Fig. 1.

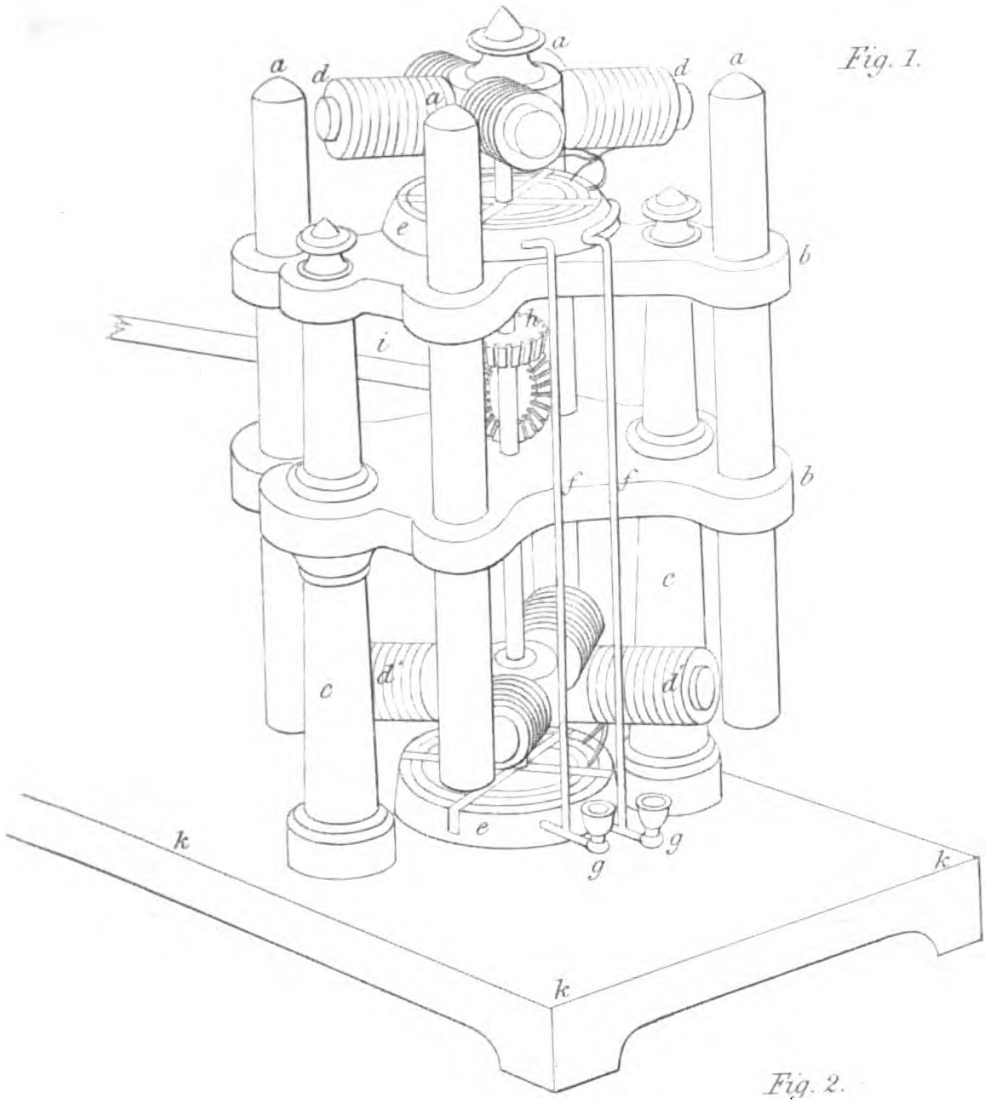
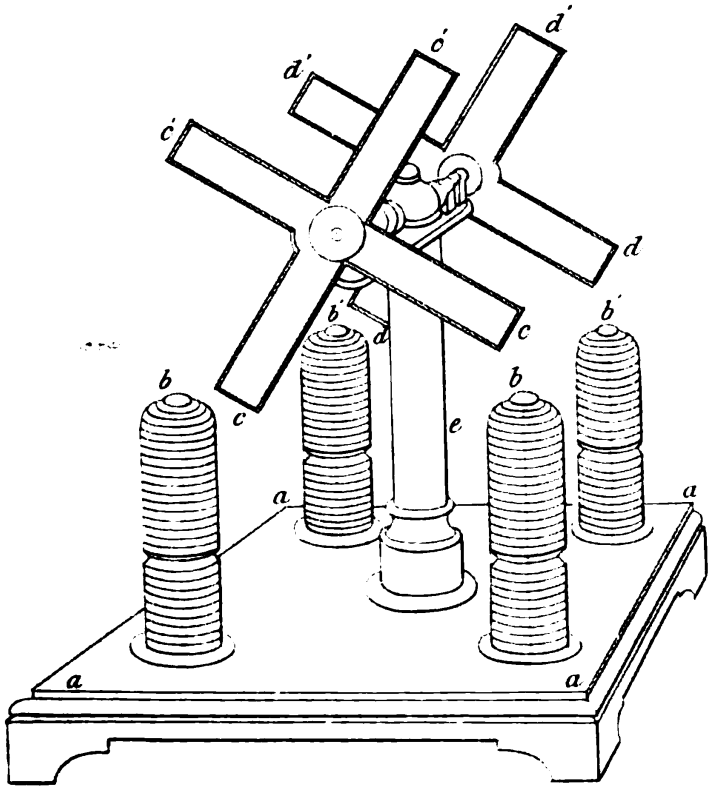


