devil, are so called from their predatory and fierce nature. They have large canine teeth and sharp molars. The second and third toes are no longer bound together, whilst the great toe is absent or small. Myrmecobius is a peculiar genus, remarkable for the great number of its back teeth. The Tasmanian Wolf is confined to that island, and will very probably soon become quite extinct, because of its destructiveness to the sheep of the colonies. It differs from all other members of the Kangaroo order in that cartilages represent the marsupial bones found in every other member of the order. The last family consists of the true Opossums, which differ from all above referred to in inhabiting America only, not Australia. They are called Didelphidæ; one species is aquatic in habit, and web-footed.

Such are the very varied forms composing the six families which together make up the Kangaroo order. What is its relation to those of the other Mammalia? Very noticeable in it is the very great diversity of form, dentition, and habit found in the order, some being arboreal and vegetarian, others terrestrial and carnivorous, &c.; nevertheless, these so varied marsupial forms possess in common important characters by which they differ from all other mammals. These characters, however, relate mainly to the structure of their reproductive organs, as to the great importance of which characters naturalists are agreed. The angle of the lower jaw is also peculiar. Almost every mammal which has marsupial bones has the angle of its jaw inflected, or else has no angle at all, whilst every animal which has both marsupial bones and an inflected jaw-angle, possesses also those other special characters which distinguish the marsupials from all other mammals. We have, therefore, at least two great groups, one non-marsupial, containing man, the apes, bats, cats, hoofed beasts, &c.—the Monodelphia; the other containing the marsupials only—the Didelphia. There is a third group containing only the Ornithorhynchus and Echidna, which form by themselves alone a third group, Ornithodelphia.

As to its zoological relations, we may therefore say that the Kangaroo is a peculiarly modified form of a most varied order of Mammalia (the marsupials), which differs from all ordinary beasts (and from man) by very important anatomical and physiological characters, the sign of the existence of which is the coexistence in it of marsupial bones with an inflected angle of the lower jaw. As to the geographical relations of the Kangaroo, a study of their distribution over the world shows that the Kangaroo is one of an order of animals confined to the Australian region and America, the great bulk of the order, including all the Macropodidæ, being strictly confined to the Australian region.

The lecturer concluded by explaining the geological relations of the Kangaroo and its order, pointing out that in Australia we have an instance of zoological "survival" connecting the existing creation with the triassic period.

## MAGNETO-ELECTRIC MACHINES*

### II.

IN 1871 M. Jamin communicated to the French Academy of Sciences a short note by M. Gramme, on a magneto-electric machine which gave electrical currents always in the same direction by the revolution of an electro-magnetic ring between the poles of a permanent magnet. The construction of the electro-magnetic or ring armature in Gramme's machine differs in some mechanical details from that of the transversal electro-magnet of Pacinotti, and the serious mistake of applying the rubbers which carry off the current at the wrong place is avoided. We must therefore regard the Gramme machine as the first effective magneto-electric machine constructed to give continuous currents all flowing in the same direction. Before entering into the details of its construction it may be useful, even at the risk of some repetition, to describe as briefly as possible the principles on which the action of the electro-magnet or ring armature depends.

In its simplest form this armature consists of a ring of soft iron, round which is wound a single closed coil of copper wire or other metallic riband, covered with silk, except at a single point in each loop of the coil, which is left exposed in order to make contacts. In Fig. 4 such a ring is shown, placed between the poles of a permanent magnet. The parts of this ring contiguous to the poles N S of the fixed magnet will acquire respectively polarity of the opposite kind to that of the neighbouring pole, while the parts of the ring O O′, at the end of a diameter

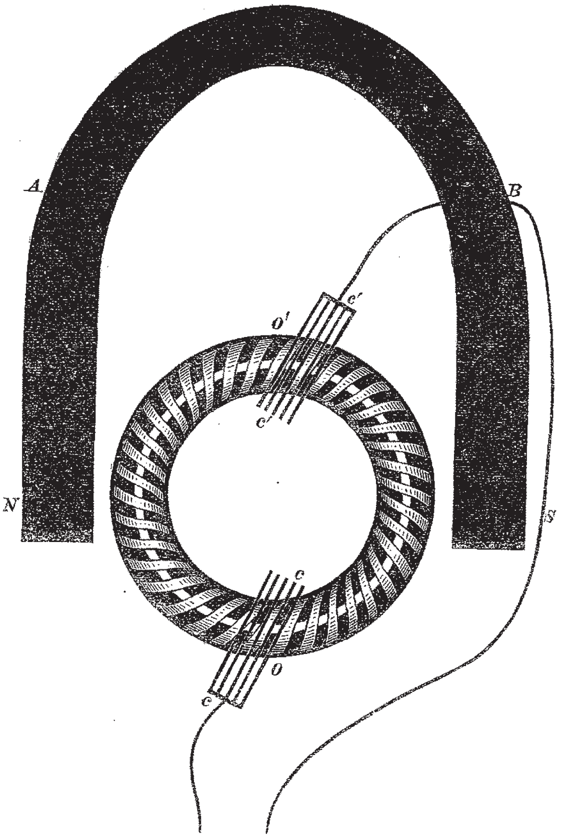


FIG. 4.—Ring Armature.

