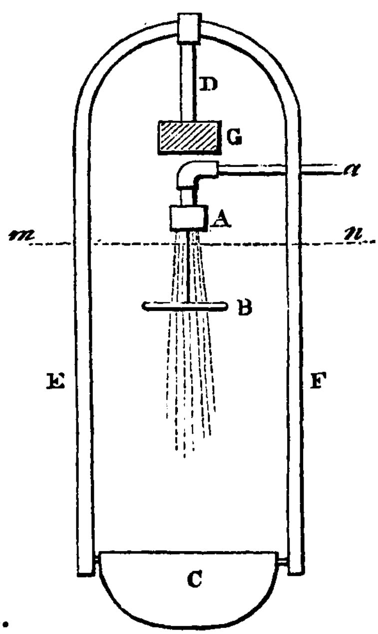
from the spilling of the acid. If the instrument is not moved, the acid, unless specially treated, may give off nitrous fumes which will corrode the surfaces of metal; or, if forgotten, it absorbs water and in time overflows, destroying the whole apparatus. Even if the air were saturated with moisture, rods of quartz would insulate as well as the lead-glass at present used does in air dried by sulphuric acid. The needle should of course be suspended by a fibre of quartz, which is far simpler to apply and adjust than the double line of silk, and superior also in other respects.

In conclusion I must express my obligations to Mr. Briscoe, a student in the laboratory, whose skill in the manipulation of gold leaf and whose suggestions from time to time have been of the greatest service. I have with perfect confidence asked him to carry out the experiments described in this paper, and the results show that the confidence was not misplaced.

XXI. *Water-spray Influence-Machine.* *By* George Fuller*.

This machine is for obtaining directly from a fall of water a supply of electricity of a high potential. It consists of four similar parts arranged symmetrically round a central vertical support, and each division has the following members.



A nozzle, A, in connexion with a head of water by means of a pipe, *a*.

A ring, B, of brass or copper wire placed vertically below A, and through which the water descends when the machine is in action.

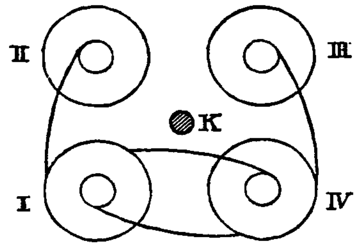
A vessel, C, placed below B to receive the water that has passed through the ring.

A brass tube, E F, between the ends of which the vessel C can turn about a horizontal axis.

* Read May 25, 1889.

An insulating glass rod, D, to the top of which the tube E F is attached, and with the lower end fixed in a part of the frame of the machine, G.

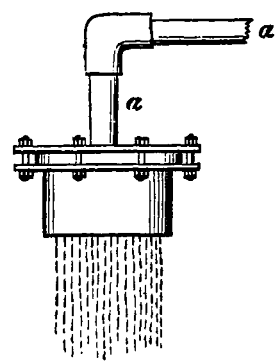
A sectional plan on *m n* shows the connexion between the four divisions, which are numbered I., II., III., IV. The wire ring of section I. is in electrical connexion with the receiver of section IV. Similarly the ring of II. is connected with I., the ring of III. with IV., and that of IV. with I.



K is a central column for supporting four arms of the machine to which are fixed the insulators D.

The discharge of electricity is taken between conductors in connexion with II. and III.

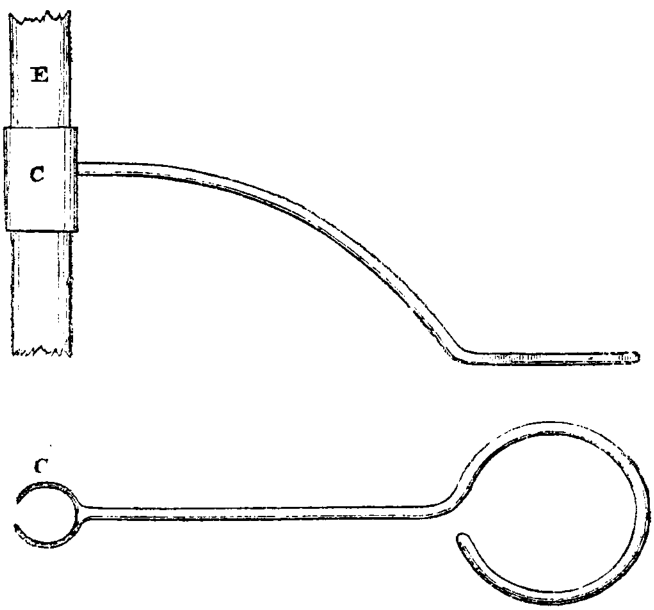
The nozzle is a flanged brass box, the bottom of which is perforated with small holes through which the water descends. It is fixed by a number of small bolts and nuts through its flange to a brass plate fixed to the supply-pipe, *a a*, and the joint is made watertight by a vulcanized india-rubber ring. A piece of fine linen covers the top of the box to strain the water before it reaches the small holes, as it was found that the water was either stopped or diverted by small particles unless this precaution was taken. The holes, which are circular, have a diameter of $\frac{1}{100}''$; as it was found that when holes $\frac{7}{1000}''$ were used the water was so much dispersed by the working of the machine that a great part of the water ceased to fall into the receivers. This great dispersion also injured the insulation, and besides this it was extremely difficult to keep these holes free.



