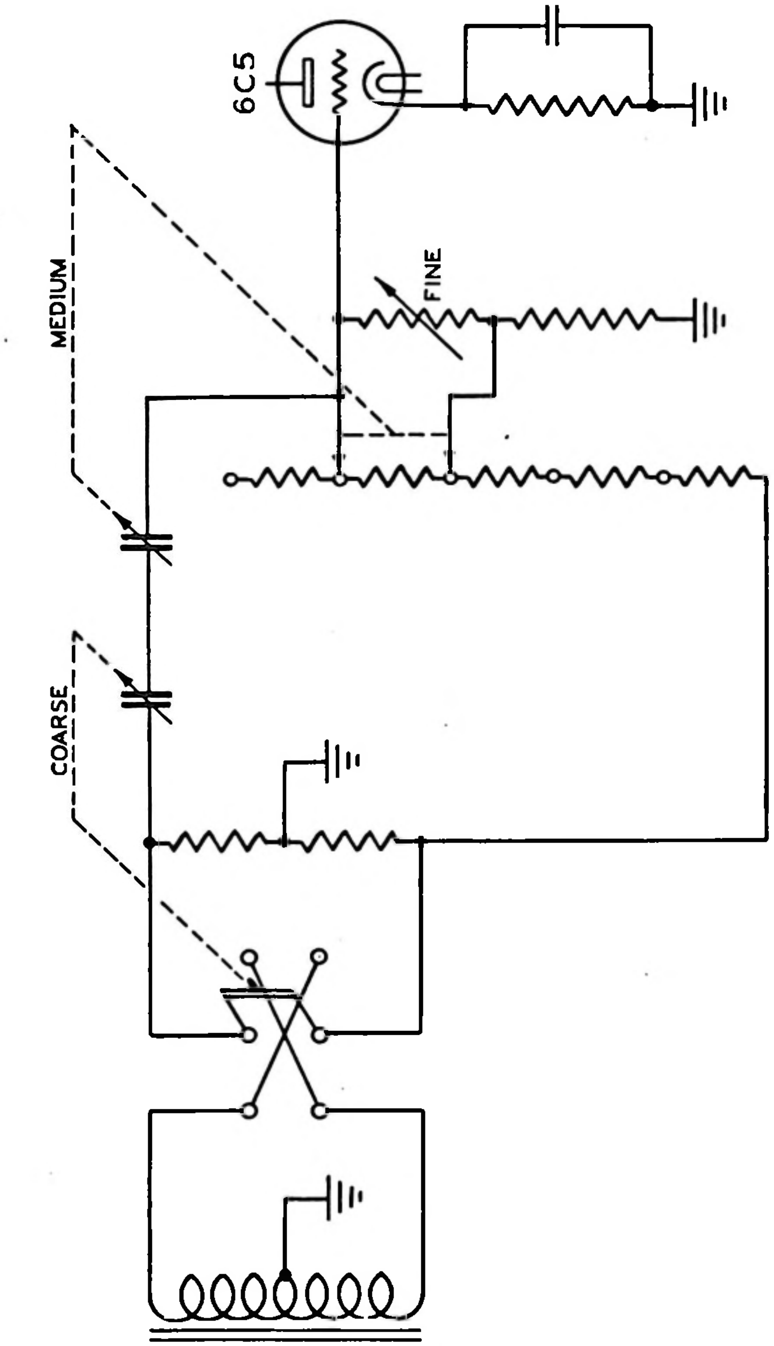


*Figure 6—Phase Shifting Network*
*(Schematic K-849405)*

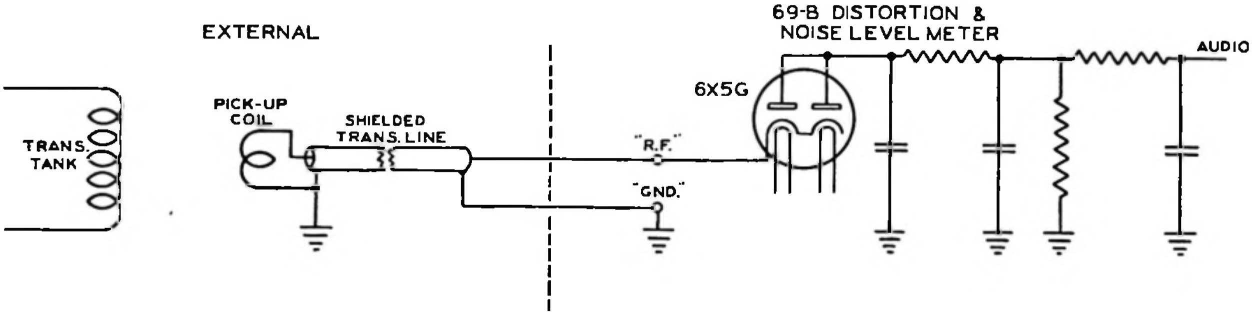


*Figure 7—R-F Rectifier*
*(Schematic K-849404)*