at right angles to the line joining the poles, will be neutral. If the ring is made of homogeneous metal, this statement will be strictly exact so long as it is at rest, but if it be made to revolve rapidly on an axis perpendicular to the plane of the fixed magnet, the poles of the ring, as well as the neutral points, will be slightly displaced, as M. Gaugain has shown, in the direction of the motion. This arises from what is called the coercive power of iron; that is, from the circumstance that even the purest iron will not acquire or lose magnetism in an inappreciably short period of time. The change in the distribution of the magnetism in the ring from this cause is, however, inconsiderable, and may easily be allowed for.

To make the explanation clearer, let us suppose that there is only one loop of wire, *a* (Fig. 5), upon the ring, and that this loop is moveable and in connection with a galvanometer *g*. If now the loop is moved along the ring (assumed to be at rest) from the neutral line O towards S′, a current will be developed in a certain direc-

* The substance of a Lecture, with additions, delivered at the Belfast Philosophical Society, March 17, by Dr. Andrews, F.R.S., L. & E. (Continued from p. 92.)

tion, the intensity of which will increase till the loop reaches S′, after which the current, always preserving the same direction, will diminish till the loop arrives at O′, when the current will for a moment fall to zero, to be succeeded by a current in the opposite direction as the loop leaves O′. This current will in like manner increase during the advance of the loop to N′, when it will attain a maximum, and afterwards diminish till it arrives at O, where, after passing through zero, the direction will again change. There will thus be a current always flowing in one direction as the loop moves from O through S′ to O′, and in an opposite direction as it moves from O′ through N′ to O. Now if the loop, instead of being moveable upon the ring, be firmly attached to it, and the ring itself carrying the loop be rotated on its axis in the plane of the fixed magnet N M S, it will be found that the currents developed will correspond both in direction and

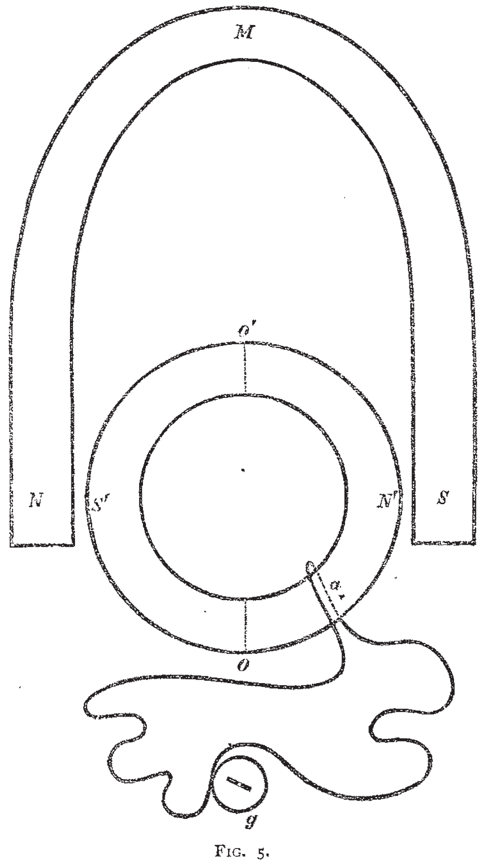


FIG. 5.

intensity with those produced in the moveable loop, provided we allow for the small displacement in the position of the poles of the ring arising from its motion.

The foregoing statement may be extended from a single loop to any number of loops forming part of a coil extending over the whole of the iron ring (Fig. 4). Each loop of such a coil, during one-half of every revolution, will tend to give a current in one direction, and during the other half, a current in the opposite direction, and the electromotive force thus produced will augment with the number of loops in the coil. If, then, metallic conductors, *c c*, *c′ c′*, are applied to the loops (whose surfaces must be exposed at one point for this purpose) as they pass through the positions O and O′, continuous currents, all in the same direction, will be obtained on rotating the ring without the use of a commutator, unless we apply that term (as Pacinotti has done) to the system of conductors or rheophori by which the currents are carried off.

