History
of
RADIO TELEGRAPHY AND TELEPHONY

WRITTEN AND ILLUSTRATED BY

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In 1879 he showed his results to several members of the Royal Society—Sir William Crookes, Sir Robert Austen, Sir William Preece, and Professor Adams. Again, in February 1880, he gave a similar demonstration to Mr. Spottiswoode (then President of the Royal Society), to Professor Huxley, and to Sir Geo. Stokes.

Mr. Campbell Swinton gave a very interesting account of the work of Hughes in the Proceedings of the Commemoration Meeting of the Institution of Electrical Engineers, February 1922, from which I quote the following note, made by Hughes in his notebook at the time, and having reference to the 1880 demonstration. (The notebook, and several others, are now in the keeping of the Science Museum authorities at South Kensington):

"February 20th, 1880.—Mr. Spottiswoode, President of the Royal Society, Professor Stokes, and Professor Huxley visited me to-day at half-past 3 p.m., and remained until quarter to 6 p.m. in order to witness my experiments with the extra current thermopile, etc. The experiments were quite successful, and at first they were astonished at the results: but at 5 p.m. Professor Stokes commenced maintaining that the results were not due to conduction but induction, and that results were then not so remarkable as we could imagine rapid changes of electric tension by induction. Although I showed several experiments which pointed conclusively to its being conduction, he would not listen but rather pooh-poohed all results from that moment. This unpleasant discussion was then kept up by him, the others following his suit, until they hardly paid any attention to the experiments, even to the one working through gas pipes in Portland Street to Langham Place on roof. They did not sincerely compliment me at the end on results, seeming all to be very much displeased because I would not give at once my thermopile to the Royal Society so that others could make their results. I told them that when Professor Hughes made an Instrument of Research it was Professor Hughes' researches, and no one else's. They left very coldly, and with none of the enthusiasm with which they commenced the experiments. I am sorry at these results of so much labour, but cannot help it.

"(Signed) D. E. HUGHES."

One can understand and sympathise with Professor Hughes' very natural feeling of disappointment, and it is pleasing to find that the very gentlemen who then appeared to belittle his work became, in the same year, his firm supporters, as is borne out by the fact that on June 7th following he was made a Fellow of the Royal Society, Mr. Spottiswoode being president, and Professors Stokes and Huxley the two secretaries and members of the Council.

Eight years later, in 1888, Professor Hughes, now an F.R.S., gave a further demonstration to Professor Dewar and Mr. Lennox. We can therefore accept his work as being fully authenticated although unpublished. Briefly, the following were his discoveries:

When engaged on some work with an induction balance he noticed some peculiarities in the behaviour of a loose contact in the circuit. This caused him to carry out a series of experiments with loose contacts, and he discovered that on the

