TABLE II. Resistance of a 11-Plate Condenser Set at .00008 m. f.
(About one-third maximum)

	300 Meters	80 Meters	40 Meters	27 Meters
Highest	.15 ohm	....	....	....
Lowest	.05 ohm	....	....	....
Mean	.098 ohm	.06 ohm	.04 ohm	.06 ohm

At first it was thought that the results for 80, 40 and 27 meters were too low since the ammeter in all probability read too high. Since then the ammeter has been calibrated at high frequency and found to be correct for 6×10^7 cycles (5 meters). In the work at 300 meters it was necessary to keep the current at or below .8 ampere, since the potential became so high that an arc started between the plates of the condenser when the current was .9 ampere.

After these results were taken the condenser was compared with three others made by different firms and it was found that there was no appreciable difference between this condenser and the average condenser.

These results show that the resistance of a good radio condenser is not excessive and that the results of Weyl and Harris, and Callis are entirely too large. Their results must be explained in some other manner. The probable explanation is as follows: The calorimeter method measures the energy that remains in the pyrex glass beaker. Any energy radiated through the glass will not cause heat. Therefore, there must be an appreciable amount of energy radiated from an ordinary circuit. In other words, there is a certain amount of resistance in the circuit which can not be ascribed to either the condenser or to the coil.

A STRAIGHT LINE FREQUENCY AUDIO OSCILLATOR.

R. R. Ramsey, Indiana University.

In a laboratory there is need of a source of alternating current of varying frequency. This need was formerly met by using alternating generators in which the speed of the rotor could be changed. Frequencies from a few cycles up to 3000 cycles were obtained in this manner. Since the three-electrode tube has come into general use, audio oscillators[1] having iron cores have been used. In order to get any considerable range of frequency it is necessary to substitute several coils and condensers from time to time. This is troublesome, and each coil or condenser calls for a new calibration.

If two oscillators which are oscillating at radio frequency are tuned so they are near the same frequency a continuous note is heard in a

[1] Ramsey, R. R. Experimental Radio (Revised), p. 59.

telephone which is connected to one of the oscillators. This note is due to the alternating currents producing beat, caused by the difference of the frequencies of the oscillators. The frequency of this current can be made anything from near zero to frequencies above the limits of hearing. The intensity of this current is small but this can be amplified to usable values by means of a resistance amplifier. If tone intensity and purity are not items, an ordinary iron core transformer coupled amplifier can be used.

The object of this paper is to describe a simple oscillator which can be set up by any one in a short time and which will answer for most purposes.

If one takes an ordinary .001 microfarad variable condenser and a coil which will give a maximum wave length of about 12000 meters and plots the frequency curve for the combination, one will get a curve which has great curvature for small capacity and becomes almost a straight line for the higher values of the capacity. One can choose two points on the curve such that the difference of the capacity is .00025 microfarads and the difference in the frequency is 5000 cycles. This curve between the two points is not far from a straight line. If one has two such oscillators and sets them so as to oscillate at the particular frequency corresponding to the first point, place a .00025 condenser set at zero in parallel with one of the condensers, and then changes the capacity of the small condenser, he can get any audio frequency he wishes between zero cycles and 5000 cycles per second. The small condenser should be made of semi-circular plates so that the capacity is proportional to the dial setting. With a 0 to 100 division dial each division on the dial corresponds to 50 cycles.

The curves in figure 1 give the calibration of an oscillator which consisted of a 400 turn honey-comb coil and an .001 microfarad condenser variable air condenser with a 0 to 100 dial. Since the capacity was found to be proportional to the dial readings the abscissas are plotted as dial readings instead of in terms of capacity. The straight line was obtained by plotting the square of the wave length, λ^2, against the dial readings. The data for this curve were obtained by comparing the oscillator to an oscillating wave meter whose maximum range was 5000 meters. The points in circles, ⊙ are the points obtained by comparing the fundamental for no beat note. The points in the squares, ⊡ obtained from the first overtone, ratio one to two, and the points in triangles, ⚠ were obtained from the second overtone, ratio one to three. Since wave length squared is proportional to capacity theoretically we should get a straight line. By drawing a straight line through the mean position of the points we get an average of all the points. By reading wave length squared off the straight line we can calculate the value of the wave length at various points and the curved line λ, is obtained. This is the curve which starts near 3000 meters and extends to near 13000 meters at the reading of 100 on the dial. By dividing the velocity of light, 3×10^8 meters, by the wave length we have the frequency. Frequency and dial settings are plotted in the curve which starts near the top for zero dial reading and curves downward to about 23 kilocycles at 100 on the dial. The lower end of the curve flattens out and a small portion of it is not far from a straight line. It will be noted that the frequency which corresponds to 57 on the dial differs from the frequency which corresponds to 82 on the dial by exactly five kilocycles or 5000 vibrations. The capacity change between the two points corresponds to 25 divisions on the dial, or one-fourth of the total of the .001 condenser, or .00025 microfarads. In figure 1 a straight line has been drawn just above the curve connecting these points, in order to show how near the curve approaches a straight line.