Fig. 2.



Mr. Watkins's Electro Magnetic Motive Machines.

XXVII. *On Electro-magnetic Motive Machines. By Mr.* Francis Watkins.

[With a Plate.]

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

PERMIT me in the pages of your next number to describe two or three modifications I have made in electro-magnetic motive machines, for I am inclined to think that any new arrangement of the working parts will interest those of your readers who hope to see realised the expectations which have been so confidently held out of successfully employing electro-magnetic power for propelling machinery.

We are indebted to Professor Joseph Henry, New Jersey College, Princeton, for the first hint, and for the first contrivance wherein electro-magnetic power is made to produce continuous motion.

In one of Silliman's American Journals for 1831 will be found Professor Henry's original description of his electro-magnetic motive machine, and as I believe it is not very generally known, I venture upon a brief description of it in this place. It consists of an electro-magnetic beam, supported horizontally on an axis passing through its centre of gravity, with two permanent steel bar magnets arranged vertically, one under each pole, of the horizontal electro-magnet, with their north poles uppermost. Without entering into the details of the method of changing the polarity of the mobile horizontal electro-magnet, the working of the machine will, I conceive, be sufficiently understood when it is stated, that by a timely alteration of the magnetic polarity (which is effected by changing the direction of the electric current inducing the polarity) of the horizontal electro-magnetic beam, an alternate series of attractions takes place between its poles and the poles of the vertical permanent steel magnets, and thus a reciprocating rectilinear motion is obtained by the vibration of the horizontal electro-magnetic beam.

Since Professor Henry's publication several modified forms of apparatus have been produced for exhibiting the electro-magnetic power. In England, as far as my knowledge extends, little as yet has been achieved beyond the construction of some very ingenious trifling machines or toys for exhibiting continued rotatory motion by this agent.

Several philosophers on the Continent have published accounts of experiments, and of machines made by them, their

object being the practical application of electro-magnetic attractive force, and one of them supposed he obtained a power equal to that of half a man. I refer your readers for an account of their labours to Part IV. of Mr. Taylor's new and highly useful quarterly publication, entitled "Scientific Memoirs." The public have also been recently favoured with notices of a small electro-magnetic machine, said to perform wonders, on the other side of the Atlantic; but in spite of the talent already brought into play, it must be acknowledged that it is yet reserved for some happy genius to hit upon the right arrangement which shall *economically* employ this electro-magnetic power *on a sufficiently large scale* to be used with the desired success.