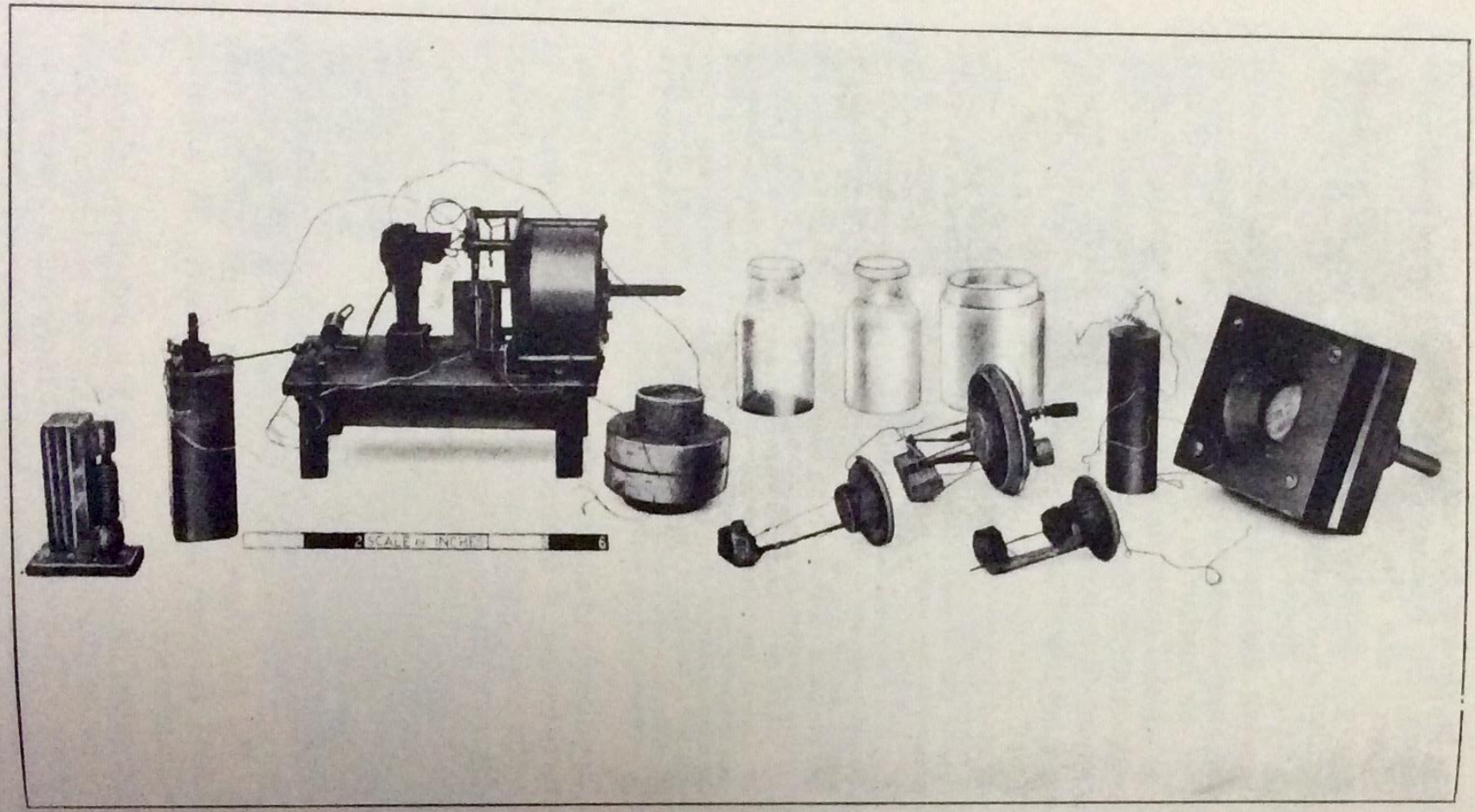

FIG. 24. Group of apparatus used by Hughes for wireless signalling, now in the Science Museum, South Kensington. (From the left) A microphone, a battery connected to Hughes' interrupter and coil from induction balance, three microphonic detectors in front of the glass jars in which he mounted them, a battery, and a home-made telephone. *(By kind permission of the Exhibition Authorities)*

sudden interruption of a current in any coil the " extra " current,* at break, caused the emission of " invisible electric waves " which became evident if a microphonic joint were used as a receiver with a telephone, and he showed that these waves penetrated solid walls and apparently travelled to great distances. He transmitted signals in this manner to a distance of about 60 feet, and on several occasions walked up and down Great Portland Street, London, with the telephone to his ear and heard them at a distance of 500 yards. He also noticed that the waves appeared to be reflected from some of the buildings.

Fig. 23 illustrates Hughes' Induction Balance, while Fig. 24 is a group of historical apparatus (62) used in these experiments. On the left-hand side is seen the transmitting apparatus. Towards the right-hand side of the photograph are several types of microphone invented by Hughes. These were really the forerunners of the self-restoring coherers used by Tommasina, Solari, Marconi, Lodge, and others at a later period.

