AN IMPROVED ELECTRO-MOTOR.*

By Theodore Wiesendanger.

While recently many minds have been at work, with more or less of success, to produce improvements in dynamo-generators of electric energy, very few have given their special care and attention to the development of the electro-motor. Experience has taught us hitherto that the efficiencies of one and the same machine for action and reaction, or for use either as a generator, or by the inverted process as an electro-motor, stand in a certain and direct proportion to each other, or that our most efficient generators, such as the Siemens, Brush and Gramme, machines prove also the most effective motors, and on the other hand that inferior dynamo-machines invariably are inefficient motors. It would, however, be hazardous to conclude from these results that this rule should hold good for all future machines, and from the results of researches I have recently made, I come to the conclusion that the motors which are to supersede those now in use could not be employed as generators. Dynamo-machines, such as now constructed, only prove efficient when their field-magnets are able to retain at all times (*e. g.*, even when the machine stands at rest) a certain and very considerable amount of residual magnetism, and for that reason their cores are made of retentive material, hard cast iron, as is the case in the Brush and Gramme machines; or if the cores consist of soft iron they are attached to large masses of hard cast iron. in such a manner that the latter are inclosed in the magnetic circuit, and form part of the cores.

Generators of the same kind, when made small in size, have cores much larger and heavier in proportion, and, moreover, the baseplate, or, as in the Weston machine, a heavy retentive cylinder, is made to form a portion of the field-magnets. But all efforts hitherto made to produce efficient small dynamo-machines with cores of soft iron only, have resulted in absolute failure, although men of the highest genius have made repeated and prolonged efforts to solve that most difficult of problems.

These curious facts conclusively prove that the theory explanatory of the action of dynamo-machines, as now universally adopted, viz., the theory of inductive action and reaction between the field-magnets and the armature, cannot any longer be considered complete or satisfactory; for even wrought iron, especially when occurring in large masses, always contains an appreciable amount of residual magnetism, more especially after it has once been subjected to strong magnetization, and if the above theory were correct and complete, then the smallest possible amount of residual magnetic energy, augmented by repeated action and reaction, would be sufficient for the starting of such a machine to action. This, however, experience proves *not* to be the case, and the theory, although stoutly adhered to, must be either abandoned or amended.

The inventors of the most recent electro-motive engines have worked—perhaps unconsciously—upon the idea that the construction and action of electro-motors are based altogether upon the same laws as those of dynamo or magneto machines, and, in accordance with that assumption, the field-magnets of the Desprez motor are made to consist of large and heavy masses of magnetized steel.

Experimenters have also for a long time past clung to the idea that the efficiency of an electro-motor—or the amount of energy to be obtained from such a machine by means of a current of given strength circulating in the coils of its armature only—bears a definite and direct proportion to the magneto-inductive power of its field-magnets, and that an increase of power in the field-magnets alone must necessarily produce greater capabilities of the machine.

This, however, is a mischievous theory, because erroneous in its very principles, and development would only lead to the hypothesis of perpetual motion. On the contrary, starting from the consideration of the fact that a very small magnetic needle, if acted upon by one of the poles of another and very powerful magnet, has its polarity destroyed or reversed, and that if one of its poles, say the N pole, is presented to a similar (N) pole of the large magnet, the former will instantly lose its characteristic qualities and be attracted by its overpowering opponent, we can only come to the one rational conclusion that the power or the field-magnets of an electro-motor, as compared to that of the magnet or magnets constituting its armature, should not surpass the limit of some certain ratio, to be determined yet by experiments carefully conducted, and that, if it surpasses the limit, the capabilities of the machine must be impaired. Acting on this principle, I have constructed a motor in which the power of the field magnets is as nearly as possible equal to that of an armature, the core of the former being very light and made entirely of soft iron; and the satisfactory results obtained from this machine are a sure sign that further investigation of the subject and experiments made with a view of determining the exact ratio of power between the magnets and armature will result in further improvement.

