(ii) The use of a standard coil with a single layer of wire, the coefficient of mutual induction of the coil and circumference of the disc being calculated by a formula obtained by the direct integration of the expression

$$\iint \frac{ds\ ds}{r} \cos \epsilon$$

for a circle and coaxial helix.

(iii) The use of a new form of contact brush at the disc circumference, which procures greatly increased steadiness in the galvanometer needle.

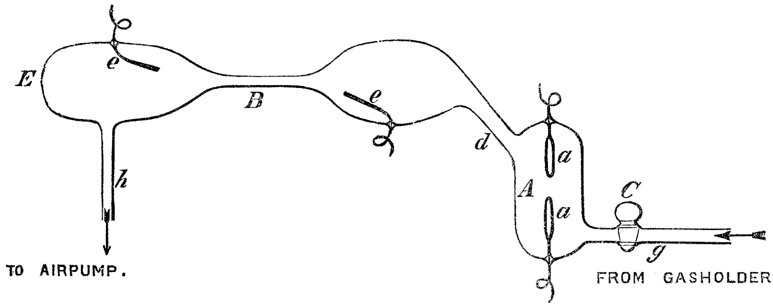
The brush consists of a single wire of phosphor bronze, perforated by a channel through which a continuous flow of mercury is maintained from a cistern of adjustable height.

Incidentally, a description is given of an accurate method of measuring the vibration frequency of a standard tuning-fork by means of a Bain's electrochemical telegraph receiver.

In conclusion, suggestions are made towards a new determination of the ohm that shall be final for the practical purposes of the electrical engineer.

II. "The Spectroscopic Properties of Dust." By G. D. Liveing, M.A., F.R.S., Professor of Chemistry, and J. Dewar, M.A., F.R.S., Jacksonian Professor, University of Cambridge. Received August 16, 1890.

The suggestion that the auroral spectrum, the principal ray in the spectrum of nebulæ, and other rays of unknown origin, might be due to meteoric dust induced us to investigate the problem whether solid particles of sufficient minuteness would act like gaseous molecules in an electric discharge and become luminous with their characteristic special radiation. The dust we employed was that thrown off from the surface of various electrodes by a disruptive discharge, and it was carried forward into the tube of observation by a more or less rapid current of air or other gas. The arrangement will be best understood from the annexed diagram, which represents a section of the glass vessel which was the principal part of the apparatus. A represents a bulb in which were the electrodes a, a to give the dust, connected by a widish tube d with the tube for observation B. The end E was blown clear, so that the narrow part of B could be observed end-on. The electrodes e, e were of platinum. The tube g, passing from A to the supply of gas, was fitted with a glass stopcock



C for regulating the intake, and the tube *h* led from the distant end of *B* to the air-pump. The air-pump was a large one worked by a gas-engine capable of keeping the pressure down to a few millimetres, even with a considerable leakage. Observations were made of the discharge in *B* at various low pressures, sometimes with, and at other times without, a Leyden jar in circuit. The sparks in *A* were generally taken with a jar, and there was ample proof, if proof were needed, of the dust derived from the electrodes, since it formed a visible deposit in the tube *d*, in the first bulb of *B*, and even on the end *E*. The air or other gas passed into *A* was filtered through cotton-wool to remove all dust before admission to the apparatus.

Various metals were used as electrodes in *A*, magnesium, iron, manganese, cadmium, fused calcium chloride, metallic sodium in a little glass cup on a platinum wire, and fragments of the Dhurmsala meteorite; but in no case could the rays of any of the substances employed be seen in the discharge through *B*, either when a Leyden jar was in circuit or not.

Incidentally, we found that magnesium electrodes were not so good as some of the other metals for these experiments, because the apparatus was never wholly free from traces of air, and lines or bright edges of bands of nitrogen fall very near the most characteristic lines of magnesium, and with small dispersion might easily be mistaken for them.

Air, hydrogen, carbon dioxide, and oxygen, were successively used as the gases passing through the apparatus, and at various pressures from 2 mm. up to 20, and, in some cases, up to 40 mm., but with the same result; no rays, due to the electrodes in *A*, could be detected in *B*. Even when one of the electrodes in *A* was sodium, and the sodium rays, orange, yellow, citron, green, and blue, were brilliant in the spectrum of *A*, not even the D lines could be detected in *B*. We should have expected that some traces of sodium *in the state of vapour* would have been carried by the stream of hydrogen into *B*; but it seems that it was not so; nor could the apparent absence of rays

due to the dust, be ascribed to mere faintness in their light, for we took photographs of the spectrum of *B*, and found that even lengthened exposures produced no evidence of rays due to the dust; nor could it be ascribed to the character of the discharge in *B*, for the discharge was varied; sometimes *A* and *B* were in the same circuit; sometimes the discharge in *B* was from a separate coil, and even the powerful discharge from a large coil stimulated by a De Meritens' magneto-electric machine, was tried.

