maximum was reached in 7–10 minutes of heating without any apparent connection with increase of temperature. The paper, when published, will present and discuss three possible explanations.

11. There are, then, apparently two general sources of thermions: (1) external, not permanent but very effective in the initial stages, and (2) internal, permanent. The first source is probably chiefly water vapor, the second consists of impurities present in the form of salts.

OHIO STATE UNIVERSITY,
December 27, 1913.

THE CHARACTER OF INTERAURAL SOUND CONDUCTION INDICATED BY BINAURAL BEATS.[1]

BY G. W. STEWART.

SOUND conduction of the bones of the head is well known. Experiments in sound localization with two tones of the same frequency but of different phase, presented one to each ear, have shown the importance of interaural sound conduction. Rostosky assumes a conduction with a lag due to longer path; Wilson and Myers assume in addition a change of phase of 180°. These theories do not account for the maxima of apparent intensity found when two tones differing slightly in frequency are presented one to each ear. The maxima as observed first by Rostosky and later independently by the writer occur as follows:

1. With rapid cycles of recurring equal phase, the cycles being less than one or two seconds, a maximum of apparent intensity occurs at zero phase difference, as has long been known, but with the cycle of greater length additional maxima appear at phase differences $180° - \delta$ and $180° + \delta$, the former occurring apparently in the ear having the tone of greater frequency.

2. With cycles greater than one second in length, the additional maxima increase in intensity with increasing cycle length until they appear of greater intensity than the original maximum.

The additional facts found by the writer are:

3. The quality of the tone at zero phase maximum is the same as that of the exciting tones, but the quality of the tone at the additional maxima is noticeably different, being less pure.

4. The value of δ is independent of the duration of one cycle, depending only on the frequency of the tones.

5. The values of δ with varying frequency as determined by Dr. Stiles and the writer are: with 256 d.v., 64.8°; 128 d.v., 54°, and 64 d.v., 32.4°.

6. Theoretical considerations assuming simple sound conduction and using the sum, the ratio, and the differences of intensities at the ears, and also the individual intensities, do not produce results consistent with the experimental facts.

[1] Abstract of a paper presented before the American Physical Society at Atlanta, December 31, 1913.

From a detailed consideration not outlined here, there appear the following conclusions:

1. That the causes producing the zero maximum are not those which produce the additional maxima.

2. That conduction from one ear to the other produces a resulting variation of intensity in each ear, and that the maximum and minimum occurring with rapid cycles can be accounted for if the sum of the two ear intensities be regarded as the determining factor. (The importance of this factor has already been pointed out by the writer.)

3. That the experimental values of δ given agree with the theory that the additional maxima are caused by forced vibrations, for $\tan \delta$ is proportional to the frequency within experimental error. This agreement is striking and demands further investigation.

Physical Laboratory,
State University of Iowa.

An Absolute Method for Determining the Ballistic Constant of a Moving-Coil Galvanometer.[1]

By Paul E. Klopsteg.

FROM the equation for damped periodic motion of a galvanometer coil, expressing the condition for the discharge of a quantity Q of electricity through the coil at rest, the value of the first maximum displacement is found by the usual method of differentiation. This value represents the ballistic throw of the slightly damped galvanometer. From the expression so found the equation for the ballistic constant is obtained. In the transformation a substitution is made which is based upon the equation for the damped coil method of measuring magnetic fields. The resulting expression is

$$K_1 = \pi \sqrt{\frac{I_0 \epsilon^{\lambda}}{10^7 R T_0 (\Lambda - \lambda)}},$$

this value of K_1 being equal to the number of coulombs per radian. I_0 is the moment of inertia of the coil, T_0 its period and λ its logarithmic decrement on open circuit, and Λ its logarithmic decrement with R ohms in the galvanometer circuit.

When the value of λ is about 2.5 per cent. of π, the value of K_1 is too large by 0.1 per cent., the difference increasing as λ grows larger. The following more exact formula may then be used:

$$K_2 = \epsilon^{\frac{\lambda}{\pi} \tan^{-1} \frac{\pi}{\lambda}} \sqrt{\frac{I_0}{10^7 R T_0} \frac{\pi^2 - \lambda^2}{\Lambda - \lambda}}.$$

An explanation is offered for the frequently observed difference between the

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