Another and very important consideration in the construction of dynamo-machines and electro-motors has not yet received that care and attention from scientific investigators which would lead to immediate progress. It is the method of motion of the revolving armature with regard to its approaching to, or receding from the poles of the field-magnets. In nearly all the machines now constructed the polar faces of the cores of the field-magnets and those of the armature are of such a shape, and the latter is caused to revolve in such a manner, that only in a small portion of the revolution its poles either approach the poles of the field-magnets or recede from them. But the most successful production of induced currents will be achieved, and the greatest amount of power will be derived from a motor, if attention is paid not merely to the *one* condition, that the armature should revolve in the most highly concentrated magnetic field possible, but also that nearly the entire motion of the revolving armature should be either one of approach or of withdrawal. Let us first of all consider the case of a machine with two poles only of field-magnets and two poles of the revolving armature.

It is usual to give the active faces of the former such a shape that a section of the same represents a portion of a true circle. See Fig. 7.

In the ordinary machines now in use the radius of the circle described by the outline of the revolving armature, and that of the larger circle described in portion by the section of the inner or active faces of the poles are nearly the same, and the two circles are concentric. (See Fig. 7.) The pole *g* of the armature only approaches the pole A of the field-magnets while moving from *c* to *d*, or where the intensity of the magnetic field of A is at its minimum. When continuing its motion from *d* to *r* and to *f*, the pole *g* can no longer be said to approach A, because the distance between the respective surfaces remains constant.

I therefore propose that the devices shown in Figs. 9 and 6 should be adopted. The radius of the circle, part of which is formed by the section *d, r, c*, is considerably larger than that of the circle described by the outline of the field of motion of the armature; *d, r, c* is, moreover, considerably less than the half of a circle and the three circles *d, r, c, f, e, h*, and that described by the outline of the field of motion of the armature are not concentric. The pole *g* of the armature, when in motion, approaches the pole, A, not only in its course from *e* to C, but also when in the most intense magnetic field of A, viz., whilst moving from C to *z* and *d*. Fig. 11 represents a section of the field-magnet's cones E F and G H, and pole's pieces N and S cast in two halves and mounted on a base board, to which they are fixed by the two bolts R and T. The same principles may be applied to machines with field-magnets of more than two poles (see Fig. 3); or the armature itself may be made of such a shape as to work under the conditions above stated (Fig. 4). But even if the poles of the armature and those of the field-magnets are of the ordinary shape, a machine with more magnets will be more perfect in its action than one with two poles only. Fig. 10 illustrates a machine in which the armature during nearly the whole of its motion either approaches to or recedes from

*A paper read before the British Association.

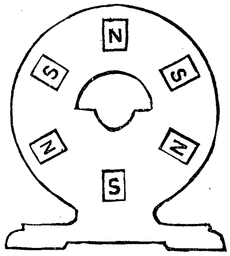

Fig. 1.

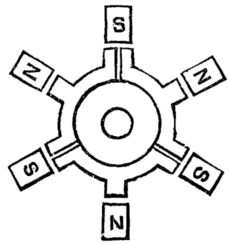

Fig. 2.

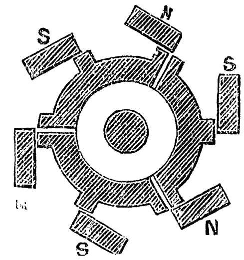

Fig. 3.

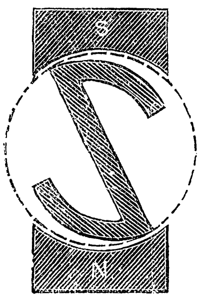

Fig. 4.

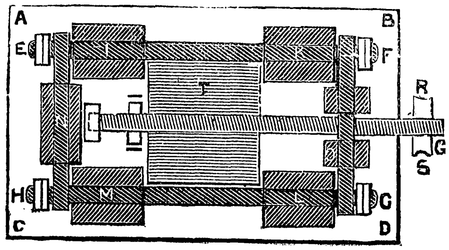

Fig. 5.

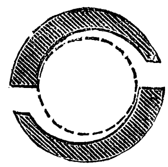

Fig. 6.

