No. 16.—*Upon the induced currents produced by the application of armatures to Horseshoe magnets and a new form of Magneto-electric Engine ; by W. R. MORSE.*

The apparatus consisted of cylindrical horseshoe electro-magnets, the wires of which were wound about the iron cores at the bend of the iron, so as to form practically straight electro-magnets with cores horseshoe in form. Upon one of the limbs of the horseshoe core a coil of fine wire was slipped so that the plane of its coils was at right angles to those of the electro-

magnet. In fig. 1, A represents the coil of the electro-magnet; B that of the induction coil. Upon exciting the electro-magnet induction currents arose in the coil of fine wire B both at making and breaking the circuit. These currents were measured by a reflecting galvanometer placed in the circuit of the coil B; and were compared with those

obtained from the same electro-magnet by placing a straight armature C D upon its poles and then exciting the electro-magnet. The following table shows the results obtained. Only the currents resulting from making the circuit are recorded, those proceeding from the breaking of the circuit being the same in value. The readings are expressed in the divisions of the scale of the reflecting galvanometer.

Without armature.	With armature.	After removal of the armature. 1st deflection.	After removal of the armature. 2d deflection.
170	210	210	170
170	209	209	170
175	209	209	170
170	210	210	175

These results show that a marked increase (in these experiments, nearly twenty-five per cent) in the strength of the induction currents results from the application of an armature to the poles of the electro-magnet. The third and fourth columns of the table show that after the removal of the armature, the first induced current which results from again making the current in the electro-magnet shows the same increased effect; but that the following current resulting from breaking the circuit of the electro-magnet falls to its normal amount. This result is noteworthy, for it shows a certain molecular change in the iron which results from the application of the armature.

Although we can thus increase the strength of the induction currents produced in coils slipped upon the limbs of an electro-

magnet, we diminish the lifting power of these individual limbs by the employment of an armature, as the following results show :

Weight lifted without armature.	Weight lifted with armature on.
249	160
300	180

In the preceding experiments the straight iron bars forming the armatures were carefully deprived of whatever residual magnetism they might possess.

Experiments were next tried upon the effect of horseshoe electro-magnets used as armatures to electro-magnets of the same character as those employed in the preceding experiments. When two north or two south poles were opposed to each other, and the magnetic circuit, so to speak, of the two horseshoe-shaped cores was closed, very feeble indications were shown by the galvanometer. When, however, a north and a south pole were opposed, and the magnetic circuit closed, the strength of the currents obtained both on the application and the removal of the armature were very marked, as the following results show :

At contact of N. and S. poles.	On removal of N. and S. poles.
+360	—359
+362	—360
+361	—361

When the horseshoe magnet forming the armature was not used, and one of the limbs of the stationary electro-magnet was quickly slipped in and out of the induction coil, induction currents were obtained, the values of which are shown below :

Placed in.	Withdrawn.
+40	—40
+40	—40
+40	—40

In these experiments the stationary electro-magnet and the electro-magnetic armature were of the same size and the same magnetic strength.

Experiments were next made upon the influence of the mass of the iron forming the armature. This was found not to have so much influence as the residual magnetism of the iron. The results were very contradictory, as the following table shows :

Weight of armature.	Deflection produced.
364 grams.	280
341	330
222	290
137	280
132	290
67	310

We are led to believe that the mass of the iron does not affect the results when it exceeds that of the stationary electro-magnet.

The induction currents resulting even from the employment of straight soft iron armatures which had been carefully deprived of residual magnetism are thus seen to be more than four times as strong as those obtained by merely slipping the induction coil on and off the limits of the electro-magnet; which is, practically, the method adopted in many later forms of the magneto-electric engine, particularly in that of the Gramm machine, in which different portions of a ring-shaped electro-magnet revolve toward and away from the poles of a horseshoe magnet. When electro-magnetic armatures are used the effects far surpass those obtained by non-magnetic soft iron straight armatures, as the preceding results show.

Professor Trowbridge suggests a magneto-electric engine of the following construction. The horseshoe armature is made to revolve about the line XX' as an axis. By the preceding experiments it has been

found that when a north and a south pole are opposed the induction currents flowing through B and A' are in the same direction and those through B' and A are also in one direction. By a suitable commutator the currents circulating through the coils on the stationary magnet can be sent through those on the armature, and vice versa. The residual magnetism in soft iron is sufficient to start the induced currents. Instead of one stationary electro-magnet it would probably be better to employ a number arranged about the axis XX. With projecting pieces of soft iron arranged upon the poles of the stationary magnets, the size of the horseshoe armature could be regulated to suit the varying conditions of speed.

Experiments are now being made on this form of engine.