UPON A MODIFICATION OF WHEATSTONE'S MICROPHONE, AND ITS ADAPTABILITY TO RADIOPHONIC RESEARCHES.*

By Alex. Graham Bell.

In August, 1880, I directed attention to the fact that thin discs or diaphragms of various materials become sonorous when exposed to the action of an intermittent beam of sunlight, and I stated my belief that the sounds were due to molecular disturbances produced in the substance composing the diaphragm.[1] Shortly afterward, Lord Raleigh undertook a mathematical investigation of the subject, and came to the conclusion that the audible effects were caused by the bending of the plates under unequal heating.[2] This explanation has recently been called in question by Mr. Preece,[3] who has expressed the opinion that, although vibrations may be produced in the discs by the intermittent beam, such vibrations are not the cause of the sonorous effects observed. According to him the aerial disturbances that produce the sound arise spontaneously in the air itself by sudden expansion due to heat communicated from the diaphragm—every increase of heat giving rise to a fresh pulse of air. Mr. Preece was led to discard the theoretical explanation of Lord Raleigh on account of the failure of experiments undertaken to test the theory.

He was thus forced, by the supposed insufficiency of the explanation, to seek in some other direction the cause of the phenomenon observed, and, as a consequence, he adopted the ingenious hypothesis alluded to above. But the experiments which had proved unsuccessful in the hands of Mr. Preece, were perfectly successful when repeated in America under better conditions of experiment, and the supposed necessity for another hypothesis at once vanished. I have shown in a recent paper read

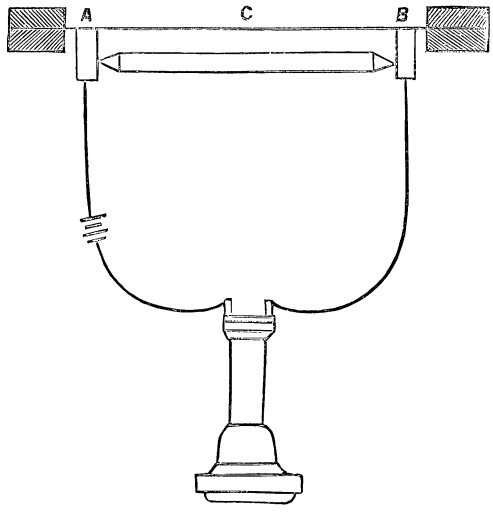

Fig. 1.

before the National Academy of Science[4] that audible sounds result from the expansion and contraction of the material exposed to the beam, and that a real to and fro vibration of the diaphragm occurs, capable of producing sonorous effects. It has occurred to me that Mr. Preece's failure to detect with a delicate microphone the sonorous vibrations, that were so easily obseerved in our experiments, might be explained upon the supposition that he had employed the ordinary form of Hughes' microphone shown in Fig. 1, and that the vibrating area was confined to the central portion of the disc. Under such circumstances it might easily happen that both the supports, *a b*, of the microphone might touch portions of the diaphragm which were practically at rest. It would, of course, be interesting to ascertain whether any such localization of the vibration as that supposed really occurred, and I have great pleasure in showing to you to-night the apparatus by means of which this point has been investigated.

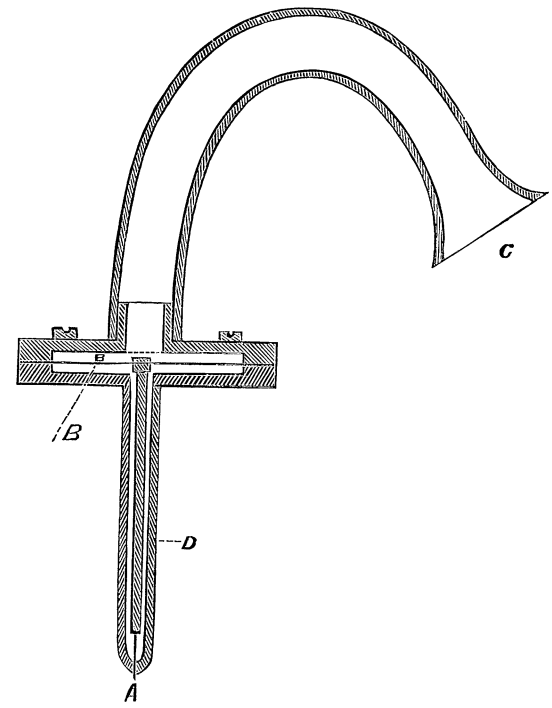

Fig. 2.

