fact that the motor must be brought to almost its normal speed by some means outside of the alternating current; and a continuous or redressed current must be supplied to the fields. In a paper read early in 1888, the author proposed to remedy these troubles by running with the alternating circuit an auxiliary continuous current circuit to excite the fields and start the motors. The latter function was performed by commutating the armature coils until the motor had attained normal speed, when the commutator was thrown out and the machine ran as an alternating motor. It was also proposed to use a friction pulley to prevent a suddenly applied load stopping the machine. Most of these suggestions have since been patented (not by the author), and some results may follow, although they do not seem to have been applied. They seem to me practical enough.

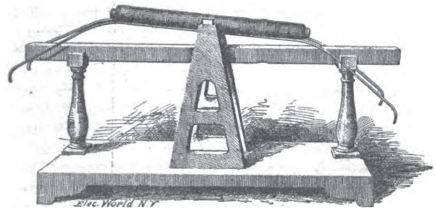
Henry's Electric Motor Constructed in 1831.

BY J. ELFRETH WATKINS.

One of the most interesting objects displayed in the loan collection of mechanical relics, etc., exhibited in the lecture hall of the U. S. National Museum at Washington during the patent centennial celebration was the original electro-magnetic engine designed by Joseph Henry in 1831, and constructed with his own hands. This machine, simple as it is, is one of the earliest applications of magneto-electricity to the production of power. Henry calls it "Reciprocating motion produced by magnetic attraction and repulsion." In July, 1831, writing to the editor of *Silliman's Journal*, he says:

"I have lately succeeded in producing motion in a little machine by a power, which, I believe, has never before been applied in mechanics—by magnetic attraction and repulsion.

"Not much importance, however, is attached to the invention, since the article, in its present state, can only be considered a philosophical toy, although in the discovery and invention it is not impossible that the same principle, or some modification of it on a more extended scale, may hereafter be applied to some useful purpose. But without reference to its practical utility, and only viewed as a new effect produced by one of the most mysterious agents of



HENRY'S ELECTRIC MOTOR CONSTRUCTED IN 1831.

nature, you will not, perhaps, think the following account of it unworthy of a place in the *Journal of Science*.

"It is well known that an attractive or repulsive force is exerted between two magnets, according as poles of different names, or poles of the same name, are presented to each other.

"In order to understand how this principle can be applied to produce a reciprocating motion, let us suppose a bar magnet to be supported horizontally on an axis passing through the centre of gravity, in precisely the same manner as a dipping needle is poised; and suppose two other magnets to be placed perpendicularly, one under each pole of the horizontal magnet, and a little below it, with their north poles uppermost; then it is evident that the south pole of the horizontal magnet will be attracted by the north pole of one of the perpendicular magnets, and its north pole repelled by the north pole of the other; in this state it will remain at rest, but if by any means we reverse the polarity of the horizontal magnet, its position will be changed, and the extremity, which was before attracted, will now be repelled; if the polarity be again reversed, the position will again be changed, and so on indefinitely. To produce, therefore, a continued vibration, it is only necessary to introduce into this arrangement some means by which the polarity of the horizontal magnet can be instantly changed, and that, too, by a cause which shall be put in operation by the motion of the magnet itself; how this can be effected will not be difficult to conceive, when I mention that instead of a permanent steel magnet in the movable part of the apparatus, a soft iron galvanic magnet is used.

"The motion, here described, is entirely distinct from that produced by the electromagnetic combination of wires and magnets; it results directly from the mechanical action of ordinary magnetism, galvanism being only introduced for the purpose of changing the poles."

At the end of sixty years the same principle that led the great physicist (who is known to the world as a discoverer rather than an inventor) to make this "little machine" is used in constructing the electrical devices which may properly be classed among the mechanical triumphs of the century of invention which have been indelibly recorded in the annals of our history by the recent patent centennial celebration.

Graphic Method for Analyzing Losses in Armature Cores, etc.*

BY R. H. HOUSMAN.

