volve from left to right when N is the north end or south pole, and from right to left when N is the south end or north pole. Owing to the attraction of the fluid, the cylinder of zinc is often drawn to one side, and prevented from mov­ing; but this may be avoided by making the space Ac suffi­ciently wide. Mr Watkins has ingeniously applied this con­trivance to the poles of a horse-shoe magnet, as in fig. 60. It consists of a horse-shoe magnet AB, fixed to a stand SS. Above each pole is suspended a double cylindrical cop­per vessel, with a bent metallic wire fixed to the top of the inner cylinder, and a vertical wire pointed at each ex­tremity, fixed in the middle of the bent wire. The lower ends of the vertical wires of each cylinder rest in the holes at each pole of the magnet. Within the above double copper ves­sels are placed two hollow cylinders of zinc, having similar bent wires with holes in the lower side of each, in which holes the upper ends of the vertical wires are inserted. When the copper cylinder is filled with dilute acid, the vol­taic action begins, all the four cylinders revolving round their respective axes. The copper cylinders turn slowly and heavily, from their weight, in opposite directions to one another, and the zinc cylinders, with great velocity, in op­posite directions to the copper ones. Very delicate sus­pensions are necessary to ensure the rotation of the copper cylinders.

A very simple apparatus for show­ing the magnetic state of a single coil, is shown in fig. 61, where Z and C represent the elements of a small galvanic battery of one zinc and one copper plate attached to a cork which floats on dilute acid. Each plate is half an inch wide, and two inches long. A piece of copper wire W, with silk thread wrapped round it, is bent into a ring, one end of which is soldered to the zinc, and the other to the copper plate. An electric current now passes in the direction of the arrow, and the ring W becomes a flat magnet, having its poles in the centre of its two surfaces, the one being north and the other south. This floating magnet will, when acted upon by a real magnet, exhibit the usual magnetic attractions and repul­sions. Mr Marsh has improved this ap­paratus by doubling the copper plate, as in fig. 62, and converting it into a vessel for holding the dilute acid. The plates are then placed in a glass cylinder which may float in water.

A very beautiful apparatus for exhibiting helical rota­tions has been constructed by Mr Watkins, and is shown in fig. 63. A horse-shoe magnet, with its poles uppermost, is fixed upon a wooden box S. Two helices of copper, having slender bars across their summit, with needle or steel points in their centre, move in conical holes drilled in the poles of the magnet, with small platina cups to hold a small portion of mercury. The lower extremities of each helix terminate in steel points, which dip into the mercury in wooden cups below, screwed to the legs of the magnet. A wire likewise goes from the lower end of each cistern, and being bent upwards, terminates in a small cup with mercury. The brass rod R, fixed to the stand, carries a forked piece MN, the ends of which are two points which dip in the mer­cury in the platina cups. On the top of the coil, another mer­cury cup is placed on the fork MN ; and when the voltaic cur­rent is made to pass through the apparatus, the helical coils will revolve rapidly in op­posite directions, the directions changing with the disposition of the wires which connect them with the voltaic battery.

We have already mentioned the fine discovery of Μ. Arago, of the power of electrical currents to develope magnetism in iron and steel. Μ. Arago found that the uniting wire of a powerful voltaic battery attracts iron filings often with such force as to form a coating round the wire ten or twelve times thicker than itself. This attraction, as he found, did not originate in any magnetism previously possessed by the iron filings, which he ascertained would not adhere to iron ; and that it was not a case of common electri­cal attraction, was evident from the fact that copper and brass filings were not attracted by the uniting wire. Μ. Arago likewise found, that the iron filings began to rise be­fore they came in contact with the uniting wire, and hence he drew the conclusion, that the electric current converted each small piece of iron into a temporary magnet. In fol­lowing out this view, the French philosopher converted large pieces of iron into temporary magnets, and also small steel needles into permanent ones. Sir H. Davy and Dr Seebeck obtained analogous results without knowing what had been previously done in France. Μ. Savary of Paris obtained also some very important results relative to the magnetic action of the uniting wires at different distances, but we have already given a brief account of them, as well as of the experiments of Professor Erman, in our article, Electricity, vol. viii. p. 574.

The next step in the progress of discovery, was that of making magnets of extraordinary power by means of a vol­taic battery. This seems to have been first accomplished by Professor Moll of Utrecht and Professor Henry of Princetown College, who was able to lift thousands of pounds’ weight by his apparatus, but as we have already given a full account of the construction of such magnets, and of the experiments of Μ. Quetelet of Brussels, and Mr Watkins of London, in our article Magnetism, in Sect, xiii. p. 761, vol. viii., we must refer our readers to that part of the work.

Since these important discoveries, however, were made, an electro-magnet of extraordinary power has been con­structed by the Rev. N. J. Callan,@@1 Professor of Natural Philosophy at Maynooth. It has the form of a horse-shoe, and is *thirteen feet long, two and a-half inches* in diameter, and weighs *fifteen stone.* The distance between its poles is seven inches, and a copper wire one-sixth of an inch in diameter, is wrapped round the bar from one pole to the other. The total length of this thick wire is 490 feet, but it is di­vided into seven parts, each 70 feet in length. A copper

@@@1 See Sturgeon’s Annals of Chemistry, &c., July 1837.