

# Low Cost AUDIO OSCILLATOR

By ROBERT W. EHRLICH

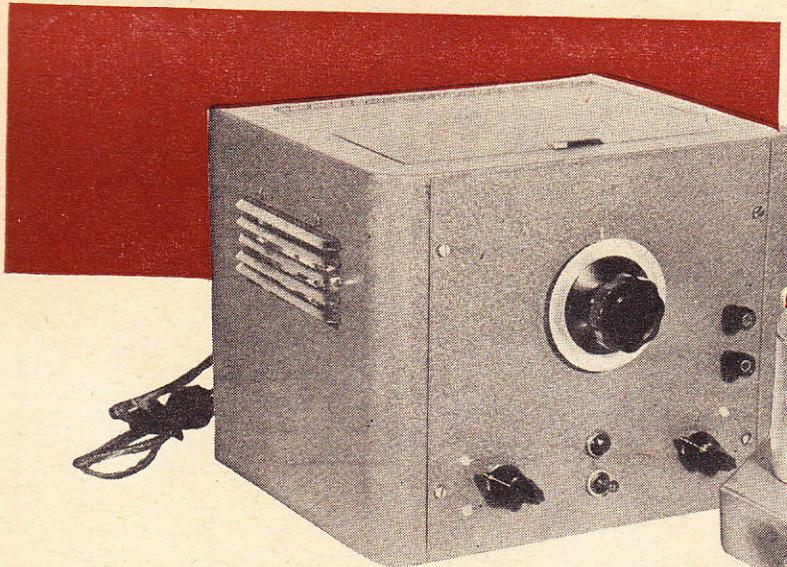


Fig. 2. Housed in an attractive cabinet, this audio oscillator makes a useful addition to the test bench.

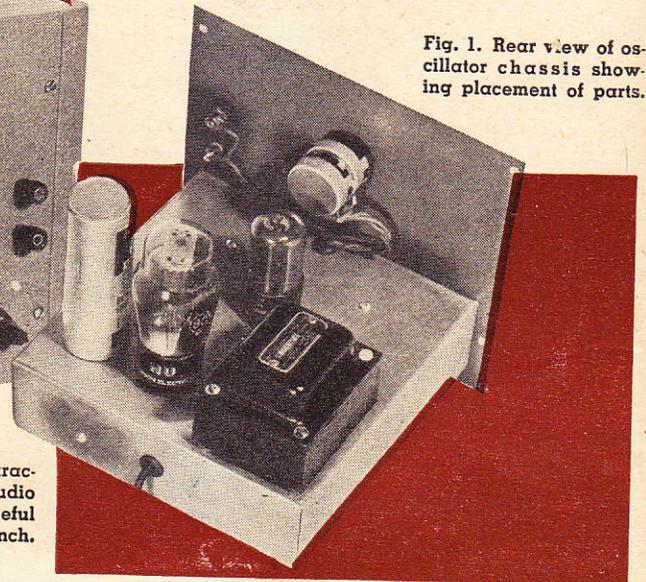
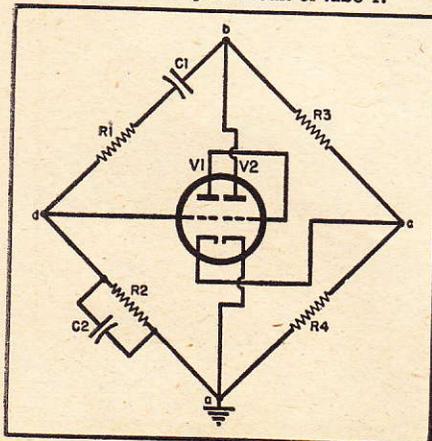


Fig. 1. Rear view of oscillator chassis showing placement of parts.

**A two tube audio oscillator utilizing resistance tuning which may be built for \$10 at present day parts costs.**

**T**HE audio oscillator described in this article was designed with the idea of providing the experimenter with a low-cost, easily-built, foolproof test instrument that could provide a good quality audio test signal at any frequency for use in testing receivers, audio amplifiers, modulators, etc. The device fulfills these conditions admirably, at only a small sacrifice of the features that appear on more expensive commercial models.

Fig. 3. Basic Wien Bridge audio oscillator circuit. Feedback takes place from the plate circuit of tube 2 to the grid circuit of tube 1.