HUGHES' MICROPHONIC DETECTORS.—At first he connected a telephone receiver across a microphonic contact of carbon and steel, using no additional E.M.F. in the receiving circuit ; but later he included a small voltaic cell in series with the microphonic contact and the phones.

Having noticed the effect of an " extra current " spark in the vicinity of a microphonic contact in the circuit of his induction balance, Professor Hughes continued his investigation along the following lines : He connected his transmitter (62), consisting of a coil of wire C, battery B, and interrupter I, by a wire W to a microphonic contact M in circuit with a telephone T, as represented in Fig. 25, and found that he could always hear the " extra spark " of the transmitter in the phone.

He tried various substances as contacts at the interrupter, and found that metal to metal produced a better effect than carbon to carbon or carbon to metal. He placed an iron core in the coil, and found that although it gave a greater visible sparking effect it diminished the strength of the received sounds in the telephone.

He also experimented with the Faraday electro-magnet at the Royal Institution, excited by a powerful battery, obtaining

* The author carried out some experimental transmissions, using the extra current spark at the contact of an electric bell to energise an aerial, and succeeded in signalling one mile by this means in 1907 (see ref. (22)).

very poor results. He therefore came to the conclusion that his microphone was influenced by the " extra spark " solely, and not by electro-magnetic induction. He used coils in transmitting and receiving circuits, placing them in the same plane and at right-angles, without affecting his results; he reduced the number of turns of wire, and even used a battery and interrupter only, without any coil, and heard the sounds as distinctly as before.

He experimented with various forms of microphonic contact, probably his most sensitive one being that which consists of a steel hook in contact with a loop of fine copper wire, previously oxidised and well smoked in the flame of a spirit lamp. These he placed in a small bottle for safety. Fig. 26 is a photograph of three such receiving instruments.

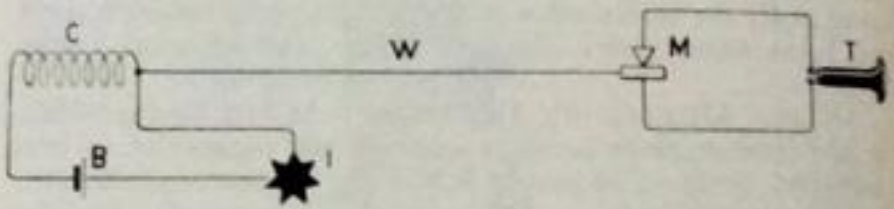

FIG. 25. Hughes' Transmitter and Microphonic Detector.

(Hughes was not the first to make use of soot in the manufacture of a microphone—**Edison** invented a microphone, using a button of compressed soot between a diaphragm and a rigid metal backing, for telephony, which he patented in the United States in 1878 (this is described in " Fifty Years of Electricity," by Fleming)—but he was the first to employ it for the purposes of his experiments to detect the then unknown Hertzian waves.)

Another form of microphone which he tested was a tube containing filings between two carbon plugs (see Fig. 27), but finding that the filings continually stuck together (or, as we should now say, cohered) and made the microphone very unreliable, he discarded it without having realised the importance of the phenomenon. Had he been a little more observant, remembering the other facts he had discovered, he could, in this little tube, have forestalled the **Branly** tube and **Marconi** coherer; but the opportunity was lost, and the credit of the early types of filings coherers is due to the work of Branly and Marconi.

Strangely enough, he also tested contacts of iron and mercury, which he found sensitive but troublesome. Thus he also unknowingly got near to the discovery of the **Costelli** and **Solari** detectors mentioned later in this work. He discovered that a microphonic contact used in conjunction with a telephone was more sensitive to a small charge of electricity than a gold leaf electroscope, and in October 1879 he made the most important discovery that the wire, as shown at W in Fig. 25, could be discarded, and that his transmitter would influence his receiver at a distance. He had discovered the elements of radio transmission and reception.