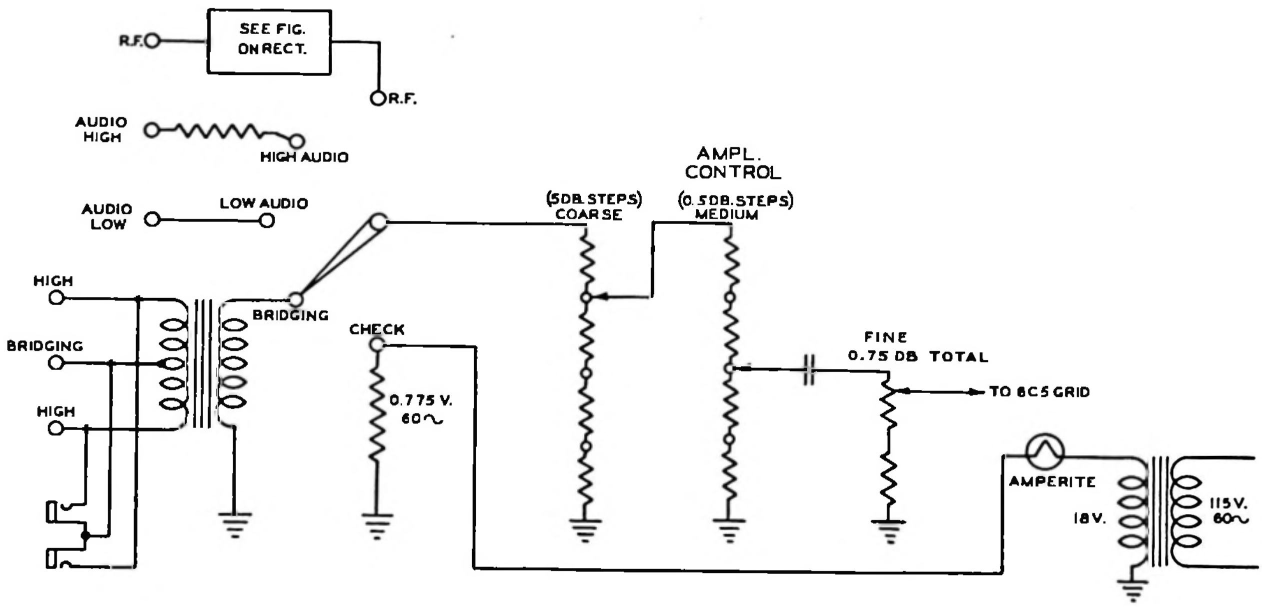


*Figure 8—Input Circuit*
*(Schematic K-849407)*

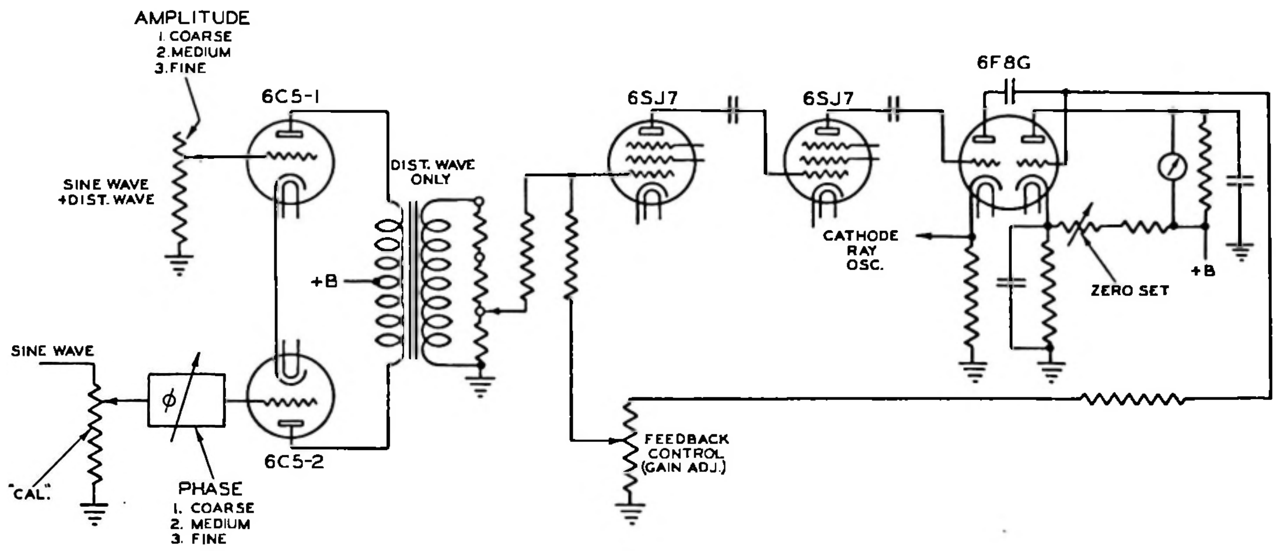


*Figure 9—Distortion Measurement Circuit (Schematic K-849406)*

