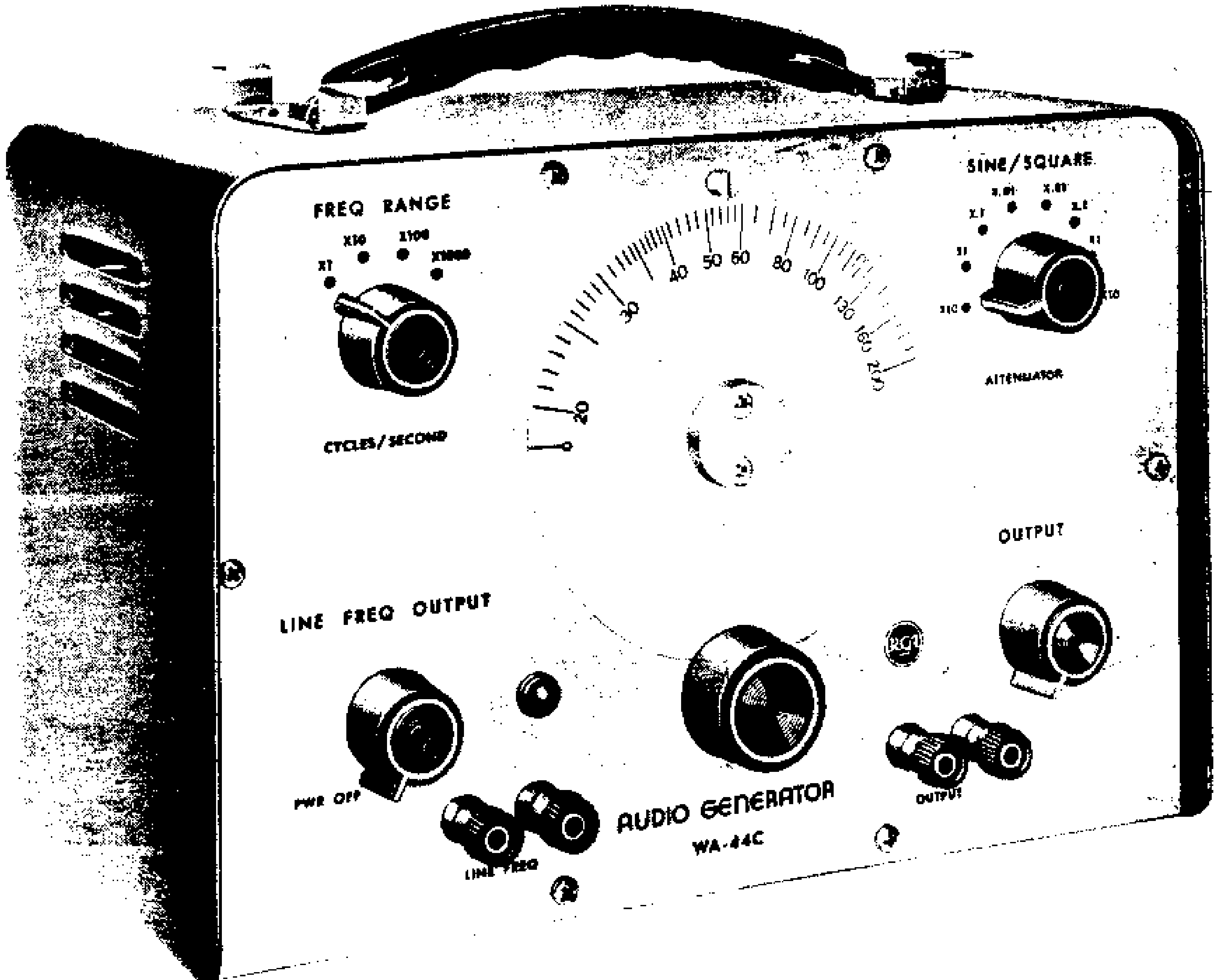
SEVENTY-FIVE CENTS

RCA

SINE/SQUARE WAVE AUDIO GENERATOR

Type WA-44C



- Specifications

Operation • Applications • Maintenance

RADIO CORPORATION of AMERICA
ELECTRONIC COMPONENTS AND DEVICES ELECTRONIC INSTRUMENTS
HARRISON, NEW JERSEY

TP-WA-44C

Safety Precautions

The metal case of this instrument is connected to the ground of the internal circuit. For proper operation, the ground terminal of the instrument should always be connected to the ground of the equipment under test

An important point to remember is that there is always danger inherent in testing electrical equipment which operates at hazardous voltages. Therefore, the operator should thoroughly familiarize himself with the equipment under test before working on it, bearing in mind that high voltages may appear at unexpected points in defective equipment. Additional precautions which experience in the industry has shown to be important are listed below.

1. It is good practice to remove power before connecting test leads to high-voltage points. If this is impractical, be especially careful to avoid accidental contact with equipment racks and other objects which can provide a ground. Working with one hand in your pocket and standing on a properly insulated floor lessens the danger of shock.

2. Filter capacitors may store a charge large enough to be hazardous. Therefore, discharge filter capacitors before attaching test leads.

3. Remember that leads with broken insulation provide the additional hazard of high voltages appearing at exposed points along the leads. Check test leads for frayed or broken insulation before working with them.

4. To lessen the danger of accidental shock, disconnect test leads immediately after test is completed.

5. Remember that the risk of severe shock is only one of the possible hazards. Even a minor shock can place the operator in hazard of more serious risks such as a bad fall or contact with a source of higher voltage.

6. The experienced operator continuously guards against injury and does not work on hazardous circuits unless another person is available to assist in case of accident.

ITEMS
SUPPLIED WITH WA-44C

1 — RCA 6X4
1 — RCA 6AQ5
2 — RCA 6U8A
1 Instruction Book

10/66
Printed in U.S.A.

Sine/Square Wave Audio Generator

Type WA-44C

Contents

Page No.

Description

The RCA WA-44C Sine/Square Wave Audio Generator is designed for general radio work, and other applications which require a sine or square wave audio-frequency signal. The instrument is ac operated from a 50–60 cycle, 105–125 volt source, and covers a range from 20 cps to 200,000 cps. This Sine/Square Wave Generator can be used for a wide variety of applications, including the direct measurement of frequency response characteristics of audio amplifiers, and the testing of loudspeakers and enclosures. In addition, the WA-44C can be used in finding the impedance of LC combinations, and in determining the frequency or speed of vibrating or rotating bodies.

The circuit of the RCA WA-44C sine-wave function consists of a "Bridged-T" oscillator with a cathode follower output stage. The square wave output is developed by using the sine wave oscillator output to drive a shaping and clipping circuit. This instrument features a circuit design that produces a stable signal, with an amplitude variation of not more than ±1.5 db. Total harmonic distortion is limited to 0.25%.

Operation of the WA-44C is straightforward. The controls of the instrument have been designed to be manipulated easily and effectively. The desired frequency is selected by means of the continuous, single-scale Tuning Dial, together with the appropriate multiple applied by the "FREQ RANGE" switch. The type of wave and the amplitude are selected with the "SINE/SQUARE" attenuator switch. The output voltage can be adjusted further with the "OUTPUT" control of the instrument. A separate output at line frequency is also provided, at an adjustable voltage up to 6 volts. The WA-44C is an extremely versatile test instrument, engineered to give long trouble-free performance. Its use in the service shop will speed the testing and servicing of any equipment which utilizes an audio signal.

Specifications

NOTE: Performance figures are for a line voltage of 117 volts, 60 cps.

Electrical:

Frequency Range: .... 20 cps to 200 kcs

Ranges:

X1	20 cps to 200 cps
X10	200 cps to 2 kcs
X100	2 kcs to 20 kcs
X1000	20 kcs to 200 kcs

Amplitude Variation of Output Voltage:
(30 cps to 100 kcs) .... ±1.5 db

Frequency Stability:
(105 v to 125 v AC line) .... ±2%

Dial Calibration Accuracy:
(20 cps to 20 kcs) .... ±5%

Sine Wave:

†Output Voltage:
(100 k Ω and 75 μμf load) .... 8 v rms or more

Maximum Total Harmonic Distortion:
(30 cps to 15 kcs) 0.5%

Square Wave:

‡Max. Tilt .... approx. 5%

†Output Voltage:
(100 k Ω and 75 μμf load) .... 10 v p-p or more

Source Impedance (200 cps)
For instrument with serial numbers above 4781

Output Range:

Sine X10	approx. 3000
Sine X1	approx. 900
Sine X.1	approx. 91
Sine X.01	approx. 9
Square X10	approx. 600
Square X1	approx. 900
Square X.1	approx. 91
Square X.01	approx. 9

Source Impedance (200 cps)
For instrument with serial numbers below 4782

Output Range:

Sine X10	approx. 3000 Ω
Sine X1	approx. 600 Ω
Sine X.1	approx. 600 Ω
Sine X.01	approx. 600 Ω
Square X10	approx. 600 Ω
Square X1	approx. 600 Ω
Square X.1	approx. 600 Ω
Square X.01	approx. 600 Ω

Power Supply:
Voltage .... 105–125 volts, 50–60 cps
Average Power Consumption .... approx. 40 watts

Tube Complement: .... 1 – 6AQ5
1 – 6X4
2 – 6U8A

Mechanical:

Dimensions:

Height	7 inches
Width	10-11/16 inches
Depth	6-1/8 inches
Weight	10-1/2 pounds

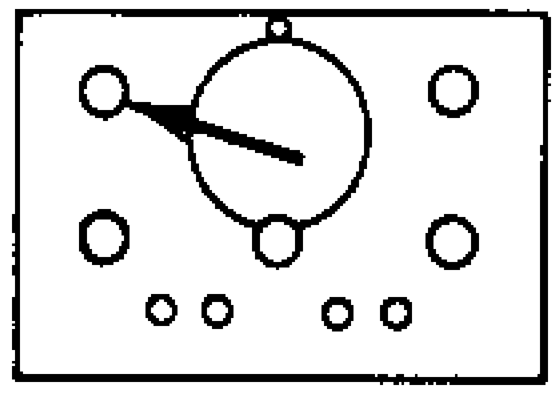
Finish
Blue Hammeroid Case, Satin Aluminum Panel

† A lower value of load impedance may decrease the output voltage and slightly increase distortion. For example, in Sine X10 output attenuator position, distortion may increase to approximately 0.35% with 100 ohms load impedance. However, in the remaining attenuator positions the use of low-resistance loads does not appreciably increase distortion.

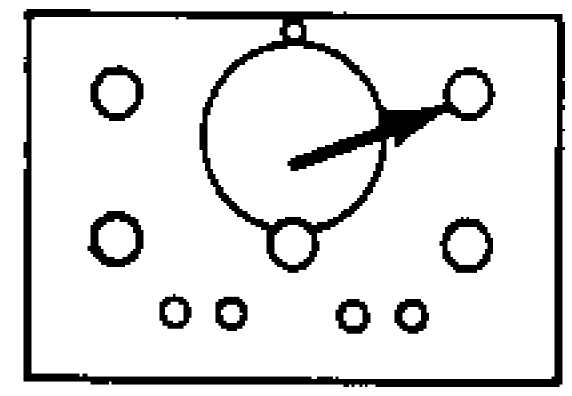
‡ The square wave at 30 cps may tilt an additional 5% with the output attenuator in the Square X10 position with loads as low as 1000 ohms. In the remaining attenuator positions however, the increase in square wave tilt is negligible when the load resistance is decreased.

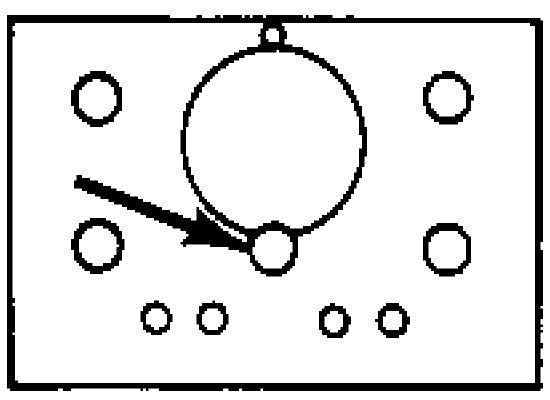
Functions of Controls and Terminals

RANGE
Selects the multiple to be applied to "TUNING CONTROL" dial frequency setting.