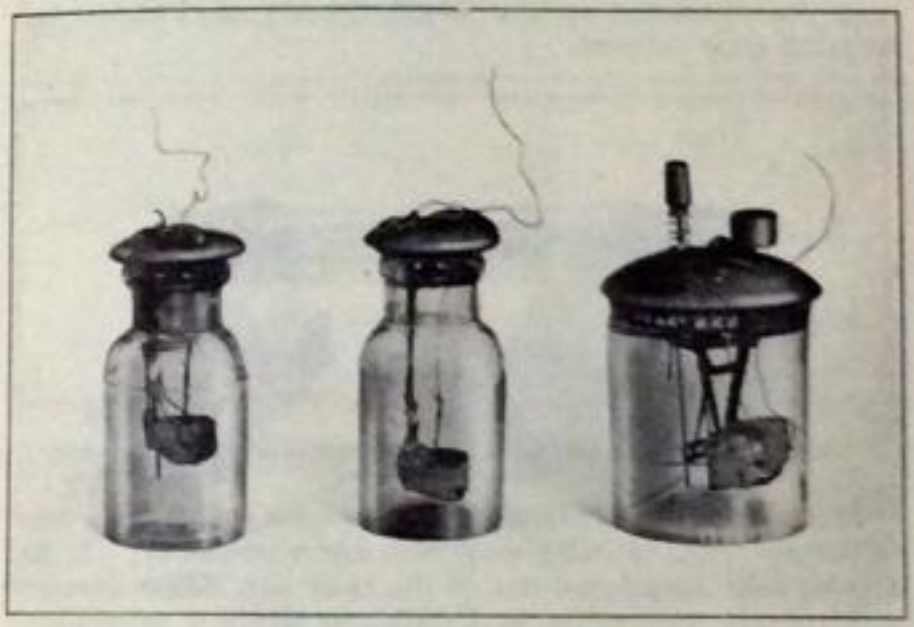

FIG. 26. Three receiving instruments devised by Hughes, which utilise various forms of microphonic contact.

In November of the same year he connected a fender to his interrupter, as he said (in his notebook), to act as a "radiator," and later he used a couple of short lengths of wire, one on each side of his "extra spark," and a similar couple of wires, one on each side of his microphone. These were very similar to the arrangements used by **Hertz**. He also found that he could obtain greatly increased results by the employment of earth connections to the transmitter and receiver.

The following statement appeared in the "Globe" of

May 12th, 1899: "Hughes' experiments of 1879 were virtually a discovery of Hertzian waves before Hertz, of the Coherer before Branly, and of Wireless Telegraphy before Marconi and others." Hughes conducted these experiments nine years before the discoveries of Hertz, and seventeen years before the advent of Marconi.

The notebooks and early apparatus of Professor Hughes are now at the Science Museum at South Kensington. An interesting account of this apparatus by Mr. Campbell Swinton appears in "Nature" for April 15th, 1922.

Hughes had previously invented the microphone in the year 1878, at which date the result of his researches thereon was communicated to the Royal Society of London and aroused great interest.

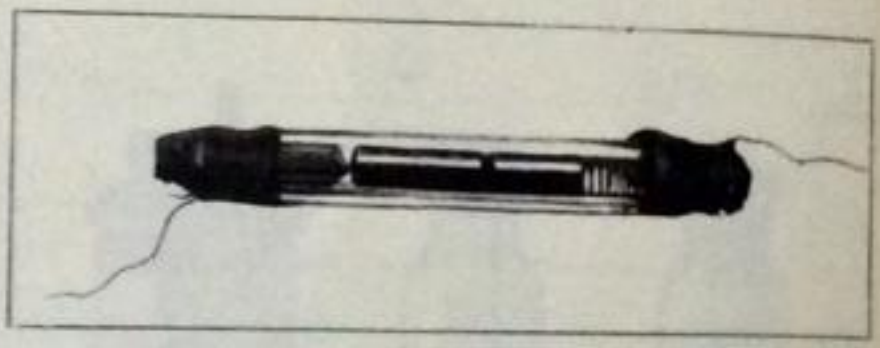

FIG. 27. One form of carbon microphone employed by Hughes which strongly resembles a coherer.