That abundance of dust was formed by the sparking in *A* was proved not only by the deposit in the tube, but by allowing the stream of gas at atmospheric pressure from the tube *h* (of course disconnected from the pump) to impinge on a flame, when the characteristic flame-spectrum of the electrodes in *A* was at once manifest. When the gas used was hydrogen, and it was burnt in oxygen, the spectrum of the electrodes was particularly well seen; also when the gas was oxygen and led into a hydrogen flame.

That the dust was of extreme fineness and capable of being carried by a stream of gas to a great distance was proved as follows:—A stream of hydrogen, at ordinary pressure, was passed through the sparking tube with magnesium electrodes, and then through more than 100 feet of metal tube in a coil, and, finally, burnt as it issued. Before the sparking began there were no signs of magnesium in the flame; but when sparks had been passing between the magnesium electrodes for a short time, the magnesium spectrum was seen in the flame. It took 55 seconds for the gas to carry the dust through the long pipe, and when the sparking ceased it was again about the same time before the magnesium disappeared from the flame. It always appeared and disappeared sharply in correspondence with the sparking. Similar experiments, but with a shorter tube, were made with other metals, iron, sodium, lithium, &c., always with like results; also a current of oxygen was passed through the sparking tube and into a flame of hydrogen, and produced similar effects. Even aluminium, which does not usually show any part of its spectrum when used as an electrode in a vacuous tube, gave, when sparked in oxygen, dust which, when carried into a hydrogen flame, showed the characteristic bands of alumina.

Considering that a sensible amount of dust was deposited in the bulbs of *B*, we should have expected that some would be deposited on the electrodes *e*, *e* in that tube, and that the discharge from electrodes so coated would give the spectrum of the metal on their surface. There is no doubt that when no discharge was taking place in *B* the electrodes *e*, *e* did receive their share of dust; and, if it had been allowed to accumulate so as to form a coherent crust, it would have given its characteristic spectrum on first passing sparks in *B*. But, so long as the dust is loose, the passage of a discharge instantly clears

the electrodes of all dust, and seems to dispel all dust from the gas through which the discharge occurs. It is well known that an electric discharge in a vessel of air has the effect of clearing out of the air all the particles that serve as nuclei for the condensation of water; and we made several experiments with a view to determine whether a similar effect was produced on the dust in our tubes. The gas from the sparking tube was carried through a glass globe, and so on to the jet where it was burned; a wire connected with one pole of a Voss or Wimshurst electric machine projected into the interior of the globe, and a patch of tinfoil on the outside of the globe was connected with the other pole of the electric machine. So long as the Voss machine was not worked, the gas carried the dust from the sparking tube through the globe, and it was seen in the spectrum of the flame, or simply in the colour of the flame when lithium was one of the electrodes; but, on working the machine so as to produce a silent discharge inside the globe, the flame, in one or two seconds, suddenly ceased to show the spectrum of the dust, and in the case of the lithium lost its red colour. When the machine was no longer worked, the spectrum or colour speedily reappeared, to vanish again suddenly when the machine was started afresh. When a narrow tube, with a piece of tinfoil outside and a wire inside, was substituted for the globe, the like results ensued.

It appears, then, not only that dust, however fine, suspended in a gas will not act like gaseous matter in becoming luminous with its characteristic spectrum in an electric discharge, but that it is driven with extraordinary rapidity out of the course of the discharge. If, then, the spectrum of the aurora be due, not to the ordinary constituents of our atmosphere, but to adventitious matter from planetary space, we conclude that such matter must be in, or must be brought into, the gaseous state, or at least have its properties entirely altered from those it possesses at ordinary temperatures, before it becomes luminous in the electric discharge.

III. "On the Specific Heats of Gases at Constant Volume. Part I. Air, Carbon Dioxide, and Hydrogen." By J. Joly, M.A., B.E., Assistant to the Professor of Civil Engineering, Trinity College, Dublin. Communicated by Professor FitzGerald, M.A., F.R.S., F.T.C.D. Received September 2, 1890.

(Abstract.)

In this first notice the specific heats, at constant volumes, of air, carbon dioxide, and hydrogen are treated over pressures ranging from 7 to 25 atmospheres. The range of temperature is not sensibly