As the unit appears in Fig. 2, all parts can be purchased at amateur rates for about \$10. It is to be expected, however, that most of the necessary parts will be found in the junk box, thereby lessening the actual cost of construction. In fact, the oscillator lends itself quite well to junk-box production, because none of the parts, with the exception of the tuning potentiometer, are at all critical.

As for performance, the oscillator will deliver an excellent sine-wave signal at frequencies between 100 cycles and 25,000 cycles, with no band changing. The maximum r.m.s. output ranges between ten and twenty volts, with an output impedance of approximately 10,000 ohms. This impedance is low enough so that hum pickup in the output leads is minimized and conventional test prods can be used.

A standard Wien Bridge circuit is used which is basically similar to that used in many commercial audio signal generators, but it contains two important modifications that make for simplicity. One is the use of a two-gang variable potentiometer as the tuning element rather than a large variable capacitor. This not only reduces the expense considerably, but also makes possible a tremendous range of frequencies in one band (over 100 to 1). The sacrifice here is, of course, some loss of accuracy in frequency calibration; however, the majority of applications do not require extremely accurate frequency information.

The other modification is that con-

trol of the feedback necessary to sustain oscillations is brought out to the front panel. This makes it unnecessary to undertake any involved alignment procedure when the oscillator is first put into operation. Furthermore additional flexibility is introduced in that it is possible to set the feedback control to produce either a sine wave or a highly distorted pulse wave that might be required for special applications.

The basic Wien Bridge circuit used in this oscillator is shown in Fig. 3.  $R_1$ ,  $C_1$ ;  $R_2$ ,  $C_2$ ;  $R_3$ ; and  $R_4$  constitute the bridge circuit through which feedback takes place from the plate of  $V_2$  to the grid circuit of  $V_1$ . This bridge is balanced when:

$$f = \frac{1}{2\pi\sqrt{R_1 C_1 R_2 C_2}}, \text{ and}$$

$$\frac{C_2}{C_1} = \frac{R_3 - R_1}{R_1 - R_2}$$

Note that the frequency of balance depends only on values of  $R_1$ ,  $R_2$ ,  $C_1$  and  $C_2$ , and that a suitable adjustment of the ratio of  $R_3$  to  $R_4$  will bring about a balance at that frequency.

Determination of the conditions necessary for oscillation in the circuit of Fig. 3 is most easily carried out by assuming a voltage between the plate and ground of  $V_2$ , and then using vector analysis to determine whether or not the voltage between the cathode and grid of  $V_1$  will be of such a nature as to sustain the assumed voltage. Fig. 7A shows vector relationships in the bridge circuit when it is perfectly balanced. Points  $a$ ,  $b$ ,  $c$ , and  $d$  in the vector diagram correspond to similarly

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lettered points in Fig. 3. Note that under the conditions, the cathode-grid voltage is zero, and it is possible to sustain the voltage (a-b) between the plate and ground of  $V_2$ . There will be no oscillation. Fig. 7B shows the vector relationships when circuit values remain the same as those in Fig. 7A, but different frequencies are assumed for the applied voltage a-b. As the frequency changes, the junction point (d) between the vectors a-d and d-b moves along the dotted circle, and the cathode-grid voltage takes on the different values shown. Note that at no time is c-d at all in phase with the applied voltage, a-b. Remembering that two reversals in phase take place between the grid of  $V_1$  and the plate of  $V_2$ , it will be realized that c-d must have a component in phase with a-b to sustain oscillations. Since the feedback is out of phase, and therefore degenerative, oscillations will not take place at any frequency.

In Fig. 7C, resistor  $R_3$  is slightly smaller than the value required for balance. While there is now some feedback at the balance frequency as well as at other frequencies, it is still degenerative and no oscillations will take place.

In Fig. 7D, resistor  $R_3$  is slightly larger than the value required for balance. At frequencies close to the balance frequency (the top of the circle), the vector c-d swings around so that it is in phase with a-b. When resistor  $R_3$  is adjusted so that the voltage c-d, as amplified by the two tubes, is just large enough to equal voltage a-b, then oscillations will take place.