In improved form, Hughes' microphone still plays a most important part in telephony and radio-telephony. It has already been mentioned that in the same year **Edison** patented a telephone transmitter in U.S.A., in which a microphone with compressed lampblack was employed, and Hughes' experiments aroused a vigorous controversy with Mr. Edison, who claimed that his ideas had been appropriated.

Hughes showed that the slightest sound was greatly magnified by his microphones. One of his favourite experiments at this time was to place a house fly in an empty match box near to the microphone. It was said that the sound of the fly's footsteps walking in the box, heard in the telephone resembled that of the tread of an elephant in a primeval forest.

The actual match box used by Hughes for this purpose is shown in Fig. 28, which also shows an early form of microphone using three iron nails.

The type-printing telegraph (Fig. 29) invented by Hughes was referred to at the commencement of this chapter. This machine was, in 1923, employed for some time for radio-transmission by the Post Office (21) on a duplex system working between London and Berlin, handling 25 messages per hour in each direction. "The one route is from G.P.O. by land wire to Stonehaven, and thence by wireless to Zellendorf, and the other route is direct from Königswusterhausen to an aerial on the roof of the G.P.O. in London, and the results so far obtained are most satisfactory." How pleased Professor Hughes would be could he see the advances that have been made since his time and find his own type-printing telegraph (which has been in constant use on land lines for many years) now being turned to account for radio-telegraphy!

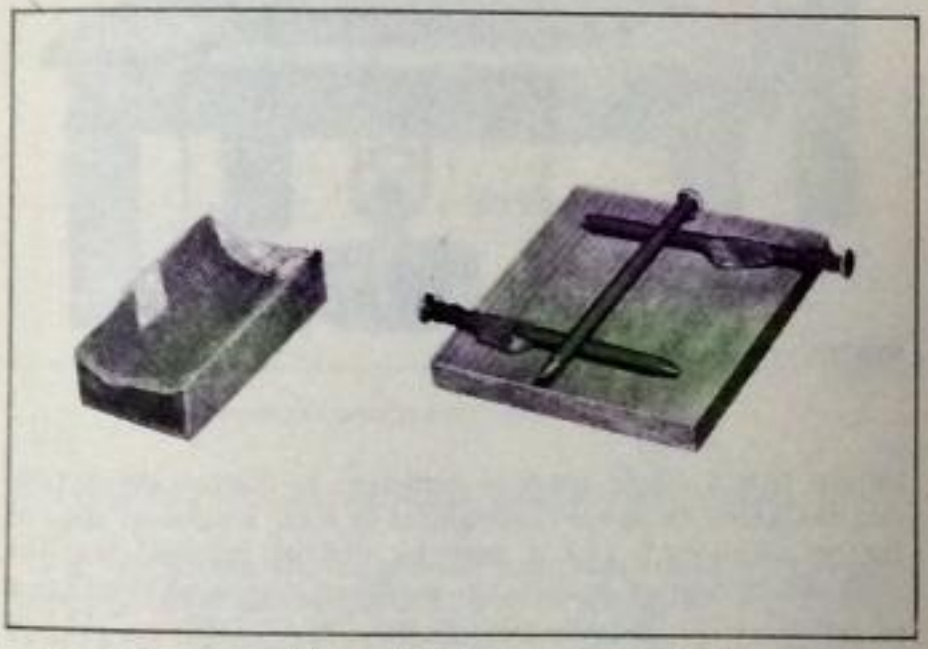

FIG. 28. The actual match box used by Hughes in demonstrating the sensitiveness of his microphone is shown here, together with his early type of microphone composed of three nails in light contact.

While there is no doubt that, working entirely by himself, with the crudest of home-made apparatus, often fastened together only with sealing wax and twisted wires, Hughes made all the discoveries before described, other workers in various parts of the world had already noticed some of the phenomena concerned, but none of them had carried their investigations to a conclusion.