It has long been known that the losses in the armature core of a continuous current dynamo may be accurately measured by running it as a motor without load, and noting the power absorbed. It was also shown by Mr. Mordey some little time ago that, by plotting the losses, so measured, at different speeds, those which are proportional to the square of the speed (Foucault currents) may be separated from those which are directly proportional to the speed (hysteresis) by a mathematical process; but this process debars the method from general use.

It is, however, possible, by a simple graphical construction, to separate the different losses without any recourse

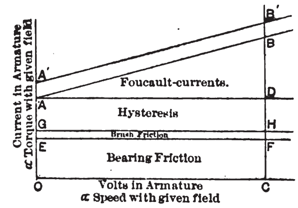


FIG. 1.—ELECTRICAL DIAGRAM.

to mathematics at all. The method is as follows: Measure the current required to run the armature as a motor light with different volts on the armature, the magnets being separately excited so as to keep the field constant. On plotting the results as a curve, as in *A B*, Fig. 1, it will be found that the curve is a perfectly straight line, cutting the axis of current at some distance from the origin.

Now, taking any point *B* on the curve, and drawing *B C* parallel to *A O*, it is evident that the total loss is represented by the product $O\ C \times C\ B$.

Next draw *A D* parallel to *O C*; this divides the area representing the total loss into two parts, one of which, *O D*, is proportional to *O C*, and the other, $A\ D \times D\ B$, is proportional to the square of *O C*, since *B D* is proportional to *A D*, which $= O\ C$. The first of these areas represents the waste of energy per second due to hysteresis and friction combined, while the second gives the loss due to Foucault currents. It must be noticed that it is the product of the co-ordinates of any point on *A B*, which represents the waste and not the area of the figure *A O C B*. In this respect the diagram resembles the characteristic of a dynamo rather than the diagram of a steam engine.

Friction of bearings and brushes must be determined separately by coupling direct to a similar motor and observing the increase of current required to drive with the fields unexcited. This will be constant at all speeds.

From this experiment draw *O E* equal to the current observed as required for friction alone; then *E F*, being drawn parallel to *O C*, the rectangle *O F* represents loss by bearing friction. By a simple experiment the loss by brush friction may be determined and *G H* drawn, so that *E H* represents the loss from this cause. The remaining rectangle, *G D*, will then show the loss due to hysteresis. It will be readily understood that only the losses represented by $G\ H \times H\ B$ (Foucault currents + hysteresis) appear as heat in the armature.

A second set of experiments may be made with a different strength of field, and plotted in a curve, *A' B'*, which is in general parallel to *A B*, showing that Foucault currents are constant for given volts. *A' B'* will be above or below *A B*, according as the change of field intensity has

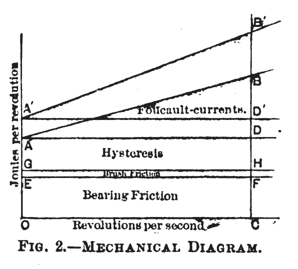


FIG. 2.—MECHANICAL DIAGRAM.

increased or diminished, the sum of the losses due to hysteresis and friction, these two varying inversely, though not in simple inverse ratio.

At a certain intensity the total losses for given volts will be a minimum; this in practice seems generally to occur between 15,000 and 16,000 lines per square centimetre in the iron of the armature, but the exact figure depends on whether friction is large or small. In machines with little friction the best intensity may be much lower. There is a curious point about the Foucault currents at high intensities (18,000 or 20,000); they show a decided tendency to *increase*, the slope of the curve *A B* becoming much steeper. This is probably due to the increased stray field in the shaft and flanges at the ends of the armature, which being solid metal may have large currents in them when the field through them reaches 200 to 300 lines per square centimetre.

