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Current Induction

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cogenic function of his liver, and of the intricate working of his sympathetic system. Von Baer gave him an account of his embryonic origin, and —but the list is endless. It is true, and no teacher denies it, that many notable contributions to human knowledge have been made by men who were never associated with the teaching profession. Darwin and Wallace, the founders of natural selection, were not teachers, but they are more than balanced by such evolutionary pedagogues as Lamarck, DeVries, Huxley, and Cope. Mendel was a teacher, and Bateson, Morgan, Punnett, Guyer, and a dozen other teaching professors have contributed largely to genetics since Mendel's day.

The pedagogue has entered and contributed to every field of human knowledge. He has done but little in literature, it is true, but science would be nothing without him. Philosophy has its James and Dewey, and Herbart, and Hegel and Kant—all professors. Music boasts of the contrapuntal writings of pedagogue Bach; Mendelssohn and Liszt were in no way greater than as teachers, and much of the superb music of the Catholic church was written by Chembini, famous pedagogue of the Paris Conservatory. And we need not mention such famous professors as McDowell, Horatio Parker, and Stielman-Kelley!

"The world's stock of knowledge is seldom augmented by pedagogues?" The man who wrote that sentence is but a puny fly vainly struggling against the web of knowledge woven about him by a universal professoriate. Try as he will, he cannot escape the ubiquitious, puissant pedagogue. But as he himself has so well said, "One does what one can."

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CURRENT INDUCTION

The modern transformer, now quite generally used in the commercial distribution of electrical power in the cities of the world, ranks next to the dynamo in importance in the electrical world. The transformer is an invention which embodies the practical application of Faraday's first experiment in current induction, in which a closed iron ring carrying a primary coil and a secondary coil was used.

Commercial transformers, Fig. I, can be observed mounted high on

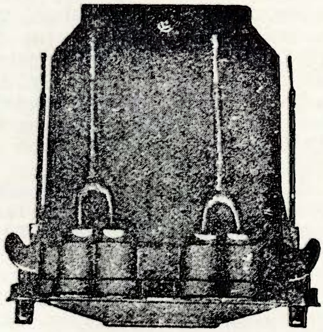

Figure 1

poles in every community where an alternating current of electricity is used for lighting purposes. The purpose of these transformers is to reduce the high voltage of the current generated by the dynamo to a lower, safe voltage for currents used in the house, store and factory.

The function of a transformer can be easily grasped from a study of the diagrammation in figure 2. In this sketch A represents an alternating dynamo. The rectangular soft iron frame shown at the center of the sketch carries a primary coil and a secondary coil. The terminals of the primary coil, with many turns of wire are directly connected to the terminals of the dynamo circuit. The terminals of the secondary coil are connected, as shown, to four electric lamps. The lamps are arranged in parallel across the leads from the transformer, which is the usual method of connecting electric lamps in a house circuit.

According to theory, the voltage of the dynamo is to the voltage between the lamp terminals in an arrangement of this kind, as the number of turns in the primary coil is to the number of turns in the secondary coil. Assuming the number of turns in the primary to be 220 and the number of turns in the secondary to be 22, we have a ratio of 10 to 1. Consequently, if the dynamo furnishes a voltage of 1100 volts then the lamp terminals will have one-tenth that much or 110 volts. If the primary of the transformer had only 11 turns then the dynamo would have to furnish 220 volts to produce 110 volts for the terminals in the home. In practice, it is customary to build a dynamo, in a case of this kind, to furnish more than 2200 volts, probably 2300 volts or 2400 volts. This extra voltage is designed to take care of the voltage loss in the leads from the dynamo to the transformer. This voltage loss varies with the distance between these two generators.

In the last sentence in the above paragraph, we refer to the transformer as a generator. This is true, since it generates a voltage in the secondary coil in accordance with the Faraday principle of induction, as is the case in the dynamo. However, the method of varying the magnetic field so as to generate the voltage in the secondary is quite different from that of the dynamo. In the dynamo, the armature is rotated to vary the magnetic field threading its circuit. In the transformer there is no mechanical motion of either coil. In the transformer, the current from the dynamo vibrates back and forth in the primary coil, flowing in one direction during half the vibration and then in the opposite direction during the other half. This current in the primary acts just like the pendulum of a clock where we see the mechanical motion taking place in one direction during half its swing and then in the opposite direction during the other half of its swing.