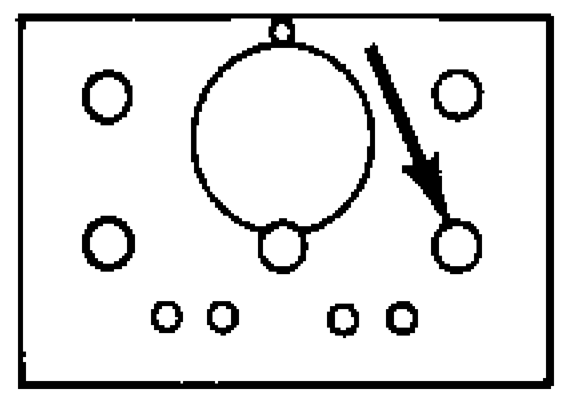


FUNCTION
Selects sine or square wave, and output voltage range.



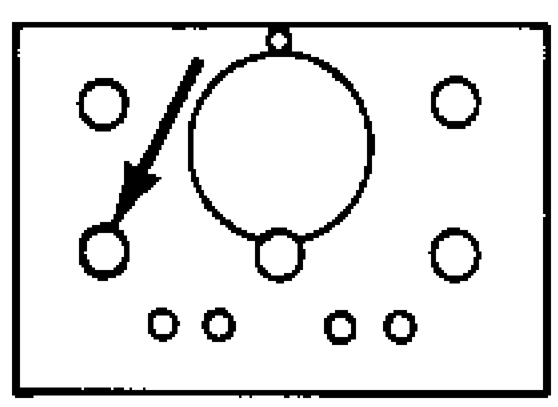


TUNING DIAL CONTROL
Continuous, single-scale dial assembly, used in conjunction with the "RANGE" switch to select output frequency.

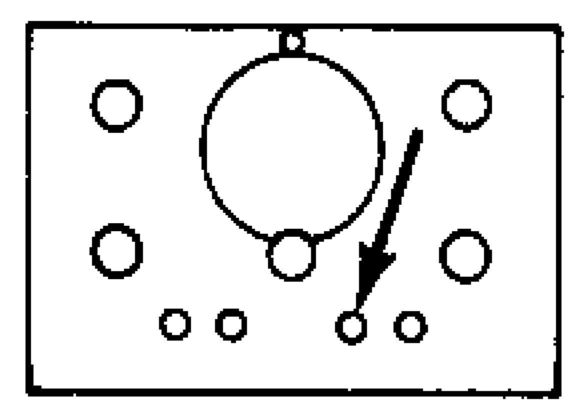


OUTPUT
Adjusts amplitude of the output signal, within range of "FUNCTION" selector.

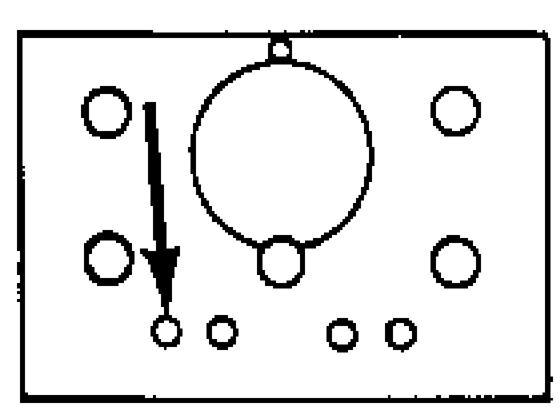
OFF-ON/LINE FREQUENCY OUTPUT
Applies power to instrument when rotated clockwise from "OFF" position, and controls line frequency voltage supplied to "LINE-FREQ." terminal.



OUTPUT-GND
Terminals for connection to the selected frequency output.



LINE FREQ.
Terminals provide a line frequency voltage, adjustable up to 6 volts.



Operation

To become familiar with controls of the WA-44C, refer to the preceding section, "Functions of Controls and Terminals."

To prepare the WA-44C for use, make the following adjustments and connections:

1. Turn the "OFF-ON, LINE FREQ" switch to the "OFF" position. Plug the line cord into an AC outlet supplying 105–125 volts, 50/60 cps.

2. Connect a set of test leads to the "OUTPUT" and ground terminals.

3. Adjust the tuning dial to the basic setting for the desired frequency.

4. Set the "FREQ RANGE" switch to the appropriate multiple. For 20 cps–200 cps, "X1"; for 200 cps–2 kc, "X10"; for 2 kc–20 kc, "X100"; and for 20 kc–200 kc, "X1000".

5. Set the "SINE SQUARE" function switch to obtain the desired waveform and amplitude. The four left-hand settings for sine-wave, and the four right-hand settings for square wave. The "OUTPUT" control can be used for further regulation of output voltage.

6. Turn the "OFF-ON LINE FREQ" switch to the "ON" position. Allow 5 minutes for the instrument to warm up.

7. Clip the cable attached to the ground terminal of the WA-44C to the ground of the circuit under test. Connect the probe or clip from the "OUTPUT" terminal to the point of signal injection.

CAUTION: The output attenuator network, C-12, R-12, and R-20 through R-24, is connected directly to the output terminals through switch S-1C. A connection between the output terminals and a circuit carrying B+ voltage may result in damage to one or more of these components. If it becomes necessary to connect the WA-44C into such a circuit, a DC blocking capacitor of suitable value should be used in series with the output terminal.

When a small signal voltage is required, as for a pre-amplifier, set the "SINE SQUARE" switch to the "X.01" position. Then, by adjusting the "OUTPUT" control, the required signal voltage can be produced.

Applications

The application information in the following paragraphs is intended to aid the technician in testing and troubleshooting audio circuits and components. These are typical applications in which the WA-44C may be used as a signal source.

Signal Tracing

Defects in PA systems, audio amplifiers, and the audio stages of radio and television receivers are quickly located with the aid of the WA-44C. Two methods can be used. The first makes use of a measuring device such as a high impedance voltmeter of the VoltOhmyst* type, or an oscilloscope such as the RCA WO-33A; the second utilizes the aural signal from the speaker. Of the two methods, the first allows for more accurate determination of amplifier and performance.

METHOD 1. Connect the output of the WA-44C to the input of the amplifier under test as described in the "Operation" section above. Although the output frequency of the generator may be set to any frequency within the range of the amplifier, 400 cycles is usually used. Adjust the output level of the generator so that the equipment under test is not overloaded.

With a known signal at the input of the amplifier, it is a simple job to trace the signal through the amplifier with a voltmeter or oscilloscope. The signal is followed from the grid of the first stage to the grid of each successive stage. The approximate gain of each stage can be determined by dividing the ac voltage at the plate by the ac voltage at the grid. When an oscilloscope is used, distortion can also be observed. Look for a stage in which the signal is lost, becomes distorted, or does not have normal amplification. A simple resistance-voltage check will usually locate the defective component or tube.

METHOD 2. This method requires no additional equipment but utilizes the signal generated by the WA-44C as an audible indication that the stage under test is operative.

* Trade Mark "VoltOhmyst" Reg. U. S. Pat. Off.

Inject the signal from the audio generator into the equipment under test starting at the primary side of the output transformer. A signal should be heard from the loudspeaker. If no signal is heard, the transformer or the loudspeaker is defective.

CAUTION: Should B+ dc voltage be present at the point of signal injection, an external blocking capacitor should be used.

After checking the primary of the output transformer, inject the signal into the grid circuit of the preceding stage. Work back toward the input end, while reducing the generator output to prevent overloading as additional stages of amplification are used in the test. Look for a stage in which the output from the speaker is lost, becomes distorted, or does not have normal gain. The defective component or tube may usually be located with a resistance-voltage check.

High-Fidelity Amplifier Measurements

Frequency response, distortion, and tone control and equalizer operation are the most important factors to be considered in checking high-fidelity audio amplifiers. The WA-44C is extremely well suited to provide the audio signal necessary for making these checks.

If measurements are taken with the loudspeaker which will normally be used with the amplifier, the effect of the reflected speaker impedance on the total response may be noted. If it is desired to test the amplifier alone, then a dummy load consisting of a resistor of the same value as the impedance of the voice coil, and of sufficient wattage to dissipate the maximum output of the amplifier, should be connected across the secondary of the output transformer.

DB Measurements

In order to study the relationship between the output voltage and the frequency response of an amplifier it is helpful to plot a curve showing the voltage output in decibels against frequency. The conversion table, Figure 2, offers a convenient means of changing voltage readings to decibels. Unless the same reference level and load impedance is used, the figures obtained from the chart will be relative values.

DBM Measurements

The graph on page 8 can be used to determine dbm values corresponding to rms ac-voltage values across a 600-ohm resistive load. A dbm value is defined as the number of decibels above or below a reference level of 1 milliwatt in 600 ohms at 1000 cycles. Zero dbm, therefore, would indicate a power level of 1 milliwatt; 10 dbm, 10 milliwatts; and 20 dbm, 100 milliwatts.

The graph makes possible rapid conversion of rms voltages to corresponding dbm values. Associated power levels can be read along the top of the graph. If the rms voltage is measured across a resistive load other than 600 ohms, the correction factors given below must be added algebraically to the dbm values read from the graph in Figure 2. For resistive loads not given in the table, the following formula should be used for determining the correction factor:

$$\text{Correction Factor} = 10 \log \frac{600}{R}$$

where R is the load in ohms. If R is greater than 600 ohms, the correction factor is negative.

Because dbm are defined with respect to a 600-ohm load, power levels correspond to voltage values. DBM can be measured in terms of rms voltages across a 600-ohm resistive load. For example, 0.775 rms volt indicates 0 dbm and 7.75 rms volts indicate 20 dbm. The decibel and ear-response curves have their closest correlation at 1000 cycles.

Resistive Load at 1000 cps	DBM*
600	8
500	+0.8
300	+3.0
250	+3.8
150	+6.0
50	+10.8
15	+16.0
8	+18.8
3.2	+22.7

* DBM is the increment to be added algebraically to the dbm value read from Figure 2, page 8.

Figure 1.

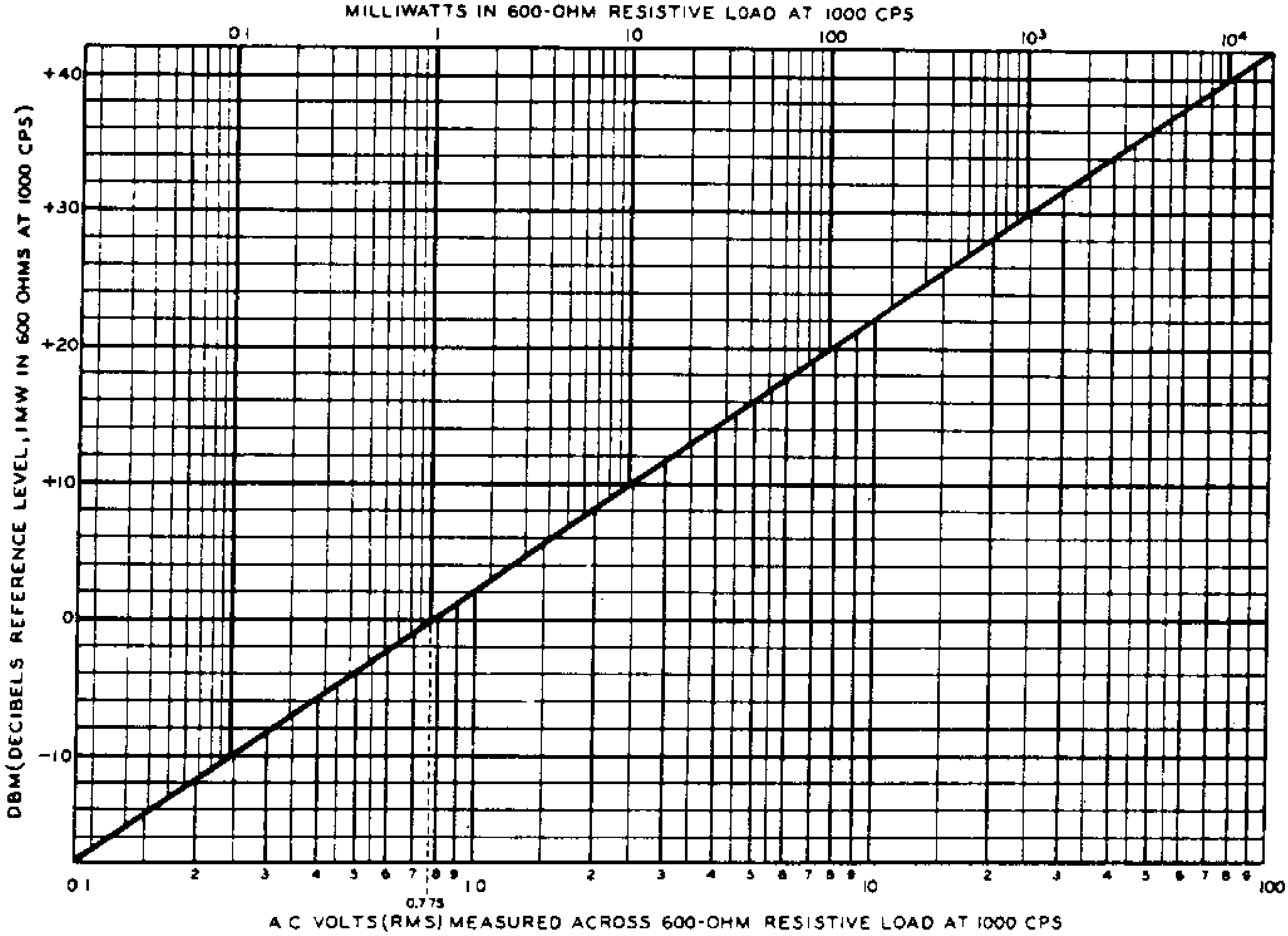


Figure 2. Graph for conversion of rms voltages to dbm values.

