THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.*

BY DR. J. A. FLEMING, M.A.

(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 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, 1,500 feet long. The end of the fine wire was soldered to one end of the thick wire, so that it made one continuous con-

ductor, wound all the same way on the bobbin. The reel, or bobbin, was of wood, two inches long by 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 340 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 drew attention to the fact that (Annals, Vol. I., p. 481,) Prof. G. H. Bakhoffner had tried a divided iron core about a fortnight before he had with one of Sturgeon's own coils, which he had lent him. Bakhoffner observed that a bundle of fine iron wires used as a core in Sturgeon's coil gave far better shocks than when a solid iron core was employed. We must therefore credit Bakhoffner 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.

![Image 1](https://example.com/image1)

**Fig. 3.** Sturgeon's Coil with Wooden Core.

Contact breaker at terminal I provided by a file. Free terminal, provided with handle 2.

"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, 1,500 feet long. The end of the fine wire was soldered to one end of the thick wire, so that it made one continuous con-

ductor, wound all the same way on the bobbin. The reel, or bobbin, was of wood, two inches long by 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 340 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 drew attention to the fact that (Annals, Vol. I., p. 481,) Prof. G. H. Bakhoffner had tried a divided iron core about a fortnight before he had with one of Sturgeon's own coils, which he had lent him. Bakhoffner observed that a bundle of fine iron wires used as a core in Sturgeon's coil gave far better shocks than when a solid iron core was employed. We must therefore credit Bakhoffner 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.

![Image 2](https://example.com/image2)

**Fig. 4.** Sturgeon's Induction Coil.

A, core of cell; B, driving wheel of contact breaker; C, driving wheel; D, wire from battery to contact breaker; E, iron core; H, handle on secondary; i, and i, wires from battery to contact clips 1 and 2; and 1 and 2, terminals. A, B, C, and H handles.

![Image 3](https://example.com/image3)

**Fig. 5.** Sturgeon's First Induction Coil.


![Image 4](https://example.com/image4)

**Fig. 6.** Clarke's Induction Coil.

m, core of cell; t, driving wheel of contact breaker; V, driven pulley. c, star wheel breaking contact with mercury in vase x.

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 Electromagnets 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-ninethieth 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

* All rights are reserved.
THE ELECTRICIAN FEBRUARY 6, 1891.

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 others, was met at St. Peter's station, where the 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. E. Elmore, and Mr. A. Elmore. The arrangements left something to be desired, the number of visitors being too great to permit of any 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 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 latter rival in the shape of a copper manufacturer, left at midnight in the form of magnetisation, and passed to the melting shed. The installation 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 cackling 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.

Some time previously Mr. Barker had invented this device for increasing a current. Mr. E. M. Clarke was a philosophical instrument maker, having a shop in the Lower Arcade, and his memory is also handed down to us as an improver of Pini's magnetoelectric 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, Lower Arcade, London, a rebuke. Various improvements 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 ratchet 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. Biebchhoffner has a description of a coil which is made with primary insulated copper wire 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.

Biebchhoffner 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.)