The vibrating or alternating current in the primary gives rise to a vibrating magnetic field in the rectangular iron core. This means that the magnetic lines of force in the iron core are directed in one direction during one half its period of vibration and then in the opposite direction during the other half. During a complete vibration of the magnetic field in the iron core the number of lines of magnetic force is rapidly changed from zero to a maximum and then back to zero in one direction followed at once by the same process in the opposite direction. In commercial transformers, Fig. 1, used for city lighting, these vibratory magnetic changes in the iron core take place very rapidly, usually sixty times per second. It is this varying magnetic field in the iron core set up by the alternating current in the primary that induces the voltage in the secondary coil, just as the varying magnetic field that threads the armature of a dynamo induces a voltage in its circuit.

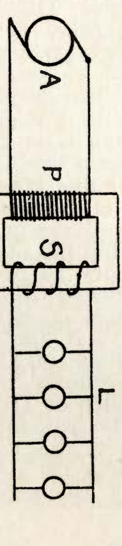

Figure 2

Having discussed from a historic point of view, the two greatest discoveries in current induction and their practical applications as found in the dynamo and the transformer, it would be well at this point to take up another form of current induction commonly termed self-induction. As the term self-induction indicates, it refers to the magnetic action of a varying current flowing through a circuit upon itself. In our preceding discussion we have considered only the case where a varying current in one circuit induces a separate current distinct from the first as in a transformer.

Joseph Henry, an American, was the first discoverer of self-induction. Quoting from Cajori's History of Physics, we have the following: "In August, 1829, while Henry was testing the lifting power of magnets wound with different lengths of wire and by means of his intensity magnet and battery had made the actual combination which constitutes the electric telegraph of today, he noticed an unexpected spark resulting from the break of a long coiled wire through which the battery current had been passing. Nature thus lifted the veil for a moment to lure him in a different direction, and it so happened that when vacation came round again in August, 1830, he had taken up the investigation of this new phenomenon. He recognized its nature, and in 1832 published it under the heading "Electrical Self-induction in a Long Helical Wire." Faraday's investigation of self-induction was not published till in 1835. Therefore the honor of discovering self-induction unquestionably belongs to Joseph Henry." From the above quotation we infer also that the construction of the first telegraph line belongs to Joseph Henry and not to Samuel F. B. Morse who brought it into commercial use.

The phenomenon of self-induction can be readily grasped from the following simple experimental illustration. In figure 3 a battery B and a key K are connected in circuit with an elongated coil of wire. In a previous article it was pointed out that

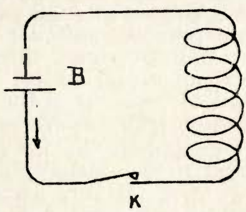

Figure 3

the magnetic lines of force around a straight current are circular with the wire at the center of the circles. The combined magnetic field of a series of circular turns of wire in an elongated coil carrying a current, however, is exactly like that of a straight electro-magnet. The lines of magnetic force when the current is flowing form straight lines in the coil passing out at one end of the coil and then curving around to return into the other end. It is evident that an elongated coil, Fig. 3, is an electro-magnet minus the soft iron core.

When the key K, Fig. 3, is closed, the current from the battery B rises gradually to its maximum because its energy is being used to build up the magnetic field, threading its circuit. This momentary loss of current energy is due to the fact that a counter current is induced which opposes its flow for the fraction of a second. On the other hand, when the current is broken by opening the key K, all the energy of the magnetic field threading the coil collapses, in a sense, on the circuit and induces a direct current which intensifies the main current for a moment causing a bright spark at the key. This bright spark, which always occurs when an electric current is broken is due to the extra current induced when the number of lines of magnetic force threading the coil are rapidly reduced to zero.

It is a spark of this kind that is utilized in the common electric cigar lighter. This extra spark is also used by means of spark plugs in gasoline engines. A simple experiment to illustrate the extra current can be performed as follows: Connect an electro-magnet in circuit with two good dry cells, Not using a key, hold the two wire ends of the broken circuit over the top of a Bunsen burner with the gas turned on. Close the circuit by bringing the two ends of the wires together and then snap them apart suddenly. The gas of the burner will be ignited by the spark of the extra current.

L. Begeman.

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ARE YOU EDUCATED?

(Continued from page 3)

of many diseases which now reach the epidemic stage in many communities. Many public buildings are poorly lighted, poorly ventilated, and poorly cared for. In most cases the cost would be no greater were the buildings as they should be. What most communities need is more people who are qualified educationally to understand and aid in the health problems of the community. Incidentally many of us will have to brush up a bit if we are to qualify under "The Ten Commandments" of Dr. Farr as an educated person.

H. Earl Rath.

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NATIONAL GEOGRAPHY MEETINGS

The Christmas vacation always brings a full quota of meetings of interest to those who are engaged in educational work. Especially does this seem true for those interested in science. Two meetings of value to geographers were held at Ypsilanti, Michigan, where the new Union building, an alumni project of the Michigan State Normal College, afforded an excellent meeting place. The first of these was the meeting of the National Council of Geography