Apparatus for Measurement of Low Pressures of Gas

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of ff'. The rod l is adjusted so that the wires of $m\,m'$ just touch the mercury; and by the levelling-screws k is so swung that m and f, and also m' and f', are exactly opposite to one another and the wires in the centres of the mercury-cups. A slit of light is then sent through w, reflected on to a screen, and the head o is then turned till the slit is split by an arbitrary vertical line on the screen. The reading of p is then noted. A current passing through the system forces $m\,m'$ away from ff'. Turn the head o until the slit of light is again brought to the mark on the screen. The angle through which it must be turned is directly proportional to the magneto-repulsion—that is, to the square of the current-strength. Many of the laws of electrodynamics may be readily illustrated by this instrument; and not only may different currents be compared with the greatest accuracy, but the absolute mechanical magneto-value of the current may be at once arrived at. By bringing the repellent magnets always to the same distance from one another, a whole class of sources of error is removed.

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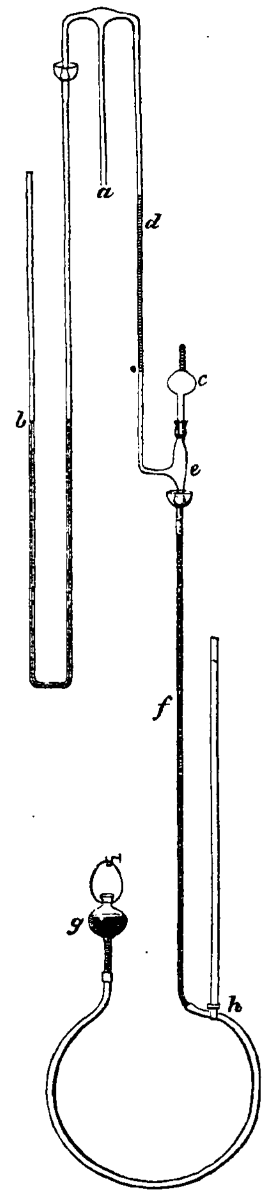
VIII. *Apparatus for Measurement of Low Pressures of Gas. By* Professor M'Leod, *Indian Civil-Engineering College, Cooper's Hill.*

This apparatus was devised for estimating the pressure of a gas when its tension is so low that the indications of the barometer cannot safely be relied on, unless indeed a very wide barometer and an accurate cathetometer be employed. The method consists in condensing a known volume of the gas into a smaller space and measuring its tension under the new conditions.

The form of the apparatus is the following:—The tube a communicates with the Sprengel, and with the apparatus to be exhausted; b is a siphon-barometer with a tube about 5 millimetres in diameter; and the principal parts of the measuring-apparatus consist of c, a globe of about 48 cubic centims. capacity with the volume-tube at the top, and d the pressure-tube; these two are exactly of the same diameter, to avoid error from capillarity. The tube at the bottom of the globe is ground into a funnel-shaped portion at the top of the wide tube e; and to the side of the latter the pressure-tube d is joined. The volume-tube at the top of the globe is graduated in millimetres from above downwards, the lowest division in this particular apparatus being 45; the pressure-tube *d* is also graduated in millimetres, the 0 being placed at the level of the 45th division on the volume-tube. A ball-and-socket joint connects the bottom of *e* with a vertical tube *f* about 800 millims. long, which is connected at its lower extremity by means of a flexible tube with the mercury-reservoir *g*; a stopcock at *h* permits the regulation of the flow of mercury into the apparatus: this may be conveniently turned by a rod, so that the operator may watch the rise of the mercury through a telescope and have the stopcock at the same time at command.



The volume-tube was calibrated in the usual way, by introducing weighed quantities of mercury into it, and making the necessary corrections for the meniscus. The capacity of the volume-tube, the globe, and upper part of the tube *e* was determined by inverting the apparatus and introducing mercury through *e* until the mercury flowed down the pressure-tube; the weight of this quantity of mercury, divided by the weight of that contained in the volume-tube, gives the ratio between the volumes; in the present case it is 1 to 54·495. While the apparatus is being exhausted, the reservoir *g* is lowered so as to prevent the mercury rising out of the tube *f*; but when it is desired to make a measurement of the pressure, the reservoir is raised and the mercury allowed to pass through the stopcock *h*. On the mercury rising into the tube *e* it cuts off the communication between the gas in the globe and that in the rest of the apparatus. Ultimately the whole of the gas in the globe is condensed into the volume-tube; and its tension is then found by measuring the difference of level between the columns of mercury in the volume- and pressure-tubes. On dividing this difference by the ratio between the capacities of the globe and volume-tube, a number is obtained which is approximately the original pressure of the gas; this number must now be added to the difference between the columns, since it is obvious that the column in the pressure-tube is depressed by the tension of the gas in the remaining part of the apparatus; on dividing this new number once more by the ratio between the volumes the exact original tension is found.