The instrument is a modification of the form of microphone devised in 1827 by the late Sir Charles Wheatstone, and it consists essentially of a stiff wire, *A*, one end of which is rigidly attached to the centre of a metallic diaphragm, *B*. In Wheatstone's original arrangement, the diaphragm was placed directly against the ear, and the free extremity of the wire was rested against some sounding body—like a watch. In the present arrangement, the diaphragm is clamped at the circumference like a telephone-diaphragm, and the sounds are conveyed to the ear through a rubber hearing-tube, *c*. The wire passes through the perforated handle, *D*, and is exposed only at the extremity. When the point *A* was rested against the centre of a diaphragm upon which was focussed an intermittent beam of sunlight, a clear, musical tone was perceived by applying the ear to the hearing-tube *c*. The surface of the diaphragm was then explored with the point of the microphone, and sounds were obtained in all parts of the illuminated area and in the corresponding area on the other side of the diaphragm. Outside of this area on both sides of the diaphragm, the sounds became weaker and weaker until, at a certain distance from the centre, they could no longer be perceived.

At the points where we would naturally place the supports of a Hughes' microphone (see Fig. 1) no sound was observed. We were also unable to detect any audible effects when the point of the microphone was rested against the support to which the diaphragm was attached. The negative results obtained in Europe by Mr. Preece may, therefore, be reconciled with the positive results obtained in America by Mr. Tainter and myself, A still more curious demonstration of localization of

* A paper read before the Philosophical Society of Washington, D. C. June 11, 1881.

[1] American Association for Advancement of Science, August 27, 1880.

[2] Nature, vol. xxiii., p. 274.

[3] Royal Society, March 10, 1881.

[4] April 21, 1881

vibration occurred in the case of a large metallic mass. An intermittent beam of sunlight was focussed upon a brass weight (1 kilogram), and the surface of the weight was then explored with the microphone shown in Fig. 2. A feeble but distinct sound was heard upon touching the surface within the illuminated area and for a short distance outside, but not in other parts.

In this experiment, as in the case of the thin diaphragm, absolute contact between the point of the microphone and the surface explored was necessary in order to obtain audible effects. Now, I do not mean to deny that sound waves may be originated in the manner suggested by Mr. Preece, but I think that our experiments have demonstrated that the kind of action described by Lord Raleigh actually occurs, and that it is sufficient to account for the audible effects observed.

ASTRONOMY.

On the 23rd ultimo, Mr. E. L. Larkin, a subscriber and contributor to this journal, telegraphed to Professor Swift, of Rochester, the discovery of a comet in the constellation of Auriga; but as others have since made the same claim, the priority of discovery awaits confirmation by those who dispense the pecuniary reward offered by Mr. Warner for all comets discovered during the present year.

We reserve until next week our report on this interesting celestial object, by which time our correspondents will have worked out the results of their observations, which have been delayed by atmospheric and other difficulties. The comet is now plainly visible, and American astronomers are on the alert to thoroughly examine it with all the appliances which modern science has placed at their command. At the date of our writing nothing reliable has been determined by actual observations, but some interesting facts, based on preliminary and partial observations, have been communicated, which, if accepted with reserve, pending final results, may be found useful to those directing their attention to the comet.

Professor Henry Draper is said to have made several successful photographs of the erratic stranger. Professor C. A. Young, of Princeton, has examined its spectrum, and reports that that of the nucleus was continuous, while that of the coma was sensibly coincident with the spectrum of the Bunsen burner flame. As seen directly in the 9½ inch equatorial, with eye-pieces of the lowest power, on the evening of the 26th, the nucleus was small and bright, with five bright jets of unequal length projecting from it a short distance. The tail showed three maxima of brightness, of which the brightest was near the axis, and was quite convex in the direction of increasing right ascension. On the 26th he states the spectrum was about the same, but the nucleus, instead of showing jets as before, was nearly surrounded by an envelope.