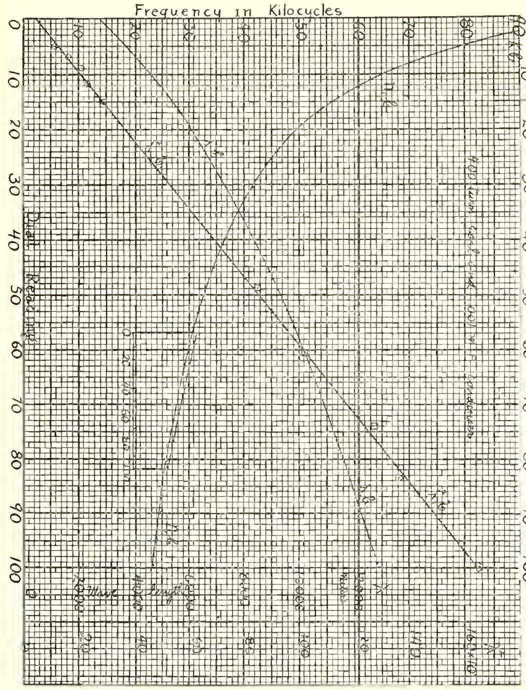

Fig. 1. Calibration curves of the audio oscillator. The curve showing the frequency is approximately a straight line through a change of frequency of 5000 vibrations.

If the oscillator condenser is clamped so as to remain fixed at the value corresponding to 57, and a .00025 condenser is placed in parallel and set at zero capacity, and a second oscillator is set so that the beat frequency between the two oscillators is zero, then as the small condenser is changed the beat frequency will change.

If the small condenser has a dial reading to 100 divisions, 0 division corresponds to 0 frequency, 100 divisions to a frequency of 5000 cycles; 50 divisions on the dial will give approximately a frequency of 2500 cycles.

If more accuracy is needed, the frequency should be read off of the curve between the two points instead of off of the straight line. Using the straight line the average error is about five per cent.

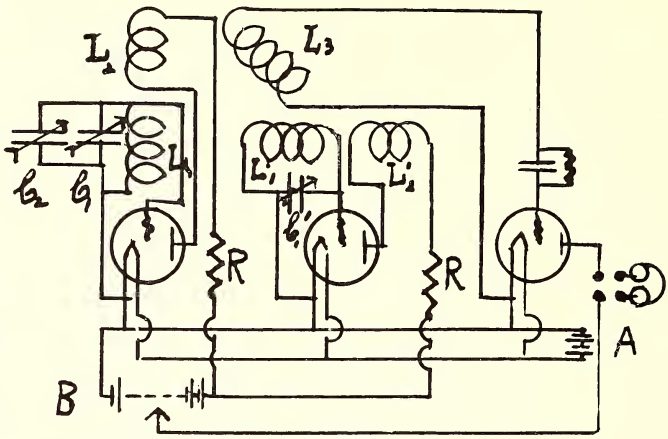

Fig. 2. Diagram of the connections of the audio oscillator.

The diagram of the connections is shown in figure 2. Each oscillator consists of a honey-comb coil of 400 turns, L_1 L_1^1 with a tickler coil of 150 turns, L_2 L_2^1, in the plate circuit, and a .001 variable air condenser, C_1 and C_1^1. Resistances of 20,000 ohms are inserted, one each in the plate circuit of the tubes which were 201A amplifier tubes. The B battery was 45 volts. The purpose of the resistances is to suppress harmonics in the oscillator.

The coils of the two oscillators are placed so that one set of coils is perpendicular to the other set of coils. The pick-up coil, L_3, is a 1200 turn honey-comb coil connected to a detector tube. This coil is placed so as to make angles of about 45° with each oscillator. C_2 is the .00025 microfarad condenser placed in parallel with C_1. The intensity of the current as it comes from the detector is great enough for most work where a head set is used. One stage of amplification makes the intensity about right. Two stages make the intensity very loud. The intensity probably changes with the frequency. Measurements have been made using an ordinary four-stage iron core transformer amplifier. The output of this amplifier changes a great amount with frequency changes, the maximum current output being for 500 cycles. The relative intensity of the sound from the loud speaker changes much more than the relative intensity of the sound from a head set in the plate circuit of the detector tube. The indications are that if a good resistance amplifier was used the intensity variation with frequency would not be so great.

In many cases the change with frequency is immaterial, since null methods are used. This is true in measuring the amplification of an audio transformer.[2]

The oscillator is very simple in construction and is one that can be made in most laboratories, either permanently or "scrambled" together for the occasion. If a greater range of frequencies is wanted, smaller coils can be used. If the oscillator is constructed with coils which give a maximum wave length of 6000 meters, two points can be found such that a difference of .00025 microfarads capacity corresponds to a frequency change of 10,000 cycles per second. With such a set more care must be used to avoid overtones than is necessary in the oscillator described.

If an oscillator is made with the above coils and enough capacity in parallel with the .001 microfarad variable condenser to make the wave length about ten or twelve thousand meters, selecting two points such that the frequency difference is 5000 cycles and the capacity difference is .00025 m. f., then the curve so joining the two points will be more nearly a straight line.

It may be well to call particular attention to the fact that all condensers used in this oscillator are of the semi-circular plate condenser type. The modern so-called straight line frequency condensers will not give anything like a straight line.

[2] Ramsey, Ind. Acad. Proc., 213, 34, 1924.