Art. IV. *On some Modifications of the* Electro-Magnetic Apparatus. *By* Joseph Henry.

Read October 10, 1827.

The subject of Electro-Magnetism, although one of the most interesting branches of human knowledge, and presenting at this time the most fruitful field for discovery, is perhaps less generally understood, in this country, than almost any other department of natural science.

Our popular lecturers have not availed themselves of the many interesting and novel experiments with which it can so liberally supply them; and, with a few exceptions, it has not as yet been admitted as a part of the course of Physical Studies pursued in our higher institutions of learning. A principal cause of this inattention to a subject offering so much to instruct and amuse, is the difficulty and expense which formerly attended the experiments—a large galvanic battery, with instruments of very delicate workmanship, being thought indispensable. But this bar to the advancement of Electro-Magnetism no longer exists; several improvements having been made in the principles and arrangement of the apparatus, which tend considerably to simplify its construction and use. Mr. Sturgeon, of Woolwich, who has been perhaps the most successful in these improvements, has shown that a strong galvanic power is not essentially necessary, even to exhibit the experiments on the largest scale. On the contrary, he has proved that it may be almost indefinitely diminished, provided the magnetic force be proportionately increased. On this principle he has constructed a set of instruments, with large magnets and small galvanic elements, which from their size and the facility of their operations, are well calculated either for the private study or the public lecture room.*

Mr. Sturgeon's suite of apparatus, though superior to any other, as far as it goes, does not however form a complete set; as indeed it is plain that his principle of strong magnets cannot be introduced into every article required, and particularly into those intended to exhibit the action of the earth's magnetism on a galvanic current, or the operation of two conjunctive wires on each other. To form therefore a set of instruments, on a large scale, that will illustrate all the facts belonging to this science, with the least expense of galvanism, evidently requires some additional modification of the

*Annals of Philosophy, New Series, vol. 12, page 375.

apparatus, and particularly in those cases in which powerful magnets cannot be applied. And such a modification appears to me to be obviously pointed out in the construction of Prof. Schweigger's Galvanic Multiplier :* the principles of this instrument being directly applicable to all the experiments in which Mr. Sturgeon's improvement fails to be useful, and to those only can it be successfully applied. The following description of the figure in *Plate* I. will render my meaning sufficiently clear.

Fig. 1, is an apparatus on the plan of the Multiplier, to show the deflection of a large magnetic needle. It consists of a coil of wire, A B, of an oblong form about ten inches in length and one and a half in width, with a small galvanic element attached to each end; the coil is formed of about twenty turns of fine copper or brass wire, wound with silk, to prevent contact, and the whole bound together so as to have the appearance of a single wire. The attachment of the zinc and copper is more plainly shown in Fig. 2, which represents a coil of only two turns of wire: on the left side of the figure the plates are soldered directly to the ends of the wire of the coil; on the right, the plate of zinc Z, is attached to the part of the wire ending with copper on the other side, while the plate of copper on the right corresponds to the zinc on the left. By this arrangement, we can instantly reverse the direction of the currents, and deflect the needle either to the right or left, by merely holding a tumbler of acidulated water so as to immerse one or the other of the double plates into the fluid. The arrows at B, formed of two pieces of card, are intended to show the direction of the currents, and they should point in the course of the wires going from the copper. N S, is the needle, about nine and a half inches long, made by binding together several watch springs, touched separately, so as to form a compound magnet; at the end are two balls of pith, to shew the movement of the needle more plainly. This instrument is complete in itself, and we receive the full effect of the instantaneous immersion of the galvanic element.

