and the two delivery valves, *d*, and by means of turning the cock 180 deg., and bringing the opening, *o*, to the one side or the other, the pumps are made to draw the water either through the pipe *q*, or the pipe *r*.

The pipes, *q* and *r*, are fastened to the box, K, which is cast, as will be seen from the engravings, in one piece, and to which is also fastened at the bottom the air vessel, whilst the delivery pipe is at the upper end of the box The plug of the cock, *g*, is pressed down in its place by means of the lever, *s*, which is provided at its end with an eccentric nose acting against the stay, *b*. This stay can be turned down (the screw bolts, by means of which it is fastened to the box, K, acting as pivots), and this being done, the barrel of the cock, *g*, with the valves, *d* and *e*, can be at once taken out, and easy access is obtained to all working parts of the pumps. It would, however, we think be an improvement to increase the height between the suction and delivery valves, and to raise the pump barrels, so that the latter might more readily clear themselves of any sand which might get into them. The parts above described, it will be noticed, are placed above the water tank, so that any leakage is found out at once The arrangement offers also great facilities for the cleaning of the valve, and for warming in case of freezing in of the water.—*Engineering*.

GRAMME'S MAGNETO-ELECTRIC MACHINE.

We illustrate on page 88 a magneto-electric machine, which is attracting a great deal attention not only from peculiarities in its construction but also from the important results anticipated from its use. The machine is described as follows by *Engineering*:

This novelty, which has quite astonished some of our leading men of science, is the magneto-electric apparatus invented by M Gramme of Paris. It will be remembered that in 1871 this gentleman succeeded in producing a machine which gave a continuous induced current. Since then, he has introduced several important modifications, which render his invention one of the most remarkable of the age.

From the time of Faraday's great discovery, devices of all kinds have been contrived for the conversion of mechanical work into proportionate electrical effects. It is interesting to examine these instruments, and to remark by what nice and gradual steps improvements succeeded one another, until the small contrivances of Pixii and Clarke gave way to the powerful machines of Nolet and Ladd. But ingenuity did not stop here; it has no "ultima Thule," and it was reserved for M Gramme to inaugurate a new era by a new application of a well-known principle. This he has done, and well done, as the apparatus now on view in the works of Messrs. Whieldon and Cooke abundantly proves.

In our issue of March 14th, we published three engravings which help to give a good technical idea of the Machine. Referring our readers to the engraving, we shall call the front view Fig. 1; the side view, Fig 2; and the horizontal section, Fig. 3 The uprights represented in Fig. 1 are cylinders of soft iron coiled round with insulated copper wire. There are six of these as shown in Fig. 2. They are 3 ft. 7 5-16 in. high and 3 5-16 in in diameter, and are connected at the upper end by a square plate of cast iron, and at the lower by a socketted base plate 31½ in. by 31½ in. When the machine is in operation, these cylinders become electro-magnets, and thus form an intense magnetic magazine. The broad circular disc (Fig. 1) is a bobbin of peculiar construction rotating between the poles of one of these electro-magnets. The poles extend over one third of its circumference. Two metallic brushes shown also in Fig. 1 are in contact with the arbor; they collect the current as it is generated, and transmit it to two large nuts, which serve as the terminals of the machine. One of the coils, the first on the left in Fig. 3, excites the electro-magnets; the other two, are connected together and produce the current to be utilised externally. The bobbin consists of a ring of soft iron, round which insulated copper wire is wound by lengths of about 10 yards. The contiguous ends of these lengths, represented by two radial lines in Fig. 1, are joined at the circumference of the ring to copper strips, which connect them with the same number of copper conductors, placed longitudinally on the arbor. These conductors are insulated from one another, and it is from them that the brushes collect the current. Thin wire is used when tension is required; and thick, when quantity.

We shall now turn from these descriptive details to the generation of the electric current. Faraday has shown that when a magnet is brought near a wire a current is induced in the latter, as shown by the deflection of a galvanometer, and that a current opposite in direction will be induced when the magnet is withdrawn, the continuance and tension of the current depending in both cases on the duration and velocity of the motion. The same effects may be rendered still more striking by inserting a bar of soft iron within the coil and alternately approaching and withdrawing a pole of a magnet. It thus appears that variations in the magnetic state of a bar are sufficient to induce corresponding currents in neighbouring conductors. Lenz has given a law by which the direction of these currents may be determined. It is plain the same results may be obtained by fixing the magnet and moving the wire-covered core. We may go further, and for the iron bar substitute an iron ring. Coiling our wire around this annular core and making it rotate uniformly near a magnet we shall obtain a uniform and continuous flow of electricity. Indeed, there is no interruption whatsoever, the currents are absolutely unintermittent. The idea of the ring belongs to M. Gramme; it is the characteristic feature of his machine. Its introduction marks an epoch in magneto-electricity. But in the Gramme machine there are no permanent magnets and no voltaic current is ever used; where, then, is the exciting source?

This is readily found in the very minute trace of magnetism induced in ordinary soft iron by terrestrial action, especially when, as in the present case, it is maintained in an upright or vertical position. It was such a Combination of circumstances, as we call a happy accident, that enabled M. Gramme to dispense entirely with the voltaic battery. In Wilde's, Siemens', and Wheatstone's, and other similar machines, it is usual, once for all, to send a current round the electro-magnets, the small amount of residual magnetism sufficing to work the machine on subsequent occasions. It appears that before M. Gramme had finished his battery arrangements the machine was set in motion by an assistant, and when he came to make connexion he found, to his great astonishment, the apparatus in perfect working order, and evolving a powerful current. This was a step beyond the simultaneous discovery of the reaction principle by Siemens and Wheatstone.

When the coils begin to rotate in presence of this infinitesimal power, a strong current is at once induced in the wires, which, in virtue of the rotation and consequent mutual reaction of the poles and coils so rapidly augments in strength that after a few seconds—almost an inappreciable period of time—the soft iron cylinders are converted into powerful electro-magnets, by the current of the left-hand bobbin (Fig. 3). The other two coils produce the current employed But the reader familiar with the machines of Holmes, Ladd and Wilde, may ask where is the commutator? To this pertinent question, we should answer there is none; and this is not one of the least interesting and important features of this beautiful invention. To illustrate the manner in which this sometimes troublesome appendage is dispensed with, let us consider the electrical state of one of the coils. The two adjacent poles develop, in the parts coming immediately under their influence, currents which flow in contrary directions in the opposite portions of the circuit. These currents are led, in the manner already explained, to the arbor of the apparatus, where they may be collected by suitable metallic pieces at the neutral points. In the present apparatus, this is effected by brushes of silvered copper wire held together by adjusting screws. It is obvious that the currents require no reversing as in other machines, and hence there is no necessity for a commutator. This is decidedly a great improvement, as is everything which simplifies mechanism without diminishing effective power. The rotation given to the coils is 350 revolutions per minute. The driving power required is from two and a half to three horse power. The current developed equals that of 525 large-size Bunsen cells.

The luminous and calorific effects are quite astonishing. A light has been obtained whose brilliancy was nearly equal to that of 1000 Carcel burners (5600 sperm candles); and a light equivalent to 900 burners was emitted during a series of experiments extending over several hours. The spectrum afforded by such intense illumination exhibited several interesting features in various lines never before observed. For lighthouse purposes, this machine has many advantages over that of the Alliance Company, generally employed. It takes up one-fourth the room, gives twice the light for the same expenditure of power, and for the same light is only half as