Special Papers.

HIGH SCHOOL PHYSICS.

By James Asher.

(*Concluded.*)

ELECTRIC MACHINES.

The theory of the Gramme electric machine, in the new High School Physics, is unsatisfactory, for experiments show that the current is not due to the magnetism of the ring. Breguet showed that the lead or displacement of brushes from the position of symmetry in a certain experiment was seven times as much as it should have been, were the displacement necessitated by retardation of demagnetization alone in the ring. Unless such lead is given, sparking occurs. The brushes must usually have positive lead when the machine is a generator, and negative lead when a motor.

Perhaps the only theory that explains the action of any magneto-electric machine, dynamo-electric machine or electric motor is mine, which I published, with cuts, in the *Electrician and Electrical Engineer*, New York, August, 1885 I discard the terms "poles" and lines of force, and locate the resultant of the magnet's ampere currents which can act on the armature. The resultant of ampere currents along the inner boundary of a magnet is between its arms, and half-way between the bend and a line joining the N and S seeking ends. This resultant current flows toward us if the bend is to our left, and the S seeking arm up permost. The resultant can act on the wire on the outside of the ring but not on that inside, for the iron ring shields it. Were there no iron in the armature, the current which the resultant would cause when the armature is turned would be nearly annulled by an opposing current on the wire inside. When we turn the ring the same way as the hands of a watch, the wire on the surface of the upper half is perpetually leaving the resultant, hence, as it is parallel to the wire, a current will flow in the same direction or towards it. The wire on the surface of the lower half perpetually approaches the resultant to which it is parallel, hence it is traversed by a current flowing the opposite way or from us. The commutator arranges these currents and brings successive sections of wire into proper action.

A nearly steady curren flows in a circuit formed by joining the brushes. When the brushes are not joined by a conductor, the two halves of the armature tend to have currents generated which oppose each other, or there is a difference in electric potential between the brushes.

I shall next explain the action of the Gramme machine, used as an electric motor. The current from a generator enters one brush and divides where the armature wire joins the commutator. One half of the current passes along the wire on the upper half of the ring; the other half passes along the wire on the lower half. The exterior of the upper half is traversed by a current flowing say towards us, while the exterior of the lower half is simultaneously traversed by a current flowing from us. We may place a resultant for the currents in the wire on the exterior of the upper half, and another resultant for the currents in the exterior of the lower half. The former resultant may be regarded as a current at the top of the armature. Similarly the latter resultant will be at the bottom of the armature. The upper is parallel to the resultant of the magnet and flows in the same direction. Hence, since parallel currents in the same direction attract, the upper part of the armature will be attracted by the resultant of the magnet. The lower resultant of the armature is parallel to the resultant of the magnet and flows in the opposite direction. Hence the lower part of the armature will be repelled. Thus the armature rotates the opposite way to the hands of a watch. Each resultant of the armature moves relatively to the armature itself, but not relatively to the magnet unless the speed be changed, when it will take a new position. This is chiefly due to the reaction of the magnet's resultant on that of the armature. Each resultant of the armature is like a dog on an endless tread power. The animal ever moves but never advances, for his forward motion is annulled by an equal motion of the endless tread in the opposite direction. The armature is like the endless tread. The two branches of the current unite at the strip of the commutator under the brush and flow along the conductor to the first brush. The commutator changes the direction of the current in each pair of sections as it passes the brushes. The iron ring shields the wire inside the ring from the action of the magnet's resultant.

My theory was adopted by the editor of *The Electrician and Electrical Engineer.* This theory explains clearly and simply the anomalous action of the Griscom motor used in running sewing machines. It also shows that the form of magnets used in nearly all electric machines is incorrect. The U magnet is utterly wrong in principle. The magnet should bend closely around the armature and form a circular curve. The Griscom and Meritens motors have magnets of this shape, and these machines are of great capacity when their weight is considered. The Griscom motor has a capacity of one-eighth horse power and drives sewing machines, yet it weighs only about two and a half pounds, and is about the size of a large apple.

The current from a Gramme machine cannot be perfectly steady, unless the number of sections of wire is infinitely great. There are rarely more than a hundred on the largest machines. An equal number of copper bars collectively form the commutator. This must be turned truly cylindrical and each bar must be separated from its neighbour by some insulating substance. After all the care and expense of construction, it is nearly impossible to prevent sparking at the commutator, which implies waste of copper. The commutator is of considerable diameter and is pressed by brushes or stiff copper springs; no oil can be used here, and the leverage of friction at such a distance from the centre of motion causes a loss of power. Besides, as the number of sections is not infinite, heating of the armature causes a loss of about five per cent. of the energy.

