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The Aerovox Research Worker

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Applications of the A.F. Test Oscillator

PART II

By the Engineering Department, Aerovox Corporation

THE January *Research Worker* discussed amplifier tests and measurements, and covered *Transformer Gain*, *Tube Gain* and *Stage Gain* in an illustrated conventional a.f. amplifier. To continue:

Overall Gain. The gain of the entire amplifier may then be measured as shown in Figures 3A and 3B. When a complete amplifier is to be measured this procedure is followed.

The overall gain, or better, the signal voltage required to deliver maximum output can be measured by first determining the power output limit.

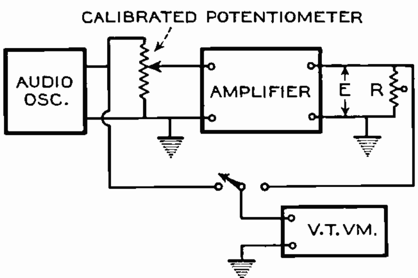

Fig. 3A

The simplest way of doing this is as follows: The amplifier is connected as in Figure 3A with an oscillator and a calibrated potentiometer. The input from the amplifier is varied from zero up. The power output of the amplifier is calculated from E^2/R and plotted against the input voltage. The rated load of an audio amplifier can be found by drawing a straight line from the origin tangent to the voltage curve. At the point from which the voltage curve drops away from the straight line, distortion begins (see Figure 4), the amount being proportional to the displacement of the curves. The allowable distortion depends upon the particular use of the amplifier and the corresponding allowable displacement of the curve from a straight line and can be determined from these conditions. Figure 4 shows such a curve for an amplifier whose constants are given in the diagram. This is a simple manner of approximating the power output of an amplifier without the use of a harmonic analyzer or expensive distortion meter. The ratio P/e at the load limit is the sensitivity of the amplifier. P is the power output in watts and *e* is the input voltage required to produce this output. The hum level in db below maximum power output is given by

$$-10\log_{10}\frac{P_p}{P_y}$$

Pp is the rated power output of the amplifier and Py is the power output with zero power input. Actually the curve in Figure 4 does not go to zero input, but the noise level at an input of .001 volts is so much greater than the output for the input voltage. This is shown by the flattening of the curve at that point.

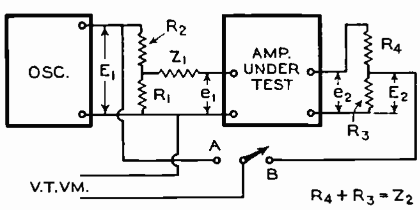

Fig. 3B

AEROVOX PRODUCTS ARE BUILT BETTER

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If the range of the VTVM is less than the voltages to be measured, a voltage divider may be used to extend the range of the voltmeter. The load resistor, R in Figure 3A is equal to the output impedance of the amplifier.

The arrangement shown in Figure 3B will prove more satisfactory if the amplifier has low input impedance, such as 500 or 250 ohms. An oscillator and attenuator are used at the input and the voltage measured across the attenuator. Z_1 is equal to the input impedance of the amplifier. The input voltage is then:

$$e_1 = \frac{E_1 R_1}{2(R_1 + R_2)}$$

Then the switch is thrown to B and the voltage is measured across the output load or a portion of the output load. The output voltage is then:

$$e_2 = \frac{E_2 (R_3 + R_4)}{R_3}$$

The gain of the amplifier, if it is an amplifier with transformer input, has been customarily expressed in db and is now:

$$db = 20 \log \frac{e_2}{e_1} + \left(10 \log \frac{Z_1}{Z_2}\right)$$

In measurements of fidelity, e_1 is kept constant while the frequency is varied and readings taken of e_2. A curve is drawn of 20 log e_2 versus frequency.

TEST DATA FOR LOAD CHARACTERISTIC OF 10 WATT AUDIO AMPLIFIER

TUBES: 1-24A VOLTAGE AMPLIFIER RESISTANCE CAPACITY COUPLED TO 1-45 DRIVER TRANSFORMER COUPLED TO 2-50 POWER AMPLIFIERS.