In the August number of your valuable Journal for 1835 (Lond. and Edinb. Phil. Mag. vol. vii., p. 107,) you favoured me by noticing an arrangement of the electro-magnetic motive machine which I had then contrived. This machine, like all others that I am acquainted with, was founded upon the fundamental principle of Professor Henry's, namely, that of varying at a particular period the polarity of the transient electro-magnet, thus obtaining a succession of magnetic attractions. It is true that Henry only obtained an alternate rectilinear motion, while his followers succeeded in producing continual rotatory motion; still the principle remained the same.

Henry's principle being universally adopted, it is clear that all those who attempted to carry out the idea of obtaining a motive power by this principle are only entitled to the credit of those modifications of the arrangement which may emanate from their mechanical ingenuity, and to such credit only do I aspire in the present communication on my machines, which I will now describe.

Fig. 1. (Plate IV.) is a representation of a working model of an electro-magnetic motive machine; *a*, *a*, *a*, *a*, are four vertical cylindrical permanent steel magnets suspended by two mahogany cross stages *b*, *b*, which are themselves upheld by two mahogany columns *c*, *c*. The electro-magnets *d*, *d*, and *d'*, *d'*, are arranged horizontally, and are attached to and supported by a metal vertical shaft very free to move. Hollow magnets would be lighter, and perhaps answer as well. *e*, *e*, are two wooden cisterns, each with two concentric troughs, and each trough divided into four parts. In the bottom of each of the partitions in the top trough, a short metal wire enters; all these short wires are properly connected with *f*, *f*, which are two main wires descending and connecting the battery current with the mercury in the partitions. A similar disposition of short wires is made with the partitions of the troughs

in the lower cistern, and then connected with the mercury cups *g*, *g*, which answer for top and bottom cisterns. The ends of the copper wire coils of each pole are judiciously joined by solder to two pendent platinum wires, and form the ends of each system of the electro-magnets, as shown in the plate. Now when the points of the pendent platinum wires impinge upon the surfaces of the mercury in two partitions placed side by side, a current passes along the wire coils, and gives a polarity of a certain kind to all the four poles of the soft iron magnets, and those of an opposite kind to the adjacent poles of the fixed permanent magnets are attracted by the latter; but after they have arrived opposite the fixed magnets, they pass a barrier, and a change takes place in the direction of the current by the pendent wires again impinging on two surfaces of mercury: that in the inner surface is now in connexion with a different electrode to what it was before, it being in the same condition as the outer one was in the first instance; and, *vice versâ*, the outer partition is in connection with the electrode which in the first instance was in the same condition as the inner. The order of the polarity in the soft iron is influenced by the direction of the electric current pervading the system of coils. It is therefore easy to conceive how the polarity of the soft iron may be reversed when the direction of the current is changed, provided, as elsewhere has been observed, this reversal is within certain limits of time.

This alternate attraction produces the revolution of the electro-magnets. The lower system of electro-magnets is at an angle as regards the upper system; so that when one system is in a position in which it operates most powerfully, the other system is at the dead point or nearly so; by this arrangement the systems assist each other over that difficulty. On the metal vertical shaft is a bevel toothed wheel *h*, which gears into another bevel wheel on a horizontal shaft *i*, which is carried away and made to produce motion, and work at a distance small pieces of machinery, such as models of tilt hammers, pumps, dredging machines, &c. A plain pulley may be affixed to the vertical shaft, and with a long band made to operate; by this means the friction of the bevel gear is saved.

k, *k*, *k*, a mahogany base for the whole instrument.

Fig. 2. This is another form of model of an electro-magnetic motive machine: *a*, *a*, *a*, *a*, a mahogany board; *b*, *b*, *b'*, *b'*, two soft iron electro-magnets with their bent parts underneath the board; *c*, *c*, *c'*, *c'*, and *d*, *d*, *d'*, *d'*, are four flat bent permanent steel magnets, arranged like the arms of a windmill, and attached to a horizontal moveable axis, which is supported on a hollow wooden column *e*.