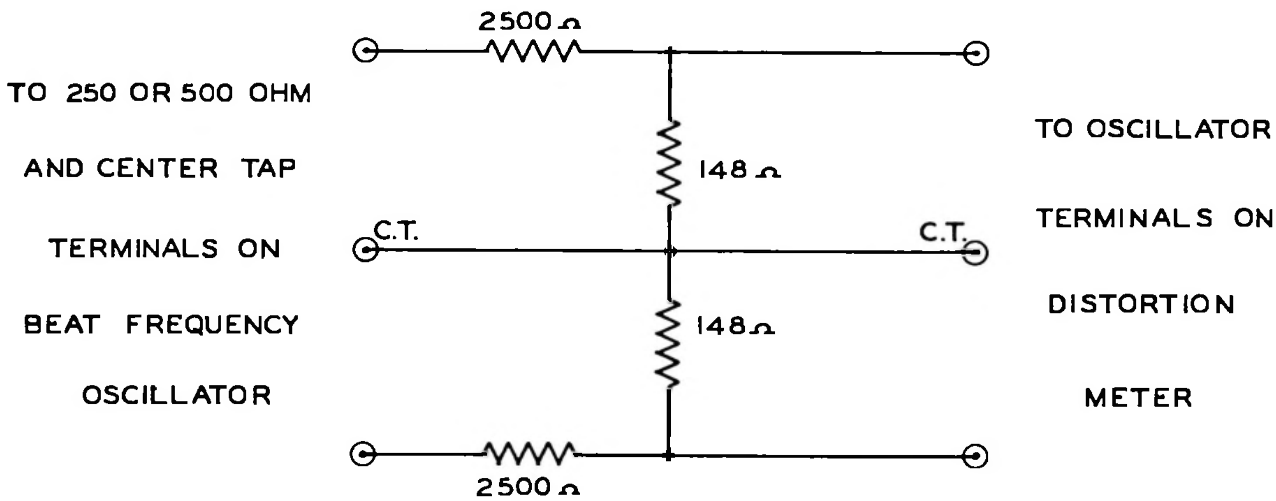


*Figure 10—Typical Attenuator (Schematic K-841775)*

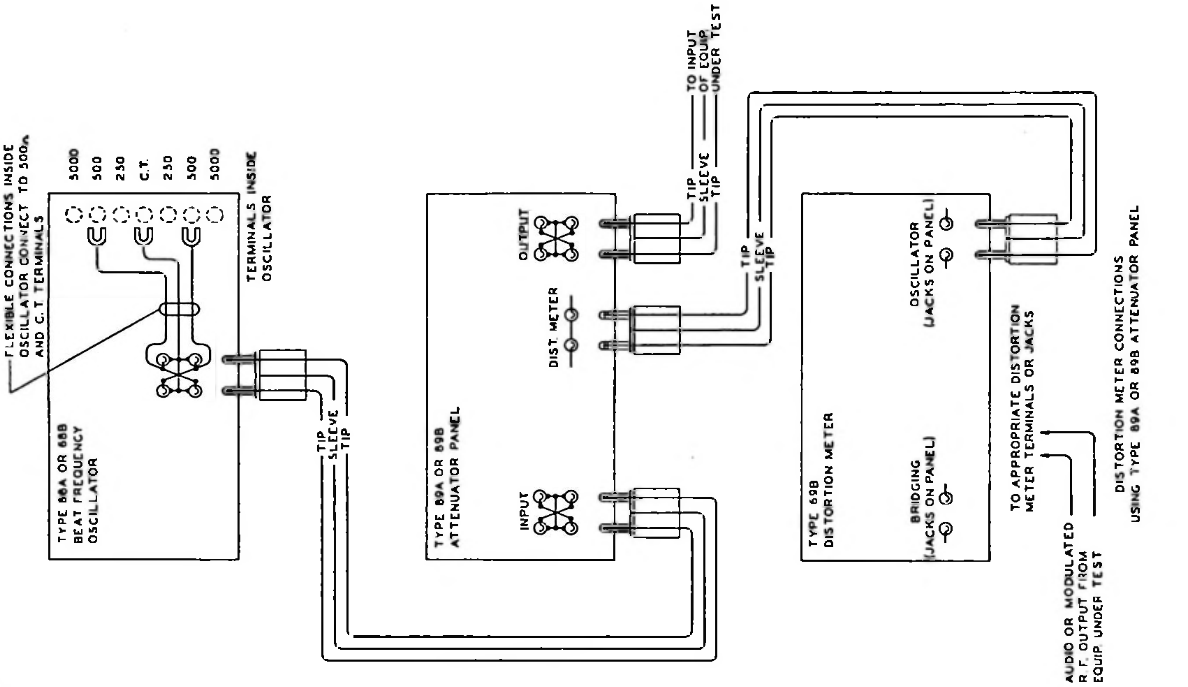


*Figure 11—Distortion Meter Connections Using 89A or 89B Attenuator Panel (P-714628)*