INPUT CIRCUIT-TO GRID OF 24A. OUTPUT CIRCUIT-500 ω

HUM LEVEL AT ZERO INPUT $-10 \log_{10} \frac{10}{0.032}$

$= -10 \times 2.495$

$= -24.95$ db. BELOW 10 WATTS

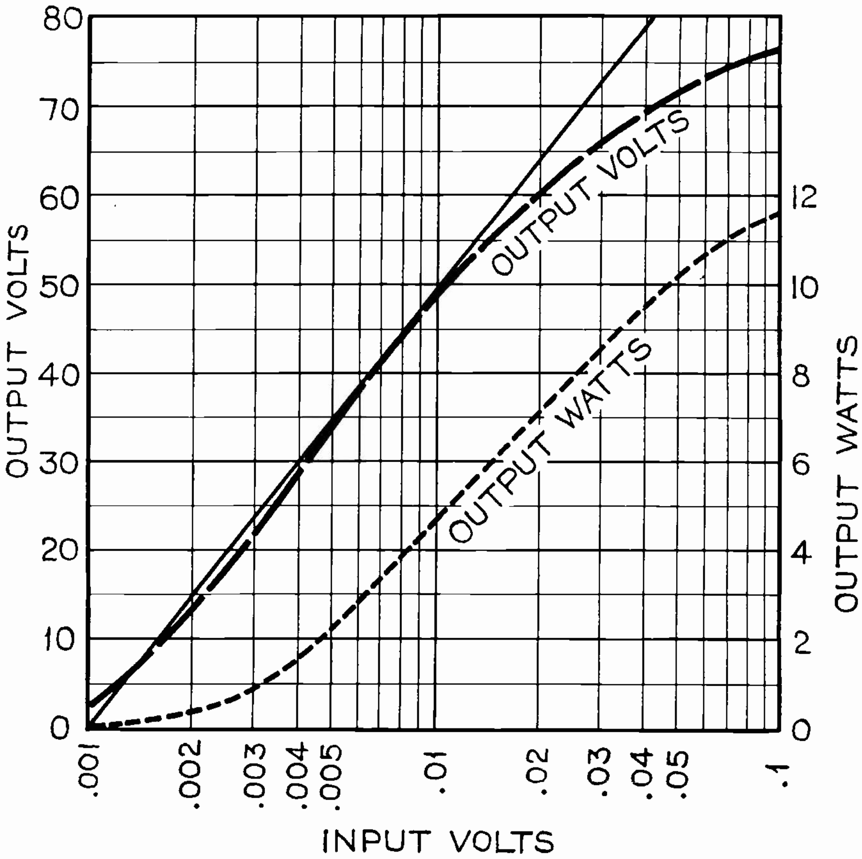


Fig. 4

Location of Resonant Points. Resonant points are points of sympathetic vibration appearing in radio speakers, headphones, cabinets, chassis and shielding. The ability of these media to vibrate, when excited by a reproduced note corresponding to their own fundamental periods, causes unpleasant emphasis of certain notes. Resonant points may be located in amplifiers by feeding in to the latter a signal from the audio oscillator. With the speaker normally used connected in the output circuit and the amplifier placed into operation, the frequency of the oscillator is slowly varied from zero to maximum. The gain should be set where the output of the speaker will not be unbearable to the ears and where differences in output level may be quickly recognized.

As the oscillator frequency is varied, resonant points of vibration in speaker, chassis, shielding, or cabinet will show up as tremendous intensifications. These points are usually rather high in frequency for chassis, tube shields and the like; low in frequency for speaker cone and cabinet.

Headphones may be checked for resonant points in the earpiece diaphragms by connecting them directly to the output terminals of the audio oscillator and varying the frequency until the points of reverberation are detected.

RECEIVER TESTS

In checking the fidelity of radio receivers, it is generally desirable to inspect the entire overall frequency response which includes the radio-frequency stages as well as the audio amplifier channel.

It is customary in this type of test to connect the variable-frequency audio oscillator to the r.f. signal generator in order to modulate the r.f. output at any frequency within the audio range. The method of connection is shown in Figure 5.

The r.f. signal generator is coupled to the receiver and a vacuum-tube voltmeter connected to the receiver output circuit across a load resistor as outlined under *amplifier testing.* The receiver is then set to admit the modulated r.f. signal, and the modulating signal carried throughout the a.f. range by adjusting the audio oscillator frequency. The input r.f. voltage is kept constant while the frequency is varied, and readings are taken of the output voltage at various frequencies as indicated by the VTVM. A curve may then be drawn showing 20 log e versus frequency.

The flatness of the curve is an indication of the fidelity of the receiver. The flatter the curve, the higher is the fidelity of the receiver. If it is desired to locate the probable causes of low fidelity, the audio channel may be studied separately, as outlined in the paragraphs on amplifier testing. Then the i.f. channel may be inspected by setting the r.f. signal generator to the intermediate frequency, coupling it into that channel and modulating the i.f. signal throughout the audio spectrum and plotting a curve of the output, as above. Finally, the r.f. and detector stages may be studied.

RADIO-FREQUENCY DEVIATION

Arrangements for the precise measurement of radio frequencies employ systems for comparing an unknown radio frequency with a suitable harmonic of a precision low-frequency oscillator-multivibrator unit. When the unknown signal frequency coincides with a harmonic of the standard, its value is identical with that of the harmonic frequency. However, this is seldom the case. The unknown frequency generally differs from the harmonic frequency by some number of kilocycles.