The preceding analysis shows two significant features of the Wien Bridge circuit. One is that for any values of  $R_1$ ,  $R_2$ ,  $C_1$  and  $C_2$ , it is possible to find a setting of  $R_3$  that will just cause the circuit to break into oscillation. The other is that oscillation is limited to frequencies very close to the balance frequency determined by  $R_1$ ,  $R_2$ ,  $C_1$  and  $C_2$ , and no harmonics thereof; from which result the inherent frequency stability and pure waveform characteristics of this circuit.

The actual circuit of the audio oscillator is shown in Fig. 4. This is the same as the circuit of Fig. 3 with the addition of a power supply and the necessary blocking capacitors for the insertion of the d.c. voltages to the tube sections. In designing the circuit, every effort was made to keep cost down. While a transformerless power supply might be used to shave expenses a little further, it was felt that an isolating transformer was necessary in order to make it possible to connect the oscillator to other apparatus that may or may not be grounded to the a.c. line.

The chassis layout and placement of parts are adequately described in the accompanying pictures and diagrams, and very little need be said. Most of the impedances were purposely kept low to avoid any problems of hum pickup that might be encountered relative to parts placement.

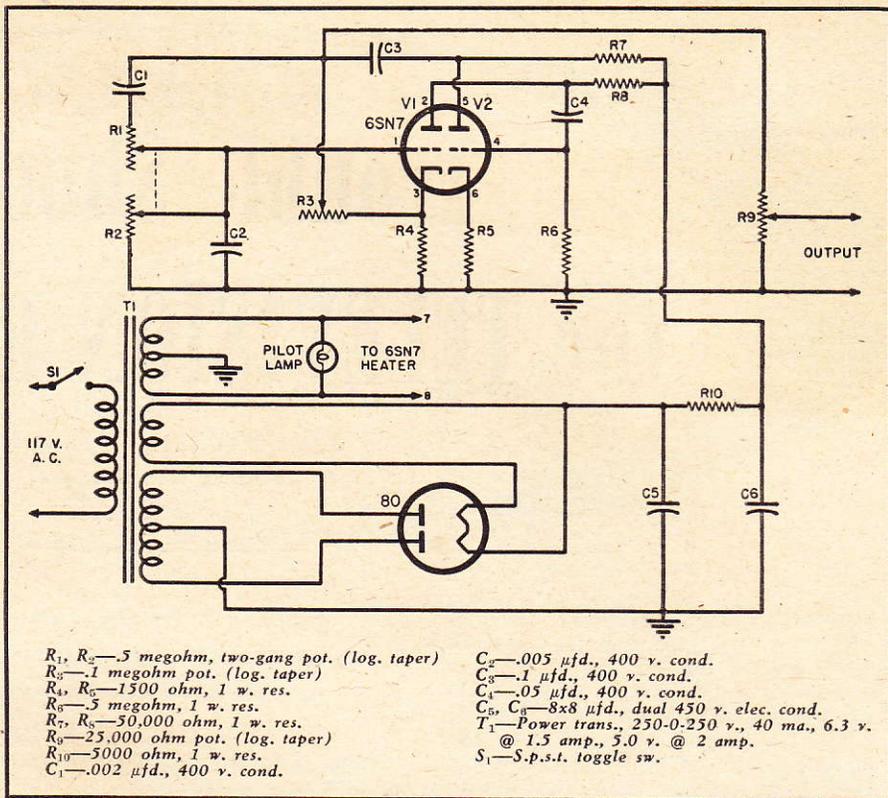


Fig. 4. Over-all circuit diagram and parts list for the audio oscillator.

Selection of parts to be used is also not very critical. It might be pointed out, however, that it is wise to use resistors and capacitors that are rated considerably higher than the wattages and voltages they will have to stand in order that stability of the unit will not be affected by overheating and breakdown of components.

