Historical Development of Science

THE BEGINNING OF RADIO TELEGRAPHY.

THE great work and discoveries of the Marchese Guglielmo Marconi and brief newspaper reports of his present activities (including the directional transmission of energy by radio as a commercial proposition) tend to conceal the fact that Marconi is not, as is frequently stated, the " father of radio ". The Marchese himself is the first to deny such a claim, and to give the credit where it is due.

It is always difficult to fix beginnings, because every scientist builds on the work of others ; in this case it is not so difficult.

The true father of radio was James Clerk Maxwell, who was born in Edinburgh in 1831, conceived the electro-magnetic theory of light probably in 1865, and died in 1879, when Marconi was only five years old. The other scientist immediately responsible for the launching of radio into existence was Heinrich Hertz, who carried out his classical experiments in the period 1886–1890, and was said to be working on " electrical oscillations and the propagation of electro-magnetic induction through space ". The child did not acquire its infantile nickname of " wireless " until later, and is just passing now into the stage when all really respectable people call him " radio ". I am being very careful in this article to refer to radio, which is undoubtedly the better word, but if I occasionally lapse, it is merely because I knew him as a child.

It is probably very difficult for most people to associate our modern radio-telephony with the electro-magnetic theory of light, as propounded by James Clerk Maxwell ; the connection lies in the fact that light and radio waves are essentially the same, so that Maxwell, having propounded an excellent and accepted theory in which light was explained as being electric and magnetic waves through space, and having suggested the creation of such waves for different wave lengths by electrical methods, the attempt to create such long wave length electrical oscillations in space necessarily followed. Hertz produced them, and, by what today would be considered very crude methods, detected them. Lodge and Branly developed improved methods of detection, whilst Augusto Righi, of Bologna, did much to advance the subject, both by contributing to the mathematical discussion and in experiments. The new " electro-magnetic induction through space ", or Hertzian waves as they were now called, still passed from wire to wire through space in a laboratory, or at the best from room to room. This was the child that Marconi took in hand, veritably, and trained for a commercial life.

The development of radio beyond the stage of sparks in a laboratory belongs to this century and some five years of the previous one. We are too crowded by events and performers to be able to see clearly, and nation still argues with nation in the popular Press as to who " invented " radio.

I have here a copy of the " Mercure de France " of May 1, 1925, in which appears an article " How Guglielmo Marconi has been able to ' invent ' Wireless ". The

article was inspired by the erection at Wimereux, near Bologna, that month of a monument supposed to commemorate the first radio dispatch received in France from across the seas, being that sent by Marconi from Dover in March, 1899, for land transmission to Branly in Paris. They exclude Clerk Maxwell, and give the whole credit for the imagining of the electro-magnetic theory of light direct to Hertz, with a casual pat on the back for their own physicist, Fresnel. Subsequently, that detector, " the coherer ", which was so important in developing commercial radio, they credit exclusively to Mons. Branly, and to Popoff and Narkebitch Yodko they give the credit for Marconi's aerials.

References to the literature, past and present, of England, Germany, France and Italy confirm one point : we may proceed to erect monuments to Heinrich Hertz as being the discoverer of the actual transmission of radio waves in *free space*, the so-called Hertzian, wireless or radio waves. A great deal of work had previously been done with regard to the transmission of actual electric waves along wires, including the operation of such tuned circuits, or circuits in resonance. Hertz published his papers on " electric waves in space " between the years 1887 and 1889. He was, of course, familiar with the work of Maxwell, and in 1884, three years before his first paper on electric waves in space, he published a paper on " the connection between Maxwell's electro-dynamic fundamental equations and those of opposition electro-dynamics ". It doubtless sounds very unpleasant and uninteresting to you, and to have little bearing on the fact that you twiddle a couple of knobs and turn a jazz band into a stock exchange report or a never-ending advertising serial at your will, but the titles of the papers produced by our modern radio engineers, who are directly responsible for radio production and development in 1937, are just as shocking.

I hope I have now, to your satisfaction, saddled James Clerk Maxwell with the initial responsibility, and Hertz with the secondary responsibility. So we will look first at this man Maxwell, and consider who he was and what he really did.