Since the standard frequency measuring assemblies employ 10-kc. multivibrators to subdivide the r.f. spectrum into 10-kc. intervals, an unknown signal will set up an audio-frequency beat note with one of these adjacent subdividing carriers. And the *deviation* of the unknown frequency may be determined exactly by measuring the frequency of this beat note. The exact frequency of the unknown signal may then be determined by adding the audio frequency to the nearest 10-kc. harmonic (when the unknown is observed to be higher in frequency than the harmonic with which it is beating) or subtracting it from the 10-kc. harmonic when the unknown is observed to be lower in frequency.

As an example, suppose that an unknown r.f. signal, as picked up by a heterodyne detector circuit or radio receiver along with standard points from a secondary frequency standard, sets up a beat note with the 5010-kc. harmonic of the standard. This beat note is measured by comparison with a variable-frequency audio oscillator, as explained in Figure 1, and found to be 200 cycles. Rotation of the receiver or detector dial shows the signal to lie higher in frequency than the 5010 harmonic with which it is beating. We have found, then, that the unknown signal frequency is 200 cycles (0.2 kc.) higher in frequency than 5010 kc. and is therefore 5010.2 kc.

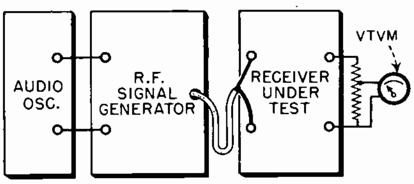


Fig. 5

This method of frequency measurement is much more precise than the more common method of interpolation and is used by the Federal Monitoring Stations with an accuracy of 1 part in several million when determining the frequencies of radio stations.

In such operations as crystal grinding and the setting of self-excited oscillators, where it is desired deliberately to set the operating frequency ahead or behind a certain known frequency, the method just described is accepted as the most accurate.

Deviation of the carrier frequency of a radio transmitter may so be determined by measuring the beat note established at any time between the carrier and a precision oscillator on the station's assigned frequency.