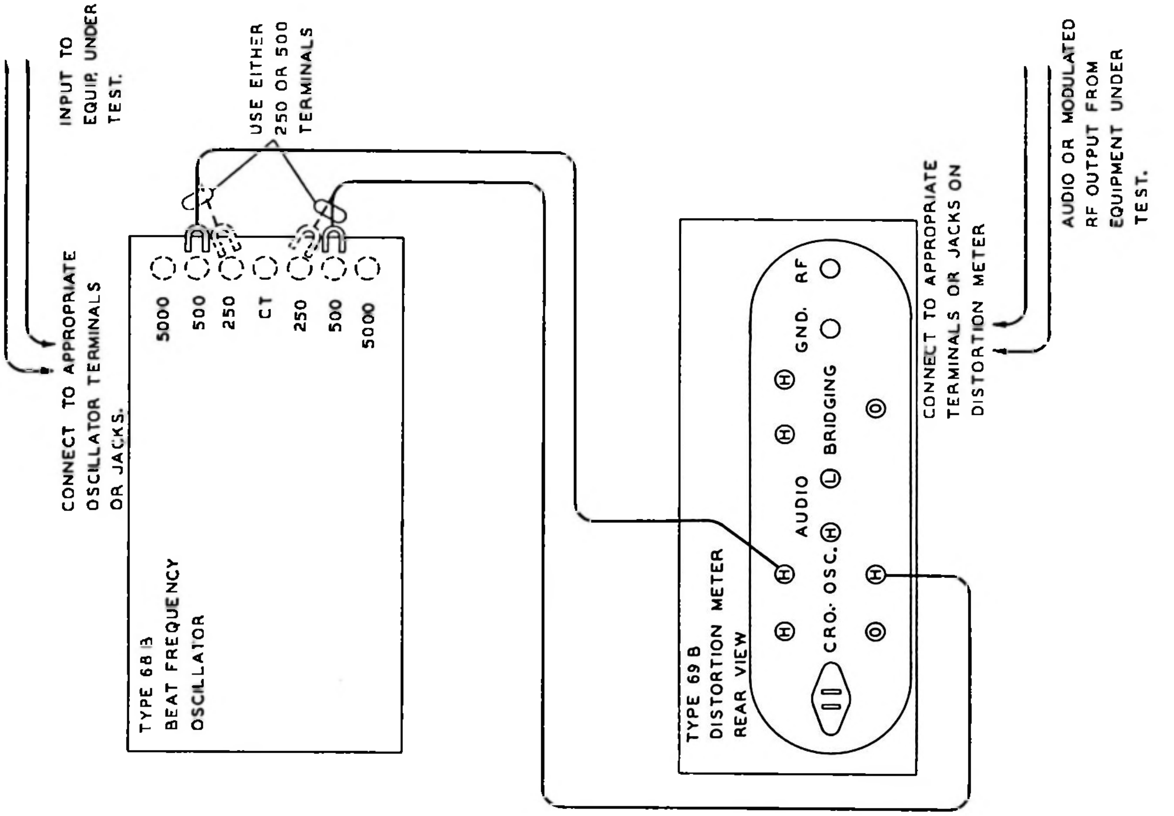


*Figure 12—Distortion Meter Connections Using Direct Wiring (M-428492)*