Fig. 3, represents a modification of De la Rive's ring on a large scale. A B, is a coil about nine inches by six, with a small cylinder of copper, enclosing another of zinc, without bottoms, soldered to its extremities, which end at *c*, the whole being suspended by a fibre of raw silk, so as to swing freely in a cup of acidulated water. When this apparatus is made sufficiently light, it invariably places itself, after a few oscillations, at right angles

*See Green's Electro-Magnetism, page 80.

to the magnetic meridian. W and E, are two pieces of card, with letters on them, to show which side of the coil will turn to the east or west: they may be properly placed by recollecting that the current from the copper to the zinc has a tendency to circulate in a direction contrary to that of the sun.

Fig. 4, is designed to show the action of two conjunctive wires on each other; A B, is a thick multiplying coil, with galvanic plates attached, in the same manner as shown in Fig. 2; *c d*, is a lighter coil, with a double cylinder, precisely similar to Fig. 3, and suspended within the other by a fibre of silk, passing through a glass tube, *(a)* the end of which is inserted into an opening *(b)* in the upper side of A B; *e f* are two wires supporting the glass tube. When the cylinder *g* and the plate C are placed in vessels of acidulated water, the inner coil will immediately arrange itself so that the currents in both coils will circulate the same way: if the vessel be removed from C, and D placed in the fluid, the coil *c d* will turn half-way round and again settle, with the currents flowing in the same direction. Instead of the cylinder, a separate battery of greater power may be used, by suspending the inner coil, as shown in Fig. 9; *h h* are cups with mercury—the upper wire should turn on a fine steel point.

Fig's 5 and 6, are front and side views of a modification of an instrument, described by Mr. Sturgeon. It consists of a dipping needle, surrounded by a multiplying coil, turned edgewise, but in all other respects similar to that of Fig. 1. If, when the needle is placed in the magnetic meridian, and the coil in the plane of the dip, a galvanic current be passed through it in a direction opposite to that of the sun, the north end of the needle will turn up, as in Fig. 7; but if in the contrary direction, it will turn down, as Fig. 8. If the coil be placed at right angles to the dip, as shown in the dotted lines, and the current passed in the first mentioned direction, the needle will not alter its position, but will be more firmly fixed in it: if passed in the contrary direction, it will turn half-way round and dip with its south end. The quadrant *q* permits the coil to be readily placed, either in the plane of the dip or at right angles to it.