Professor Boss of the Dudley Observatory determines the diameter of the nucleus to be seven seconds or 1500 miles, at an estimated distance of 45,000,000 of miles.

Professor Asaph Hall considers it most probable that the comet is identical with that discovered by Professor B. A. Gould at Buenos Ayres of the 1st of June. On the 26th ultimo an observation was made at the naval observatory, Washington, which indicated "the position of the comet at its lowest culmination, obtained with the transit circle, was at 11 h. 27. P. M., Right ascension 5 h., 48 m., 384-100 s., North declination, 57 deg., 40 m., 52 sec.

THE LUNAR ECLIPSE.—The eclipse of the moon on June 11 was seen under favorable conditions at the Naval Observatory, Washington. The only observations of importance were observations of occultation of B. A. C. 5862, and two faint stars during the eclipse.

THE OHM.

A British Association committee has been reappointed for the remeasurement of the Ohm, and of other units. It is not to their work, however, that we wish now to draw attention, but rather to a good stroke in the right direction, done in the Cavendish laboratory by Lord Rayleigh with the assistance of Dr. Schuster and others. The old British Association apparatus has been fitted up again, with such improvements as the criticism of nearly twenty years has suggested. It will be remembered that this is the only method in which the measurement of transient currents by ballistic galvanometers is not employed. A circular coil of insulated wire forming a closed circuit rotates about a vertical axis, and the electrical current induced in it by the earth's magnetism gives a steady deflection to a magnetic needle at its centre. The manifold precautions, calculations and corrections which have to be entered into by the experimenters are given by Professor Fleeming Jenkin and others. One important correction is that which is due to the self-induction of the coil which retards the current, and a most important fact has been brought to light by Lord Rayleigh, namely, that this self-induction is considerably greater than it was thought to be by the original committee. Professor Rowland, assuming that an unknown error existed proportional to the square of the speed of the rotation, has found that the original experiments of the committee lead to the result that the Ohm is 0.74 per cent. smaller than it was intended to be, and his own experiments lead to its being 0.89 smaller. Kohlrausch found it nearly 2 per cent. too great, and Weber thought it correct. The Cavendish laboratory experiments lead to its being 1.05 per cent. too small, and the elaborate paper to the Royal Society in which this result is given promises a redetermination with new apparatus on the same principle. In making the present determination a new method of suspension of the needle, a stroboscopic method of measurement of the speed—the old governor and the tinkling bell being discarded—and driving the coil by means of a water turbine instead of by hand, are some of the improvements which have been introduced.

It is to be remembered that no re-measurement of the Ohm can ever effect our use of it as a standard. It is no longer to be regarded as exactly equal to one thousand million C. G. S. units, but this is of no more consequence than the fact that one gramme is no longer regarded as being exactly equal to the mass of a cubic centimetre of water at 4° C.—*The Electrician.*

ALCOHOL IN WATER AND AIR.

An interesting discovery has been brought before the Academy of Sciences by M. Muntz, Chief of the laboratories belonging to the Agricultural Institute. He has found that alcohol is distributed throughout the universe, in the sun, air, water of the ocean and streams. It is a known fact that fermentation is a general phenomena in air, water and earth; This fermentation gives off CO^2, and as a necessary consequence, alcohol. This is what the experiments of M. Muntz have demonstrated; he has been able to prove the presence of alcohol in water, etc., by reducing the alcohol to an *iodoform* state by means of iodate and carbonate of soda. The precipitate which is obtained even in the presence of a millionth quantity of alcohol, affects the crystalline form of the snow examined under the microscope. The alcohol is produced in earth containing organic matter in decomposition, and hence it extends into the waters of streams, and into the atmosphere. Still, the portions are so infinitesimal that a water-drinker will never feel himself "alcoholized;" the dose of alcohol contained in a cubic metre of water (1000 litres), being at the most a gramme.—

ELASTIC RESTORATION OF CAOUTCHOUC.—Objects made of this substance easily lose their elasticity. Dr. Pol, however, avers that their elasticity may be restored by plunging them for an hour into a mixture composed of 2 parts of water and 1 part of ordinary ammoniac.