Good Housekeeping in the Condenser Plant

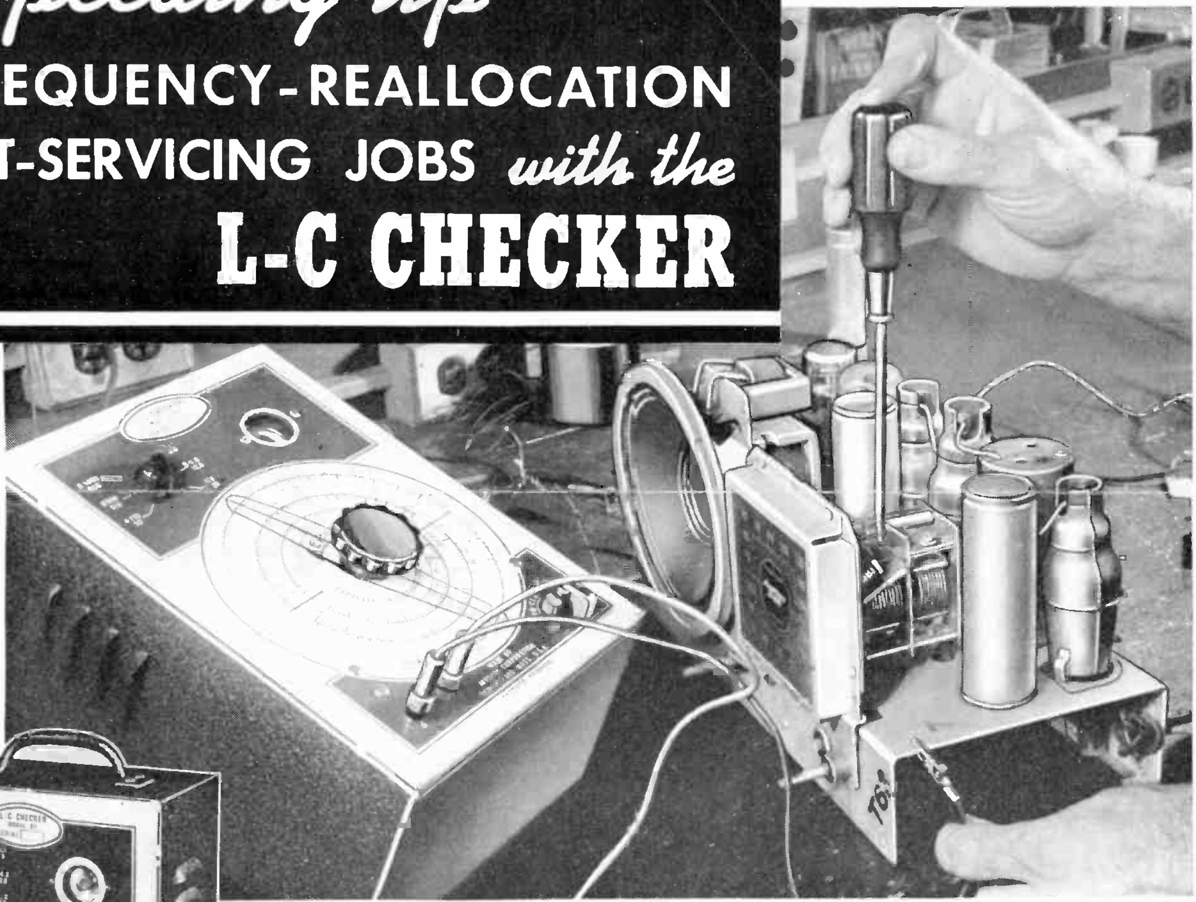
Visitors Impressed

VISITORS to the giant Aerovox condenser plant at New Bedford, Mass., are invariably impressed by the good housekeeping. Heavy maple floors are kept immaculate by thorough sweeping and oiling; painted walls and ceilings are spotless; containers liberally placed about the plant take care of scrap and rubbish; girl workers wear colored smocks designating their respective departments; veritable hospital garments, caps and rubber gloves are worn by those handling etched foils and electrolytes to prevent contamination of the product—and so on. "Hospital clean" is the mark set by the management, and a morning inspection makes certain that no department and no worker are spoiling the perfect score.

Good housekeeping is relatively easy in the Aerovox plant. First of all, there is plenty of elbow room available, out of the total of 433,000 square feet of space. Second, every piece of equipment, every worker, has been assigned the most advantageous space based on long studies and blueprint allocations before the company moved up from its former Brooklyn plant. No longer are there the handicaps of haphazard growth in old quarters. Third, an abundance of windows and skylights means a thoroughly daylighted plant with a minimum of artificial illumination during the working hours.

That good products come out of clean plants, is the belief of the Aerovox management. And that accounts for the "Hospital Clean" rule that prevails in this condenser plant.

Speeding up FREQUENCY-REALLOCATION SET-SERVICING JOBS *with the* L-C CHECKER



Ask to See It . . .

● Your local Aerovox jobber can show you the L-C Checker. Examine it critically. Glance through the very comprehensive and thorough Manual supplied with the instrument. And then note that the L-C Checker is yours for only $29.50, including Manual and tubes, complete. Ask for descriptive bulletin on the L-C Checker. Or if you prefer, write us for same.

● Some 12,000,000 push-button radio sets are directly affected by the shift in frequency of the majority of our broadcast stations on Saturday, March 29th, at 3 A. M. And, in lesser degree, millions of other sets are also affected to the point of requiring some servicing. Thus a tremendous job opens up for the enterprising radio servicemen. It is a hurry-up job. Speed is of the very essence. And the serviceman who has the right equipment for a speedy, thorough, satisfactory job, is going to get his share of this boom. In this case "the right equipment" simply means the L-C Checker.

To begin with, the standard broadcast range has been extended from a high frequency limit of 1500 KC up to 1600 KC. The tuning range of the majority of receivers can probably be so extended, by shifting the i.f. and by changing the padding capacitors on the main tuning condensers. The L-C Checker, tuned to 1600 KC, will greatly facilitate padder adjustments or the installation of new padders.

Then there are the troublesome heterodyne whistles that will develop in some receivers, when stations with strong signal intensity operate on double the frequency of the receiver's i.f., due to the reallocation of frequencies. In this case it may be necessary to shift the i.f. to one side or the other of the usual 445 KC i.f. frequency. Here again, the L-C Checker, providing the test frequency, will facilitate such alterations.

The L-C Checker will speed up the alignment of r.f. circuits. It will help check the tracking of the oscillator. This instrument, after all, serves as a signal generator in determining the frequency range of the receiver and for other functions.

And of course the L-C Checker still retains its previous attractions for the serviceman, such as checking condensers for effective capacity and for shorts, opens, intermittents, while still connected in circuit; measuring resonant circuits; locating frequency absorption loops in r.f. equipment; determining resonant frequencies of r.f. chokes; measuring inductance including distributed capacity of coils; measuring antenna, transmission lines, etc.; checking wide-range r.f. filters; tuning wave traps, etc., etc.

So, more than ever before, the L-C Checker is the one indispensable service instrument fully in step with the very latest servicing problems.

AEROVOX CORPORATION

New Bedford, Mass.

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