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

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

values of the ballistic constant in a given instrument with a strip or ribbon upper suspension, on the two sides, A and B, of the scale. This difference is due principally to a certain amount of torsion in the lower suspension which necessitates a corresponding amount of "counter torsion" in the upper suspension in order to keep the coil in the position of the null reading. The effect of torsion in a strip suspension is to shorten it, the case resembling that of a bifilar suspension for angles less than 180°. For a throw in one direction, say A, the coil must be raised; in the opposite direction the turning moment of the force of gravity acts in the same direction as the electromagnetic torque. Consequently with a given quantity of electricity the throw in the direction B is greater than in the direction A.

The same "bifilar effect" introduces an error into the determination of I_0 of a coil by the comparison of vibrations method when a strip is used as the suspension fiber, unless the masses of the coil and of the comparison disk, as well as their amplitudes, are the same. The error due to this effect becomes negligible if a wire of circular cross-section is used as the suspension fiber.

PHYSICAL LABORATORY,
UNIVERSITY OF MINNESOTA.

RANGE OF α-PARTICLES IN AIR AT DIFFERENT TEMPERATURES.[1]

BY ALOIS F. KOVARIK.

THE range of α-particles in any substance depends on the nature and the number of atoms in the path. And we find, therefore, that the range varies inversely with the pressure of a gas; similarly, we should expect that the range varies inversely with absolute temperature. This has been tacitly assumed to be true. In some experiments on the ionization by the α-particles I have found it convenient to test this experimentally between 90° and 362° absolute. The apparatus and method were after Geiger and Nuttall. Bulbs used as ionization vessels were of two sizes, 5 cm. and 9 cm. radius, respectively. The bulbs were metallic. The temperature was obtained by means of a thermocouple placed near the center of the bulb. The α-ray substance used was a polonium plate of about 4 mm. diameter. The lowest temperature was obtained by immersing the bulb in liquid air and the highest temperature by immersing the bulb in boiling water. Intermediate temperatures were at room temperature and the temperature obtained when the apparatus was packed in ice. The pressure-ionization curves gave sharp breaks for the ordinary temperatures, but at the low temperature the change was not as abrupt, a rounded bend being obtained. This was no doubt due to some convection currents (which must have existed as the neck of the bulb protruded from the liquid air). However, the pressure at which the α-particle just reached the walls of the bulb could be fairly accurately determined from the

[1] Abstract of a paper presented at the Atlanta meeting of the American Physical Society, December 30, 1913.