cone having a thin india-rubber membrane stretched over its narrow end. A small metal disk was attached to the centre of the membrane and connected to earth by a fine wire. A metal contact-piece adjustable by a screw could be made to just touch a point at the centre of the disk. When contact was made it completed an electric circuit which passed to a recording station, and there, by means of an electro-magnet, actuated a style writing a record on a band of travelling smoked paper. On the same band a tuning-fork electrically maintained and a seconds clock actuating another style wrote parallel records. The circuit was continued to the gun which served as a source, and stretched across its muzzle. When the gun was fired, the circuit was broken, and the break was recorded on the paper. The circuit was at once remade. When the wave travelled to the receiver it pushed back the disk from the contact-piece, and this break, too, was recorded. The time between the breaks could be measured in seconds by the clock signals, and in fractions of a second by the tuning-fork record. The receiving apparatus had what we may term a personal equation, for the break of contact could only take place when the membrane travelled some finite distance, exceedingly small no doubt, from the contact-piece. But the apparatus was used in such a way that this could be neglected. In some experiments in which contact was made instead of broken, Regnault determined the personal equation of the apparatus.

To eliminate wind as far as possible reciprocal firing was adopted, the interval between the two firings being only a few seconds. The temperature of the air traversed and its humidity were observed, and the result was finally corrected to the velocity in dry air at 0° C. by means of equation (10).

Regnault used two different distances, viz. 1280 metres and 2445 metres, obtaining from the first Uo=331∙37 met./sec.; but the number of experiments over the longer distance was greater, and he appears to have put more confidence in the result from them, viz. U0=33o∙71 met./sec.

In the *Phil. Trans.,* 1872, 162, p. 1, is given an interesting deter­mination made by E. J. Stone at the Cape of Good Hope. In this experiment the personal equations of the observers were deter­mined and allowed for.

*Velocity of Sound in Air and other Gases in Pipes.—*In the memoir cited above Regnault gives an account of determinations of the velocity in air in pipes of great length and of diameters ranging from 0∙108 metres to ι∙ι metres. He used various sources and the method of electric registration. He found that in all cases the velocity decreased with a diameter. The sound travelled to and fro in the pipes several times before the signals died away, and he found that the velocity decreased with the intensity, tending to a limit for very feeble sounds, the limit being the same whatever the source. This limit for a diameter ι∙ι m. was U0=33o∙6 met./sec., while for a diameter 0∙108 it was U0=324∙25 met./sec.

Regnault also set up a shorter length of pipes of diameter 0∙108 m. in a court at the College de France, and with this length he could use dry air, vary the pressure, and fill with other gases. He found that within wide limits the velocity was inde­pendent of the pressure, thus confirming the theory. Com­paring the velocities of sound Ui and U2 in two different gases with densities pi and ρ2 at the same temperature and pressure, and with ratios of specific heats 7b 72, theory gives

U1∕U2 = √ {γ1p2∕72p1 J∙

This formula was very nearly confirmed for hydrogen, carbon dioxide and nitrous oxide.

J. Violle and T. Vautier *(Ann. chim. phys.t* 1890, vol. 19) made observations with a tube 0∙7 m. in diameter, and, using Regnault’s apparatus, found that the velocity could be represented by

33\*∙3(ι+C√P),

where P is the mean excess of pressure above the normal. According to von Helmholtz and Kirchhoff the velocity in a tube should be less than that in free air by a quantity depending on the diameter of the tube, the frequency of the note used, and the viscosity of the gas (Rayleigh, *Sound,* vol. ii. §§ 347-8). Correcting the velocity obtained in the 0∙7 m. tube by Kirch­hoff’s formula, Violle and Vautier found for the velocity in open air at oo C.

U0 = 331∙ιo met./sec.

with a probable error estimated at =fc o∙ιo metre.

It is obvious from the various experiments that the velocity of sound in dry air at oo C. is not yet known with very great accuracy. At present we cannot assign a more exact value than

Uo = 331 metres per second.

Violle and Vautier made some later experiments on the propagation of musical sounds in a tunnel 3 metres in diameter *(Ann. chim. phys.,* τ905, vol. 5). They found that the velocity of propagation of different musical sounds was the same. Some curious effects were observed in the formation of har­monics in the rear of the primary tone used. These have yet to find an explanation.

*Velocity of Sound in Water.—*The velocity in water was measured by J. D. Coliadon and J. K. F. Sturm *(Ann. chim. phys.,* 1827 (2), 36, p. 236) in the water of Lake Geneva. A bell under water was struck, and at the same instant some gunpowder was flashed in air above the bell. At a station more than 13 kilometres away a sort of big ear-trumpet, closed by a mem­brane, was placed with the membrane under water, the tube rising above the surface. An observer with his ear to the tube noted the interval between the arrival of flash and sound. The velocity deduced at 8∙ιo C. was U=1435 met./sec., agreeing very closely with the value calculated from the formula U2 = E∕p.

Experiments on the velocity of sound in iron bave been made on lengths of iron piping by J. B. Biot, and on telegraph wires by Wertheim and Brequet. The experiments were not satis­factory, and it is sufficient to say that the results accorded roughly with the value given by theory.

*Reflection of Sound.*

When a wave of sound meets a surface separating two media it is in part reflected, travelling back from the surface into the first medium again with the velocity with which it approached. Echo is a familiar example of this. The laws of reflection of sound are identical with those of the reflection of light, viz. (1) the planes of incidence and reflection are coincident, and (2) the angles of incidence and reflection are equal. Experiments may be made with plane and curved mirrors to verify these laws, but it is necessary to use short waves, in order to diminish diffraction effects. For instance, a ticking watch may be put at the focus of a large concave metallic mirror, which sends a parallel u beam ” of sound to a second concave mirror facing the first. If an ear-trumpet is placed at the focus of the second mirror the ticking may be heard easily, though it is quite inaud­ible by direct waves. Or it may be revealed by placing a sensitive flame of the kind described below with its nozzle at the focus. The flame jumps down at every tick.

Examples of reflection of sound in buildings are only too frequent. In large halls the words of a speaker are echoed or reflected from flat walls or roof or floor; and these reflected sounds follow the direct sounds at such an interval that syllables and words overlap, to the confusion of the speech and the annoyance of the audience.

Some curious examples of echo are given in Herschel’s article on tt Sound ” in the *Encyclopaedia Metropolitana,* but it appears that he is in error in one case. He states that in the whispering gallery in St Paul’s, London, “ the faintest sound is faithfully conveyed from one side to the other of the dome but is not heard at any intermediate point.” In some domes, for instance in a dome at the university of Birmingham, a sound from one end of a diameter is heard very much more loudly quite close to the other end of the diameter than elsewhere, but in St Paul’s Lord Rayleigh found that “ the abnormal loudness with which a whisper is heard is not confined to the position diametrically opposite to that occupied by the whisperer, and therefore, it would appear, does not depend materially upon the symmetry