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The AEROVOX Research Worker

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring to the Radio Experimenter and Engineer authoritative, first hand information on condensers and resistances for radio work.

VOL. 13 NO. 1 JANUARY, 1941

50c per year in U.S.A.
60c per year in Canada

Applications of the A.F. Test Oscillator

PART I

By the Engineering Department, Aerovox Corporation

THE *variable-frequency audio oscillator* may be viewed as the audio counterpart of the r.f. standard signal generator. Accordingly, we may recognize it as a standard audio-frequency generator furnishing a sine-wave voltage of controllable amplitude at any frequency which may be selected between the limits of approximately 20 and 20,000 cycles per second.

There are two types of audio test oscillator in present general use. The *beat-frequency* type has been in use for a number of years and its employment of the heterodyne beat-note method of obtaining audio frequencies is widely understood. The *resistance-capacitance* type is of comparatively recent appearance and its circuit arrangement is decidedly simpler than that of the beat-frequency type. Either type may be fitted with a direct-reading dial for continuous variation of the output frequency, but the higher stability and circuit simplicity of the R-C type allows the use of pushbuttons for rapid shifting of the frequency in small steps, and this feature is being incorporated into that type.

The basic circuit differences appearing in the two types of audio test oscillator, as well as the two underlying theories of operation, have been adequately explained in the periodical literature and will not be dwelt upon here.

The prime purpose of the variable-frequency audio oscillator is the generation of standard-frequency voltages of controllable amplitude throughout the a.f. spectrum, and that very ability renders it invaluable in all tests and studies requiring audio voltages at particular frequencies within that spectrum. Until comparatively recent date, the audio test oscillator was a piece of required equipment only in laboratories engaged in research and development. At present, however, the demands imposed by modern public address amplifier systems and high-fidelity radio receivers compel its inclusion among required equipment in efficient radio service shops.

The utility of the variable-frequency audio oscillator in broadcast station maintenance is, of course, well known. It is the source instrument in such routine techniques as the periodic inspection of studio and modulator "sound" channels; the study and development of remote line systems, new automatic audio-frequency equipment; and, often, in the determination of distortion and modulation percentage tests.

In the following paragraphs we list some of the prominent applications of the audio test oscillator. We are fully aware that the instrument has multitudinous further uses and that a separate paper might easily be written on any one of those listed. It has been our aim, however, to complete the picture as closely as possible within our space limitations and to expound only those applications which are apt to find most ready demand in the workaday life of our average reader.

FREQUENCY GENERATION

The variable-frequency audio oscillator, as already pointed out, is primarily a standard-signal audio-frequency generator. As such, it makes available any frequency within the so-called a.f. spectrum; i.e., generally between 20 and 20,000 cycles per second. There are on the market at this writing a few wide-range oscillators that extend the high-frequency end of the range beyond the commonly conceived audio-frequency band—one, at least, to a frequency as high as 50 kc. to meet the demands of various wide-band channels appearing in television and allied equipment. Most standard audio test oscillators do, of course, operate considerably lower in frequency than 20 cycles, but most of the dials appearing on these commercial instruments are not graduated far below that frequency.

The voltage delivered to the output circuit is sine-wave in shape, possessing therefore very negligible distortion throughout the frequency range. The output voltage amplitude is controllable by means of a gain control or attenuator built into the instrument as a general rule. At any one setting of the amplitude control, the output voltage varies over only a few decibels as the frequency is varied between opposite limits of the audio-frequency spectrum, the maximum variations occurring usually below 100 cycles and above 10,000 cycles. The accuracy of the generated frequencies is sufficient for the exacting laboratory studies requiring this type of instrument, any error being never more than a very few percent of the stated value.

Suitable flat-characteristic amplifiers are included in the audio test oscillator, and these generally are terminated by an output circuit (transformer in most cases) providing a choice of low or high-impedance coupling.

As an audio-frequency generator, the oscillator is applied to the various tests requiring inspections of equipment at a number of quickly chosen frequencies, as will be shown in the subsequent paragraphs.

Bridge Generator

In various a.c. bridge operations requiring an alternating current of good waveform and controllable amplitude, the variable-frequency audio oscillator is particularly adaptable. For example, a certain capacitance measurement might require a 1000-cycle test voltage, while another type of bridge inductance measurement might indicate a 400-cycle voltage. The audio test oscillator may be set to either of these, or to any other required frequency, quickly.