James Clerk Maxwell was born at Edinburgh on June 13, 1831. His mother died when he was eight, but he was the constant friend of his father, who himself was " interested ", as were most other Edinburgh residents of his time, in experimental science. He taught young James to observe, and to record his observations—a fundamental lesson for a scientist. The father, who had been a lawyer, settled after marriage on his small estate of Middlebie, where the boy lived until he was ten, playing with his cousins and with the family vassals—his father was laird—whilst he was tutored for Edinburgh University, where it was hoped to send him when he reached the ripe age of thirteen.

When he was ten it was decided to send him to school, and he was accordingly led to the Edinburgh academy in 1841. Interested in doing things, and in reasoning, he was not happy in the presumably cultured classical atmosphere where he found himself now. It is said of him during this period that he worked incessantly, but did not advance, and objected to the life of " gerund-grinding ". Arriving at school at the age of ten, in the second month of second term, and dressed in a fashion slightly different from that of his friends, he was unduly warmly received, and no doubt this bad reception sent him into himself to such a great extent that he later became the renowned mathematician and physicist—*the* outstanding man of his period—and

his stormy reception at the Edinburgh academy has quite possibly been visited upon you, in that you have been made to spend some twenty pounds on a radio set for the family.

He was badly mauled ; he returned to his home with his dear aunt in Herriot Row " with his tunic in rags, and ' wanting ' his shirt, his neat frill rumpled and torn ".

He was nicknamed " Dafty ", and the name stayed with him throughout his school career. In his first few years there he was unhappy and unpopular, failing regularly not only in Latin, but also in Arithmetic ; he was interested and excelled in Scripture Biography and in English. It was not till he reached a higher class and had disposed of his " 800 irregular Greek verbs " that he began to expand ; and in 1845, with a good mathematics master (Mr. Gloag), we find him writing home that he had " the 11th prize for scholarship, the 1st for English, the prize for English Verse, and the Mathematical Medal ".

From now on Maxwell was obviously marked to be a mathematician and physicist. He was very interested in light and in magnetism. To keep the Edinburgh Academy abreast of the times, the sixth and seventh classes together had lessons in " Physical Science ". Campbell, who was in the same class as Maxwell, tells us that the lessons were read by one of the classical masters from a textbook, and that the only thing he distinctly remembers about those hours is that Maxwell and Tait seemed to know much more about the subject than did the teacher. (Tait also was a well known physicist in later years.)

In 1847, not till he was sixteen, did Maxwell go on to the University of Edinburgh. He specialized in Mathematics and Science, and, being able to develop his originality and choose his friends, was much happier, and as Forbes, his lecturer in Natural Philosophy (Physics), said on his certificate at the end of his second year, " His proficiency gave evidence of an original and penetrating mind." His letters to his friends during this period are largely of his work—very flippantly written, I am afraid. He was making electric batteries for himself with jam jars, doing electro-plating, and playing with an " electric telegraph " which he constructed. And he read, wrote, and studied, a pronounced interest in optics, electricity and magnetism being apparent.

In 1850 Maxwell went as a student to Cambridge University, the home of science, and took most of his toys with him—bits of gelatine, gutta percha, unannealed glass, magnetised steel. He readily absorbed the matter presented to him, and benefited from the added opportunities now afforded him to acquire knowledge, but remained just as whimsical and flippant, some of his scientific poems being charming. As undergraduate and scholar, and later fellow of Trinity, he read widely, thought widely, and experimented. In 1856 he applied for a chair in Natural Philosophy at Aberdeen rendered vacant by the death of Mr. Gay, received the appointment at the end of the year, married in 1858, and found his chair abolished or withdrawn from beneath him in 1860 on the fusion of the colleges at Aberdeen. He then applied for the chair in Natural Philosophy at Edinburgh to be rendered vacant on the retirement of his old friend James Forbes, but was unsuccessful, his old classmate Tait being given the position.

In 1860 he went to King's College, London, and was working on the electrical units, which led to the relationship between electro-magnetic and electro-static units, comparing the constant relationship with the velocity of light. He was on the committee on electrical standards, and this probably is the genesis of radio-telegraphy. Clerk Maxwell pointed out that, in accordance with his electro-magnetic theory for the transmission of light, and other ether waves, the ratio of the units should be equal to the velocity of light. He first published his theory in a semi-popular form in the Philosophy Magazine in 1861 and 1862. His friendship with Faraday during this period was doubtless stimulating.

