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RAILWAY ELECTRIFICATION.

By H. L. Kirker, Resident Engineer, W. E. & M. Co., St. Clair Tunnel.

(Continued from last issue.)

Granting that electrification is the logical means of increasing the capacity of congested steam roads, and granting that the examples of three systems (the direct current third rail, the single phase trolley, and the three phase double trolley) demonstrate the commercial success of electrification in specific cases, it is not true that the technicalities of electrification are a handicap to the acquisition of a working knowledge of the subject. The electric motor is based on a principle as simple as that of the steam engine. Just as the steam engine depends on the expansive property of steam, so the electric motor depends upon the magnetic properties of the electric current. The magnetic properties of the electric current have been known for almost a century. They had no commercial significance, however, until discovery was made of a mechanical means of generating electric current. Faraday made this epoch-making discovery 76 years ago, and thereby started the industrial revolution that this subtle form of energy is effecting. Faraday, starting with the fact that current can produce motion, succeeded in demonstrating that motion can produce current. Industrialism harnessed Faraday's discovery to the steam engine. Given the steam driven dynamo, the evolution of the electric locomotive was inevitable. The magnetic properties of the electric current on which Faraday based his researches, which resulted in his discovery of a method of inducing current, are manifested by the two simple facts, that currents flowing in the same direction attract one another and currents flowing in opposite directions repel one another.

INDUCTION.—In basing his research Faraday reasoned that since current produces magnetism, why, magnetism should produce current, and he discovered that by changing the magnetic conditions around a wire he could induce a current in the wire during the time the change in magnetic conditions was taking place. By the way of a mental picture he imagined the wire-carrying-the-current to be encircled by a magnetic field, and represented this field by lines of force. He knew that sending a current through a wire set up a field around the wire, and that stopping the current withdrew the magnetic field. Now this dilation and contraction of the magnetic field incident to starting and stopping the current causes the lines of force to cut across adjacent wires. He discovered that this cutting of the lines of force across the adjacent wire induces an electric pressure in the adjacent wire. The result is the same whether the wire is stationary and the lines of force cut across the wire, or lines of force are stationary and the wire cut across the lines of force.

So electric current is induced in a wire by making the wire cut lines of force. The induction coil or transformer, as it is known commercially, is the classical adaption of the idea. The simple transformer consists of two coils of insulated wire wound on a common iron core. Sending an alternating current through one of the coils sets up an alternating field in the common iron core. This alternating field cuts across the second coil and induces alternating current in the second coil. The pressure of the current set up in the second coil depends on the rate of cutting lines of force. The rate of cutting depends upon the number of lines of force, on the frequency with which they reverse, and the number of turns in the secondary coil. A big core, a high frequency, and a secondary of many turns means a high voltage in the secondary coil. This transformer enables heavy alternating current of low voltage to be converted into a light current of high voltage. Small current means light line wire. High voltage means great power with small currents. High voltage consequently means long distance transmission of great power with small currents at small loss with a small line wire. The transformer then is the basis of long distance transmission of electric energy. It raises the voltage to the high pressure required for long distance transmission, and lowers the voltage to a safe working pressure at the point where the power is used.

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THE DYNAMO.—The induction coil assumes the existence of an undulating current. Faraday applied his discovery to the production of alternating current. Having found that the cutting lines of force could induce current, he proceeded to induce current by moving a wire across a magnetic field. The dynamo is a machine for moving wires across a magnetic field—a machine for cutting lines of force. The essence of the elementary dynamo is a dense magnetic field and a coil of wire that rotates in this field. The greater the rate of cutting, the greater the voltage induced in the rotating coil. This rate can be increased by increasing the number of lines of force in the field, by increasing the number of turns in the coil, and by increasing the rate of rotation of the coil. Ordinarily, however, dynamos are built for moderate voltage and transformers are used to raise the alternating current to the high potential required for long distance transmission.

THE COMMUTATOR.—Since induction implies alternating current, whether the inducing apparatus be the transformer or the dynamo, the dynamo can be made to give continuous current—like that supplied by the storage battery. Alternating current is rectified by the commutator. The commutator is simple enough, but a description of it is rather tedious, and need not be given here. It will suffice to recall that in the transformer, while the field is dilating with the increasing primary current, the dilating field cuts across the secondary coil and induces a current in the secondary coil of opposite direction to that in the primary, and, while the field is contracting with the decreasing primary current, the contracting field cuts across the secondary wires and induces a secondary current of the same direction as the primary. That is to say, the direction of the induced current changes with the change of direction of the motion of the field. Likewise in the dynamo the direction of the induced current in the armature wire cutting across the field under the north pole, is opposite to the direction of the current induced in the same wire when cutting across the field under the south pole of the dynamo. Consequently it is necessary to group the armature coils and arrange the commutator taps in such a way that if the beginning of the coil leads to the posi-