Frequency Response Measurements

Three methods are generally accepted for measuring the frequency response of audio amplifiers. The first utilizes a sine-wave signal of known input voltage and frequency. The output voltage is measured at the voice coil and plotted (as the ordinate) against the frequency (as the abscissa). The second method is similar to the first except that an oscilloscope is used as an output indicator. This technique allows for the observation of distortion as well as output. The third method requires the use of a square-wave input signal. This technique allows for broad band measurements and eliminates the necessity of a point-by-point frequency check.

METHOD 1. Connect the WA-44C to the amplifier input as described in the section on "Operation." Connect a VTVM, such as an RCA WV-77E or WV-98A VoltOhmyst, to the output of the amplifier. Adjust the output level so that maximum rated power is delivered to the voice coil. See the section on "Radio Receiver Frequncy Response Measurements," page 17, for the method of determining the voltage reading necessary for rated power output.

Starting at a frequency below the estimated response of the amplifier, record the voltage reading. Increase the frequency of the audio generator in 10 cycle steps until 100 cycles is reached, 100 cycle steps until 1000 cycles is reached, and 1000 cycle steps until the limit of the amplifier response is reached. Convert the voltage readings to dbm and plot a curve of dbm versus frequency. The ideal amplifier, will have constant output voltage over the entire frequency range provided the input voltage is kept constant.

METHOD 2. An oscilloscope that has been voltage calibrated, such as the RCA WO-33A, may be substituted for the vtvm. The measurement technique is identical with that used for the vtvm. This method, however, has the added advantage of allowing a visual inspection of the output waveform. Distortion and spurious responses are readily seen on the oscilloscope.

METHOD 3. Square wave testing using an oscilloscope is the most rapid way of checking the response of an audio amplifier. Since a square wave is composed of many harmonics of the fundamental frequency, an amplifier that passes a square wave without distortion, has in effect responded to all of the harmonics that go to make up the square wave.

The traces illustrated in Figure 3 show some typical amplifier responses. Before the amplifier is checked, the output of the WA-44C should be observed on the oscilloscope so that the input waveshape is known. The use of the square wave frequencies 20, 100, 500, and 2500 cps should be sufficient for testing amplifier response to beyond 10,000 cps.

Tone Controls

If the amplifier under test incorporates tone control circuits, care must be taken to set these controls so that they have a minimum effect on the frequency response of the amplifier. In some cases these controls have a "flat" position, in other cases the point of minimum effect will have to be determined experimentally.

Set the WA-44C to a frequency in the treble range, 3000 cps is a possible starting point. Vary the bass control and notice the effect on the output voltage. Similarly, vary the treble control. If the treble control produces a large voltage change, lower the frequency of the audio generator. Alternately vary the bass and treble controls and adjust the frequency of the generator until a frequency is found at which both bass and treble controls have minimum effect on the output voltage. This frequency can be used as a reference frequency for plotting a curve of output voltage versus frequency. The effect of varying the bass control should be plotted from the lower limit of the amplifier up to the reference level, while the effect of varying the treble control should be plotted from the reference level frequency to the upper frequency limit of the amplifier.

Assume that 1000 cps has been found as the frequency at which the bass and treble control have the least effect on the output voltage. Set the bass control to minimum and take output voltage readings with the frequency varied from 30 to 1000 cycles. Set the bass control to maximum and repeat the output voltage readings as the frequency is varied.

The same process is followed in determining the effect of the treble control except that the output voltage reading need not be taken below 1000 cycles.

From these voltage readings four curves may be plotted. Usually they are plotted in decibels on the same base line (see page 8) so that comparison of the results are easily seen. These curves indicate the frequency response of the amplifier with minimum and maximum bass and treble. Intermediate positions of both controls are sometimes plotted to give an overall picture of the effect of varying these controls.

Checking Phonograph Equalizers

Phonograph equalizers are simple networks used to compensate for attenuation or boost in the record which is introduced during the recording process. The usual cross-over frequencies (the frequency below which the bass is attenuated) are 250, 300, 350, and 500 cps. Various record manuafcturers use different cross-over frequencies, and consequently they have different recording curves. Some typical record curves are shown in Figure 4.

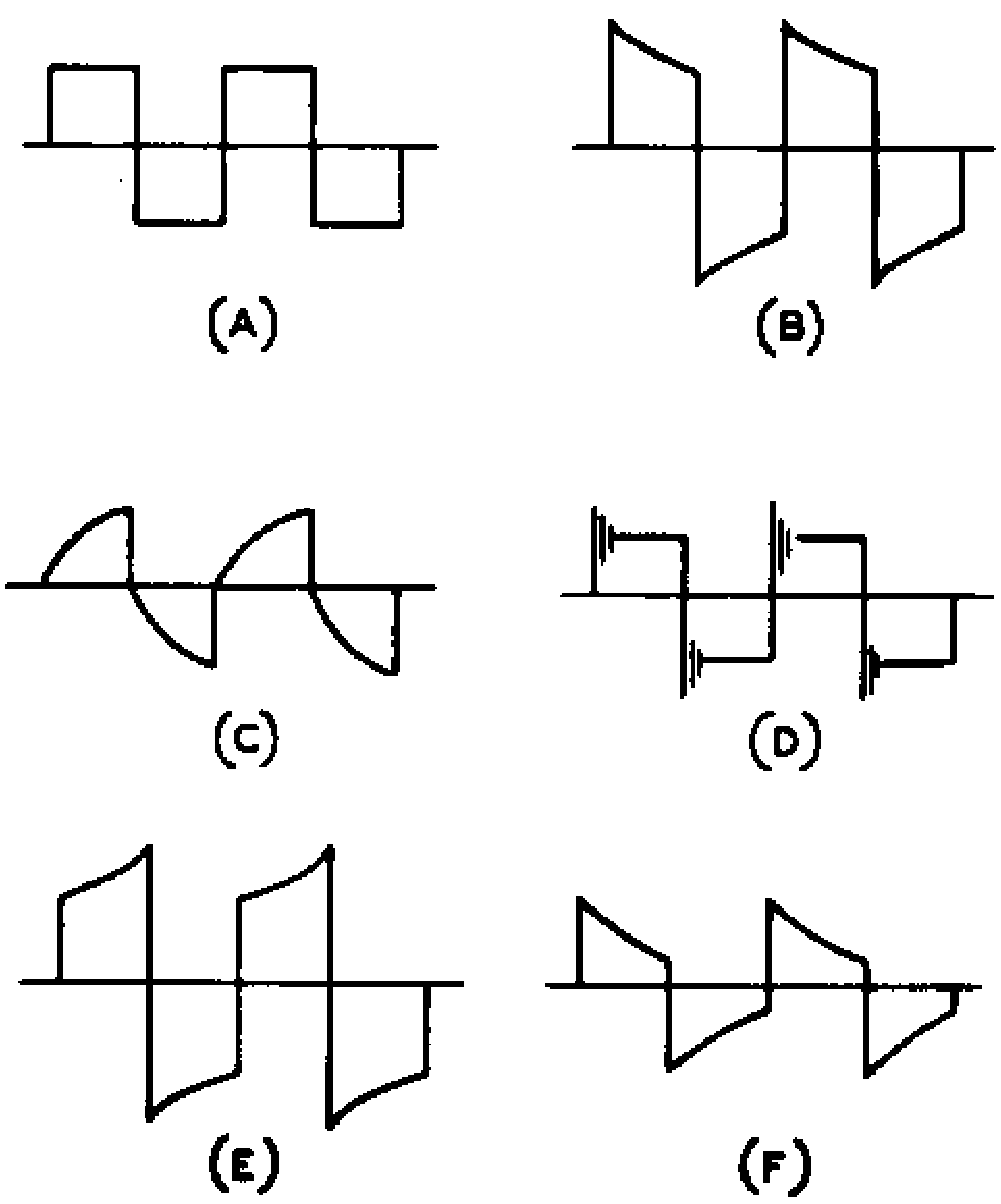


Figure 3. Typical amplifier response patterns. (A) Normal square-wave (B) High-frequency boost (C) Poor high-frequency response (D) High-frequency oscillations (E) Low-frequency boost (F) Poor middle-and-low-frequency response.

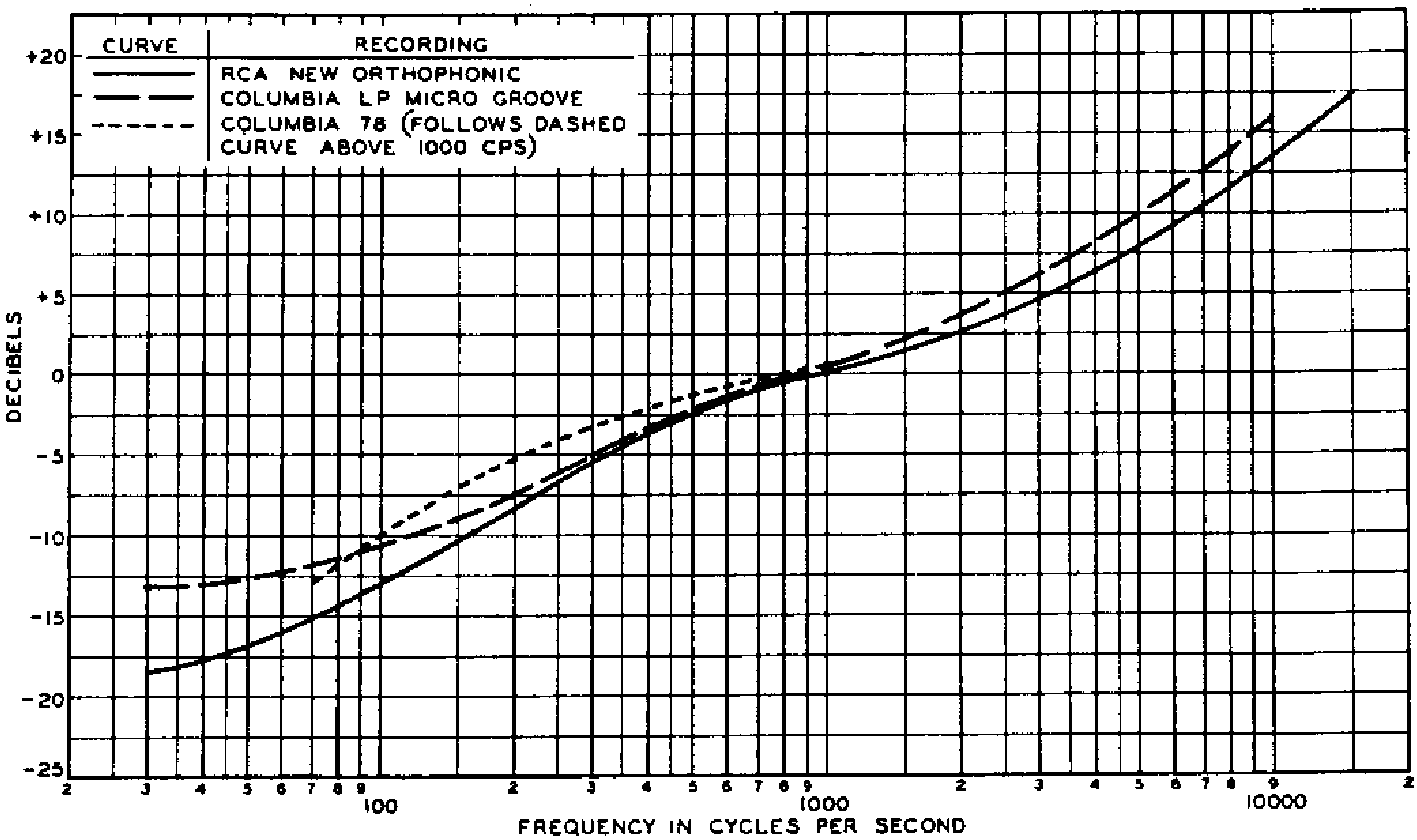


Figure 4. Typical recording characteristics

The recording curve is used as the basis for designing equalizer networks. A properly designed equalizer in an ideal amplifier will have an output which is the inverse of the recording curve. In other words, if the recording attenuates frequencies below 500 cps at a certain rate, the equalized amplifier must boost these frequencies at the same rate.