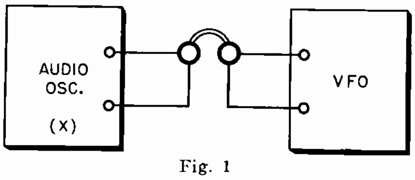


Fig. 1

Exact-Frequency Source

The audio test oscillator, as a generator of standard frequencies, finds application in such operations as the testing of motors (particular example, the synchronous motors employed in electric clocks) that are to run at certain power-line frequencies normally encountered. The oscillator makes possible the simulation of the frequency drifts expected in the service in which the motors are to be used. In applications such as the foregoing, the audio oscillator is followed by sufficient audio amplifier stages to deliver the power required to propel the small motor.

FREQUENCY IDENTIFICATION

The variable-frequency audio oscillator, as a standard-frequency generator, is well known for its function in identifying unknown frequencies within its range. Some form of comparison between the known and unknown frequencies is employed. One method is illustrated in Figure 1. Here the signal voltage of unknown frequency is applied to one telephone of a standard headset, while the signal voltage of known adjustable frequency from the oscillator, VFO is applied to the other telephone.

The operator adjusts the signal amplitudes until they are both approximately equal (or of slight inequality, if this arrangement is necessary to accommodate his particular difference in right- and left-ear sensitivity) and carries the frequency of VFO slowly through the audio range. Within a few cycles either side of the unknown frequency from oscillator X, a beat note is set up, becoming a slow waxing and waning condition as the exact frequency of X is approached, and disappearing entirely in favor of signal reinforcement when both oscillators are set to the *same* frequency. The frequency of X is read at that point from the dial of the standard oscillator, VFO.

Visual Method. An alternative method would employ a suitable vacuum-tube mixer circuit with the two signal voltages being applied to separate grids and the beat note (and zero beat) conditions being indicated by a suitable meter or electric eye operated in the tube plate circuit. This method is somewhat more accurate, since it eliminates the human error due to natural inability to recognize exact zero beat.

Beat-Note Applications. The same system of frequency identification can be employed to identify the heterodyne beat between two radio-frequency oscillators in particular applications to be discussed later.

Identification of Sounds. Either of the foregoing methods, visual or aural, might be used also to identify actual sound pitches, although this operation may be better carried out with a specialized instrument such as a *sound* or *wave analyzer*. If the unknown tone is sufficiently loud to be heard, it may be compared directly to the variable-frequency audio oscillator which is connected to feed a loudspeaker or headset. The operator, listening to both sounds—that of the unknown tone and the reproduced VFO signal—adjusts the oscillator to "zero beat" and reads the frequency from the instrument dial.

If the unknown tone is too weak to be compared easily with the VFO signal, it may be fed into an appropriate microphone-amplifier setup terminated by a speaker, headphones, or mixer circuit, as required by the application.

Thus the pitch of musical instruments, automobile horns, single-frequency machine noises, and the like may be determined.

AUDIO AMPLIFIER MEASUREMENTS

As pointed out earlier, the variable-frequency audio oscillator is invaluable in all tests and measurements performed on audio amplifying equipment, from the simplest amplifier used in a radio receiver or hearing aid to the mammoth public address systems for outdoor coverage. It is this application that has placed the instrument in the radio serviceman's required equipment category.

To illustrate amplifier tests and measurements, the reader is referred to Figure 2 which shows a conventional a.f. amplifier with screen, suppressor and cathode circuits of the tubes and all power supply wiring omitted for simplicity.