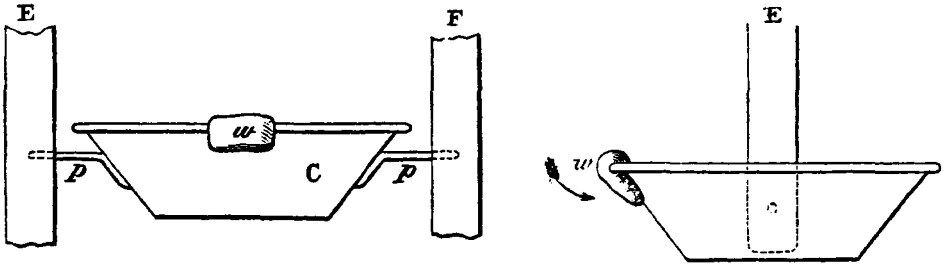
With regard to the number of holes. In the nozzles of sections I. and IV. there are six arranged in a circle of $1\frac{1}{4}''$ diameter. For those of sections II. and III., either a pair with twelve holes each in a circle of $1\frac{1}{4}''$ diameter, or with eighteen holes in a circle of $1\frac{3}{4}''$ diameter.

The rings are made of brass or copper wire of about $\frac{1}{8}''$ diameter. The inside diameter of the rings used with the nozzles with six and twelve holes is $2\frac{1}{4}''$, and with the eighteen holes $2\frac{3}{4}''$.

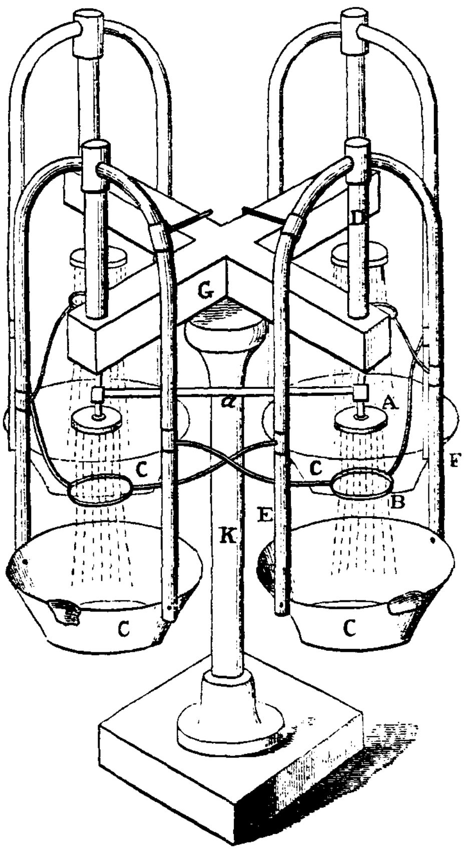
The wire of each ring is continued and fixed to a clip of split brass tube, C, which slides upon the brass tube E or F.



This enables the depth of the ring below the nozzle to be adjusted, which is of importance, as the greater the head of water employed the greater must be the distance between the two, as the ring should be fixed at the point where the small streams of water break up into spray. The receiving vessel, C, may be of glass or metal, as the former material, from its constant state of moisture whilst the machine is working, seems to conduct the electricity as effectually as the latter. In the author's model they were at first of glass, but one of them having been broken they were replaced by receivers of zinc. The receivers are supported by pins, *p*, *p*, which are soldered to them at one end, whilst their free ends rest in holes drilled in E and F. To make the receiver self-acting they are hung so that when a leaden weight, *w*, is fixed, as shown in sketch, the vessels being empty, they would turn in the direction of the arrow if they were not prevented by stops soldered to them which press against E and F; but when



the receivers are nearly full of water, their balance is such that they turn in the opposite direction and so empty themselves. The four receivers are made to turn towards the axis of the machine and to deliver the water into a metal bath, which for continuous action should be connected with a drain.



The following are some of the dimensions of the author's model :—

Zinc receivers 8″ diameter at the top.

Brass tube E and F $\frac{3}{8}$″ diameter.

Glass rod D $\frac{3}{4}$″ diameter, with an insulation of 4″.

From the rim of C to the lower surface of A, 9$\frac{1}{4}$″.

From the rim of C to the underside of stand, 1′ 1″.

From centre to centre of insulators D across the centre line of instrument, 1′ 1″.

