THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.*

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(*Continued from page 397.*)

In Sturgeon's *Annals of Electricity*, Vol. I., p. 418, there is a mention of the meeting of the London Electrical Society held on August 5, 1837, when Sturgeon read a paper on "Secondary Electric Currents," illustrated by a powerful double-wire horse-shoe electro-magnet which had been presented to him by Prof. Callan, of the R.C. College, Maynooth. This paper or lecture stimulated several minds, and particularly that of Sturgeon himself. On page 470 of the *Annals*, Vol. I., we have another Paper by him on "An Experimental Investigation "of the Influence of Electrical Currents on Soft Iron as regards "the thickness of metal requisite for the full display of

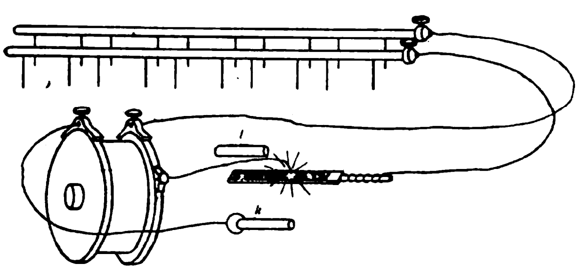

FIG. 3.—Sturgeon's Coil with Wooden Core.

Contact breaker at terminal *l* provided by a file Free terminal, provided with handle *k*

"Magnetic Action, and how far these pieces of iron are "available for Practical Purposes." He constructed a double-wire helix on Callan's plan. He wound on a wooden bobbin a naked copper wire insulated with sealing-wax varnish. One wire was a copper bell wire, 260 feet long, forming the inner or lower coil; and the upper or outer coil was a thinner copper wire, 1,300 feet long. The end of the fine wire was soldered to one end of the thick wire, so that it made one continuous con-

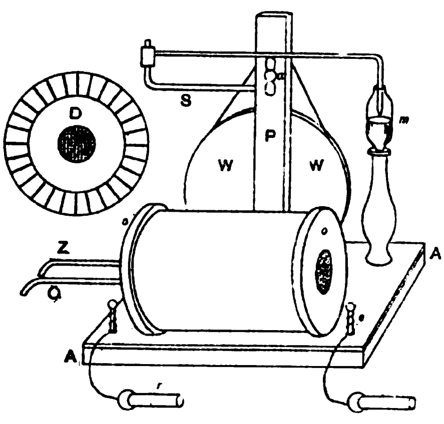

FIG. 4.—Sturgeon's Induction Coil.

Z and C, wires from battery *o o*, coil. A A, base of coil. W W, driving wheel for contact breaker. *a*, cam lifting a wire attached to arm S. *m*, a mercury contact.

ductor, wound all the same way on the bobbin. The reel, or bobbin, was of wood, two inches long between the cheeks. (*See* Fig. 3.) Strips of silk were interposed between the layers of wire. Hence, Sturgeon's coil was a short, wide coil, wound on a hollow wooden core, and not like Callan's magnet, which was long and thin. Sturgeon applied to his coils a break-and-make arrangement, consisting of a wire dipping in a mercury cup in one case and of a notched zinc disc in the other. (*See* Figs. 4 and 5.) The mercury cup-break was worked by a revolving cam and lever, and gave about 36 breaks per second when the cam was turned round by a winch. With the zinc disc he got 540 breaks per second. He put a *solid* iron core in the bobbin, and he was delighted to find that he got powerful shocks from the secondary circuit when the current from one or two cells was interrupted in the primary. He then made a very curious observation. He found that with the solid iron core the shock was much diminished in amount when the revolving contact-breaker went above a certain speed. After some trials he substituted a bundle of fine iron wires for the solid core, and he got very much better results. He draws attention to the fact that (*Annals*, Vol. I., p. 481,) Prof. G. H. Bachhoffner had tried a divided iron core about a fortnight before he had with one of Sturgeon's own coils, which he had lent him. Bachhoffner observed that a bundle of fine iron wires used

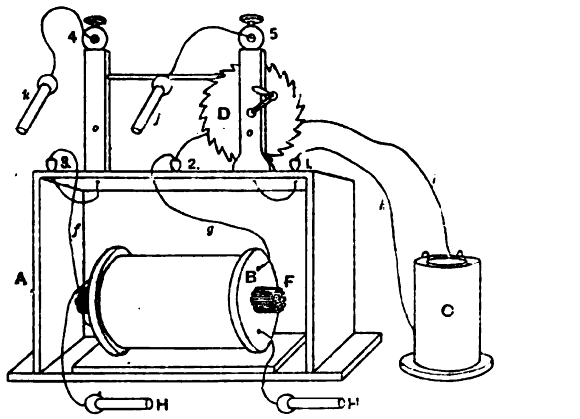

FIG. 5.—Sturgeon's First Induction Coil.