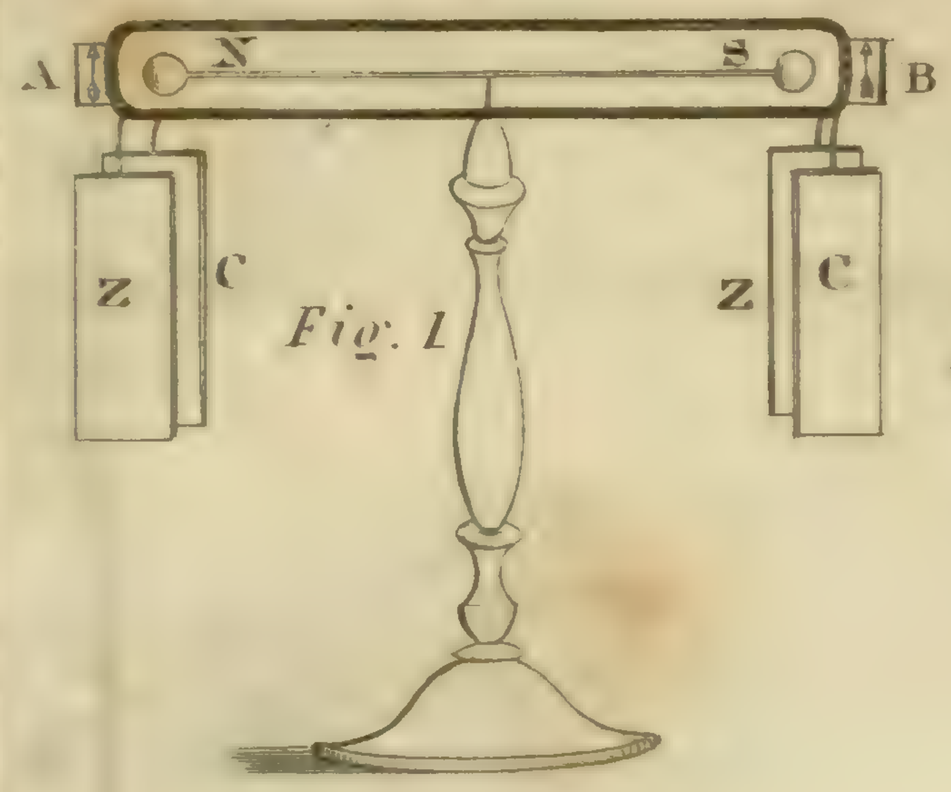

Fig. 1

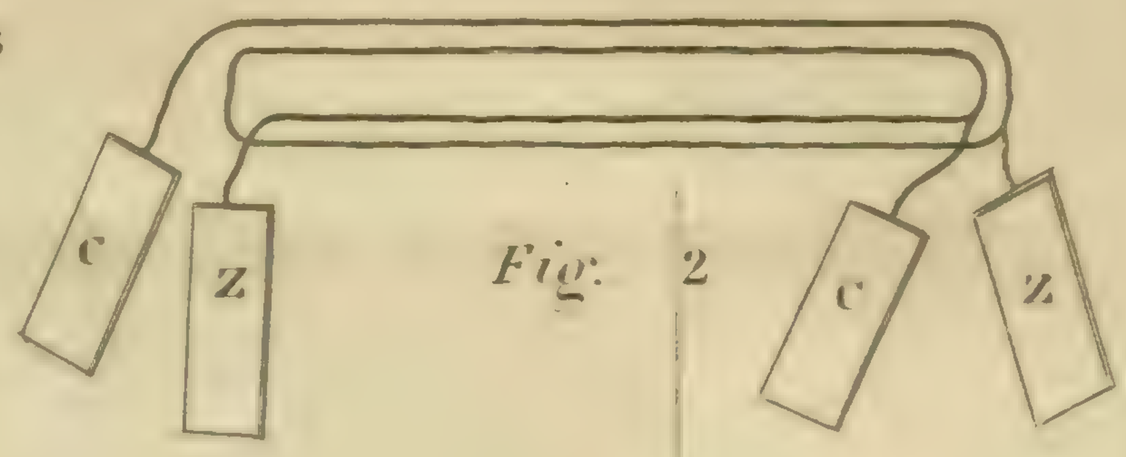

Fig. 2