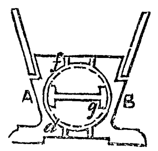

Fig. 7.

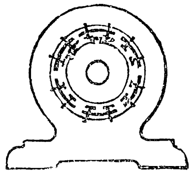

Fig. 8.

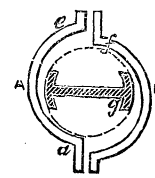

Fig. 9.

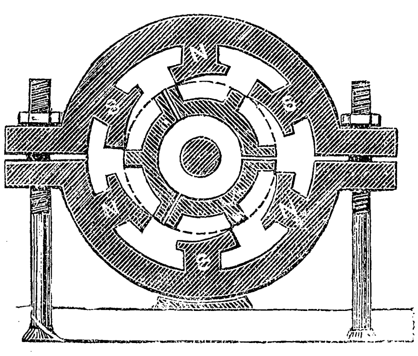

Fig. 10.

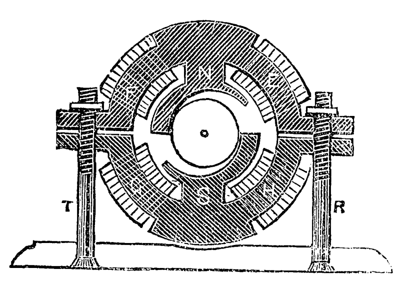

Fig. 11.

Wiesendanger's Improved Electro-Motor.

the pole of the field-magnets. In such machines the motion of the poles of the armature is also more in a line, coincident with the line of attraction as exercised between the two systems of poles; while in machines with field-magnets of two poles only the motion of the poles of the armature is at times at angles of 45 degrees to one degree from the direct pull.

I may, perhaps, be allowed to call attention to another matter of importance, awaiting further research. We find that in the three types of dynamo-machines, as constructed by Siemens, Gramme and Wilde, the relative positions of the axes of the field-magnets and those of the armatures are altogether different. Yet the three systems work well. We are unable, however, to state with certainty which positions of the axes are the best, or why any one of these positions should be better than the others, and in the face of experience, the theory of tubes or lines of force is little more than a hypothesis, with all its diffusion, vagueness and uncertainty.

Having so far considered general principles chiefly, I now beg to describe this motor (Fig. 5). A B C D is a wooden baseboard, E F G H a frame, consisting of the two parallel round rods F E and G H, and the two flat bars F G and E H, made of the best wrought iron, and carefully softened. The four bars are screwed together at the corners, and supported by four brass brackets over the baseboard. These inner rods form the compound core of the field magnets, a combination, as it were, of two horseshoe magnets, whose similar poles (S S and N N) form the junctions. Thus we have practically two poles only, a S and a N pole. Six coils of insulated copper wire are wound over the different portions of this core, shown in the drawing; the active pole-pieces are left exposed for a long distance, bearing no coils, The spindle P L, which carries a Siemens armature of the old form, or an armature with a compound tubular core; the commutator and pulley traverses the flat crossbar F H. The core of the armature is made of sheets of charcoal-iron, and it bears a coil of stout insulated copper wire. The commutator is of the ordinary kind, consisting of two half-tubes of brass, insulated from each other and from the spindle, and each forming one of the terminals of the coil. Fig. 2 represents a sectional view of a compound machine, acting on the same principles; Fig. 1 is a view of the two-end castings which hold the field-magnet. This machine contains a system of six field-magnets and six poles, and a compound armature with six poles. The current is to be reversed six times for each revolution, and to accomplish this I have devised the following commutator (see Fig. 8): —In these machines, also, the poles of the field-magnets or those of the armature may be of such a shape as to be nearly always approaching to, or receding from, each other, while in active motion,

The development of most important machines is destined to reach a certain stage of perfection, when further improvements cannot be accomplished by the inventor unaided; the second and important factor needed then is the co-operation of inventive and investigative talent with capital. This stage of perfection has been reached in the steam-engines, gas-engines, printing-machinery, etc., and it may be said to be rapidly approached by the progress made in dynamo-machines and electro-motors.