A, box containing coil. B, induction coil. C, battery. D, zinc disc contact breaker. F, iron core. H H, handles on secondary. *h* and *i* wires from battery to contact cups 1 and 2. 4 and 5, terminals. *k* and *j* handles.

as a core in Sturgeon's coil gave far better shocks than when a solid iron bar was employed. We must therefore credit Bachhoffner with being the first to recognise the value of a divided iron core. W. Sturgeon noted that a rolled-up sheet of tinned iron put in as a core increased the shocking power in an extraordinary degree beyond that obtained when a solid core was used, and that with a bundle of fine iron wires as a core the shocks were more increased still. Sturgeon claimed that his coil was an advance on Callan's, and certainly when we regard the sketch of Sturgeon's first coil, we see that he gave to the appliance practically the general form which it has retained ever since. This coil of Sturgeon's was exhibited to the London Electrical Society in August, 1837.

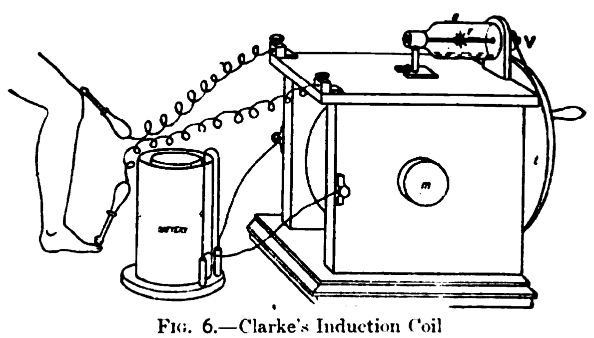

FIG. 6.—Clarke's Induction Coil

m, core of coil. *t*, driving wheel of contact breaker. V, driven pulley. *r*, star wheel breaking contact with mercury in vessel *s*.

We come next to another important Paper by Callan, dated September 11, 1837, printed in Vol. I., p. 491, of Sturgeon's *Annals of Electricity*: "On a Method of Connecting Electro-magnets so as to Combine their Electric Powers, and on the Application of Electro-magnetism to the Working of Machines."

Callan wound on each of two iron bars a couple of wires, first a copper wire one-twelfth of an inch in diameter put on in one layer, and second, a copper wire one-ninetieth of an inch in diameter, and 150ft. long wound over the first. Each wire was carefully insulated both from itself as well as from the iron and the other wire. It is clear from the description which follows that in making these two induction coils Callan did *not join* the end of the secondary wires to the end of the primaries, but left the secondary distinct and insulated from the primary. He then *joined the primaries of these two induction coils in parallel* on a large galvanic cell, and the secondary coils he joined in series, and he obtained from the secondaries in series, a shock greatly in excess of that which he obtained from either of them separately. He points out that the secondaries must be so united that the electromotive forces in each are added and not opposed to each other, and he surmises that if a hundred such induction coils could be arranged with secondaries in series and primaries in parallel on a very large quantity battery that it would be possible to have a shock equal to that of 100,000 or 200,000 single cells.

On page 493 (*Annals*, Vol. 1) he says:—"In making "electro-magnets which are to be connected for the purpose "of obtaining increased electric intensity, care must be taken "*not to solder* the thin wire to the thick wire of the magnet, "but to leave both ends of the thin wires projecting."

In a note he recommends that for lecture purposes the thick wire coil and the thin wire coil should be wound on separate bobbins, the thick wire bobbin being made to slide inside the thin wire bobbin, and he says that such a pair of separate coils was given by him to Mr. Cottam, the secretary of the Manchester Mechanics Institute, during the lecture he gave there. Hence it is to Callan that we owe this simple piece of apparatus, now found in every physical laboratory, and it is to him that we are indebted for an induction coil having two separate wires, one thick and the other thin, used as an induction coil. Furthermore, he says that about four months before writing this Paper he coiled on a cylinder of wood (hollow) about 10 feet of covered copper wire, one-eighth of an inch in diameter, and over this 200ft. of very thin-covered wire, and an iron bar was put into the hollow of the bobbin. With 20 pairs of plates (*i.e.*, cells) on the primary, he got severe shocks even without the iron core, and when the core was put in he got a shock even on making the contact with the battery.

A little later in the first volume of Sturgeon's *Annals of Electricity* we reach a Paper by a Mr. E. M. Clarke, on an induction coil (*see* Fig. 6), for giving shocks with a single pair of plates. There is nothing more in this than a description of a Callan's or Sturgeon's coil. The secondary wire was one ninety-second of an inch in diameter, and the contact breaker was a Barker's wheel, or copper star, revolving so that the tips of its spokes just dipped in mercury in a bottle.

