SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLIFIED INSTRUMENTAL METHOD OF MEASURING SOUND ABSORPTION COEFFICIENTS

SINCE the foundation of the science of architectural acoustics by the late Professor W. S. Sabine,[1] of Harvard, many instrumental methods have been devised to take the place of the ear-reverberation method described by Sabine. Among these instrumental devices are those of Chrisler and Snyder,[2] Wente and Bedell[3] and others.

While most of these instrumental schemes have been quite successful in reducing the measurements to purely objective values, thus eliminating the ear as a source of possible error, yet in most cases the instruments themselves are quite complex and they are not easily assembled from apparatus usually found in physics laboratories. For this reason an effort was made in the present case to devise an apparatus which would be simple, easily assembled and yet reliable.

The usual procedure in instrumental practice as regards sound absorption measurements in reverberation rooms is to make use of the sound decay formula, as developed by Jäger,[4] which, when modified to make it applicable to instrumental methods, is as follows:

$$A_1S_1 = \frac{4\,V \times 2.3 \log_{10}\left(\frac{E_1}{E_2}\right)}{C\,(t_2 - t_1)} \qquad (1)$$

where A_1 is the average coefficient of absorption of the walls, ceiling and floor of the empty reverberation room,

S_1, the area exposed to sound
V, the volume of the room
C, the velocity of sound at the temperature of the room
E_1, a certain sound energy level intensity
E_2, a subsequent sound energy level intensity
t_1, a time in seconds corresponding to E_1
t_2, a time in seconds corresponding to E_2.

When absorbing material is added to the room, equation (1) becomes

$$A_1S_1 + A_2S_2 = \frac{4\,V \times 2.3 \log\left(\frac{E_1}{E_2}\right)}{C\,(t_2 - t_1)} \qquad (2)$$

where A_2 and S_2 are the coefficient of absorption and the area of the material respectively. It is thus obvious that if we have some method of determining E, the sound energy level in the room at any given time, t, it is possible to evaluate A from a curve obtained by plotting values of $\log_{10}E$ against corresponding values of t.

The method being used at Indiana University is essentially as follows:

Sound is produced in a reverberation room by blowing a metal organ pipe of standard make with compressed air at constant pressure as measured by a manometer. After the sound has been maintained for a time, considerably longer than the reverberation time of the room, the air is suddenly cut off and a sound decay curve is made from points determined by the recording apparatus herein described.

The recording apparatus consists of a Jenkins and Adair condenser microphone,[5] the output of which is amplified by a four stage transformer coupled A.C. amplifier as illustrated in the accompanying diagram, Fig. 1. The output of this amplifier is fed through

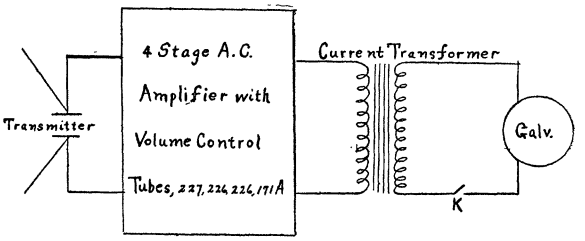

FIG. 1. Diagram of recording apparatus.

a volume control potentiometer into a step-down current transformer from which it passes to a thermo-couple galvanometer,[6] which reads directly in arbitrary energy units. The observer and all the recording apparatus except the microphone is in a room adjoining the reverberation room.

In making a determination of sound absorption, a metronome is set vibrating with a certain period. In coincidence with a given click of the metronome the air is cut off by a valve. At some subsequent click (say the second or third), the key K, is closed, which results in a deflection of the galvanometer. The process is repeated for other settings of the metronome, and of course several readings are taken for each setting, to insure a conservative average. If,

[1] W. S. Sabine, Collected Papers. Harvard Press, 1922.

[2] Chrisler and Snyder, *Bur. Stand. Jour. Research*, Vol. 5, Oct., 1930.

[3] Wente and Bedell, *Jour. Acous. Soc. Amer.*, 1: 422, April, 1930.

[4] C. Jäger, *Wiener Sitz Ber.*, Vol. CXX, 2a, p. 613, 1911.

[5] Note:—An ordinary double button microphone may be substituted for the condenser type thus eliminating special batteries. The outfit then becomes all A.C. and quite portable.