The WA-44C may be used to determine the response of an equalizer by feeding a low-frequency signal into the input and plotting the output in db (see page 8) as the frequency is increased to the cross-over point. Comparison with the recording curve for which the equalizer is designed will show the points of variation.

Input and Output Impedances

The input and output impedance of amplifiers and similar circuits may be quickly determined by means of a signal from the WA-44C and a vtvm. This method is accurate if the impedance to be measured is resistive, approximate if it is reactive.

Since most amplifiers have inputs which are mostly resistive, it is sufficient to check the input impedance with a low-frequency signal. A frequency of 50 cps may be used when checking a high-fidelity amplifier. For checking the input impedance of a PA system, or an amplifier with limited low-frequency response, a test frequency of 100 cps may be used.

Set the frequency of the WA-44C to either 50 or 100 cps depending on the quality of the equipment under test. Connect the WA-44C to the amplifier; set the OUTPUT control so that there is a convenient reading on the vtvm scale. Keep the signal level low so that the amplifier is not overloaded. Connect the potentiometer (R_1) into the circuit and vary its resistance until the voltage indicated on the vtvm is one-half the original value. The resistance of the potentiometer is then equal to the input impedance.

Output impedances are measured by the same technique except that the potentiometer (R_o) is shunted across the output of the amplifier. Since the output impedance changes as the frequency is varied, it is advisable to check the output impedance over a wide band of frequencies.

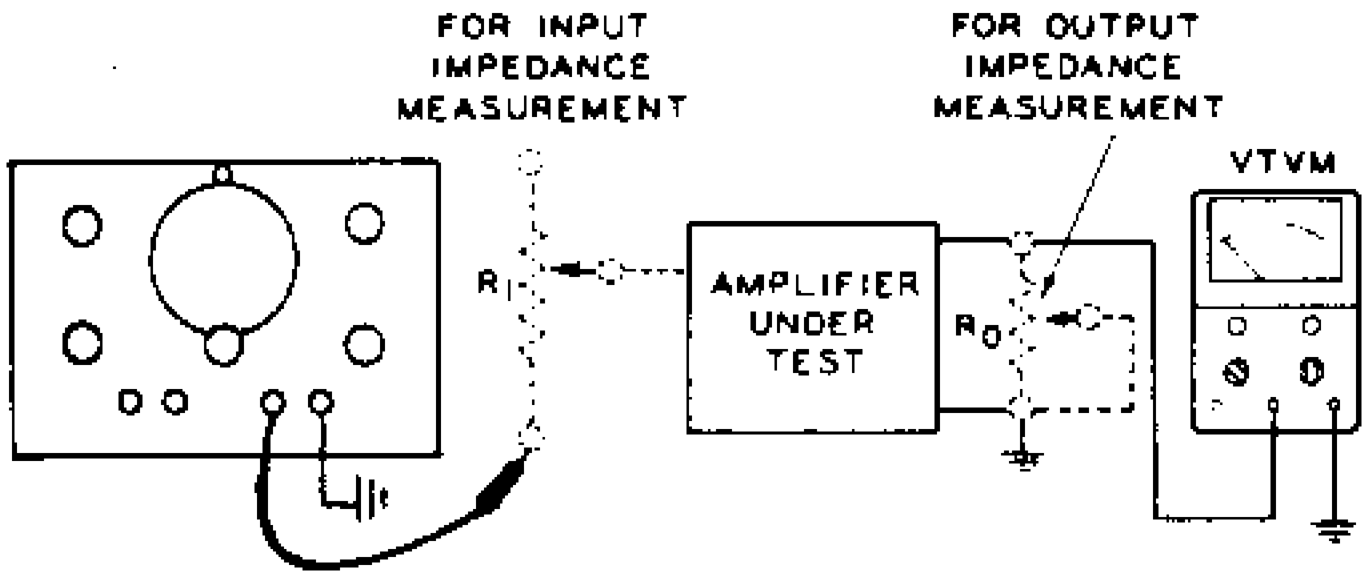


Figure 5. Test setup for input and output impedance measurements

Intermodulation Distortion

Intermodulation distortion is due to the interaction of two or more frequencies in a non-linear amplifier. This interaction results in the modulation of one frequency by the other, thereby producing spurious frequencies. The extent of this type of distortion is expressed as a percentage, and is, in most cases, a better indication of the quality of an amplifier than is a measurement of total harmonic distortion.

The simplest and most direct method of measuring intermodulation distortion is the one developed by the Society of Motion Picture and Television Engineers. This method consists of simultaneously feeding a low-frequency and a high-frequency signal into the amplifier under test; the low-frequency signal having an amplitude four times that of the high-frequency signal. The modulation of the high frequency signal is measured directly with an intermodulation distortion meter, or it can be determined by the use of an oscilloscope and a suitable filter.

The WA-44C provides a 60 cps signal from the LINE FREQ. terminal which, in conjunction with a higher frequency signal from the output terminal of the WA-44C, can be used for intermodulation tests. The equipment set-up is shown in Figure 6.

Set the WA-44C so that the output is 2 volts at 3000 cps. Connect a lead to the LINE FREQ. terminal and adjust the LINE FREQ. OUTPUT control so that 2 volts are available at the terminal. The attenuator consisting of a 10000-ohm resistor and a 39000-ohm resistor is used to provide the proper voltage relationship at the input of the amplifier.

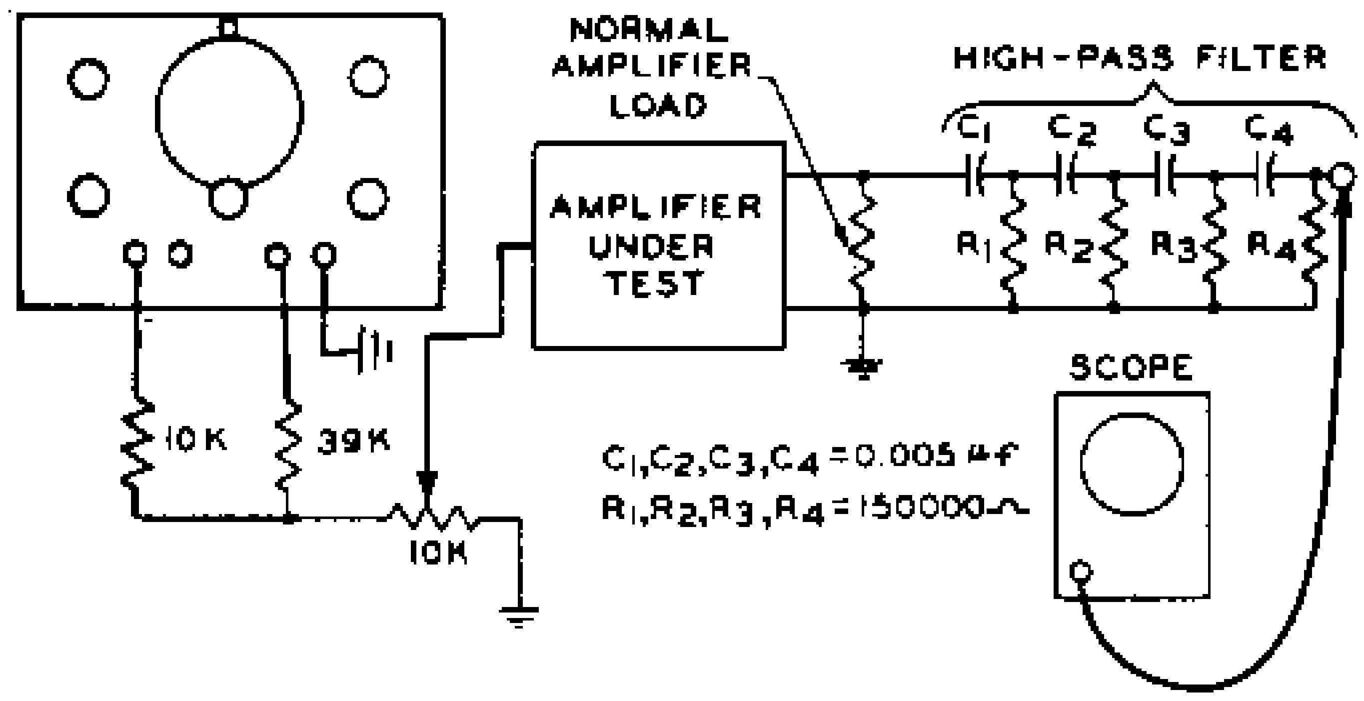


Figure 6. Circuit for intermodulation distortion measurements

The function of the high-pass filter is to bypass the low frequency signal so that only the high frequency signal appears at the vertical input of the oscilloscope.

If intermodulation distortion is present the 3000 cps signal will be modulated by the 60 cps signal, and the trace will appear as shown in Figure 7. The percentage modulation distortion may be determined by use of the formula

$$\% \text{ I D} = \frac{100\ (B-A)}{A}$$

where A = peak value of the unmodulated signal
B = peak value of the modulated signal.

Resonant Frequency of Loudspeakers

It is often important to know the resonant frequency of a loudspeaker. This is especially so in the designing or the tuning of a loudspeaker enclosure. The test setup shown in Figure 8 may be used to determine the resonant frequency of loudspeakers. The speaker should be held in open air away from any large surface which might act as a load and change the resonant frequency. At resonance the voltmeter will indicate a voltage peak. In most loudspeakers the resonant frequency is in the range from 50 to 250 cps.