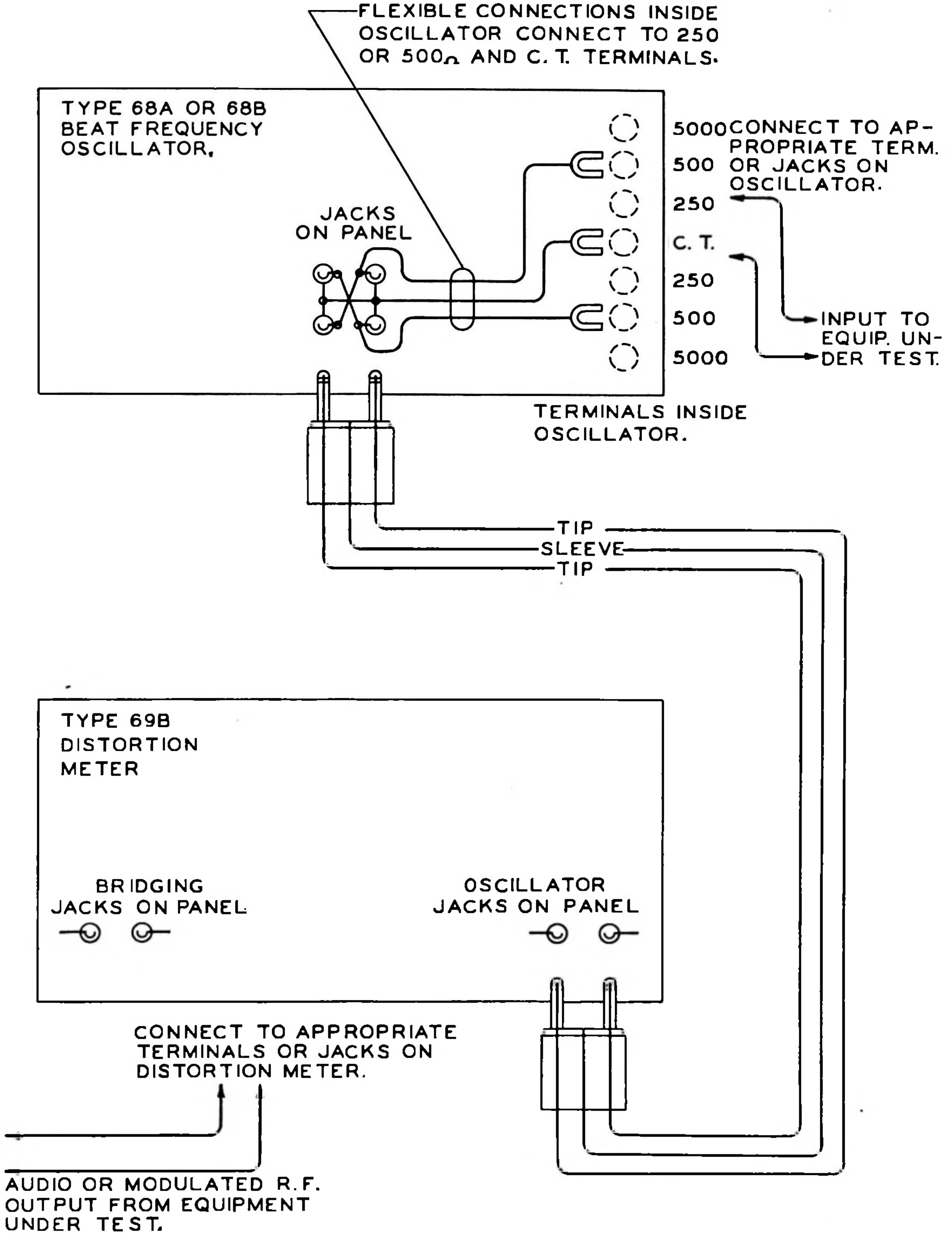


*Figure 13—Distortion Meter Connections Using Patch Cords (M-428505)*