The arrangement of the axis could not be shown in the

figure, but it has a contrivance of points dipping successively into the mercury in a divided wooden cup. One partition of the cup is connected with one element of the battery, while the other partition is in communication with the other element of the battery. The communicating wires from the division in the cup proceed down the hollow wooden column to the coil of wires surrounding the soft iron, while the battery wires proceed up the column, but not in contact, and finish by being connected to two separate cups with mercury, in which revolve two small circular discs of platinum affixed to the axis, one on each side of the divided cup, and supported by two wood arms from the top of the column. The dipping points are so insulated and arranged on the axis that they reverse the direction of the current in the wire coils, and so effect the order of polarity in the soft iron magnet: this being accomplished at the right period the motion of the permanent steel magnets is obtained.

Two pullies are attached to the axis, bands from which will urge trifling pieces of machinery.

I have constructed a more simple form of motive machine than that of fig. 2. Plate IV. It has only one electro-magnet and two permanent steel magnets. The axis or shaft is of the same description as that with the four magnets: it works remarkably well, and the axis having only to carry one system of magnetic arms revolves with great velocity, and raises nearly an equal *weight* in the same time and distance as that with the four magnets.

The batteries I employ for obtaining the electrical currents are small, and constructed upon the plan proposed by Professor Daniells, King's College, London, and called by him the constant battery. This plan of the battery I consider to be original and the best devised for constant action and convenience of manipulation.

When we reflect that magnetic attractive force is the fundamental principle upon which the motive machines act, the limited space through which this force operates to a working amount, and our imperfect means of developing its powers, it may be excusable if we pause before giving in the present state of our knowledge an unreserved assent to the ultimate success of employing its agency as a prime mover on an extensive scale.

I have mentioned that many trifling machines or philosophical toys, in addition to those I have just now described, have been constructed, and plenty more, I have no doubt, will be brought forward and work very successfully; and when they operate by continued rotatory motion of the shaft, carry-

ing delicately suspended mobile magnets, the shaft and mobile magnets may be made to revolve with considerable velocity.

Many hundred revolutions in a minute have been assumed as the rate of speed of some of the already constructed revolving shafts and mobile magnets; but is it imagined that magnetic attractive force alone actuates the machine so many times within that period, and causes the great velocity? for such a condition of things, I respectfully submit, cannot exist. We certainly have mechanical arrangements which enable us to alter many hundred times in a minute the direction of the inducing electric current about the soft iron; but the polarity of the soft iron cannot be changed so rapidly if Herschel and Babbage's law be just, for they say "*time is an essential element of induction**," and it is by the induction of the electricity in the wire coils embracing the soft iron that the magnetism in the soft iron is induced, and thereby an attractive force gained. I am not aware that it has yet been determined what is the exact time necessary for the full development of the inductive process, yet experiments tend to prove that it is within the limit of many hundred times in a minute; and as it is necessary for the constant employment of the magnetic attractive force in its full effects that the polarity of each of the opposing poles of the fixed magnets should be in opposite states to the advancing poles of the mobile magnets, it is clear that if the *time* has not transpired necessary for the transient magnet to acquire its full and proper polarity, there will not be the whole effective magnetic attractive force gained.

What is it then that aids the rapid revolution of the mobile magnets and carrying shaft when they are light and very free to move, unless it be, their own inertia, when they have acquired a certain velocity, kept up, and contributed to at intervals in the revolution by the original prime mover, viz. magnetic attractive force? Now this inertia is a power that is soon overcome by additional friction, as may be observed when a very small portion of weight is added to a shaft which without the additional weight revolves rapidly. The diminution of velocity is immediately perceptible; and supposing that the slight extra weight thus counteracts the advantage gained by the inertia, then under such circumstances we have only the primitive magnetic attractive force of the machine left for mechanical purposes.