(Continued on page 15)

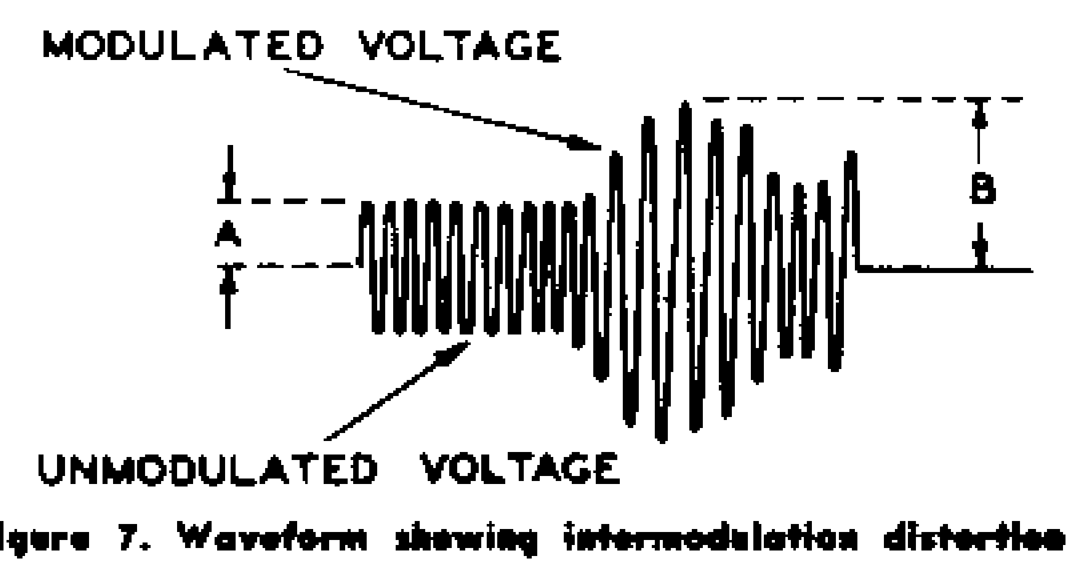
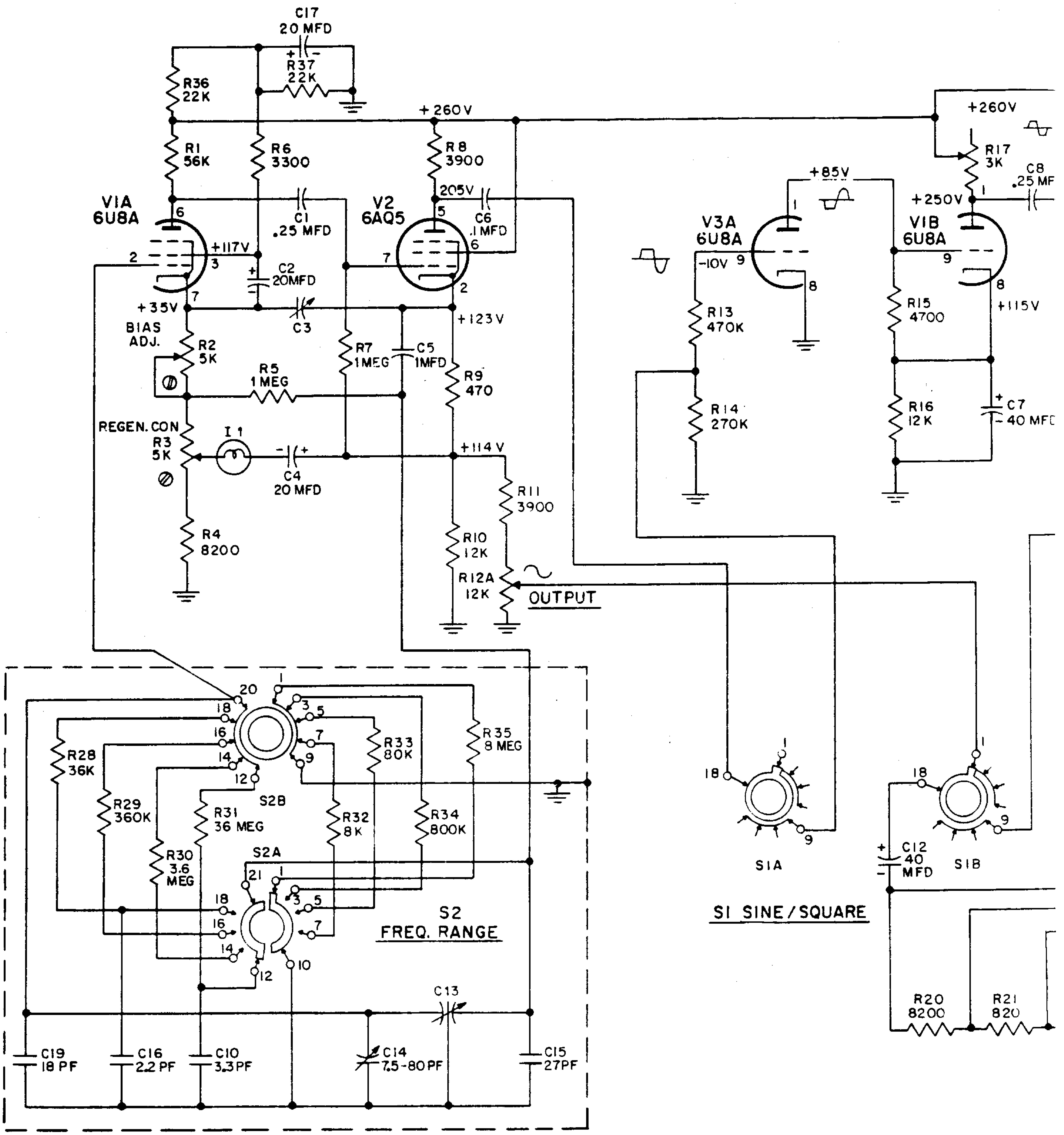
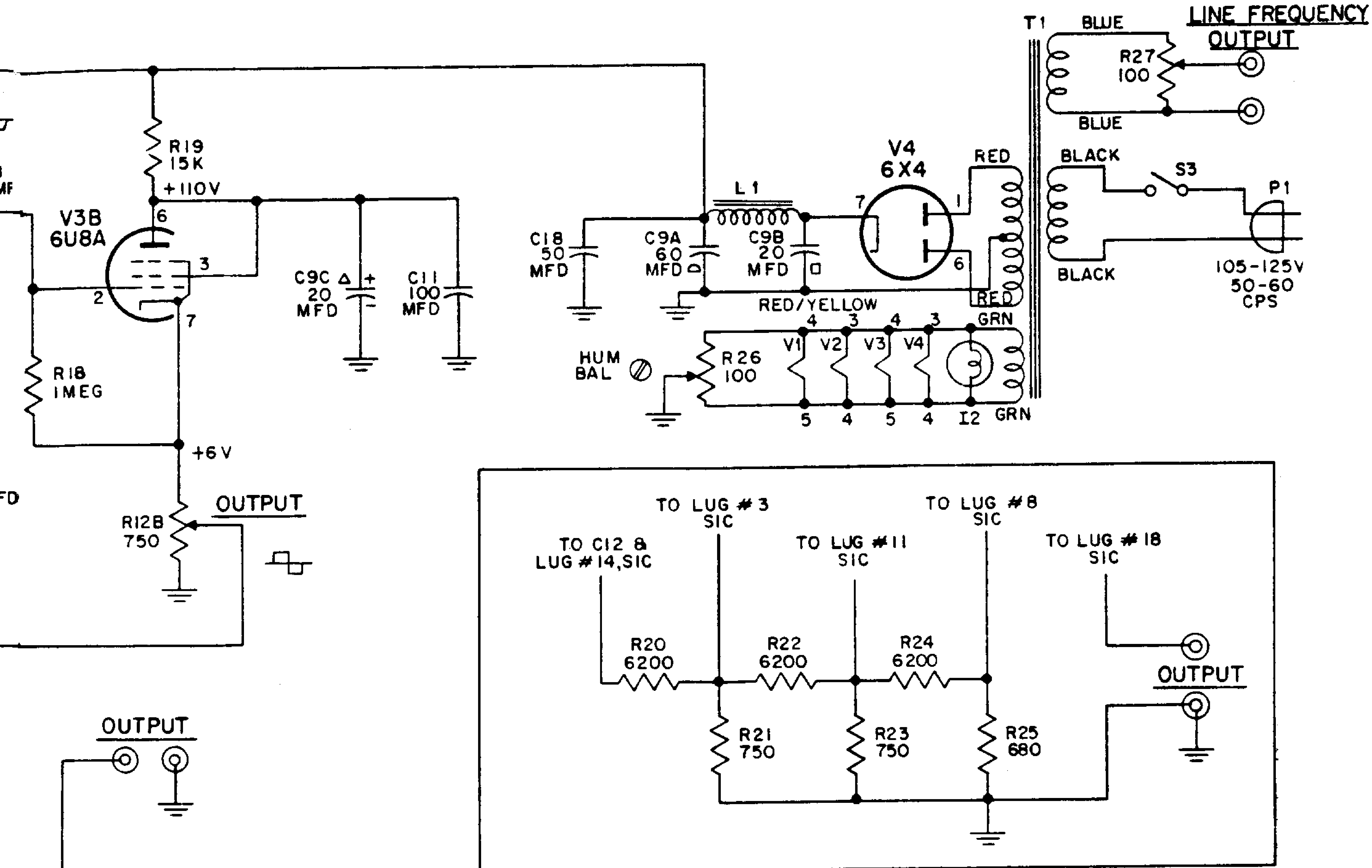
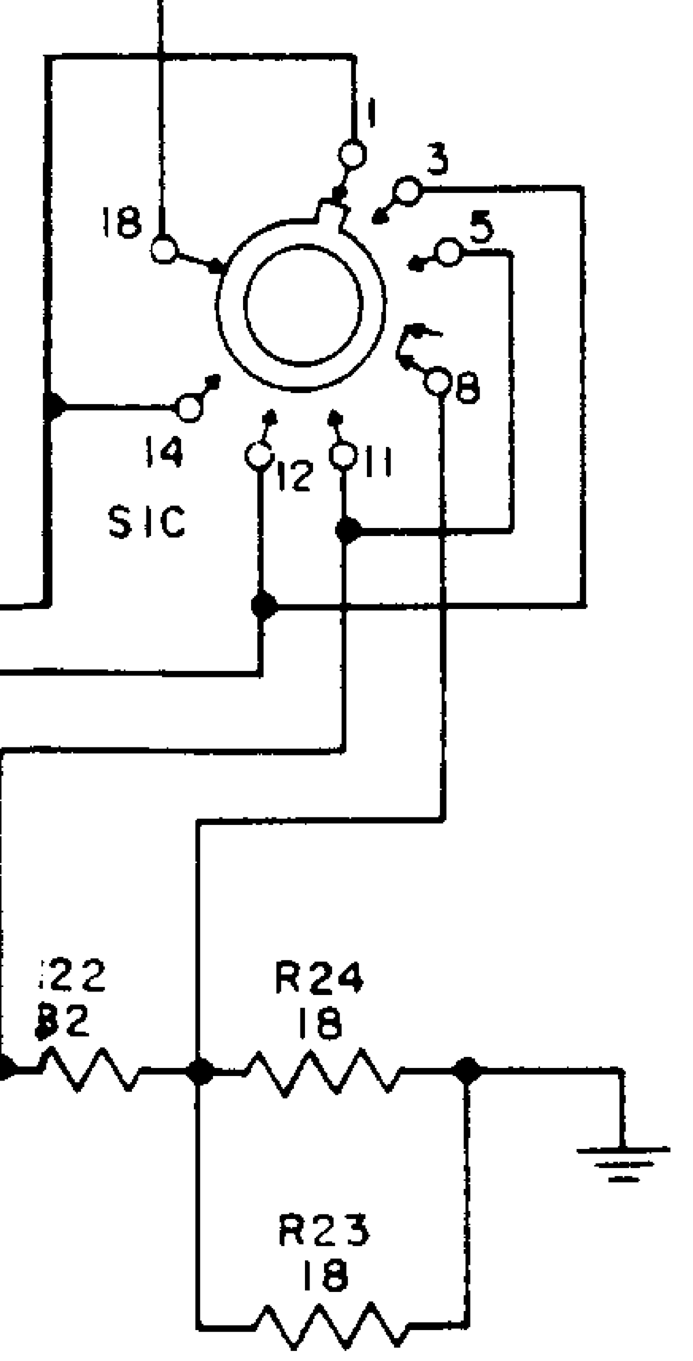


Figure 7. Waveform showing intermodulation distortion


C17
20 MFD
R37
22K
R36
22K
+260V
R1
56K
R6
3300
R8
3900
V1A
6U8A
V2
6AQ5
205V
C6
.1 MFD
C1
.25 MFD
+117V
C2
20MFD
+35V
C3
+123V
BIAS
ADJ.
R2
5K
R7
1MEG
C5
1MFD
R5
1 MEG
R9
470
REGEN. CON
R3
5K
I 1
C4
20 MFD
+114 V
R11
3900
R4
8200
R10
12K
R12A
12K
OUTPUT
+85V
V3A
6U8A
-10V
R13
470K
R14
270K
+260V
R17
3K
C8
.25 MF
+250V
V1B
6U8A
R15
4700
+115V
R16
12 K
C7
40 MFD
S1A
S1B
C12
40
MFD
S1 SINE/SQUARE
R20
8200
R21
820
R35
8 MEG
R33
80K
R28
36K
R29
360K
R31
36 MEG
S2B
R32
8K
R34
800K
R30
3.6
MEG
S2A
S2
FREQ. RANGE
C13
C19
18 PF
C16
2.2 PF
C10
3.3 PF
C14
7.5-80 PF
C15
27PF



ATTENUATOR NETWORK IN INSTRUMENTS WITH SERIAL NUMBERS BELOW 4782



NOTES:

1. "FREQ. RANGE" SWITCH, SHOWN IN "X1" POSITION.
2. "SINE SQUARE" SWITCH, SHOWN IN "SINE X10" POSITION.
3. ⊘ INDICATES SCREW DRIVER ADJUSTMENT.
4. D.C. VOLTAGES MEASURED WITH VOLTOHMYST* BETWEEN POINTS SHOWN & CHASSIS GROUND.
5. ALL RESISTORS VALUES IN OHMS, EXCEPT AS NOTED.
6. SWITCH WAFERS ARE SHOWN AS VIEWED FROM FRONT (SHAFT-END). WAFERS ARE LETTERED CONSECUTIVELY FROM FRONT TO REAR. S1A DENOTES SWITCH NO. 1, WAFER A, ETC. THE SOLDER LUGS & CONTACT POINTS OF THE WAFERS ARE NUMBERED FROM 1 TO 22, IN CLOCKWISE DIRECTION, STARTING WITH THE FIRST LUG TO THE RIGHT OF THE MOUNTING SCREW HOLE, AT THE TOP OF SWITCH.