He resigned his post, after two severe illnesses, in 1866, and retired to Glenlair, his Scottish home. He was then only 35. It was there that his great work on electricity and magnetism (not published till later) took form. In a letter of his, written from Glenlair in January, 1865, he says : " I have also a paper afloat, with an electro-magnetic theory of light, which, till I am convinced to the contrary, I hold to be great guns." This paper was published in 1865. In 1871 he was offered, and with some reluctance accepted, the newly formed Chair of Experimental Physics in the University of Cambridge, which occupied the new laboratories which the Duke of Devonshire, then Chancellor of the University, had built and desired to furnish for the University. The work of arranging and furnishing this, the Cavendish Laboratory, occupied him till the spring of 1874, when the experimental work was commenced, and the laboratory formally opened. Having, amongst many other things, given to the world the connection between light and electricity, the foundation on which others were to build, he died in 1879, at the age of 48.

The wide net cast by his electro-magnetic theory of light has caught many wonderful discoveries, some of which would undoubtedly have saved his own life if he had lived in a generation such as ours, which enjoys the results of his researches.

And next, to Hertz. Born in 1858, he also died young, his wonderful life of scientific activity ending in his thirty-seventh year. Oliver Lodge delivered an address on him a few months after his death in 1894, and said, talking of the Hertzian waves, about to begin their encircling of the globe under the direction of Marconi, these words : " In mathematical and speculative physics others had sown the seed. It was sown by Faraday, it was sown by Thomson and by Stokes, by Weber also, doubtless, and by Helmholtz ; but in this particular department it was sowed by none more fruitfully and plentifully than by Clerk Maxwell. Of the seed thus sown Hertz reaped the fruits. Through his experimental discovery, Germany awoke to the truth of Clerk Maxwell's theory of light, of light and electricity combined, and the able army of workers in that country (not forgetting some in Switzerland, France and Ireland) have done most of their gleaning after Hertz."

What did Hertz do ? He produced electro-magnetic waves, similar to those of light, but much longer, by sparking between knobs from an induction or " shock " coil. It does not detract from his work in any way to say that Faraday and Helmholtz gave him the induction coil, and that Maxwell gave him the underlying ideas and the mathematical theory. He produced intentionally the first long wave electro-magnetic waves, waves of electro-magnetic induction, Hertzian waves, wireless waves, radio waves—call them what you will—and detected them at a distance in his room, by the

little sparks they induced across tiny gaps in adjacent circles or rectangles of wire. Thus was radio actually born. The value of his work was appreciated by fellow scientists, and amongst the general public he acquired what might best be described as a certain modest notoriety in connection with this one set of experiments alone.

Born in 1858, he was 21 when Maxwell died, and in that year he published his first serious paper. It was between 1887 and 1889 that he published his papers on " electric waves ", those papers which inspired Guglielmo Marconi to carry on the research work, so that within a few years he sent the waves from transmitting set to receiving set in the fields, applying the process to telegraphy.

This article deals with the discovery of the waves, but we can still afford space to credit Marconi with the first use of the electro-magnetic waves for purposes of telegraphy, in 1895. After that we meet a medley of names of great or greater physicists, developing the applied science or carrying on with purely scientific and mathematical investigations on the subject, with the name of Marconi standing out persistently. There would have been a big pause in the development of radio but for the simultaneous development of the thermionic valves which you now use in your receiving sets, and which are used on a much grander scale at the transmitting end. Their existence is due to Professor J. A. Fleming, who had studied electron emission from hot wires in the then new " Edison electric lamps " as far back as 1883. It was not till 1904, however, that he made his first valve, taking some old type carbon filament lamps and surrounding the filament by a metal cylinder carried on a platinum wire sealed through the bulb. On putting these in the circuit of the oscillating electric current coming from the aerial, the current was only able to flow as a negative current from hot filament to plate, so that these lamps operated as " valves " to let the current through in one direction only. They were first known as Fleming valves, and we would be happy to hear them so called again to keep alive the memory of the discoverer.

Out of a little beginning, the credit for which must undoubtedly be given to Maxwell and to Hertz, has grown a subject which is the basis of an entirely new profession, that of the radio engineer.