[6] The current transformer and thermo-couple galvanometer are of commercial type and may be secured at nominal cost.

now, the apparatus is calibrated to read in decibels of decay and the output volume control is set accordingly, it is immediately apparent that the values for coefficient of absorption may be calculated from the slope of the curves obtained by plotting values of $\log_{10}E$ against corresponding values of t.

Fig. 2 is a set of curves plotted from data taken as indicated. These curves show the logarithmic

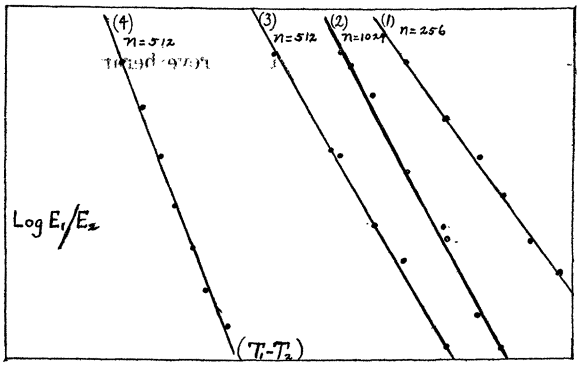

FIG. 2. Decay curves. (1), (2) and (3). Empty room values. (4). Room treated with 30 square feet of material.

nature of the decay quite as well as similar curves obtained by more complicated recording devices. The values for absorption coefficients obtained in this manner have been checked against values for the same kinds of materials found by observers in other laboratories and against values found by the ear method in another room at Indiana University and the agreement is very good.

It will be noted that a coincidence determination is substituted for a duration of time measurement in the older method. It is of course obvious that coincidence determinations are capable of a very high degree of accuracy, a conclusion which is borne out by the fact that the points thus determined fall so nearly exactly on a logarithmic decay curve.

It was intended at first to make an automatic device to cut off the air, and at some subsequent time to close the key, but measurements made in the manner described seem to indicate that little or no improvement would thus be afforded, probably not enough to warrant the added complication.

The apparatus was devised as a means of carrying out a research problem in architectural acoustics which is now in progress under the direction of Professor Arthur L. Foley. The writer wishes to acknowledge his counsel in the matter, and also the many suggestions offered by Professor R. R. Ramsey, of the physics department.

JAMES F. MACKELL

DEPARTMENT OF PHYSICS,
INDIANA UNIVERSITY

A NEW DEHYDRATING AGENT FOR HISTOLOGICAL TECHNIQUE

RECOGNIZING the usefulness of a substitute for ethyl alcohol to be used as a dehydrating agent in histological technique, the writer experimented with isopropyl alcohol over a period of 18 months. Isopropyl alcohol, 98 to 99 per cent., may be obtained for about $2.85 per gallon. This percentage may be used directly as absolute alcohol if necessary. It may be made completely absolute by distillation from rock lime.

In the experiments pieces of animal tissues were treated in the usual way (merely substituting isopropyl for ethyl alcohol). Permanent slides made by the paraffin method were set aside for several months and were found to be perfectly good when examined. Later a piece of earthworm which had remained in a paraffin block for a year was sectioned and excellent slides were obtained. In the meantime a class of 38 men with no previous experience in histological technique was given isopropyl alcohol to use. These men made slides of Opalina, changing the grades of alcohol and xylol by pipetting the various solutions from small vials containing the Opalina. They also made whole mounts of trematodes, etc., using either cedar oil or xylol after the alcohol. Finally each man made serial sections of tapeworm proglottids. In every case the technique following the use of isopropyl alcohol was more successful than the technique of previous classes which had used ethyl alcohol.

From the various experiments made, the writer proved that not only is isopropyl alcohol as good a dehydrating agent for animal tissues as ethyl alcohol, but in addition that its use affords important advantages. It does not harden animal tissues as much as ethyl alcohol. Consequently whole mounts of large objects are less likely to break up and tissues imbedded in paraffin seem to section with greater ease. Isopropyl alcohol may be obtained readily by any one since it is not intoxicating. This fact should be of special interest to high-school teachers of biology. The only disadvantage is that it costs more than ethyl alcohol. This is compensated in part by the fact that isopropyl alcohol is less likely to disappear from the laboratory.

I suggest that some one interested in plant histology experiment with isopropyl alcohol to see if it is not superior to ethyl alcohol in respect to the extreme hardening effect of the latter upon certain plant tissues.

O. C. BRADBURY

WAKE FOREST COLLEGE,
WAKE FOREST, N. C.