SWITCH POSITIONS.

S2 FREQ RANGE	S1 SINE/SQUARE	
1—X1	1—SINE X10	5—SQUARE X.01
2—X10	2—SINE X1	6—SQUARE X.1
3—X100	3—SINE X.1	7—SQUARE X1
4—X1000	4—SINE X.01	8—SQUARE X10

IN SOME UNITS, R-31 MAY BE TWO 18 MEG RESISTORS IN SERIES.

Schematic Diagram of WA-44C

Replacement Parts List

WA-44C

Sine-Square Audio Generator

When ordering replacement parts, include serial number and code number of instrument. Order parts, by stock number, through a local RCA Distributor.

Symbol No.	Description	Stock No.
	Capacitors	
C1, C8	Ceramic, .25 mf, 400v	220912
C2, C4 C17	Electrolytic, 20 mf, 250v	220913
C3	Trimmer, 5-80 pf	220916
C5	Paper, 1 mf, 200v	220915
C6	Ceramic, .1 mf, 400v	
C7, C12	Electrolytic, 40 mf, 150v	220914
C9A, C9B, C9C	Electrolytic, 3-section	220227
	60 mf-450v	
	20 mf-450v	
	20 mf-250v	
C10	Ceramic, 3.3 pf, 10%, 500v	99680
C11	Electrolytic, 100 mf, 150v	210139
C13	Variable, 2-gang	220228
C14	Trimmer, 7.5-80 pf	220917
C15	Ceramic, 27 pf, 600v, 1%	221709
C16	Ceramic, 2.2 pf, 20%	220226
C18	Electrolytic, 50 mf, 250v	109227
C19(a)	Ceramic, 18 pf, 1000v	
	Resistors	
R1	Composition, 56k, ½w, 10%	
R2, R3	Variable, dual, 5k, 5k	220235
R4	Composition, 8.2k, ½w, 10%	
R5, R7, R18	Composition, 1 meg, ½w, 10%	
R6	Composition, 3.3k, ½w, 10%	
R8	Composition, 3.9k, 2w, 10%	
R9	Composition, 470 Ω, 1w, 10%	
R10	Composition, 12k, 1w, 10%	
R11	Composition, 3.9k, 1w, 10%	
R12A, B	Variable dual, 12k, 750 Ω	220236
R13	Composition, 470k, ½w, 10%	
R14	Composition, 270k, ½w, 10%	
R15	Composition, 4.7k, 1w, 10%	
R16	Composition, 12k, ½w, 10%	
R17	Variable, 3k, ½w	221708
R19	Composition, 15k, 2w, 10%	
R20(b)	Composition, 8.2k, ½w, 5%	
R21(c)	Composition, 820 Ω, ½w, 5%	
R22(b)	Carbon, 82 Ω, ½w, 5%	
R23(c), R24(b)	Carbon, 18 Ω, ½w, 5%	

Symbol No.	Description	Stock No.
R25(d)	Composition, 680 Ω, ½w, 5%	
R26	Variable, 100 Ω	220237
R-27, S-3	Variable, 100 Ω, w/switch	220247
R28	Carbon Film, 36k, ½w, 1%	99759
R29	Carbon Film, 360k, ½w, 1%	220922
R30	Carbon Film, 3.6 meg, ½w, 1%	220920
R31	Carbon Film, 36 meg, 2w, 2%	220239
R32	Carbon Film, 8k, ½w, 1%	220923
R33	Carbon Film, 80k, ½w, 1%	220923
R34	Carbon Film, 800k, ½w, 1%	93843
R35	Carbon Film, 8 meg, 1w, 1%	220240
R36, R37	Composition, 22k, 1w, 10%	
	Switches	
S1	Rotary (Function) 8 position, 3 wafers	220216
S2	Rotary (Range) 4 positions, 2 wafers	220217
	Miscellaneous	
T1	Transformer, power	220214
L1	Reactor	220215
I1	Lamp, 3w, 120v	
I2	Lamp, pilot, #47	
	Lampholder Assembly	
	Socket	57761
	Jewel	54660
	Board, Laminated Circuit	220218
	Dial, circular	220248
	Dial Hub	220229
	Dial Indicator Assembly	220228
	Foot, rubber, Atlantic Rubber #16B-6040	
	Handle, black	219120
	Knob, blue plastic	211953
	Knob, w/pointer, blue plastic	212148
	Panel, front	220219
	Pinch Drive Assembly	220230
	Shaft Extension, insulating	220249

(a) Used only in instruments with serial numbers above 4781.
(b) Value of resistor in instruments with serial numbers below 4782 was 6.2k.
(c) Value of resistor in instruments with serial numbers below 4782 was 750Ω.
(d) Used only in instruments having serial numbers below 4782.

Tuning a Bass-reflex Enclosure

The test setup shown in Figure 8 can also be used to determine the proper port opening and enclosure volume necessary to produce the best possible low-frequency response. Excessive enclosure volume and too large a port will produce "boom." On the other hand, a port of insufficient area and an enclosure which is too small will not extend the low-frequency response of the speaker.

A properly tuned enclosure will show two voltage rises, one above and the other below the resonant frequency of the loudspeaker. The size of the port and the volume of the enclosure should be adjusted so that these voltage rises are as small as possible and of equal amplitude.

In cases where the voltmeter does not give an adequate reading, an oscilloscope should be used as an indicating device. A line-to-voice-coil transformer may also be used to effect a proper match.

If the amplifier which will be used with the speaker under test is available, connect the WA-44C to the amplifier input, and the speaker to be tested to the amplifier output, and use the voltmeter as indicated above.

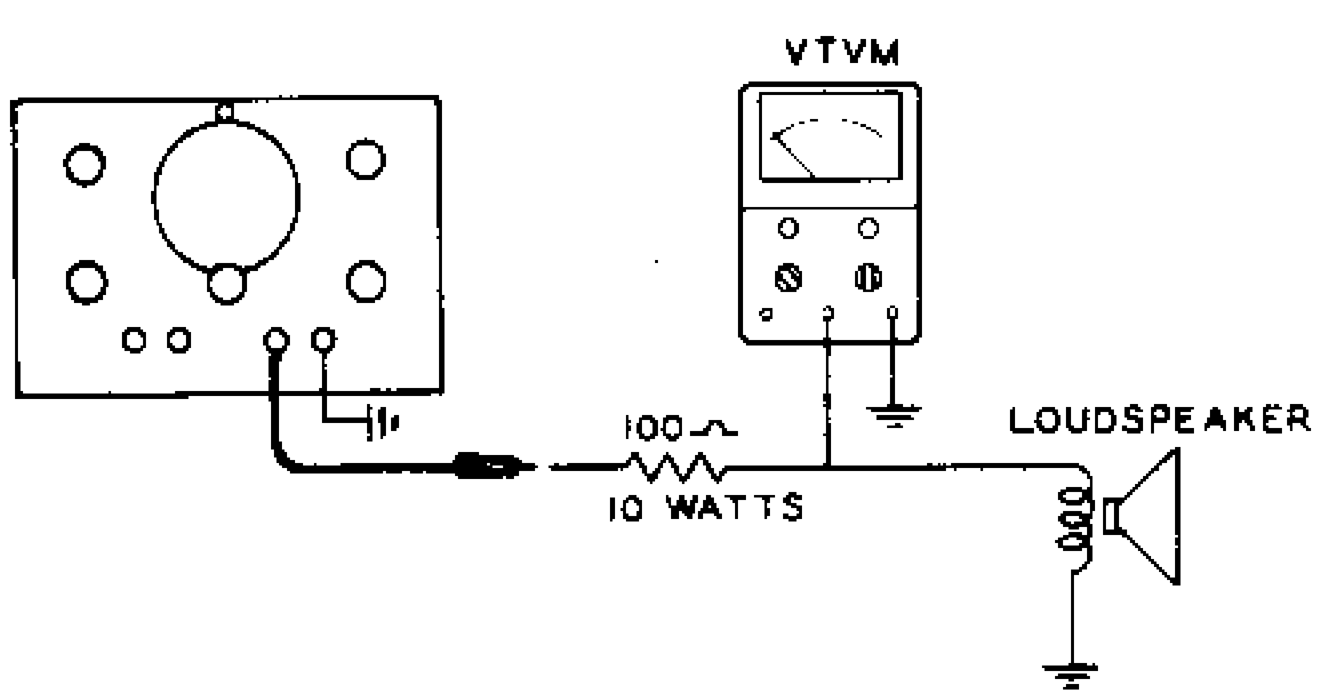


Figure 8. Test setup for determining the resonant frequency of loudspeakers, and for tuning bass-reflex enclosures

Locating Speaker and Cabinet Rattles

Vibrations and rattles which are sometimes produced in cabinets and speakers when certain audio frequencies are reproduced, may be found by feeding the output of the WA-44C into the audio section of a receiver or amplifier, and varying the frequency of the generator from 20 cps through the audible range, until the vibration is heard. Cabinet vibrations are easily found by damping the sections of the cabinet with the hand until the vibration stops or is diminished. Once the section is located, regluing, or bracing the section will usually correct the trouble. Speaker rattles require repair of the defective part, or reconing.

Determining Unknown Frequencies

Unknown audio frequencies may be determined with the WA-44C. Two methods are commonly used, the "zero beat" method and the use of Lissajous figures. The first is based on an aural indication, the second requires the use of an oscilloscope.

With the "zero beat" method, both the output of the audio generator and the signal of unknown audio frequency are connected to the input to a high-gain audio amplifier. Adjust the frequency of the WA-44C until the two frequencies "zero beat." The WA-44C will then be at the same frequency as the unknown frequency.