An example will best illustrate this. A quantity of gas was compressed into the volume-tube, and the flow of mercury was arrested when its surface reached the lowermost division on the tube. The volume was then $\frac{1}{54 \cdot 495}$ of its original volume, and the difference between the levels of the mercury in the volume- and pressure-tubes was 66·9 millims.; this number, divided by 54·495, gives 1·228 as the approximate pressure. 1·2 must therefore be added to the observed column, which thus becomes 68·1; and on dividing by 54·495, the number 1·2497 is obtained as the actual pressure.

The relations existing between the contents of the other divisions of the volume-tube and the total contents of the globe were determined by measuring the tensions of the same quantity of gas when compressed into the different volumes. By this means the values of the divisions 40, 35, 30, 25, 20, 15, 10, 9, 8, 7, 6, 5, 4, 3, and 2 have been found; the experimenter is thus enabled to employ a division suitable to the quantity of gas with which he has to deal. The smallest division contains only $\frac{1}{1492 \cdot 35}$ of the globe; consequently when a quantity of gas has been condensed into this space, its original tension will be multiplied 1492·35 times. In one case an amount of gas, which originally filled the globe, exhibited a pressure of only ·5 millim. when it had been compressed into the smallest division of the volume-tube; this indicates an original pressure of only ·00033 millim.

When measuring a tension, it is advisable to make two readings under different condensations, and to take the mean of the results. The following will give some notion of the precision attainable:—

I. At division 5 ·0225, „ 2 ·0235 } Mean ·0230.

Remeasured.

At division 5 ·0228, „ 2 ·0236 } Mean ·0232.

II. Barometer 0 millim.:—

At division 10 ·1985, „ 5 ·1980 } Mean ·1982.

Remeasured.

At division 10 ·1953, „ 5 ·1967 } Mean ·1960.

III. Barometer 0·6 millim.:—

At division 15 ·5488, „ 10 ·5488, „ 6 ·5501 } Mean ·5492.

Remeasured.

At division 15 ·5464, „ 10 ·5464, „ 6 ·5480 } Mean ·5469.

IV. Barometer 1 millim.:—

At division 20 1·2042, „ 15 1·2069 } Mean 1·2055.

Remeasured.

At division 20 1·2082, „ 15 1·2099 } Mean 1·2090.

V. Barometer 1·5 millim.:—

At division 30 1·9139, „ 25 1·9080 } Mean 1·9109.

Remeasured.

At division 30 1·9041, „ 25 1·9039 } Mean 1·9040.

VI. Barometer 2·1 millims.:—

At division 35 2·6017, „ 30 2·6073 } Mean 2·6045.

Remeasured.

At division 35 2·6160, „ 30 2·6220 } Mean 2·6190.

It may be mentioned incidentally that connexions for apparatus may be conveniently made by means of ball-and-socket joints of glass. The ball is made by thickening a piece of tube in the blowpipe-flame, and the socket by cutting in half a thick bulb blown on a glass tube. The ball is then ground into the socket by means of emery and solution of soda, and afterwards polished with rouge and soda solution. When slightly greased and with a small quantity of mercury in the cup, a joint is obtained which is perfectly air-tight and flexible*.

IX. *On a simple Arrangement by which the Coloured Rings of Uniaxial and Biaxial Crystals may be shown in a common Microscope. By* Dr. W. H. Stone.

The author was not aware that any arrangement had been hitherto supplied to the ordinary microscope other than an extra top to the eyepiece containing a supplementary stage and an analyzer. This could only be considered a clumsy expedient.

The objects to be obtained were clearly two :—first, to transmit the rays at considerable obliquity through the plate of crystal; secondly, to gather these up and form a real image within the tube of the microscope. Amici had accomplished this by a special combination of lenses which bears his name; it might, however, be done simply by placing a screwed diaphragm on the end of the upper draw-tube within the body of the microscope. The screw should be that ordinarily used for object-glasses. To this an object-glass of long focus was fitted, and another of higher magnifying-power in the usual place. The whole body was then drawn out and adjusted to a telescopic focus on a distant object. The lower objective formed the object-glass of the telescope, and the inner objective with the Huygenian eyepiece a compound ocular. On reinserting the

* Since the above was written Dr. Sprengel has pointed out that Mr. Hartley (Proc. Roy. Soc. vol. xx. p. 141) has described as a "Sprengel joint" a connexion between two glass tubes made by grinding a conical tube into a conical cup and placing mercury or water in the cup. The difference between this and the one above mentioned is obvious: the former is quite rigid, the latter perfectly flexible.