With the variable-frequency audio oscillator and a suitable vacuum-tube

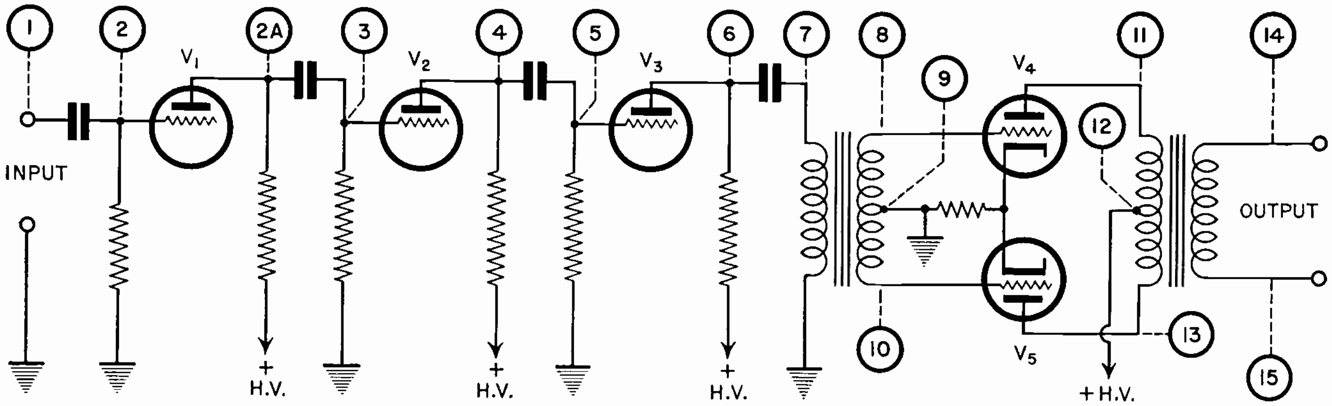


Fig. 2

voltmeter, such measurements as gain or loss in individual stages or in the entire amplifier may be made, the response studied, and resonant points located.

Transformer Gain. The gain of an individual transformer, such as T_1, may be checked by connecting the oscillator output to point 7 and ground. The amplifier power is switched off and the oscillator set to a suitable frequency, such as 400 cycles. With the VTVM connected between 7 and GND., the voltage applied to the primary is measured. The VTVM is then transferred to bridge points 8 and 10 and the voltage reading taken there. If T_1 is a step-up transformer, this last voltage reading will be higher than the first by a factor equal to the turns ratio of the transformer. If it is a step-down transformer, the secondary voltage will be lower by the corresponding turns ratio.

If the VTVM is then connected between 8 and 9 or 9 and 10, the voltage reading will indicate the gain in each half of the secondary winding. If the secondary center tap has been carefully placed, these two readings will be identical.

The same operation may be made on transformer T_2, here the VFO is connected between 11 and 13 and the VTVM between 14 and 15. To inspect the exactness of the primary center tap on this transformer, the VFO may be connected to 14 and 15 and its output voltage reading taken with the VTVM. The meter is then transferred successively to 11-12 and 12-13, and across each of these latter terminal combinations the voltage reading should be identical. In both of the foregoing center-tap measurements, the percentage by which the voltages across separate halves of the winding differ is the percentage by which the center tap is misplaced. The difference between the voltages measured across primary and secondary in either of the gain measurements is a direct indication of the gain through the transformer. For example: the voltage at the output of the oscillator might be found to be 1 volt RMS, while that across the secondary winding is 3 volts. The gain through that transformer would then be 3.

The gain measurements may be repeated at other frequencies than 400, carefully measuring each time the voltage at the primary (output of oscillator) and that of the secondary to determine if gain is falling off or increasing as the frequency is changed.

Tube Gain. Tube gain may be measured in any of the stages by applying a known voltage from the oscillator to the grid and measuring the a.c. output voltage at the plate of the tube. Here again, the frequency of the signal voltage may be changed to study the frequency-gain characteristics.

As an example, it may be desired to find the actual gain afforded by tube V_1. The oscillator is connected between point 2 and ground and the voltage between 2 and GND measured with the VTVM. The meter is then connected between point 2A and GND and a higher reading obtained there. The factor by which the applied voltage from the oscillator must be multiplied to equal the plate output voltage represents the gain afforded by the tube. For example: if the voltage delivered to the grid (point 2) was found to be 0.5 volt and that present at point 2A is 5 volts, then the tube gain is 10.

It must be remembered that in these tube and stage gain measurements, the amplifier must be placed *in operation* and steps must be taken to prevent passage of current through the oscillator output circuit from point 2 or through the VTVM from the high-voltage point 2A. Suitable fixed blocking condensers will in general take care of both of these requirements.

Stage Gain. The gain of an entire stage may be measured in a similar fashion with the amplifier in operation, but all components associated with the input and output circuits of the stage must be included. This would embrace input- and output-circuit coupling condensers or transformers. Thus, to measure the gain of the second stage, the oscillator is connected between 3 and GND and VTVM measurements made successively between 3 and GND and 5 and GND. In this manner the actual gain through the entire stage is measured by noting the difference between the voltages applied to the grid of V_2 and to the grid of V_3.