Some time previously Mr. Barker had invented this device for interrupting a current. Mr. E. M. Clarke was a philosophical instrument maker, having a shop in the Lowther Arcade, and his memory is also handed down to us as an improver of Pinii's magneto-electric machine. Mr. Sturgeon comments on Clarke's Paper, and, for appropriating without sufficient acknowledgment Mr. Barker's wheel and his own coil, he gives Mr. Clarke, of 11, Lowther-arcade, a dignified rebuke. Various improvers having been given the clue, took up the manufacture of induction coils. On page 205 of the *Annals of Electricity*, Vol. II., a Mr. Nesbit sends a description of a coil; it had a revolving rachet wheel as a contact breaker. A primary coil, consisting of 400ft. of thick wire, and a secondary of 1,700ft. of thin wire, and as a core a bundle of very fine iron wire. This description is dated February 10, 1838. This coil gave very severe shocks when the primary was excited, with one cell of half a square foot of active surface. Nesbit put oil on his break to reduce the noise and check the spark. Four days later, on February 14, 1838, Prof. G. H. Bachhoffner has a description of a coil which he made with two separate insulated copper wires and a core of insulated iron wires, and he notes that if the core of fine iron wires is enclosed in a tinplate tube it ceases to act as a divided core, and becomes no better than a solid core. He claims the original suggestion of using a divided iron core, and it appears from what he says that at first he used lengths of cotton-covered iron wires in a bundle as a core.

Bachhoffner refers also to a self-acting contact breaker which he put on one of his coils, and which he says was made by Mr. Neeve, of 11, Great St. Andrew's-street, Seven Dials, who made for him this magnetic contact breaker superior greatly to the spur wheel of Barlow or the notched disc of Sturgeon, both of which required to be actuated by hand.

(*To be continued.*)

THE ELMORE PROCESS OF DEPOSITING COPPER.

We have already recorded the fact that a Press visit was made on Tuesday, January 27th, to the Elmore Company's works, near Leeds.

Towards 9 o'clock on Tuesday morning a goodly gathering of Press-men for both technical and non-technical journals, engineers, chemists, electricians, and other experts assembled at St. Pancras, and were conveyed in a special Pullman to Leeds, luncheon being served *en route*. With but little delay the tour of inspection began, the company being conducted by Mr. F. L. Rawson, Mr. Stepney Rawson, Mr. F. Elmore, and Mr. A. Elmore. The arrangements left something to be desired, the number of visitors being too great to permit of any one cicerone sufficing, while no systematic attempt to break up the crowd into several small parties was made. Mr. Rawson acted chiefly as spokesman when necessary, a duty that should rather have been performed by one of the Messrs. Elmore, on account of their more direct and intimate knowledge of the working of the process.

After regarding a heap of Chili bars which serve as the raw material, and which were stated somewhat hyperbolically to contain "97 per cent. of copper, and any amount of impurities," the visitors signed their names to guard against the possibility of the unauthorised intrusion of any hated rival in the shape of a copper manufacturer, left their watches to avoid risk of magnetisation, and passed to the melting shed. The installation is of a somewhat temporary character, the present output being small; the furnaces are of the usual type, and merely serve to run down the bars for the production of granulated copper. The time occupied in fusing each charge is about three hours. On this occasion this time had not fully elapsed, but in order to show the actual operation of granulating, the metal from one of the furnaces, though still somewhat sluggish, was run into a ladle, conveyed therein to the water tank, the slag skimmed off, and the copper allowed to trickle into the water.

The violence of the evolution of steam resulting from this operation was not very great, the chief cause of crackling and spurting being the presence of remaining particles of slag which cooled less evenly than the metal. A portion of the product was taken out of the tank for inspection; it was in the form of fairly even sized irregular fragments, mixed with a little slag.

From the melting shed a move was made for the dynamo-room, the boiler-house, containing two boilers, each capable of developing 250 horse-power, being passed on the way. Here was a fairly-complete plant. Three Edison-Hopkinson dynamos, by Mather and Platt, and one Elwell-Parker dynamo not yet in position, constitute that part of the equipment at present. Three engines, each of 70 horse power, by Willans and Robinson, are in place, two driving Mather and Platt dynamos, and one with a dynamo on the same bedplate as itself. A place for a horizontal Fowler engine was being prepared to cope with the larger output that will be required when the second tank-shed is fitted. One of the Willans engines, coupled to a Mather and Platt dynamo, has the excellent record of having just completed a seven months' run, absolutely continuous; its companion is at present supplying all the power needed, which is only about 50 horse power. This yields a current of 750 amperes, at a pressure of 50 volts, the dynamo being run at 450 revolutions per minute; a larger nominal output is possible, but cannot be safely attained from these dynamos with continuous running, as they heat too much, the temperature rising steadily for about 24 hours after starting. The process being essentially one in which continuous running is necessary, even the possibility of injurious overheating must be carefully avoided.

The leads are copper bars, about $1\frac{1}{16}$ in diameter, and run to a switch-board in one corner of the room. By means of these, the current from any one of the dynamos or of the whole number can be distributed to the tank-sheds.

After inspecting the dynamo-room the company passed to the tank-shed, containing 60 tanks, part only of which are at present in use. Nothing particularly novel or striking had been seen up to this point, but in the tank-room the plant and methods of working characteristic of the process were open to inspection. The arrangements are of the simplest. Their nature can best