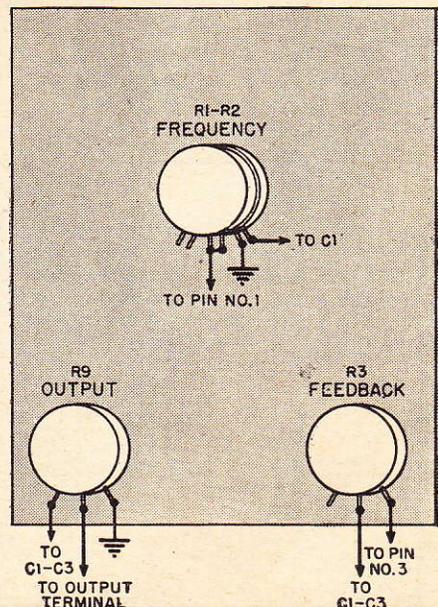
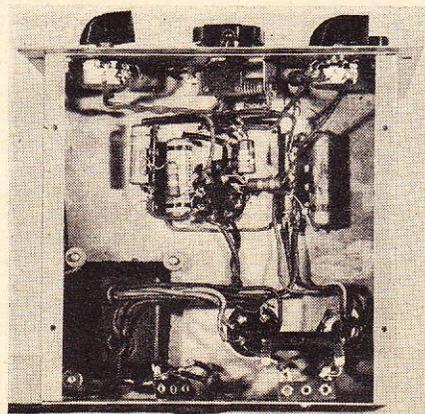
In selection of potentiometers, it is important to note that they are all of the logarithmic-taper type. This taper is used in conventional volume control units, so it should not be difficult to find the correct parts. It is also important to observe the connec-

tions shown in Fig. 5 for the potentiometers. If they were connected incorrectly, calibrations on the main tuning potentiometer would be very crowded near one end, and the setting of the feedback control would be extremely critical. With correct connections, the frequency calibrations space out about equally for every octave (See Fig. 8), and adjustment of feedback can be accomplished smoothly and easily.

It is not so important to use a logarithmic taper for the output control, but it is more convenient. The total  
(Continued on page 106)

Fig. 5. Proper connections for potentiometers used in the test oscillator. All potentiometers are of the logarithmic-taper type.

Fig. 6. Bottom view of chassis.



# OUTSTANDING VALUES

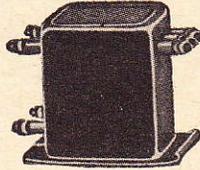
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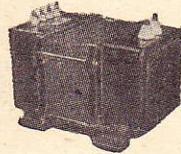


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#### Audio Oscillator

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signal voltage across this control is approximately 15 volts, while most amplifiers require an input of only 1/2 volt or 1/4 volt. A logarithmic-taper control, connected as shown in Fig. 5, spreads the low-output range over a wide arc and makes it easy to adjust for these outputs while still allowing for greater output if desired.

Placing the unit into operation is a relatively simple matter, and, wired correctly, it will work the first time it is turned on. As a rough performance check, connect a pair of high-impedance headphones to the output, set the output control to a fairly low value to avoid overloading the circuit, set the frequency dial about mid-scale, and adjust the feedback control until oscillations just take place as indicated by a tone in the headphones. Then swing the frequency dial back and forth over the entire range. Very little adjustment of feedback should be required to produce oscillations from the lowest frequency, where the dial is fully clockwise, up to a frequency which is above the range of audibility.

It will be noted that the unit will stop oscillating some distance away from the high-frequency end of the dial. This is normal, and is a result of loss in gain caused by lowered impedance of the potentiometer. Oscillations should not drop out, however, until the frequency is somewhat above the audible range. It is not advisable to try to force oscillations in this dead region at the high end of the dial through the use of the feedback control; because the audio frequency so obtained will be no higher than the upper limit observed with a normal setting of the feedback control, and a considerable adjustment of feedback will be required when returning to lower frequencies.

The over-all frequency range can be checked with the aid of an oscilloscope or a comparison oscillator whose frequency calibration is already established. If, for some reason, it is desired to shift the frequency range, this can be done by changing the values of  $C_1$  and  $C_2$ . Making either capacitor smaller will raise the frequencies, and vice-versa. Changing these values will not extend the over-all frequency range but will simply shift the entire range of the instrument higher or lower as desired.

Some extension of the over-all range can be obtained through the substitution of a 1 megohm double potentiometer for the .5 megohm unit specified for  $R_1$  and  $R_2$ , along with suitable readjustment of  $C_1$  and  $C_2$ . This will

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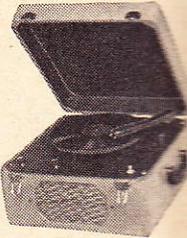


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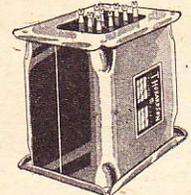


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