I find these conditions maintained in my small models, and also in one on a much larger scale which I have made; for on augmenting the size of the machine you augment the size of the revolving shaft and its magnets; friction increases conse-

[* See Phil. Mag., First Series, vol. lxvi. p. 98.—Edit.]

quently in a very rapid proportion, while the space gained through which the magnetic attractive force operates is increased comparatively in a very small degree.

It is truly surprising how limited is the ratio of improvement in the power of a machine by enlarging its magnets, as we then unfortunately increase the weight of the moving parts. I have noticed before, that the model with one pair of steel magnets, with four arms, and one electro-magnet, raised a weight through a certain space in a given time. Now when the model with two pair of steel magnets with four arms and two electro-magnets was experimented with, it was found that the latter was not so much more powerful than the former as we might have been led to expect.

It should be remembered that the means employed to change the direction of the current and the weight of the axis or shaft in both cases were exactly alike; therefore I conceive it was the extra friction of the axis caused by the extra weight of the additional pair of steel magnets that decreased the inertia of motion, and thus prevented the available power increasing to the amount anticipated.

I have not remarked upon the resistance of the air to the revolving arms, for that must be a retarding action in all cases of revolution. Besides the arms cut the air edgewise, therefore they are under the most favourable circumstances as regards that point.

It has been suggested as the means of gaining more power o multiply the number of fixed and moveable magnets, and so contrive that the forces should conspire to produce their sum at the working point, and we may infer that an advantage to a certain degree may be gained by a skilful arrangement; but if my views are correct, the power gained could be obtained on a large scale from other sources more œconomically.

I am well aware it frequently occurs in the application of a philosophical principle or a mechanical arrangement that there is a considerable difference between a model and that of a large working machine; it therefore behoves all persons experimentally engaged in the application of a principle or a power to bear this in mind, and not to decide too hastily because they fail several times with models. And I am also aware that my arrangement is faulty, and not the most judicious that could be contrived, although one of them is very simple; yet it does appear from the nature of the force we employ, and its small distance of working action, that we must look forward and hope for a better knowledge of the nature of the mysterious and invisible agent which is to actuate our machines before complete success crown our endeavours.

Human perseverance has achieved wonders; and as the subject engrosses considerable attention just now, and we rejoice to find by the periodicals that the Emperor of Russia has placed at the disposal of M. Jacobi and a scientific committee 500*l.* for the purpose of making experiments, we may indulge in the hope that before long some successful results will be the fruits of their labours, and that a new method of employing magnetism will be discovered; for from the present mode, if my notions be correct, we have little to hope for on a large scale, and playthings are not worth the mechanician's notice.

I remain, Gentlemen, yours, &c.,

FRANCIS WATKINS.

XXVIII. *Physical, Chemical, and Physiological Researches relative to the Torpedo; and some Remarks on the Contractions of the Frog.* *By* C. H. MATTEUCCI (*read before the French Academy by* M. Becquerel)*.

M. MATTEUCCI has presented to the Academy a Memoir on the electrical phænomena of the torpedo, as also several notes relative to the contractions produced in the frog by the contact of the muscles with the nerves. These having been submitted to the examination of a committee composed of MM. Breschet and Pouillet and of myself, we have the honour of laying before you an account of these various researches.

The sensation which the torpedo causes when it is touched has long ago attracted the attention of physicists and physiologists, on account of its analogy with that produced by an electrical battery, but it is only a few years since that it has been decidedly proved that both were owing to the same cause. Although all the principal circumstances of this phænomenon had previously been carefully studied, yet no one had succeeded in demonstrating its electrical origin from the want of suitable apparatus.

John Davy made known in a paper published in 1832 a great number of important data, such as the action of the discharge upon the magnet needle, and the chemical compounds; but the direction of the electrical current produced on this occasion was not well known until after the experiments made at Venice, 1835, by two of your members, and from which it resulted that the superior part of the electrical organ gives positive electricity, and the inferior part negative electricity. Matteucci has confirmed with the galvanometer and frogs

* Translated by Mr. Francis from the *Comptes Rendus*, No. 23, Dec. 1837.