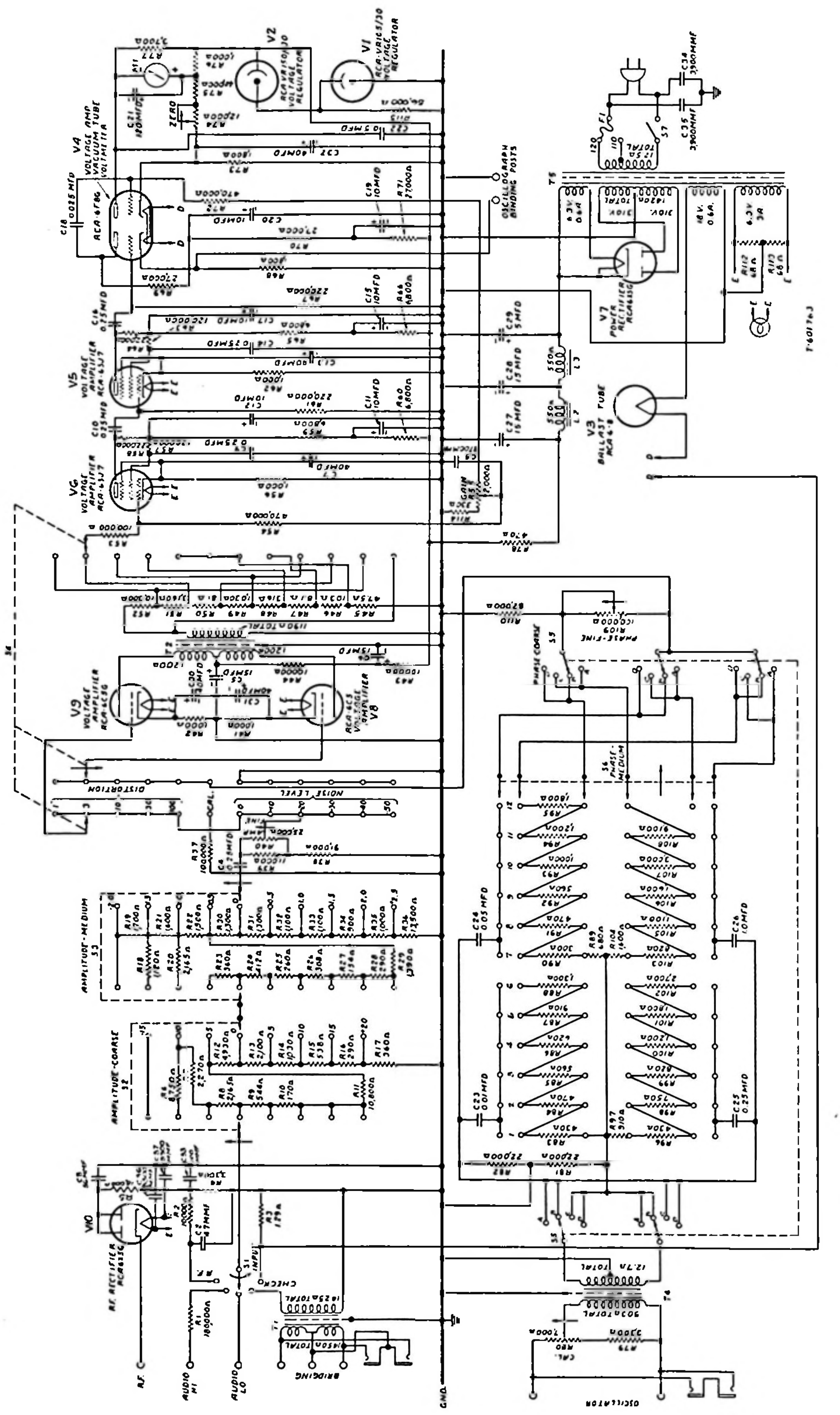

*Figure 14—Distortion and Noise Meter (Schematic T-601763)*

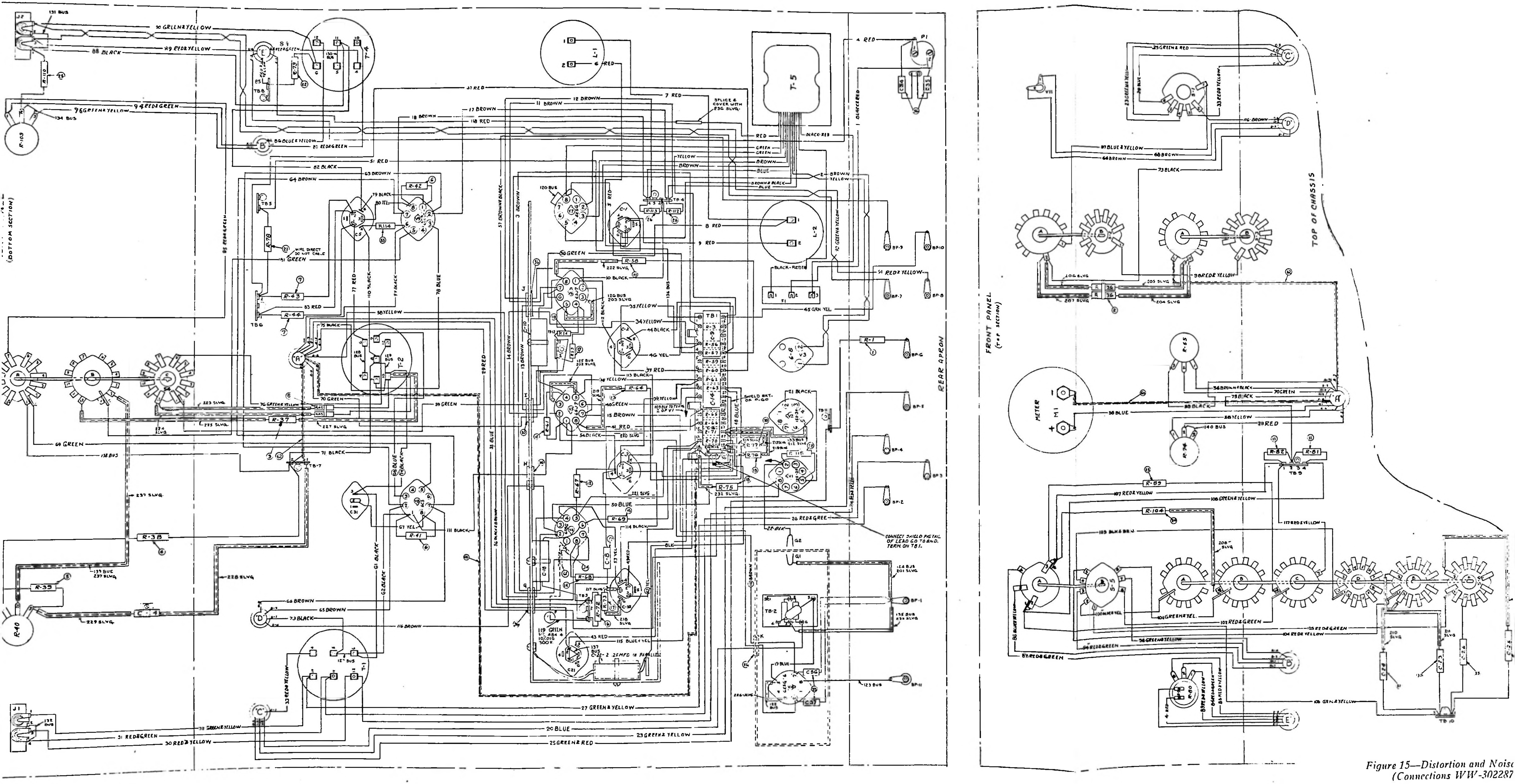