The Gramme machine is very expensive. The smallest sold by Ritchie of Boston costs $80. It is a very small hand machine to be used on lecture tables, and furnishes a current only about equal to that from three carbon cells.

The commutator must soon be abolished. Alternating current machines have no commutator, but the currents are very dangerous; besides, they can only be used for a few purposes, such as supplying certain electric lights, shocking, and working one or two telegraph and electric clock systems. The Terranti-Thomson is a machine of this kind. The Gramme may have no commutator and yet give a nearly continuous current if the armature have only one layer of bare wire. Two springs may press it, one on either side. The current will be of very low tension, but it is more nearly steady than in the common Gramme, for the number of sections is virtually increased. Each turn of wire is a section. A few machines and instruments give a perfectly steady current; for example, those used to show the rotation of a conductor round one extremity of a straight cylindrical magnet. If no generator be used, and we make a closed circuit, on mechanically rotating the conductor round one arm of the magnet, a steady current in one direction will flow Faraday's copper wheel rotating between the arms of a magnet will also give a steady current. The Delafield dynamo, too, gives a current of this kind. In all these the tension is very low, for there is only one ply of the rotating conductor. A dynamo of this kind can scarcely be used for anything but electro-plating. All electric motors have commutators, except those which I have mentioned, when used as motors, which is almost never the case.

A few machines have no iron in the armature, the Elphinstone and Vincent for example, a very efficient continuous current machine. The Terranti-Thomson also has no iron in its armature. Certain machines have no wire on the armature, for example, the magneto-electric machines in Wheatstone's dial telegraph, and his magnetic exploder for blasting. These give alternate currents. The Siemens, Weston, and Edison machines have a cylindrical iron armature core, whose entire surface is wound lengthwise with insulated copper wire.

I think a dynamo can be made which will give currents of either high or low tension. A machine of surpassing simplicity with no friction but at the bearings; a machine with neither commutator, brushes, springs, nor sectors. The current will be absolutely uniform and in the same direction whether the machine be turned backward or forward. It will cost and weigh much less than any other of equal capacity, and cannot become disordered. It will be as much superior to the Gramme as the latter is to those of Pixii, Saxton, and Clarke.

Most of the electric machines in use are based on the Gramme, especially in relation to the commutator. The Gramme machine was invented by Dr. Pacinotti of Italy, in 1861. It stood with the arms vertical, and the axis of the armature was between the arms of the magnet and also stood in a vertical position. The armature was near the top of the machine and the commutator near the bottom. The armature had an iron tooth between every two successive sections of wire on the ring. The machine was first used as an electric motor; but its inventor showed that it was reversible. I shall say a few words about this reversibility. If we turn a chain pump we get a current of water flowing upwards. If we pour water down the pipe the chain and sprocket wheel will now run in the opposite direction. So with a dynamo having a commutator; if you turn it you get a current of electricity. Send a current to it and it will turn in the opposite direction. The Pacinotti machine slept ten years in the Philosophical Museum of Pisa University, when Z. T. Gramme of Paris, awakened it; turned it over on its side; placed the arms at right angles to their former position; took out its teeth; gave it a better appearance; made it run; got a powerful and nearly steady current; obtained patents, gold medals, riches, and the applause of the world.

Strathroy, *November 12, 1887.*

For Friday Afternoon.

THE OBSTINATE STOVEPIPE.

A man gets on a tipping box,
With all his patience fled,
And glares up at the stovepipe joint
He holds above his head.

His hands are black with polish paste,
His face tattooed with soot;
And down his arms and down his back
Sharp pains unnumbered shoot.

Ten thousand ways, ten thousand times,
He tries to make it fit;
The more of ways and times he tries,
The further he's from it.

His wife and children gazing on,
Are petrified with fear,
Awaiting the catastrophe
That comes this time of year.

It comes:—A burst of adjectives,
And then a madman's roar,
A man and box and stovepipe, too,
Are found upon the floor.

* * * * * *

The doctor comes with arnica,
And little blister cup;
The tinner comes as usual,
And puts the stovepipe up.

TICK TOCK.

"Tick tock! tick tock!"
Says the clock—"half-past three."
"Tick tock! tick tock!"
"Half-past three" still we see!
It must be the hands are caught,
That is why it tells us naught,
Tho' it ticks and ticks along
As if there were nothing wrong!
"Tick tock!"

"Tick tock! tick tock!"
Many a word, many a word,—
"Tick tock! tick tock!"—
Just as useless, I have heard.
These—the folks who tell us naught—
Ah! perhaps their hands are caught!
'Tis the busy ones that know
Some hing worth the telling.—So
"Tick tock! tick tock!"

—*Maria J. Hammond, in St. Nicholas.*