In order to obtain currents of high intensity, the single coil must be replaced, as in similar machines, by a number of coils of thin wire rolled one above the other and carefully insulated. To carry off the current, these coils must be divided into separate helices, with the adjacent terminals of the wires of the helices in metallic connection, so that the iron ring may be always surrounded by an endless conductor of great length. I have already described the arrangements adopted in the transversal electro-magnet of Pacinotti. The construction of the ring armature in Gramme's machine will be readily understood from Fig. 6, in which it is represented in different stages of its construction, so as to show the manner in which the principal parts are connected.* At A a section of the iron ring itself is shown, composed of a bundle of iron wires; at B B the helices, or bobbins, are seen both in section and detached; and at R R the form is shown of one of the insulated copper conductors, to which the contiguous ends of the wires of the helices are attached, and from which the current is drawn off by means of rubbers or brushes formed of flexible bundles of copper wire. These brushes are so applied at the neutral positions of the ring that they begin to touch one of the conductors R, before they have left the preceding one. In this way no actual break or interruption occurs in the current. The permanent magnets employed in the smaller

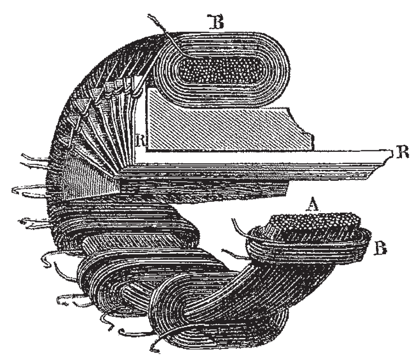


FIG. 6.—Gramme Armature.

Gramme machines are on the improved construction of M. Jamin.

With a small machine, on the Gramme construction, very remarkable electrical effects may be obtained. I will give the results of a few experiments which I recently made with one of the two machines exhibited at the late meeting of the British Association, and which are now in Queen's College, Belfast. This machine was able to heat to full ignition in daylight a platinum wire one foot in length, and weighing 12 grains. With a voltameter formed of two slips of platinum foil, exposing each a surface of 1·25 square inches, and at the distance of half an inch from each other, immersed in dilute sulphuric acid, water was freely decomposed. For 100 turns of the machine, the volumes of the mixed gases collected at different rates of turning were as follows:—

| | | | |
|---|---|---|---|
| In | 34 seconds | ... ... | 2·60 cubic inches |
| „ | 45 „ | ... ... | 2·53 „ |
| „ | 75 „ | ... ... | 1·45 „ |
| „ | 135 „ | ... ... | 0·35 „ |

From these observations it appears that, under the conditions of this experiment, the quantity of water decomposed for the same number of revolutions of the ring increases quickly with the rate of the motion till a certain

* I take this opportunity of expressing my obligations to M. A. Niaudet-Breguet for his kindness in enabling me to give the admirable figures of the Gramme Machine which illustrate this paper They first appeared in a short work on the Gramme Machine, recently published by M. Breguet, to which I beg to refer for more detailed information regarding its practical applications ("Machines Magnéto-électriques Gramme." Par M. A. Niaudet-Breguet. Paris, 1875).

rapidity is attained, after which little further change occurs.

An interesting experiment may be made with these machines, which illustrates a well-known dynamical principle, by turning the machine at a steady rate, with the wires for transmitting the current disconnected, and observing the great additional force required to maintain the motion on connecting the wires.

The machine may be converted into an electro-magnetic one by transmitting the current from a voltaic pile through the helices of the iron ring, which will then rotate upon its axis. If the current be supplied by another magneto-electric machine, the same result will be produced, and we shall thus have mechanical force, after assuming the form of current electricity, reappearing, but with some loss, in the form of mechanical force. In an experiment on the large scale described by M. Breguet, the loss amounted only to thirty per cent. If during this experiment the machine which supplies the current has its motion reversed, the other machine will soon come to rest, and afterwards begin to turn in the opposite direction. The intensity of the current, M. Breguet remarks, augments with the velocity of the rotation, the electromotive force having been proved by experiment to be proportional to the velocity. At first view it might appear that the resistance would remain constant; but as the intensity is found not to be proportional to the velocity of an invariable circuit, we are led to the conclusion that the resistance of the machine is not constant. This important point has been established by M. Sabine, but the details of his experiments have not been published. The increase of resistance is, however, so small, that a machine which gives with a velocity of 100 turns per minute a current equal to that of one small Bunsen's element, will give with a double velocity a current equal to two such elements a little larger, and with a quadruple velocity a current equal to four still larger elements of Bunsen. It is certain that this increase of electromotive force cannot be indefinite, but must tend towards a limit; but this limit does not appear to have been reached even with a velocity of 3,000 turns per minute.