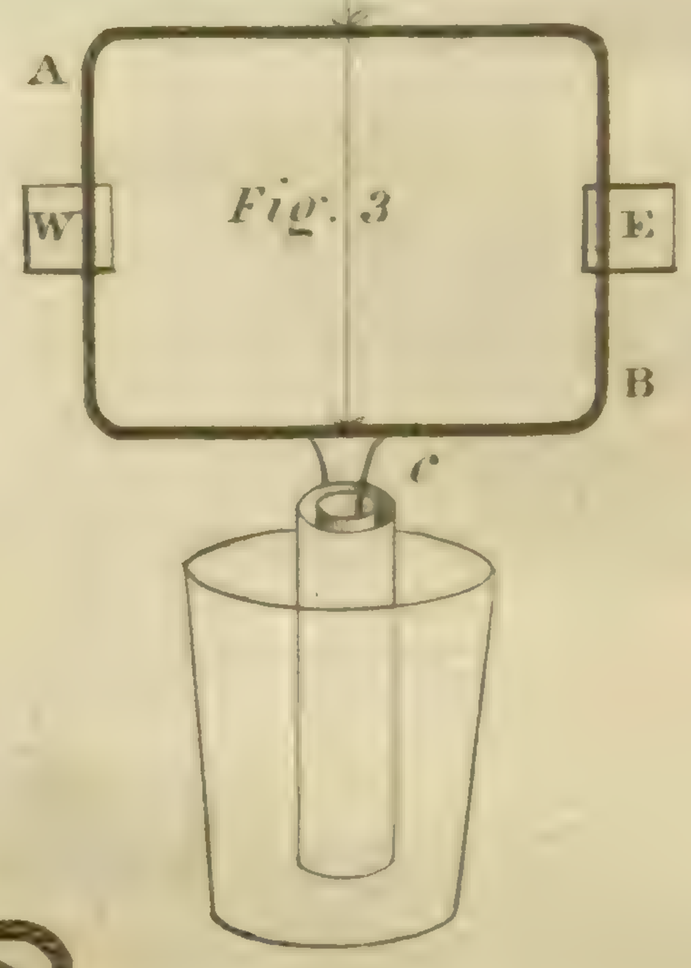

Fig. 3

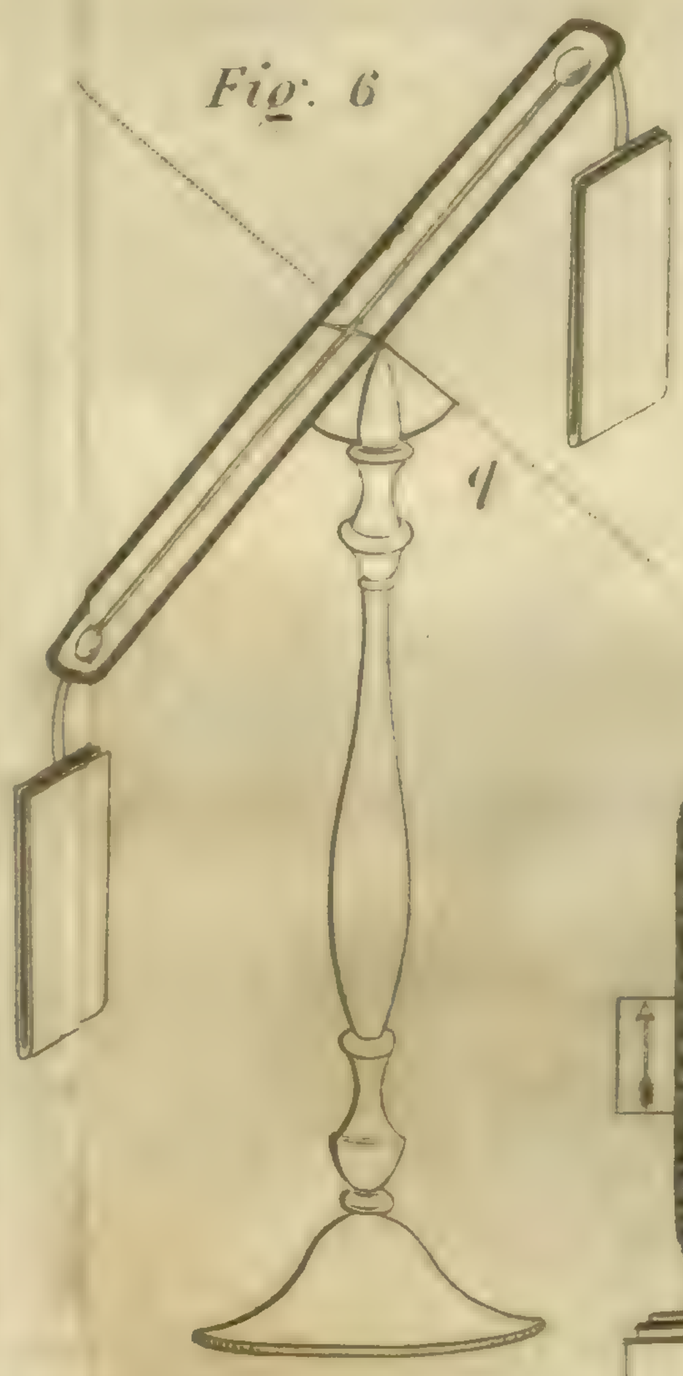

Fig. 6