The use of an oscilloscope provides a visual means of determining an unknown frequency. Connect the output of the WA-44C to the horizontal input terminal of the scope. The signal of unknown audio frequency is applied to the vertical input terminal of the oscilloscope. Vary the frequency of the WA-44C until a stationary pattern is seen on the screen. This

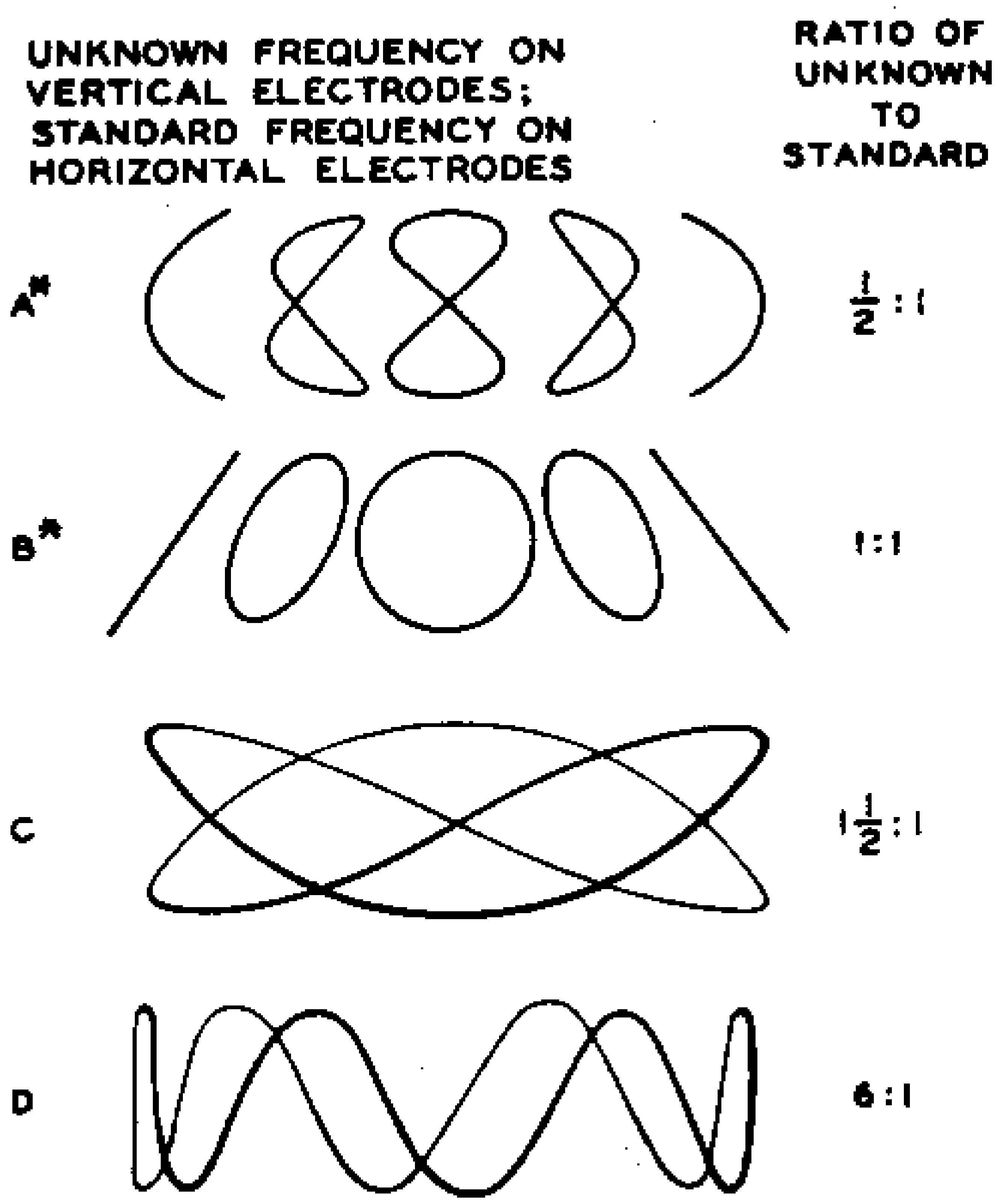


Figure 9. Typical Lissajous figures

pattern, known as a Lissajous figure, is used to determine the ratio of the known to the unknown frequency. The ratio is equal to the number of horizontal loops divided by the number of vertical loops. Several points in the frequency range of the audio generator may produce Lissajous figures, each one will give the same result. It is most convenient, however, to choose the pattern with the least number of loops. See Figure 9 for some typical patterns.

Resonant Frequency of LC Circuits

The WA-44C may be used to determine the resonant frequency of either series or parallel LC circuits, by using the setup shown in Figure 10. L_P and C_P show the connections used for checking a parallel circuit, and L_S and C_S are the connections used for checking a series circuit.

Tune the audio generator through its range starting with the low band. The resonant frequency is the one at which there is maximum indication on the voltmeter when a parallel circuit is being tested, and minimum indication on the voltmeter when a series circuit is under test.

R_L is not critical, it is shunted across the LC combination to flatten the resonant curve so that the voltage maximum or minimum is approached more slowly. 100,000 ohms is a suitable trial value. Reducing the value of R_L will peak the resonant curve, while increasing the value of R_L will flatten the curve.

Determining Inductance and Capacitance

The inductance of unknown audio-frequency coils and transformers may easily be determined with the circuit shown in Figure 10. The 100,000 ohm value of the load resistor may be reduced if more peaking is desired, or increased if the resonant curve is to be flattened.

Connect a capacitor of known value across the unknown inductance so that the two form a parallel circuit. Vary the frequency of the generator until maximum voltage is obtained. This frequency is the resonant frequency of the circuit.

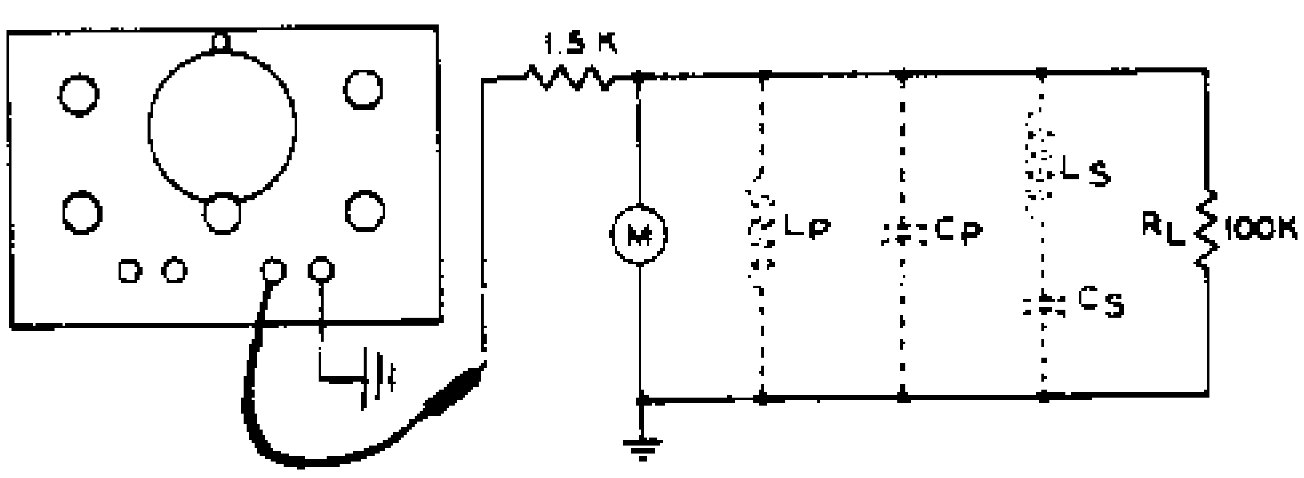


Figure 10. Test setup for determining the resonant frequency of LC circuits, and for determining the value of an unknown inductor or capacitor

When the resonant frequency is known, the inductance may be calculated from the formula.

$$L = \frac{25,330}{f^2C}$$

where L = inductance in henrys
f = frequency in cycles
C = capacitance in microfarads

The values of unknown capacitors may be found by the same method, using an inductor of known value.

Stroboscopic Speed Measurements

The use of a stroboscopic technique for measuring or observing periodic motion provides a simple method for determining rotational speed and vibration frequencies. The speed of phonograph turntables, reciprocating engines, motors and machinery with vibrating or rotating parts may be determined by stroboscopic methods.

This method utilizes the WA-44C to control the frequency of the on-off cycle of a neon lamp. A neon lamp, a battery of sufficient voltage to fire the neon lamp, a potentiometer, and a strobe disc are needed. Connect the audio generator as shown in Figure 11. The positive terminal of the battery is connected to output of the generator.

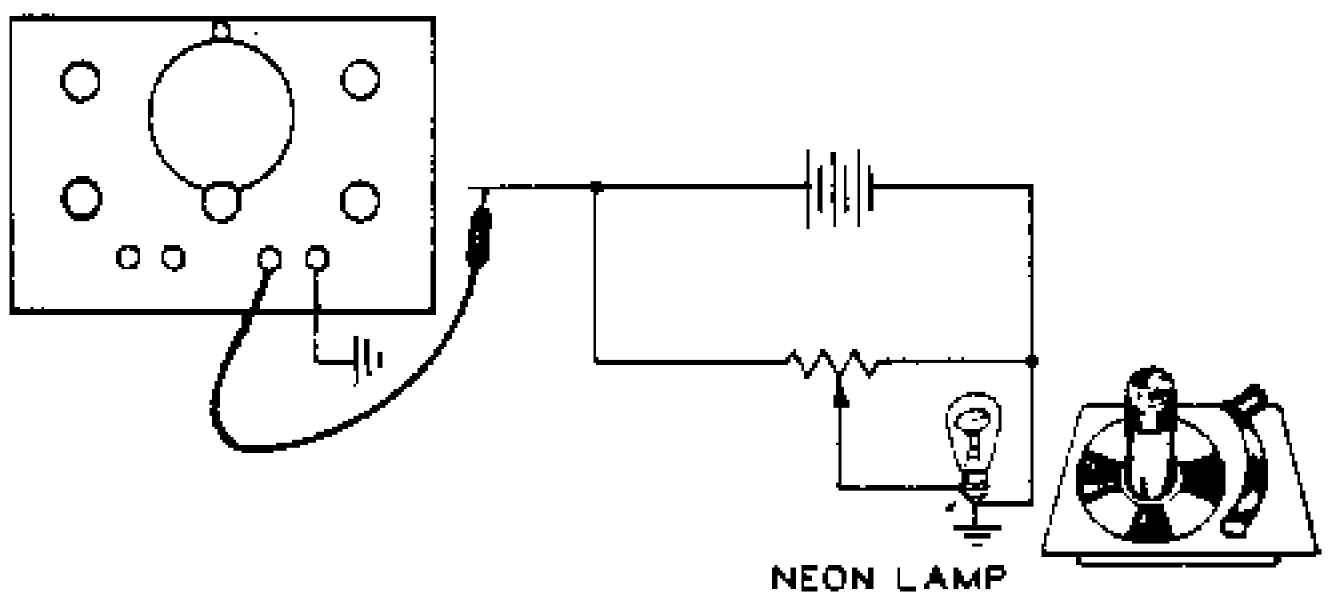


Figure 11. Arrangement for stroboscopic speed measurements

The strobe disc is made of cardboard or stiff paper and is composed of an even number of equal-size alternating black and white segments. This disc is placed on the rotating body.

Before speed measurements can be made, the system must be adjusted so that the neon lamp fires only when pulsed by the generator. Turn the generator on and set the "OUTPUT" control to minimum. Adjust the battery voltage until the lamp just glows, then reduce the battery voltage by about five volts, or until the lamp just goes out. Turn the "OUTPUT" control to maximum; the neon lamp should light. Start the rotating device and hold the neon lamp close enough to the strobe disc so that the disc is illuminated. It may be necessary to darken the room or to reduce local lighting in order to obtain best results. Vary the oscillator frequency, starting at the low end, until the disc appears stationary and the segments on the disc are normal in width. Read the generator frequency from the generator dial and calculate the speed of the rotating device by means of the formula below.

$$S = \frac{60 \times f}{n} \text{ rpm}$$

where S = speed in rpm
n = number of black segments
f = operating frequency of the WA-44C in cps.

EXAMPLE: If the disc has six black segments and the oscillator frequency is 300 cps when the disc appears motionless, the speed of the rotating device is:

$$S = \frac{60 \times 300}{6} \text{ rpm}$$
$$= 3000 \text{ rpm}$$

Stroboscopic Vibrator Contact Alignment

Vibrators may be tested under dynamic conditions by using the set-up described above, except that the strobe disc is not used.

Bring the neon lamp close enough to the vibrator, while the vibrator is in operation, so that the contacts are illuminated. Turn the tuning control until the vibrator action is "stopped" or "slowed down." Contact alignment can then be easily observed.

Radio Receiver Frequency Response Measurements

The over-all response of a radio receiver may be determined by applying an rf signal modulated by the WA-44C to the antenna terminals and measuring the output across the voice coil as the modulating frequency is varied. An rf signal generator such as the WR-49B which has provision for external modulation, and an ac voltmeter, such as the VoltOhmyst are necessary auxiliary equipment.

