MEASUREMENT OF THE AMPLIFICATION CONSTANT OF AN AUDIO TRANSFORMER, PRINCIPLE OF THE NEUTRODYNE.

R. R. RAMSEY, Indiana University.

The following gives a very simple and exact method of measuring the amplification ratio of an audio transformer. At the same time a careful study of the principles involved will show why many neutrodyne receivers failed to "neute" after they were built. The apparatus needed is two variable condensers, a telephone, a buzzer, a dry-cell, and a telephone coil.

Connect up the apparatus as in figure 1. The buzzer battery and telephone coil, T, is simply a convenient source of alternating current. The coil T is the telephone coil which is found in all telephones connecting the microphone to the other parts of the system. A, is the transformer to be measured. The diagram indicates that the secondary of the transformer is connected reversed. This means that if the sec-

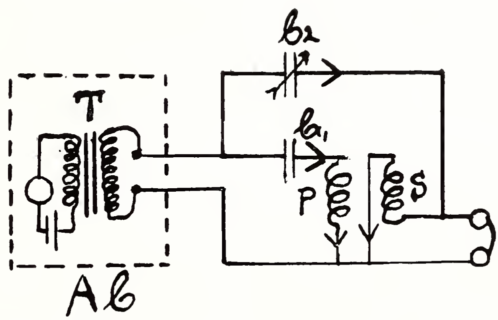

Fig. 1. Diagram showing connections for the apparatus used in the measurement of the amplification constant of an audio transformer.

ondary coil is wound in the same manner as the primary coil the inside end of the secondary coil is connected to the outside end of the primary coil. These two ends and a terminal of the telephone are connected to one terminal of the alternator (buzzer system). The condensers C_1 and C_2 are connected to the other end of the alternator. The other terminals of the condensers are connected to the loose terminals of the coils, C_1 to the primary coil and C_2 to the secondary coil. The telephone is also connected to this last point.

The principle of the experiment can be seen from the diagram. Suppose that at some instant the current is increasing through the condensers in the direction indicated by the arrow. I_1, the current through the condenser C_1, is running down through the primary coil of the transformer. This induces a current up through the secondary coil of the

"Proc. Ind. Acad. Sci., vol. 34, 1924 (1925),"

transformer. If this induced current is just equal to I_2, the current which passes through the condenser, C_2, then there is no current left to go through the telephone and there is no sound in the telephone. Or mathematically,

$$M\ dI_1/dt = L\ dI_2/dt, \text{ or } M\ I_1 = L\ I_2$$

where M is the mutual inductance of the transformer and L is the self inductance of the secondary of the transformer.

Since M is proportional to n_1n_2, and L_2 is proportional to n^2_2, where n_1 and n_2 are the number of turns of wire in the primary coil and secondary coils respectively, then

$$n_2/n_1 = L/M = I_1/I_2 = C_1/C_2 = A$$

where A is the amplification constant of the transformer.

The currents can be shown to be proportional to the capacities of the condensers by considering the equation for alternating current when we have resistance capacity and inductance in the circuit,

$$I = \frac{E}{\sqrt{R^2 + (1/Cw - Lw)^2}}$$

When the capacity C is small, as in this case, practically all the impedance is due to the term 1/Cw. Thus considering R and L to be zero we have

$$I = ECw, \text{ and } I_1/I_2 = C_1/C_2$$

No sound or a minimum sound in the telephone tells us when this condition is obtained and the ratio of the condensers gives us the amplification constant of the transformer.

If the condensers are ordinary variable condensers which are exactly alike, that is, if the capacity is proportional to the scale readings and if the two have the same capacity when set alike, then the scale readings can be substituted for the capacities and the amplification is the ratio of the readings of the dials. (For methods of measuring capacity see "Experimental Radio", page 14.)

Instead of ordinary audio coils any transformer, such as those used with 60 cycle current can be measured in this manner also. If the ratio of the transformer is determined the method can be used to compare the capacity of a condenser with a known capacity. There is no fixed rule for using the markings on the terminals of the coils when connecting the transformer. All manufacturers do not mark their coils in the same manner. Connect the coil up and if the telephone does not show a minimum sound, reverse the connections on one coil—primary, say.

Instead of the condenser C_1 the capacity of a tube can be used as in figure 2. In this case the capacity of C_2 must be very small. However, the transformer connections can be made such that C_2 is larger than C_1. It will be an interesting variation to measure the capacity of the tube with the filament cold and then again when the filament is hot. It will be found that there is not much change of capacity.

It will be seen that we are making the capacity of one condenser neutralize the effect of the other condenser. With the case of the tube the condenser neutralizes the capacity of tube.

If our coil is a neutrodyne coil and our condenser is a neutrodyne condenser, and if we connect a second tube in place of the telephone so as to act as an amplifier we have the last two tubes of the neutrodyne hook-up. By placing another tube, neutrodyne condenser and coil in front of the second tube, and by replacing our buzzer outfit by a third neutrodyne coil connected to an aerial we have the regular neutrodyne hook-up. Since we are using radio frequency alternating current instead of ordinary alternating current the last tube must be a detector and a grid condenser with leak must be inserted.

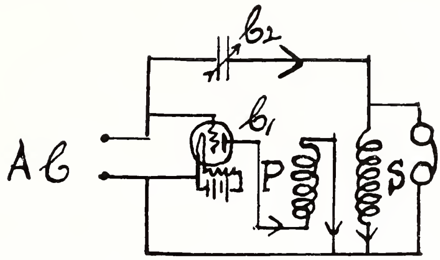

Fig. 2. Diagram showing connections when using a tube in the circuit.

The amplification ratio of neutrodyne coils is about five. This means that the capacity of the neutrodyne condenser must be one-fifth of that of the tube. It is hard to make a variable condenser of such small capacity. It is customary to connect the neutrodyne condenser to a tap on the secondary instead of to the grid end of the coil. Between this tap and the filament end there are as many turns as there are in the primary coil. Connected in this manner the neutralizing condenser has about the same capacity as the tube.