The gain of the last stage may be measured by applying the oscillator signal voltage between 7 and GND and measuring successively the voltages across those two points and the points 14 and 15. In this manner, both input and output transformers are included to give the true per-stage gain and not just the tube gain or the gain of tubes and one transformer.

The gain of each stage or any combination of stages may be investigated at various frequencies. These tests will often reveal incorrect or faulty components through the discovery of low gain values.

Type F

PRONG-BASE MIDGET ELECTROLYTICS

Type	Cap. Mfds.	D.C. W.V.	Size DxH	List Price	Net Price
F2J	10x450		1x2	$0.75	$0.45
F4J	20x450		1x2	1.10	.66
F8J	40x450		1x3	1.60	.96
F22J	10-10x450		1x2	1.20	.72
F44J	20-20x450		1x3	1.65	.99
F222J	10-10-10x450		1x3	1.55	.93
F16H	80x400		1-3/8x2	2.45	1.47
F22F	10-10x250		1x2	1.05	.63
F44F	20-20x250		1x2	1.10	.66
F6D	30x150		1x2	.70	.42
F44D	20-20x150		1x2	1.00	.60
F66D	30-30x150		1x2	1.10	.66
F64D4A	30-20x150 +20x25		1x2	1.15	.69
F33F4A	15-15x250 +20x25		1x2	1.10	.66
F22J4A	10-10x450 +20x25		1x3	1.30	.78
Metal or bakelite washer					5c each

PRONG-BASE MIDGET
The FUTURE STANDARD
ELECTROLYTIC

● Compact, economical, simply mounted and wired, it is natural that the Prong-Base Midget Electrolytic should find a leading place among popular condenser types. And with millions of such units already in use, this type has already become a commonplace replacement. Its convenience cannot be beat. Prongs slip through fibre (for insulated or floating can) or metal (for grounded can) elliptic washer rivetted, eyeletted or bolted to chassis, and are bent over. Terminal lugs slip through large center hole in washer, for soldered connections.

AEROVOX has sought to perfect this popular type in matters of more rugged terminal design and eliminating all possible trace of electrolyte leakage. An entirely new plug and lug construction has been developed. A more rugged, leak-proof and corrosion-proof prong-base midget electrolytic thus becomes available for still greater popularity of this type.

Ask Your Jobber . . .

Ask to see these latest Aerovox Prong-Base Midget Electrolytics, Type F. Use them in your next assembly where normal-duty compact electrolytics are required. Use them to replace wornout prong-base electrolytics. Ask for new catalog—or write us direct.

IMPROVED DESIGN . . .

Try wobbling the prongs of the new AEROVOX prong-base midgets. They are absolutely rigid. Then do the same thing to usual units. That tells the story of better construction.

In place of conventional two bakelite discs separated by sheet of flat rubber, AEROVOX construction employs cup-shaped molded soft-rubber disc with side walls. Single bakelite disc fits within walls of cup-shaped disc which in turn rests squarely on flat (not sloped as usual) shoulder of can, for snug, perfect fit. Cup-shaped disc has several slotted protrusions or sleeves molded in same. Through said sleeves pass anode or positive tabs which, beyond bend inside sleeves, join with soldering lugs. Compare this with straight mechanical leakage path found in conventional construction. As noted in diagram of AEROVOX construction below, electrolyte cannot reach junction of tab and lug because of soft-rubber seal.

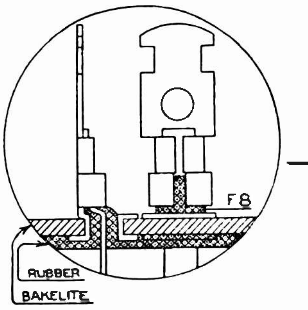
Mechanically, AEROVOX construction provides maximum ruggedness because lugs are actually eyeletted to bakelite disc—not just held between discs as in usual construction. All strain is removed from anode tabs. Impossible to loosen connections.

Square shoulder can instead of usual sloping shoulder, means that cap or plug not only rests solidly in place for positive seal, but danger of shearing cathode tab is eliminated.

Internal corrosion eliminated by use of hi-purity aluminum for tabs. Bakelite corrosion eliminated by rubber sleeves through bakelite holes or slots.

Positive pinhole vent instantly responds to excess gas pressure yet is normally self-sealing. This in contrast to usual construction wherein gases ooze through tab slots, often carrying along electrolyte to cause external corrosion.

Triple sealed—double sealing between cover and can, and additional sealing of all tabs in soft rubber.



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