PAPERS FROM THE PROGRAM OF THE PHYSICS SECTION

MULTIPLE RESONANCE IN VIOLINS

R. B. ABBOTT and R. O. JENKINS, Purdue University

The object of this investigation was to determine the lower resonance frequencies of the air cavities of violins when the tops and bottoms were not allowed to vibrate and also when they were allowed to do so. It was thought best to use a siren, a vibration meter and tuning forks for determining resonance frequencies rather than a telephone receiver and variable oscillator such as used by F. M. Chambers. The work was carried on because there was much uncertainty regarding the position of strong resonance bands and points for low frequencies, which aid in strengthening the fundamentals and lower partials of the violin tones. This object was accomplished by the locating of one strong band, two fairly strong points and one weaker point all below 1,100 vib. per sec. Methods and results are given in the following report.

To keep the top and bottom of a violin from acting as diaphragms coupled to the air cavity, it was buried in sand leaving only the F holes uncovered. Tuning forks of different frequencies or a siren of variable frequency were held over the F holes and resonance frequencies noted for maximum reinforcement of the resulting sound. As a result, one strong band was located at 256 to 340 vib. per sec.; strong points were found at 512 and 728 vib. per sec.; one weaker one was evident at 1,024 vib. per sec.

With the violin out of the sand and free to vibrate, the above methods were repeated, also a vibration meter was used to indicate maximum vibrations of the top and bottom of the violin when a variable frequency sound was produced in the neighborhood by a siren or organ pipe. A number of violins were tested in this way with the result that approximately the same resonance band and points were located. However, the resonance was stronger.

The object of this investigation included an attempt to check the experimental results with the present acoustical theory. The values of the conductivity of F holes and the volume of the air cavities of violins were determined experimentally for use in the following theoretical work. Calculations were made from the theory of Helmholtz resonators, first, assuming that the cavity of the violin acted as a single resonator; second, that it acted as two parallel resonators.

In the first cast the results were as follows: The conductivity of the F holes was found to be $K = 4.68$ c.g.s. units and the volume of the cavity $V = 1{,}970$ cu. cm. The velocity of sound C at 20° C. was 34,500 cm. per sec. The theoretical resonance frequency is $F = \frac{C}{2\pi}\sqrt{\frac{K}{V}}$. This gives $F = 268$ vib. per sec. which falls within the lower limit of the resonance band.

In the second case, the air cavity was assumed to be divided into two parts by a plane through the middle of the F holes and considered as two parallel resonating cavities. The formula for calculating the resonance frequency in this case was developed from the analogy to similar electrical circuits with parallel connections. In this electrical case for resonance the current is all in phase with the electromotive force and the wattless component is zero. This condition for two parallel circuits with reactances X_1, X_2 and impedances Z_1, Z_2 is expressed as follows:

$$I_1 \sin \theta_1 + I_2 \sin \theta_2 = \frac{EX_1}{Z_1Z_1} + \frac{EX_2}{Z_2Z_2} = 0.$$

When the analogous acoustical terms are substituted in the above equation and the proper violin data are substituted for the constants its solution gives the resonance frequency F = 334 vib. per sec., a value which falls within the upper limit of the resonance band found by experiment. This suggests that this resonance band is due to multiple resonance between the limits of the above frequencies.

After investigating many violins of both old and modern makes, it was found that this strong resonance band occurs in all models approximately between the same frequency limits. This result must be so, for the reason that violin makers have always thought that they must keep the size of the F holes and volume of the inside of the violin the same, regardless of other modifications in models.

A NEW FOCUSING DEVICE FOR ELECTRON DIFFRACTION

WILLIAM I. CALDWELL, Purdue University

Up to the present time all the methods used to study crystal structure by electron diffraction have been adaptations of x-ray methods. Although these methods have been successful they all possess inherent difficulties. These difficulties arise from the low penetrating power of the electrons and from the short wave lengths of the electrons at moderate velocities. An attempt has been made to find a method that will obviate, in so far as possible, these difficulties.

The diffraction of radiation by powdered crystals is usually considered as the summation of a large number of Bragg reflections. However, the work of Brentano[1] suggested another viewpoint which, it can be shown, is applicable to all diffraction methods. Brentano's reasoning was somewhat as follows:

Let ABCD (Fig. 1) be a section of a toroid, the surface generated by rotating the arc of a circle ABC about its chord AC. EF is tangent

[1] Phy. Soc. London 38:184, 1926.