In Fig. 1 all the quantities have been measured electrically; hence it may be called the electrical curve to distinguish it from another diagram which may be derived from it, in which the quantities are measured in mechanical units. The electrical diagram has the disadvantage that for each intensity of field a separate friction line has to be drawn, which makes it difficult to distinguish how much of the whole loss is electrical and how much frictional, when there is more than one curve drawn on the same diagram. This difficulty is obviated by plotting revolutions per second instead of volts along the horizontal axis, and work per revolution in joules instead of current along the vertical axis. It will be noticed that the product of these two is expressed in watts (or work per second), as before, but it only requires an alteration of scale to make the co-ordinates revolutions per minute and foot-pounds per revolution respectively, in which case the product ÷ 33,000 gives horse power.

In this diagram the same friction line holds good for all intensities, and the frictional and electrical losses are separated by the line *G H* (Fig. 2). It will also be seen that the quantities *G A* and *G A'* represent the losses by hysteresis, in joules per cycle, at the two intensities, for which *A B* and *A' B'* are drawn, respectively. The loss per cubic centimetre from this cause is always found to be much greater than that generally given.

* From *The Electrician*, London.

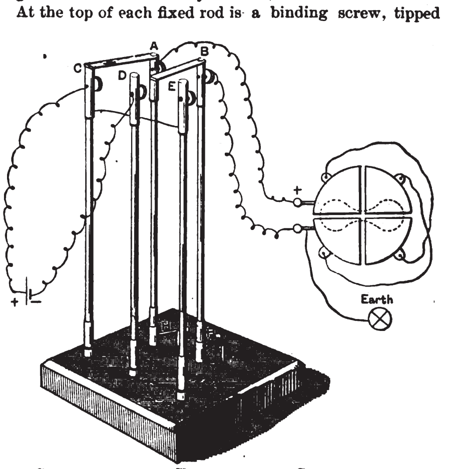
An Electrostatic Commutator.*

BY ROLLO APPLEYARD.

The electrostatic commutator here shown is a simple apparatus, of small capacity and high insulation, for effecting all the ordinary connecting operations with electrometers.

It consists of five insulating rods, three of which, *C*, *D*, *E*, are fixed; *A* and *B* are fitted into brass sockets in the baseboard with spring washers, so as to be capable of turning about a vertical axis by handles, *H*.

At the top of each fixed rod is a binding screw, tipped



COMMUTATOR FOR ELECTROMETER CONNECTIONS.

with platinum, and having a slightly convex surface of contact.

The rods *A*, *B* carry contact springs with corresponding hollows at their rubbing ends, so that when the handle is moved the spring slides on and drops into place easily.

The screws *C* and *E* are connected permanently together by a wire.

A and *B* are the quadrant terminals; *D*, and either *C* or *E*, are for the test wires. This method of connecting prevents all possible chance of short-circuiting a cell under test. By sliding the springs on to *C* and *D* the quadrant in connection with *A* becomes +, and that jointed to *B* is —. We may reverse by sliding the springs to *D* and *E* respectively.

The electrometer quadrants are connected together by joining *A* to *C* and *B* to *E*—in which position the springs should always be left after a test.

In intermediate positions the quadrants are completely insulated. When very high insulation is required, some dessicating arrangement may be employed. With a slight modification of the handles, a place might be found for this commutator inside the electrometer case itself, the handles being entirely outside, below the base.

Ganz Alternate Current Motors.

In Fiume, Austria, four 10 h. p. Ganz alternate-current motors are applied to working passenger elevators, and two others will shortly be added. The International Electric Company has a central station in Fiume capable of supplying 80,000 watts, of which 30,000 watts are used for transmission of power and 10,000 watts for lighting the Fiume railway station. In the finished station there will be more than 100 h. p. for motive power, besides current for lighting the docks and all the warehouses alongside. The Ganz motors are of 10 h. p., very similar to their type "A" alternate-current dynamos. The current is brought in parallel at 2,000 volts, and is transformed down to 50 volts for the motors, which, moreover, are all connected in par-

* From *The Electrician*, London.