The development of the latter machines is followed by the scientific world with greater interest, and it evokes more eager expectations than that of other machinery, chiefly because it is not, and cannot be, identified with the solution of a problem limited within the confines of mechanical difficulties and commercial interests, but necessitates a further and deeper investigation into that great and subtle power, electricity, whose manifestations are so striking in their effects, so mysterious in their nature, so promising of great results in an immediate future, so fertile a field of research to the pioneer of science.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. 1880.

THE British Association for the Advancement of Science met at Swansea on the 4th of September last, under the presidency of Dr. Ramsey, who took as the subject of his address, "The Recurrence of Certain Geological Phenomena in Geological Time." His object appeared to be to show that all known geological formations have been produced under physical circumstances closely resembling, if not identical, with those with which we are more or less familiar. Through the various geological epochs he traced this identity of operations in respect to the metamorphism of rocks, the products of volcanoes, the upheaving and denudations of mountain chains, the deposit of great *inland areas* of salt, a recurrence of fresh-water conditions in lakes and estuaries, and glacial influences. His conclusion was that from the Laurentian epochs down to the present day all physical events in the history of the earth have varied neither in kind nor in intensity from those of which we now have experience.

The conclusions drawn from this address are summed up in the closing words of Professor Ramsey's discourse, as follows:

"In opening this address, I began with the subject of the oldest metamorphic rocks that I have seen—the Laurentian strata. It is evident to every person who thinks on the subject that their deposition took place far from the beginning of recognized geological time. For there must have been older rocks by the degradation of which they were formed. And if, as some American geologists affirm, there are on that continent metamorphic rocks of more ancient dates than the Laurentian strata, there must have been rocks more ancient still to afford materials for the deposition of these pre-Laurentian strata. Starting with the Laurentian rocks, I have shown that the phenomena of metamorphism of strata have been continued from that date all through the later formations, or groups of formations, down to and including part of the Eocene strata in some parts of the world. In like manner I have shown that ordinary volcanic rocks have been ejected in Silurian, Devonian, Carboniferous, Jurassic, Cretaceo-oolitic, Cretaceous, Eocene, Miocene, and Pliocene times, and from all that I have seen or read of these ancient volcanoes, I have no reason to believe that volcanic forces played a more important part in any period of geological time than they do in this our modern epoch. So, also, mountain chains existed before the deposition of the Silurian rocks, others of later date before the Old Red Sandstone strata were formed, and the chain of the Ural before the deposition of the Permain beds. The last great upheaval of the Alleghany Mountains took place between the close of the formation of the Carboniferous strata of that region and the deposition of the New Red Sandstone. According to Darwin, after various oscillations of level, the Cordillera underwent its chief upheaval after the Cretaceous epoch, and all geologists know that the Alps, the Pyrenees, the Carpathians, the Himalayas, and other mountain chains (which I have named) underwent what seems to have been their chief great upheaval after the deposition of the Eocene strata, while some of them were again lifted up several thousands of feet after the close of the Miocene epoch. The deposition of salts from aqueous solutions in inland lakes and lagoons appears to have taken place through all time—through Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous. Eocene, Miocene, and Pliocene epochs—and it is going on now. In like manner fresh-water and estuarine conditions are found now in one region, now in another, throughout all the formations or groups of formations possibly from Silurian times onward; and glacial phenomena, so far from being confined to what was and is generally still termed *the* Glacial Epoch, are now boldly declared by independent witnesses of known high reputation, to begin with the Cambrian epoch, and to have occurred somewhere, at intervals, in various formations, from almost the earliest Palæozoic times down to our last post-Pliocene "Glacial Epoch."

If the nebular hypothesis of astronomers be true (and I know of no reason why it should be doubted), the earth was at one time in a purely gaseous state, and afterwards in a fluid condition, attended by intense heat. By and by consolidation, due to partial cooling, took place on the surfate, and as radiation of heat went on the outer shell thickened. Radiation still going on, the interior fluid matter decreased in bulk, and, by force of gravitation, the outer shell being drawn towards the interior, gave way, and, in parts, got crinkled up, and this, according to cosmogonists,