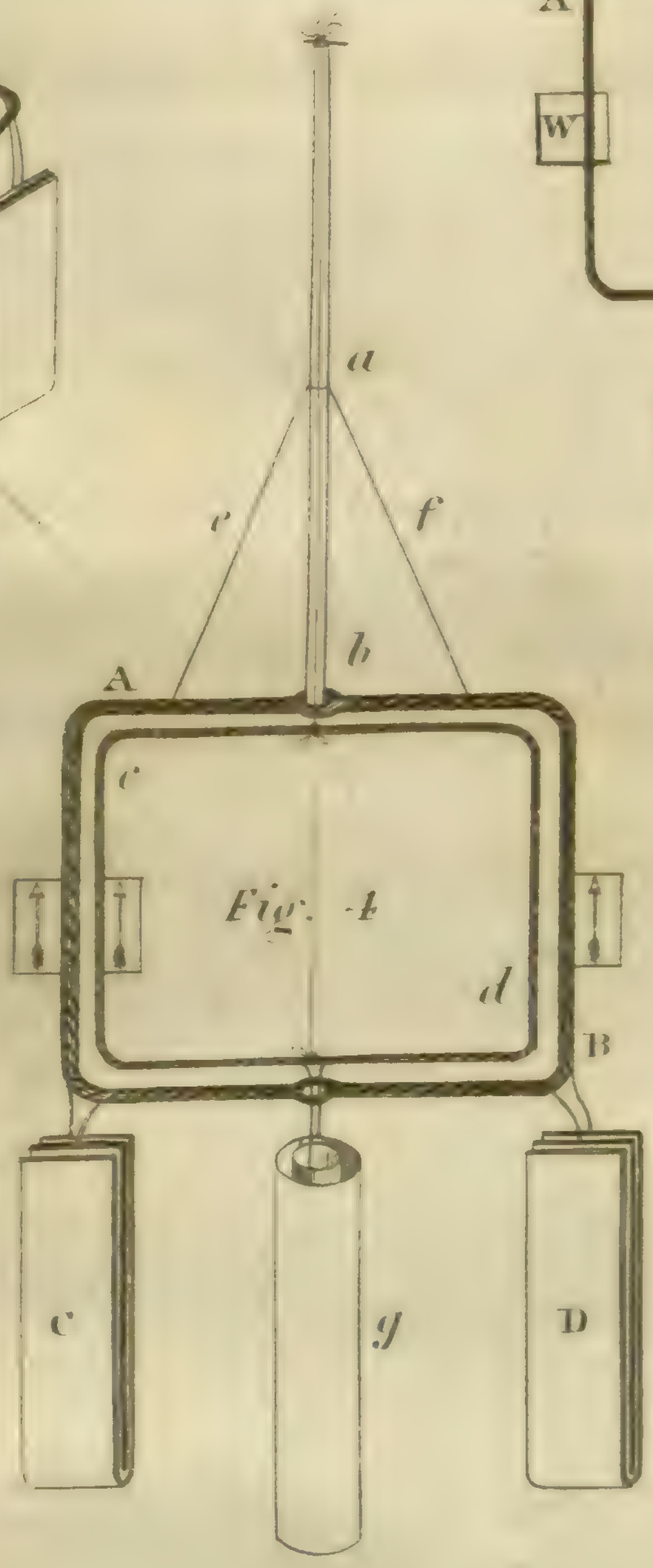

Fig. 4

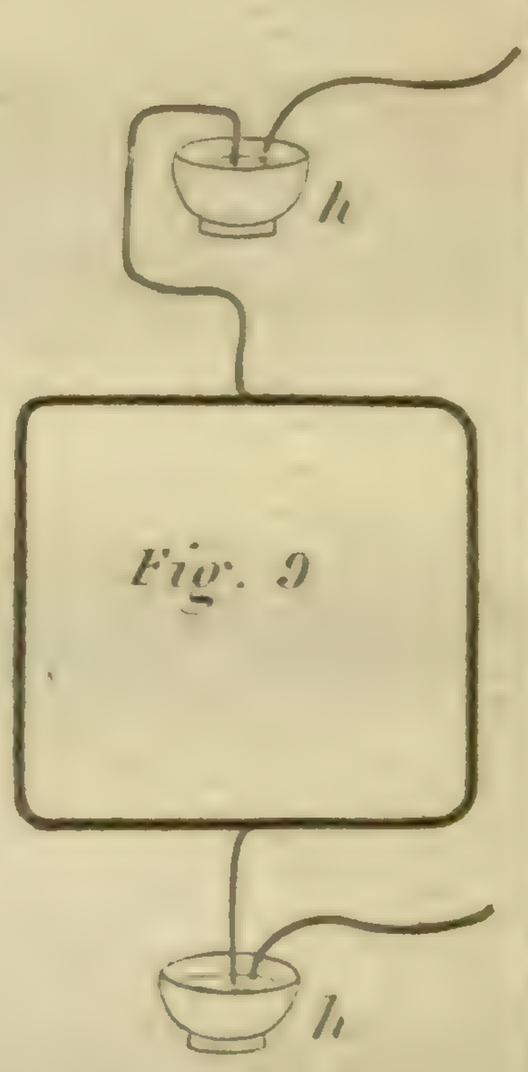

Fig. 9

Fig. 5

