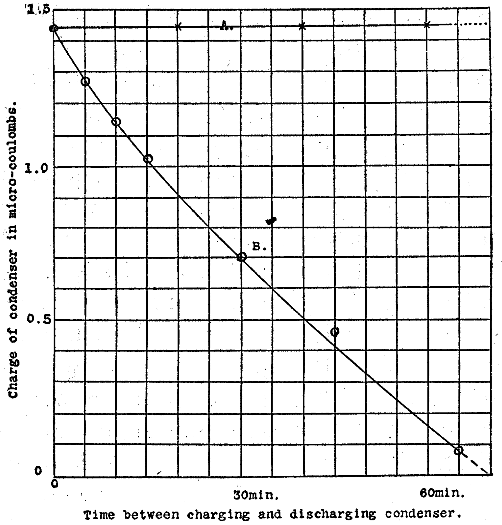
'Inferences from Maxwell's theory concerning the motion of pure ether' (Wissenschaftliche Abhandl. B. III., p. 526, Wiedem. Am. Vol. LIII., p. 135–143).

M. I. Pupin.

Columbia University, April 2, 1896.

A METHOD OF DETERMINING THE RELATIVE TRANSPARENCY OF SUBSTANCES TO THE RÖNTGEN RAYS.

The fact that the Röntgen rays have the power of dissipating the charge of a perfectly insulated electrified body was established by Professor J. J. Thompson,* and furnishes us one of the simplest methods of detecting the rays. This effect is the basis of a very simple method of making quantitative measurements of the intensity of the radiation. If we take a condenser and allow the Röntgen rays to fall upon it, we shall find that there is a very considerable diminution in its insulation resistance, and that the charge of the condenser is gradually dissipated. This is illustrated by the



curves A and B in the accompanying figure. A was obtained under the ordinary conditions. B was obtained when the Crookes tube was in action, and placed about six inches from the wooden side of condenser. The curve A was determined before, and again immediately after the determination of B. The two determinations of A were identical, showing that the effect of the Röntgen ray on the insulation disappeared with the cessation of the ray. In making these measurements a Nalder micro-farad condenser was used, the condenser being charged with a standard Clark cell. It is evident, therefore, that it is possible to compare the transparency of different substances by allowing the rays to pass through screens made of the substances and placed between a Crookes tube and the condenser and measuring the resulting leakage of the condenser.

I am now engaged in making a series of measurements, using this method and a condenser especially constructed for the purpose, and hope to give the results in a subsequent number.

It would seem that the method is capable of giving results much more quantitative in character than any that can be obtained by photographic methods.

Wm. Lispenard Robb.

Trinity College, March 25, 1896.

*London Electrician, February 7, 1896.

AN APPARATUS FOR THE STUDY OF SOUND INTENSITIES.

The study of sound intensities presents many difficulties to the physicist as well as to the psychologist; the determination of the equality of loudness of two sounds, as well as of the law of relation between the physical cause and the sensational result is perhaps the most serious one. The facts that sounds must be estimated successively and should be of a constant intensity from beginning to end further complicate the problem. The method of the falling ball has been most frequently used; it consists in dropping a ball successively from two different heights and recording the minimum difference in height necessary to enable the observer to determine which fall gives rise to the louder sound. The objections to this method are many and obvious; it answers well enough for a demonstration, but not for exact research. A second method consists in moving an object producing a constant sound, such as a ticking watch, or a tuning fork, uniformly towards or away from the ear, and recording the minimum change in position, that enables the observer to determine whether the sound has grown louder or lower. This has advantages over the falling ball, but is far from satisfactory; and both are alike limited in the scope of their applicability. There is also an electrical apparatus, an audiometer, that is useful in determining the sensitiveness to minimal sounds, but is not so satisfactory for determining differential sensibility; the sound moreover is very artificial, difficult to listen to, and difficult to reproduce. A common defect of all the methods is the difficulty of determining by an objective test whether the sound produced by the apparatus on one occasion is really the same in intensity as in a succeeding trial.