(*To be continued.*)

## *ON THE TEMPERATURE OF THE HUMAN BODY DURING MOUNTAIN-CLIMBING*

In the year 1869 both Dr. Wm. Marcet, of Nice,* and Dr. Lortet, of Lyons,† published the results of thermometric experiments prosecuted by themselves on themselves during the ascent of Mont Blanc. Both physiologists discovered that during the act of ascent, if it were rapid and prolonged for any considerable time, the temperature of the body fell considerably, as much as 3·6° F. in the case of the English, and even 8·6° F. of the French observer. The temperature was taken in the mouth, and read off by means of a small reflector attached to the thermometer, which is a much more satisfactory manner of recording reducing temperatures than the employment of maximum registering instruments. Dr. Marcet tells us that in order to assure himself that the cooling of the body during the ascent was really due to the muscular effort, and not to the effect of the rarefaction of the air, he made one ascent (from Cormayeur to the plateau of Mont-Frety, about 2,440 yards high) partly on mule-back. After having gone two-thirds the distance, his temperature was 97·5° F., when, leaving the mule, he performed the rest of the journey on foot as quickly as possible. Just before arriving at the end, his temperature was not above 95° F., or 2·5° below what it was thirty-five minutes before, at the lower level. Another peculiarity observed by this author is that the body-temperature, after having diminished during an ascending walk, rapidly rose again upon rest being taken, or on the speed being reduced.

All these unexpected results have, from the absence of fresh facts to throw light upon them, been but little discussed. It has been asked whether the above-described fall of temperature depends on the transformation of the energy of muscular action into work instead of, as usual, into heat in the body. The answer to this question is, however, not so easy as it might at first sight appear. If the exalted temperature of warm-blooded animals in a state of rest is the index of the amount of internal work done by the heart and the respiratory muscles, then extra muscular work will produce a proportionately greater rise of body-temperature, as it is employed in doing less external work, and the reverse; from which consideration it is rendered theoretically probable that the rise in temperature attending a rapid ascent of an incline would be much less considerable than that accompanying a similar effort which is attended by no external effect. In fact, the temperature of an individual in the act of throwing oranges forcibly away in all directions should be scarcely above the normal, whilst if he continually throws one up, again catching it, his temperature should rise considerably. In the one case the muscular effort is employed in heating the ground against which the moving oranges come in contact whilst being brought to rest; in the other case the energy lost to the body in the upward projection of the mass is regained in the form of heat when the muscles of the limbs resist its downward movement in catching it.

At this stage of the inquiry the elaborate investigations of Prof. Forel, of Lausanne,* prosecuted with indefatigable industry during the last four years, form an important addition to the literature of the subject. This physiologist, in a most painstaking and thorough manner, has investigated the whole problem, together with all the minor details associated with it: the results he has arrived at have consequently a wider interest than the simple solution of the question which originally led to their being commenced.

In his earlier series of experiments, Dr. Forel, whilst staying at the Rhone Glacier, at Zermatt and at the Lake of Geneva, ascended the Grimsel, the Riffel, and to Chigney, as well as to other neighbouring heights, in the end arriving at the following conclusions:—firstly, that the method of measuring the body-temperature in the mouth is not sufficiently precise for the study of the influence of muscular exercise on the general temperature of the body; and, secondly, that the act of ascending normally produced an *elevation* of the temperature of the body to the extent of several tenths of a degree, which diminishes during the subsequent repose, in tending to regain the normal standard.

These results, obtained in 1871, being directly at variance with those of Doctors Marcet and Lortet, Dr. Forel repeated his experiments with greater precision during the years 1873 and 1874. He commenced by determining the relative values of the different regions of the body in which it is possible to employ the thermometer for the estimation of the general temperature. More than a hundred observations in the floor of the mouth led him to reject that position for the thermometer, chiefly because it is next to impossible, during muscular exercise, to retain the mouth closed for any considerable time in a cold, dry, rarefied air. The palm of the hand, the arm-pit, and the external auditory meatus were rejected as being even less advantageous. The rectum was the last resource, and its advantages were found to be so great that all the most important results, to be mentioned directly, were arrived at from temperatures obtained in that situation.

The author commenced by forming a curve which repre-

* "Archives des Sciences Physiques et Naturelles." 5e serie, t. xxxvi. p. 247. (Geneva.

† "Recherches Physiologiques sur le Climat des Montagnes" (Paris.)

* "Expériences sur la Température du corps Humain dans l'acte de l'ascension sur les Montagnes." (Geneva and Bale, 1871 and 1874.)