On the Perturbation of Normal Modes of Vibration

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suggested by others for synthetically controlling reverberation, such as the electro-optical, electro-mechanical, mechanical recording, and the reverberation-chamber methods, are discussed. The paper also outlines other uses for the magnetic tape system in the study of acoustic phenomena both synthetically and analytically.

10. A General Purpose Vibration Meter. H. H. SCOTT, *General Radio Co.* (*20 min.*)—The popularity and usefulness of the sound level meter have created a demand for a vibration-measuring device of similar character—easy to use, accurate, and adaptable to a wide range of applications. To provide such a general-purpose vibration-measuring device a new and unusual type of instrument has been developed. Based upon the experience gained in the manufacture of hundreds of sound level meters, a stable, high gain amplifying circuit has been developed, giving a satisfactory response at frequencies as low as 2 cycles per second. The use of an acceleration-type pick-up plus two stages of electrical integration provides the user with the choice of acceleration, velocity, or displacement characteristics, all in a single instrument. Among the many other features are a stable internal calibration system, instantaneous push-button control of the integrating circuits, a semilogarithmic meter with special damping characteristics, and a single-control dual attenuator providing a wide range of sensitivity. The factors involved in the choice of the various electrical and mechanical characteristics and some actual results obtained with the instrument will be described. (Illustrated with slides.)

11. A Demonstration of the Chromatic Stroboscope as a General Purpose Frequency Meter. O. H. SCHUCK AND R. W. YOUNG, *C. G. Conn, Ltd.* (*15 min.*)—Experience has shown that the chromatic stroboscope is very useful as a general purpose frequency measuring instrument, even though it was originally developed for musical instruments. Its inherent accuracy of 1/20 percent can be made available above its nominal 4000-cycle upper limit by the use of easily constructed frequency dividers, one of which will be shown. A demonstration will be given illustrating important advantages of this method over the other available methods in range, accuracy and speed.

12. On the Perturbation of Normal Modes of Vibration. R. H. BOLT, *University of Illinois*, A. M. CLOGSTON AND H. FESHBACH, *Massachusetts Institute of Technology.* (*20 min.*)—A recently developed boundary shape perturbation theory[1] has been applied to the calculation of acoustic normal frequencies and wave patterns in enclosures which deviate somewhat from rectangularity. The method is quite general; it is applicable to any form of irregularity if the amount of distortion is "small," provided solutions for the basic form are obtainable. Specific formulas have been derived for trapezoidal and parallelogram shapes. Calculated frequencies and wave patterns are found to agree closely with experimentally measured values reported previously.[2] An experiment has been devised to test the range of validity of the perturbation calculations for one case. A small test chamber was built with walls which could be shifted continuously in plan to give trapezoids of constant area, but having any desired degree of deformity between a rectangle AB and an isosceles triangle of base $2A$ and height B. A number of normal frequencies were traced through the whole range of shapes. For wall angle shifts up to about 15° the perturbation calculations hold very well. The perturbation method promises to yield information bearing on the problem of sound diffusion in irregular rooms.

[1] H. Feshbach and A. M. Clogston, Phys. Rev. **59**, 189 (1941).
[2] R. H. Bolt, J. Acous. Soc. Am. **11**, 184 (1939).

13. The Modulation of Sound Decay Curves. R. B. WATSON, *Harvard University.* (*15 min.*)—The irregularity of decay curves has long been noted as a difficulty in the measurement of the reverberation time of a room. It has been suggested that these irregularities may be an important factor in the evaluation of the subjective acoustic qualities of a room. The departures from an exact exponential decay arise from three causes: (1) Beats are produced by interference among the resonance frequencies of the room. (2) Multiple decay rates result from the shape of the room or the non-uniform distribution of absorption on the walls. (3) The direct waves from the source and its first images are important for large or highly absorptive rooms, and at high frequencies. To investigate these phenomena, objective measurements have been made on nine rooms of widely differing sizes and shapes. Apparatus has been designed which compensates for the exponential slope of the decay, leaving only the remaining variations to be recorded by a high speed level recorder. Experimental data are presented for the nine rooms.

14. Sound Absorption Coefficients and Acoustic Impedance. RICHARD L. BROWN AND PHILIP M. MORSE, *Massachusetts Institute of Technology.* (*20 min.*)—The relation between normal acoustic impedance and the various types of absorption coefficient has been discussed and specific formulas for the coefficients in terms of acoustic impedance have been published.[1] Contours of constant absorption coefficient plotted as a function of the real and imaginary parts of acoustic impedance plotted on a linear scale are families of circles for both the *normal coefficient*, the coefficient which in the Sabine reverberation formula usually determines the initial rate of sound decay for rectangular chambers and low frequencies, and for the familiar *free-wave absorption coefficient* for any single angle of incidence. Similar contours for the Sabine or *statistical absorption coefficient*, which determines the rate of decay for completely diffuse sound, are shown to be very nearly circular. These plots, together with measured impedance curves or the equivalent electrical circuits of a sound-absorbing structure, are useful in designing materials and mountings for optimum sound-absorbing properties. The curves give theoretical explanation of the empirical value found by Sabine[2] for the average cosine of the angle of incidence for frequencies above 500 c.p.s. Graphs of the absorption coefficients plotted as functions of magnitude of impedance for various values of impedance angle show that for angles greater than 45° the treatment of a complex