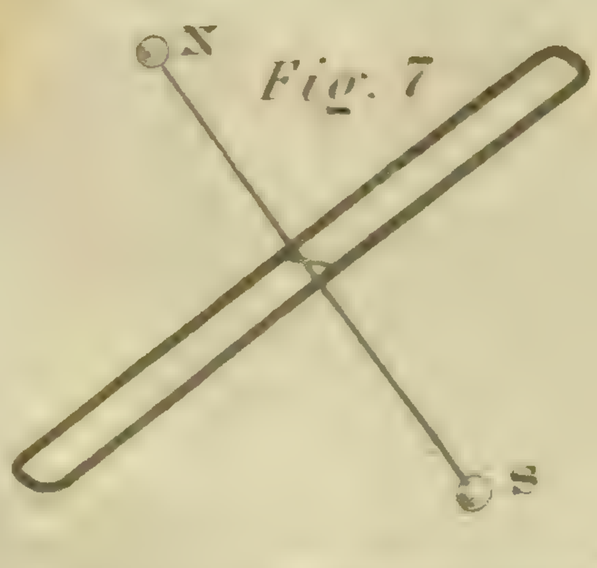

Fig. 7

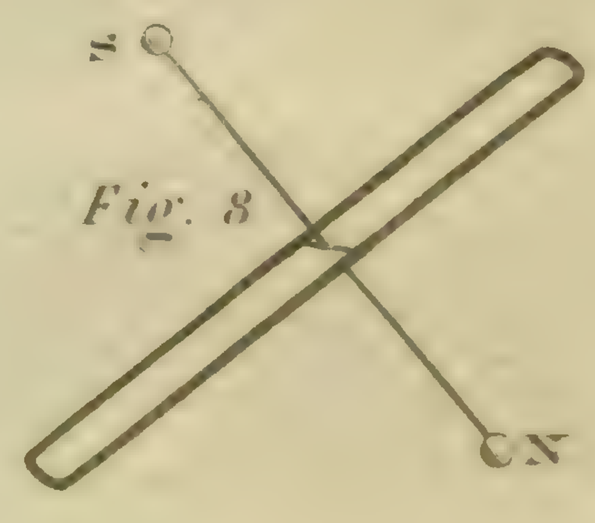

Fig. 8