*Figure 15—Distortion and Noisc*
*(Connections WW-302287*

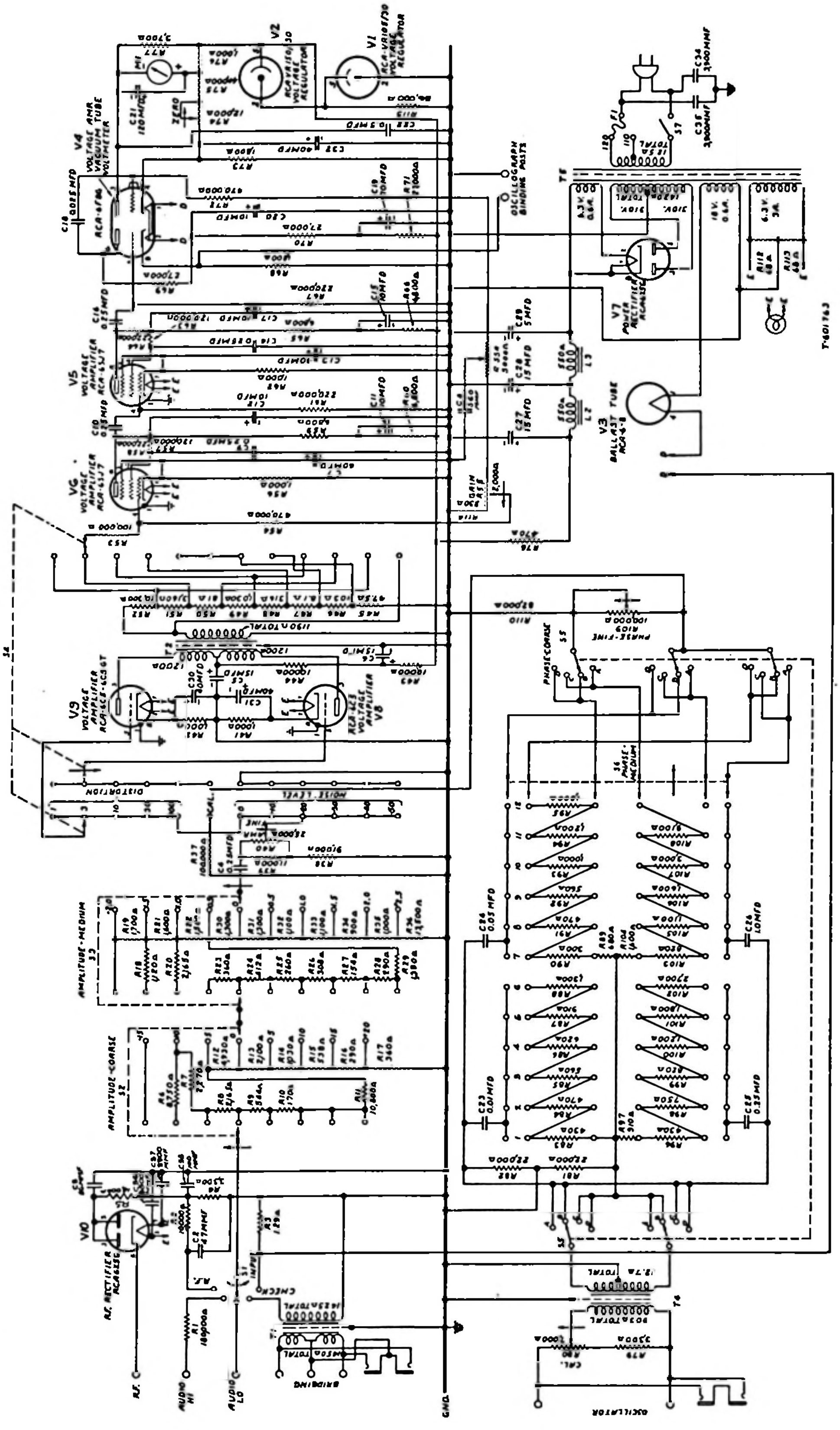

*Figure 14—Distortion and Noise Meter*