It was in the attempt to secure a means of gradually increasing the intensity of a sound, just as the siren gradually changes the pitch, that I succeeded in devising a moderately satisfactory apparatus for this purpose. No apparatus can be regarded as completely satisfactory unless its operation depends upon a principle that clearly establishes the relation between the physical stimulus and the sensational result. Unfortunately the physicist is not as yet ready to define and measure the various factors contributing to the tones produced by the the apparatus about to be described. In the absence of such knowledge the apparatus can be proposed only as an empirical solution of certain phases of the study of sound intensities. The apparatus makes use of the principle of the singing flame. A singing flame consists of a very fine jet of gas, burning through an aperture of about one millimetre, under a long, narrow glass tube; the pitch of the resulting tone varies in an inverse sense with the size of the tube. (For details see Tyndall, *Sound*, Lecture VI.) The sound is due to the vertical vibrations of the flame, the pitch being determined by their frequency and the intensity by their amplitude. The amplitude, however, can be directly observed; the flame is first turned down until the sound just ceases to be heard, and this point is noted on a millimetre scale placed in back of the flame; when the flame is turned up to any given point the intensity of the resulting sound is clearly marked by the amplitude of the flame, as determined by the height of the flame above the zero point just described.

The other requisite of the problem is a means of delicately regulating the flow of gas and thus the intensity of the sound. This was accomplished as follows: An ordinary steam valve was taken apart and the coarse thread adjustment replaced by a fine one ($\frac{1}{40}$ inch), at the same time giving the end of the pin a delicate taper; the handle of the valve was then firmly fixed to the center of a wheel ten inches in diameter; this larger wheel was moved by the friction of a smaller wheel one inch in diameter, having at its center an index moving over a dial eight inches in diameter. In this way a movement of the index along the circumference of the dial magnified about 100 times the change in the height of the flame. The height of the flame is first determined for a few points by sighting it through a lens, and the divisions of the dial are then made accordingly.

One further difficulty remained, namely, to secure a constant pressure of gas. This was accomplished with sufficient accuracy by forcing the air out of a bell jar (fitted with a gas cock at its neck) by immersing it in water, and then filling it with illuminating gas from the city supply. The movement of the bell jar as it descended into the water, and thus forced the gas to the flame, was carefully guided and the weight of the glass jar itself exerted a sufficient pressure. The apparatus is extremely sensitive and must be kept free from vibrations and draughts of air.

The use of the apparatus in the experiments for which it was designed is to determine the minimum change in the amplitude, the nature of which, *i. e.*, whether an increase or decrease of intensity can be detected. A sound of an agreeable intensity (and determined by a constant height of the flame) is taken as a starting point, and the subject informed that this sound will very gradually increase or decrease in loudness; he listens carefully with his head in a fixed position and answers as soon as he is confident of the direction of the change. The operator slowly moves the index in one direction or the other, takes the position when the answer is given and also the time of the experiment.

How far this apparatus will be serviceable for other methods of studying the sensibility to sound intensities is in some measure still to be determined. It may be noted, however, that it lends itself readily to determining absolute sensitiveness to sound; for one has only to note the minimum height of flame giving rise to a just audible sound with the head at a fixed distance from the apparatus. For the method of just observable difference one may have the flame sound, stop it, and sound it again with a slightly modified intensity until the difference between the two sounds becomes perceptible. For the method of right and wrong cases the same mode of use is available, except that the difference between the two sounds in any one series of experiments remains constant. By the method of the average error one should have two singing flames sounding alternately, the subject attempting to set one of them so that the sound it emits equals in intensity the standard sound. To all these applications there are as yet two objections: First, the sound does not begin immediately after the flame is allowed to play, but takes a considerable time to rise to its full intensity. The sound may be stopped instantly by suddenly lowering the flame, or placing a card at the top of the glass tube; but its inertia in starting introduces a disturbing factor. The second objection refers to the difficulty of constructing two such pieces of apparatus exactly alike, so that two flames vibrating with the same amplitude may be regarded as giving out sounds of equal intensity. Neither of these difficulties is insurmountable, and it is to be hoped that they will be solved as occasion demands.

In concluding, it may be well to indicate again that the success of the apparatus is due to the fact that the change in amplitude, and hence in intensity, can be directly observed; secondly, that the sound is fairly pure, of a definite pitch, agreeable and continuous; and thirdly, that it may be most delicately changed. All these advantages result from the use of the singing flame as a source of sound.

JOSEPH JASTROW.
UNIVERSITY OF WISCONSIN.

HOW NATURE REGULATES THE RAINS.

WHEN American enterprise invaded with its iron cavalry the mountain regions of the West, many established theories were put to new tests and not all sustained themselves. The relations of plant life to water supply as found on the eastern half of the Continent had led our fathers to believe that the destruction of forests would invariably and inevitably result in the depletion of adjacent streams and to all consequent evils. So potent is the thick shade