The Electrical Action of the Machine.

An instrument made of only sections I. and IV., with their rings connected with their receivers, as shown above, will charge itself; and the difference of potential of the two receivers may be such that sparks $\frac{1}{2}$ inch long may occasionally pass between them, though more usually $\frac{3}{8}$ inch is the longest that can be obtained with a head of water of about 23 feet. With this arrangement, after every discharge the potential of the rings is nearly equalized; whereas in the machine with four sections, I. and IV. keep up the difference of potential of the rings of II. and III.

With respect to the action of the machine, the author, whilst giving the considerations from which it was constructed, must leave to the electrician to determine whether they have anything to do with the true explanation of the phenomena. The water, at the point where it is divided into drops by the resistance of the air, is electrified by induction from the rings; the former being in connexion with the earth through the unbroken water of the stream, and the action seems similar to that employed in Sir W. Thomson and Professor Silvanus Thompson's water-dropping accumulators. That such is the case appears to follow from the fact that, if the rings are either placed much above or much below the level where the water breaks into spray, the machine ceases to work. When the rings are at their proper level there is an additional action; for the particles that are inductively electrified are split up into numberless minute particles, some of which are so fine that they float about in the air and do not fall into the receiver. And it is this breaking up of the water into minute particles that the author thinks may account in part for the effect produced; for when a number of spheres that have been electrified unite into a mass of less surface, their potential in the latter state is higher than in the former.

Another point which the author thinks must be taken into consideration is the speed with which the particles move through the ring, as it was only when he experimented with a fall of some feet instead of inches that he obtained a potential high enough to produce sparks. With a very slow speed the attraction of the ring is too strong for the water, so that it at last, as in Sir William Thomson's apparatus, bends against it. That the division of the drops into minute spray plays a part in the action of the machine seems to be shown by the fact that sparks of the same length, in the same state of the atmosphere, have been obtained from it when the velocity of the water has been very much diminished. The sparks, as a rule, have not been so numerous per minute, but the water has been divided into finer spray. At times, even with half the delivery of water, the same length of spark has been obtained.

One experiment the author has made in which the spray was not obtained by the action of gravity, but by a steam "atomiser," as it is called. The water and steam passed through a copper wire ring $1\frac{1}{2}''$ diameter, connected with one of the receivers of an apparatus made up of sections I. and IV., as above. The nozzle was $\frac{5}{8}''$ from the ring and $5\frac{5}{8}''$ from the receiver. Sparks $\frac{1}{4}''$ in length were taken freely from the receiver, which is a better result than has been obtained with a fall of water of some 23 feet. What was very observable in this case was the very small amount of water used, a small teacup-full being passed over in some five or six minutes; and the author has recorded in his notes that the experiment was made on a very wet day.

Adding to the number of jets does not seem to increase the power of the machine, either in quantity or potential, at all in proportion to the number added; though the action of an electrical machine is so eccentric that it is difficult to be certain of this, for at times the nozzle with eighteen jets has given much better results than the one with twelve jets.

It has been stated that, in the machine as made, the rings are $1''$ larger in diameter than the circle of the jets, and it is found that they give a better result than when larger rings are used; but in some experiments with a small flow of water a ring $3\frac{1}{2}''$ diameter gave as large a spark as one of $1\frac{1}{2}$. In the dark, electricity is often seen to fly off from the rings, the water on them being made into pointed-shaped drops.

The machine in its present form is by no means powerful, as with a small Leyden jar attached to it the longest spark has hitherto been $1\frac{1}{8}''$, the head of water being about 23 feet. The state of the atmosphere has very great influence on the working of this machine; for though in all states of the weather electricity will be generated, it requires a fairly dry atmosphere to give $1''$ sparks.

It may be mentioned that the machine has only been tried in a small bath-room, which is a very unfavourable place for electrical experiments; and it perhaps is worth mentioning, that on one occasion sparks were only obtained when window and door were open and the machine was in a thorough draught.

To what extent the power of the machine may be increased it is difficult to predict; but the author thinks that the experiment with the atomiser points to high velocity in the water, combined with minute subdivision, as the direction in which any future attempts should be made.

Prof. S. P. Thompson enquired whether the length of the spark was limited by leakage along the glass rods or by the spray passing between the receivers, and in reply Mr. Fuller said he thought the former leakage the most important.

XXII. *On the Molecular Weight of Caoutchouc and other Colloid Bodies.* *By* J. H. Gladstone, *Ph.D., F.R.S., and* Walter Hibbert, *F.I.C.**

During the last meeting of the British Association at Bath, we gave a preliminary account of some attempts to determine the molecular weights of caoutchouc and a few other substances by Raoult's method. We have since repeated most of the experiments and largely extended the inquiry, and it seems to us that the results have a certain physical as well as chemical interest.

It is evident that this method is the only one that offers

* Read May 25, 1889.