*(Schematic T-601763)*

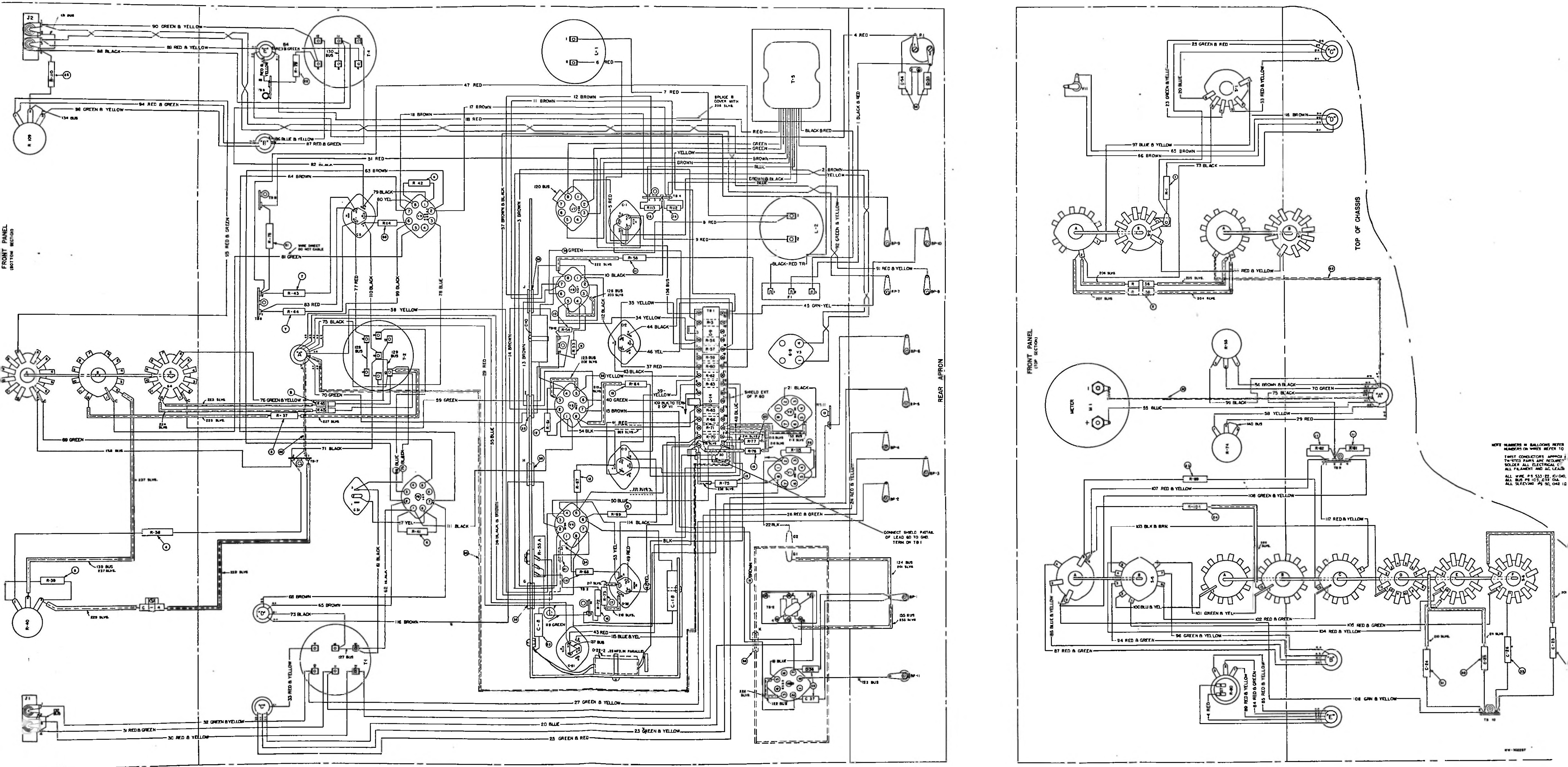


*Figure 15—Distortion a*
*(Connections WW*