The test set-up is shown in Figure 12. The WA-44C is connected to the terminals provided for external modulation on the rf generator, and the output of the rf generator is fed to the antenna terminals of the receiver under test. The ac voltmeter is placed across the voice coil.

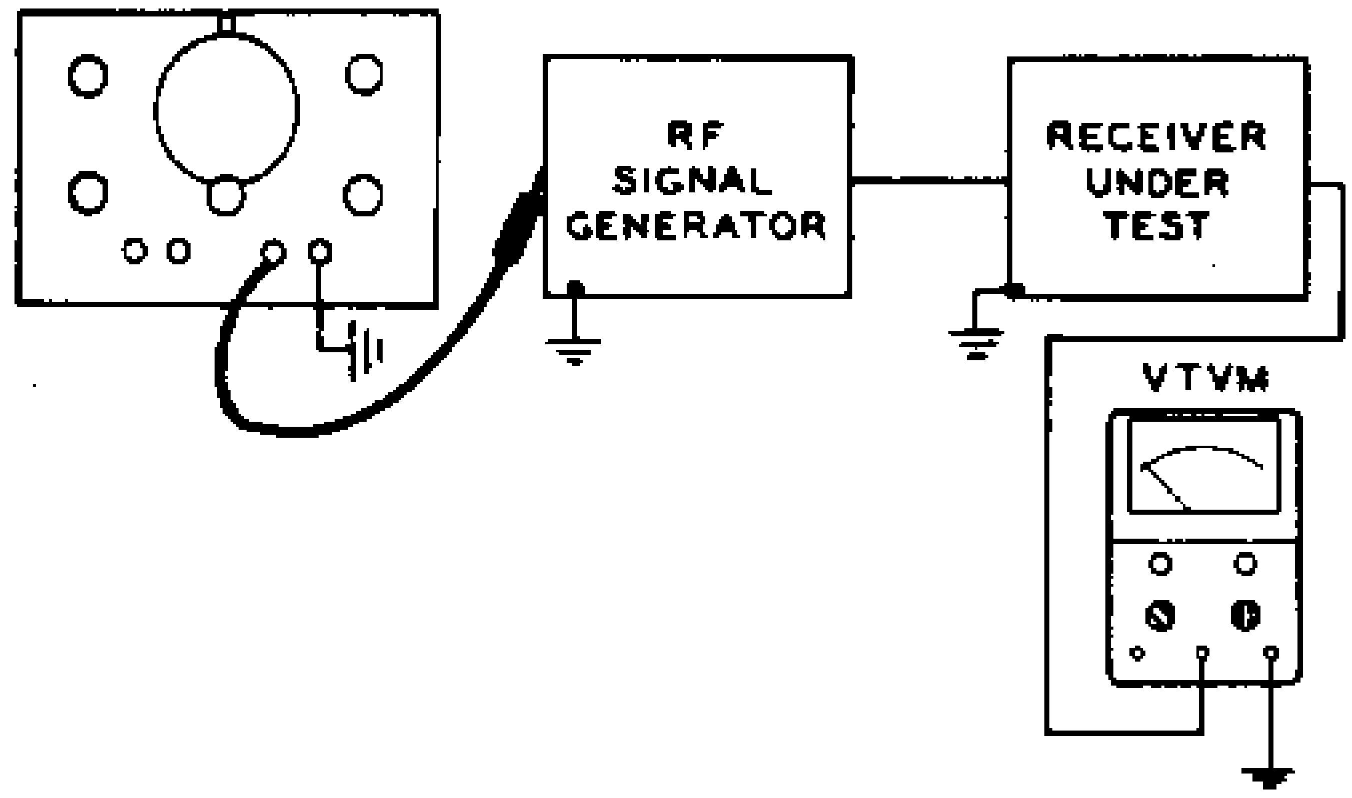


Figure 12. Test setup for modulating an rf generator

Before checking the frequency response of the receiver it will be necessary to align the reciver to the mid point of the rf test oscillator carrier. This is done as follows:

1. Set the rf generator to 1000 kc.
2. Set the WA-44C to 5000 cps.
3. Set the receiver dial to 1000 kc.
4. Turn the receiver on, and adjust the tuning of the receiver so that maximum sound is heard. This maximum point may be checked by means of the voltmeter across the voice coil.
5. Shift the audio generator frequency to 400 cycles and adjust the rf generator until the voltmeter indicates that the rated power is delivered to the receiver loudspeaker.

The voltmeter reading necessary to obtain the rated power output may be calculated from the formula:

$$E = \sqrt{WZ}$$

where E = voltmeter reading in volts
W = power output in watts
Z = voice-coil impedance in ohms.

If the voice-coil impedance is not known, its approximate value may be calculated by multiplying its dc resistance by 1.3.

EXAMPLE: If the rated undistorted power output is 2 watts and the voice-coil impedance is 3.2 ohms, the voltmeter reading (E) for the rated output is:

$$E = \sqrt{2 \times 3.2} = \sqrt{6.4}$$
$$E = 2.53 \text{ volts}$$

A meter reading of 2.5 volts is sufficiently accurate. Starting with a frequency of 30 cycles, increase the frequency of the WA-44C through the range that is to be tested. It will be necessary to monitor the percentage modulation to make sure that it is maintained constant as the frequency is varied. The voltmeter reading will indicate the response of the receiver at various frequencies. If desired, the output voltage may be plotted against frequency to show overall frequency response.

Determining Loss of Fidelity

The WA-44C may be used to localize a stage in a radio receiver in which there is loss of fidelity in the audio section. Connect a vtvm across the voice coil of the receiver. Starting at the output stage and working back to the second detector, feed a signal into the grid circuit of the stage under test. Vary the frequency of the audio generator from about 30 cps to the limit of the receiver response. A sharp decrease in output voltage as the frequency is increased indicates a loss in response in the stage following the test point. In sets which incorporate frequency compensation, the effect of the compensation must be taken into account in order to determine whether a drop in output is due to normal compensation or to a defective stage.

NOTE: Many table model radios are not designed to pass frequencies above 4000 cps.

Maintenance

Suggested Equipment for Alignment of the WA-44C

1. VTVM such as RCA WV-98A or WV-77E VoltOhmysts.*

2. Oscilloscope such as WO-91A having excellent square wave response characteristics and equipped with low capacity probe.

3. Distortion analyzer such as Barker & Williamson model "400", or equivalent.

4. Standard Audio Frequency Generator, such as Hewlett Packard Model 200AB, or equivalent.

Circuit Description

The oscillator circuit in the RCA WA-44C is comprised of V-1A and V-2. With S-1 in the "SINE" wave function, the output is taken from the cathode of V-2 and fed through the output divider network R-11, R-12A, C-12, and R-20 through R-25, then through S-1C.

With S-1 rotated to the "SQUARE" wave function, the oscillator output is taken from the plate of V-2 and fed through C-6 and S-1A to grid of V-3A where the square wave shaping action begins. The sine wave is reshaped to a square wave by the amplification and limiting action of V-3A, V-1B, and V-3B. A slight degree of regeneration occurring through the network of these three tube elements is effected to decrease the rise time of the square wave without overshoot. The square wave signal is taken from the cathode of V-3B to the output terminals through the divider network R-24, R-20 through R-25, then through S-1C.

Oscillator frequency variation on the four ranges is controlled by adjustment of C-13, which is a front panel control. The frequency ranges covered by C-13 are determined by selection of resistors in the "Bridged-T" network by the Frequency Range Switch, S-2A and S-2B. Output voltage over the tuning range of C-13 is effected through adjustment of C-14.

Representative wave forms and DC voltage measurements for a typical instrument are included on the schematic diagram. Indicated voltages measured with an RCA VoltOhmyst such as the WV-98A or the WV-77E, or equivalent. Voltages should hold within ±20% with 117 volts AC supply.

Output and Frequency Adjustment

1. Turn instrument on and allow at least 15 minutes for warm-up before making adjustments.

2. Connect the VoltOhmyst to the WA-44C output terminals; set VoltOhmyst selector switch to "AC" and the "Range Switch" to the "20 V" range.

3. Set the WA-44C "OUTPUT" control to maximum (clockwise) position and the "SINE SQUARE" switch to the "SINE X10" position.

4. Check the position of the WA-44C tuning dial against the tuning condenser C-13 position. With C-13 fully meshed, the dial reference mark (just below "20") should align with the pointer. If it does not, loosen the set screw in the dial coupling on the side of the condenser shaft and adjust the dial reference point to coincide with pointer.

5. Set the "FREQUENCY RANGE" Switch to the "X10" position and the main frequency tuning dial to the "200" calibration point.

6. Adjust R-2 and R-3 to their maximum clockwise position.

* Trade Mark "VoltOhmyst" Reg. U. S. Pat. Off.

7. Note the output voltage indicated on the VoltOhmyst, adjust R-2 until there is a 10% reduction in the indicated output voltage. Next adjust R-3 so that the indicated output voltage is reduced to 8 volts RMS.

8. Rotate the WA-44C main tuning dial to the "20" point and note the indicated output voltage. Return the dial to the "200" point and note the indicated output voltage. Adjust C-14 so that the output voltage at 20 to 200 is within ±0.5V. Note it may be necessary to repeat this operation and steps 7 and 8 in order to achieve an output voltage of 10V RMS over the entire tuning range.

9. Connect Oscilloscope probe across output terminals of WA-44C. Connect Hewlett Packard or equivalent Audio Frequency Generator to external sweep input terminals of the Oscilloscope. Set Oscilloscope sweep selector to "external" and adjust both the WA-44C and the Hewlett Packard Generators to 2000 CPS, using 200 CPS X 10 on the WA-44C. Adjust the output level of both generators for proper sweep width and trace amplitude. When properly adjusted, a circular Lissajous pattern should appear in the Oscilloscope screen, indicating the two generators are operating at the same frequency. A slight readjustment of C-14 may be necessary to swing the WA-44C to the correct frequency.

10. Perform step 8 again to check flatness of output. Re-check step 9 if any adjustment of C-14 is necessary.

11. Adjust both the WA-44C and the Hewlett Packard or its equivalent to 20 KC, using the 200 dial marking with the Frequency Range Switch on the WA-44C set to X100. Adjust C3, located directly behind V2, for circular Lissajous pattern.

NOTE: In some instruments, a small gimmick capacitor has been added to trim the high frequency end of the band. This capacitor consists of two lengths of insulated hookup wire twisted together, and connected to the circuit as indicated in the schematic.

Distortion

Disconnect the VoltOhmyst and Oscilloscope leads from the WA-44C and connect the distortion meter to the WA-44C output terminals. Calibrate the distortion meter and measure the percentage of distortion. It should be 0.25% or less. If the distortion exceeds 0.25%, reset the distortion meter to the "CALIBRATE" position and adjust R-2 for a reduction of 5% in the output voltage. Recheck the distortion. It now should be under the 0.25% figure. Occasionally a small amount of readjustment of R-2 and R-3 may be necessary to achieve minimum distortion. If the 0.25% figure is not achieved, replace or check V-2, V-1 or Lamp I-1. Check components in the sine wave oscillator circuitry.

Hum Balance Adjustment

The hum balance control, R-26, is located at the left rear corner of the chassis as viewed from the front. The method prescribed for adjustment follows:

1. Connect distortion meter across the output terminals.

2. Set Frequency Range Switch to "X1" position.

3. Set "SINE SQUARE" output selector switch to "SINE X10" position (fully counterclockwise).

4. Set "OUTPUT" control to maximum.

5. Adjust frequency dial to 120 cps and adjust distortion meter to read per cent of distortion in usual manner. Adjust R-26 for minimum reading on the distortion meter.

Square Wave Adjustment

1. Connect the Oscilloscope to the output terminals of the WA-44C, using low capacity probe.

2. Turn "Sine/Square" switch to "Square X10" position.

3. Observe square wave pattern on the oscilloscope over the various frequency ranges of the WA-44C.

4. Note R-17, located beneath the printed circuit board and mounted upon the gusset plate. Adjust R-17 for minimum square wave tilt as observed on the oscilloscope screen.