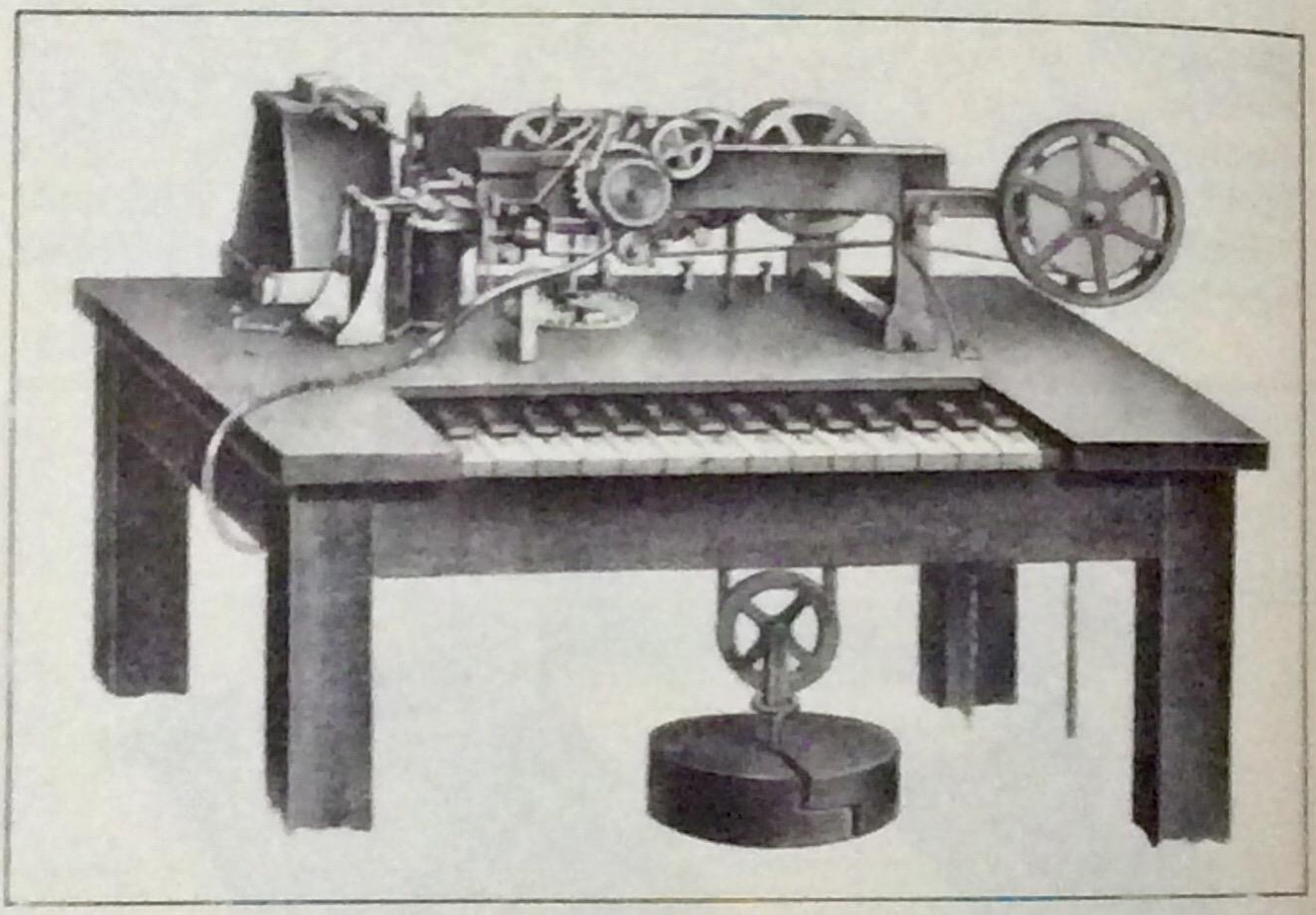

FIG. 29. Hughes' Type-printing Telegraph.