these latter cases a part of the current produced by the external electro-motive force must be considered as caused by electrolytic convection, and this part vanishes very slowly and never completely.

The quantity of electricity which was carried to the platinum electrodes when they were free of hydrogen, was exactly proportional to the electro-motive force applied to the cell, down to forces of $\frac{1}{1000}$ Daniell. From this is to be inferred that no kind of chemical or molecular force exists in the interior of the electrolytic fluid, which is able to prevent the ions of the electrolyte from moving about in the interior of the fluid, till they have got the distribution required for the equilibrium of the electric forces. For if such a force existed, we ought to find an inferior limit to the electro-motive forces, which are able to charge the electrodes like a condenser.

2. On the Average Pressure due to Impulse of Vortex Rings on a Solid. By Sir William Thomson.

3. On the Crushing of Glass by Pressure. By Professor Tait.

In the course of my examination of the "Challenger" thermometers, I was once surprised by a sudden bell-like vibration of the massive iron cylinder (nine inches thick) in which the apparatus to be tested was enclosed. This was due to the giving way of the protecting-sheath of one of the thermometers, at a pressure of a little over four tons weight on the square inch. When the pressure was let off, the bulb of the thermometer was found to have been crushed to an almost impalpable powder. I then determined to make a set of experiments with the view of finding under what amount of distortion glass gives way. For this purpose I employed the smaller compression apparatus which I have already described to the Society. Its capacity is about ten cubic inches only, so that a couple of strokes of the pump produce a pressure of three to four tons weight.

I procured a number of pieces of glass tubing, with very varied ratios of external and internal diameter. These were all drawn from the same melting in the Leith Glass-works, and consisted of ordinary lead-glass.

By means of a small telescope, with a micrometer scale in the eye end, the ratio of the internal and external radii was measured for each end of each tube. The tube was then cut into five, seven, or nine lengths, and these were numbered (in order) by marked slips of paper inserted into them. They were then carefully and strongly sealed at each end, a small quantity of shot being put into each to make them sink in water.

By means of the external gauge I have already described to the Society, the pressure at which Nos. 1, 3, 5, &c., gave way was measured, and it was found that when the tube from which they were cut was stronger at one end than at the other, the breaking pressures for the separate pieces were in the proper *order* of magnitude. The results were, as was to be expected, not very accordant; but, as a fair average result, the common lead glass gives way when subjected to a shear of about $1 \pm \frac{1}{230}$

(combined with a compression of about $\frac{1}{600}$ in every direction).

Hence a very thick tube of such glass will not resist more than about 14 tons weight on the square inch of external pressure.

The formulæ from which this was calculated are given in my paper of May 17, 1880 (Proc., vol. x. p. 572). They give, for a pressure of one ton weight per square inch, the following for the innermost layer of a cylindrical tube of external and internal radii a_1 and a_0 :—

$$\text{Radial compression} = \frac{a_1^2}{a_1^2 - a_0^2} \left(\frac{1}{8100} - \frac{1}{3200} \right),$$

$$\text{Tangential} = \frac{a_1^2}{a_1^2 - a_0^2} \left(\frac{1}{8100} + \frac{1}{3200} \right),$$

$$\text{Longitudinal} = \frac{a_1^2}{a_1^2 - a_0^2} \frac{1}{8100}.$$

The first terms of these expressions indicate a uniform compression, the other terms the crushing shear. [It is curious to note that this compression is *less* (for the same pressure) in a solid rod ($a_0 = 0$) where there is no shear, than in a tube.]

The walls of these tubes, when they gave way, were crushed into fine powder, which gave a milky appearance to the water in the compression apparatus. But the fragments of the ends were larger,

and gave much annoyance by preventing the valves of the apparatus from closing. To remedy this inconvenience I enclosed the glass tube in a tube of stout brass, closed at the bottom only, but was surprised to find that it was crushed almost flat on the first trial. This was evidently due to the fact that water is compressible, and therefore the relaxation of pressure (produced by the breaking of the glass tube) takes time to travel from the inside to the outside of the brass tube; so that for about $\frac{1}{10000}$ th of a second that tube was exposed to a pressure of four or five tons weight per square inch on its outer surface, and no pressure on the inner. The impulsive pressure on the bottom of the tube projected it upwards, so that it stuck in the tallow which fills the hollow of the steel-plug. Even a piece of gun-barrel, which I substituted for the brass tube, was cracked, and an iron disc, tightly screwed into the bottom of it to close it, was blown in. I have since used a portion of a thicker gun-barrel, and have had the end welded in. But I feel sure that an impulsive pressure of ten or twelve tons weight would seriously damage even this. These remarks seem to be of some interest on several grounds, for they not only explain the crushing of the open copper cases of those of the "Challenger" thermometers which gave way at the bottom of the sea, but they also give a hint explanatory of the very remarkable effects of dynamite and other explosives when fired in the open air. [It is easy to see that, *ceteris paribus*, the effects of this impulsive pressure will be greater in a large apparatus than in a small one.]

4. On the Cause of the Sounds produced in the Microphone Receiver. By Professor James Blyth.

In the microphone, or loose contact receiver, we have two or more small blocks of carbon resting lightly against each other, through which the interrupted current from the transmitter is passed. At the points of contact, a strong heating and cooling effect must take place every time the current is interrupted or otherwise varied. This heating and cooling will cause corresponding expansions and contractions of the air or other medium surrounding the points. These produce undulations in the medium, which, striking against the sides of the containing vessel, set them