HEINRICH HERTZ: A CENTENARY TRIBUTE

January this year marked precisely one hundred years since the premature death of one of radio's most important figures. In that month in 1884, what would nowadays be considered a quite trivial infection in a tooth led to a deadly generalised infection of the blood — Septicaemia — and to the premature death of young German scientist Heinrich Rudolf Hertz.

by PETER R. JENSEN, VK2AQJ

Born in the city of Hamburg in February of 1857, Hertz was just 37 years of age when the bacterial infection carried him off. Given his work on the Electromagnetic Field, and what it was to lead to in the work of other scientists and experimenters, this can only be considered a great tragedy. However it was a tragedy that in Victorian times was not easily to be avoided, and only many years of subsequent medical experimentation could change that situation. It was not until the 1940's that the first antibiotic, Penicillin, became available — and with it, the capacity to treat such a condition so that it could be cured with relative ease.

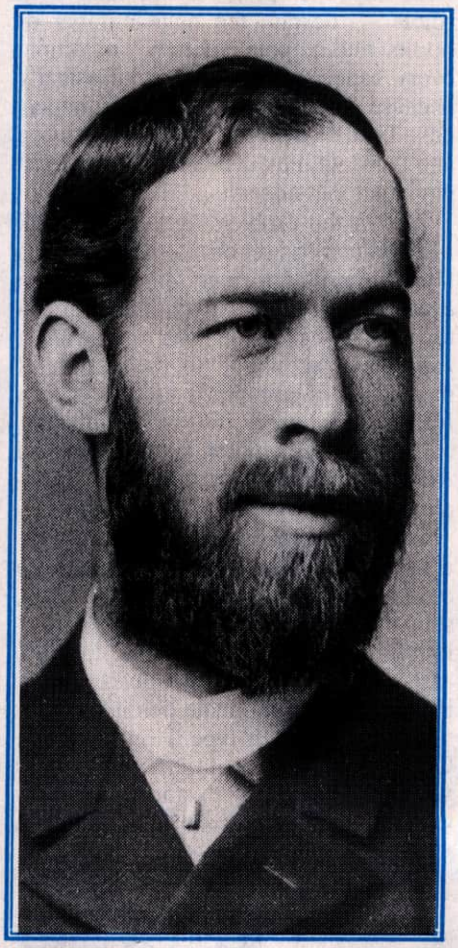
That Hertz was a capable and dedicated scientist there is no doubt, based on the obituaries and tributes that he was to receive after his death. One of those obituaries was to have profound repercussions.

Trained initially at the Berlin Academy of Science, Hertz's professional advancement was rapid and by 1885, he was already a Professor at that Karlsruhe Technical College. It was at this institution, soon after his appointment, that he commenced his most important experiments. These were to lead to a paper in July of 1888 which had the rather ponderous title, 'On the Finite Velocity of Propagation of Electro-magnetic Actions'.

This paper was the culmination of experimental work to investigate the implications of earlier studies of a theoretical nature by the eminent Scot, James Clerk Maxwell, published in 1866.

In attempting to analyse the speculations of the well known researcher in electromagnetic phenomena, Michael Faraday, Maxwell had employed a mathematical model. Contrary to his usual approach to such problems, Maxwell had *not* employed a mechanical analog but had relied entirely upon a theoretical, mathematical approach. Not only this, but in order to make the model work correctly, Maxwell had introduced the concept of the 'displacement current'.

This involved a form of electrical energy which appeared to be able to move through a dielectric substance



which he described as the 'aether'. At that time the aether was seen as a strange material of intangible form and largely unknown physical characteristics, but which was capable of allowing the passage of light.

Maxwell speculated that fluctuations of such a 'displacement current', would cause fluctuations of what he called the 'electro-magnetic field'. This was a very disquieting notion for many 19th century scientists, and one that was not received with general enthusiasm. Indeed some noted scientists such as Von Helmholtz, one of Hertz's teachers, and Lord Kelvin were thoroughly scornful of Maxwell's work.

It appears that Hertz may well have been encouraged to investigate this phenomena by his scientific colleagues, in the hope that he would show that the electro-magnetic field was a fiction and simply the product of erroneous mathematics by Maxwell.

In the event, and with the assistance of a number of elegant and quite simple experiments, not only did Hertz establish the existence of the electro-magnetic field, but he also showed that it was undoubtedly the mechanism by which light waves were transmitted. Further, he was able to demonstrate the velocity of wave propagation through the field as being the same as that which had already been established for the velocity of light — approximately 300,000 kilometres per second, or 186,000 miles per second.

To modern users of the radio frequency spectrum, the basis of Hertz's experiments involved a very familiar concept. This was the detection of 'standing waves', although in 1888 this was derived from the concept of optical interferometry.

What Hertz was to do was to project a beam of high frequency radio energy along the length of his laboratory and reflect it from a metal sheet hung on the wall at the far end. He was then able to detect the crests and troughs in the two beams of energy, where they mutually interferred with each other, to form the characteristic nodes of a standing wave. This of course remains the basis of today's method of measuring resonance in antenna feeders, described as the 'standing wave ratio' or SWR as it is now more commonly known.

n this work, Hertz used r his transmitter the then-mmon laboratory instru-ent, the Induction or humkorff Coil and a odified form of Leyden Jar pacitor, or so he believed it be. In reality this latter ele-ent we would nowadays call a dipole tenna with end loading elements. To ertz it was a Leyden Jar, 'opened up' to rm a radiating surface.

The detector was even more simple, onsisting of a loop of wire ap-roximately 600mm in diameter. This op was cut to length to resonate with e transmitter dipole with its end load-g. Where the loop came to a gap at e ends of the wire, a micrometer spark ap was formed. Here it was possible to e minute sparks, which occurred when positive node of energy was inter-epted by the loop and where the two eams of radio frequency energy added gether positively.

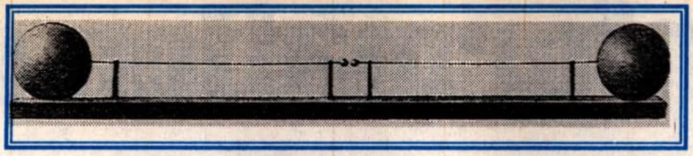
The physical arrangements for the ansmitter and the receiver are shown in e attached diagram.

It might be thought that the fre-uency of operation of this arrange-ent of rods and plates would be very asy to determine. However, in 1888, his was a voyage of discovery on com-letely uncharted waters and there little oubt that Hertz knew only vaguely here he was, in terms of the radio fre-uency spectrum.

On the basis of a number of estimates f where the experiments were carried ut, it appears that they were located be-ween 30 and 200MHz (megahertz). It eems likely that the critical results came rom two sets of experiments involving requencies at both ends of this range, he higher frequency being used to estab-ish the critical standing wave and hence he velocity of the radiated wave.

Apart from the uncertainties en-gendered by the novelty of the experi-nent, the place in which Hertz was working undoubtedly contributed to the anomalous results that he obtained ini-tially. In particular the size of the laboratory (15 by 14 metres) was clearly quite small for even the wavelengths in use at a frequency of 200MHz.

However, worse was the existence of cast iron columns set only 8m apart, creating a central space 12m long by 8m wide. In addition, a large iron stove used to heat the laboratory was located only a metre or so away from the centre line of the laboratory. Evidently all of these physical elements contributed to distor-tions of the local electro-magnetic field in the laboratory.



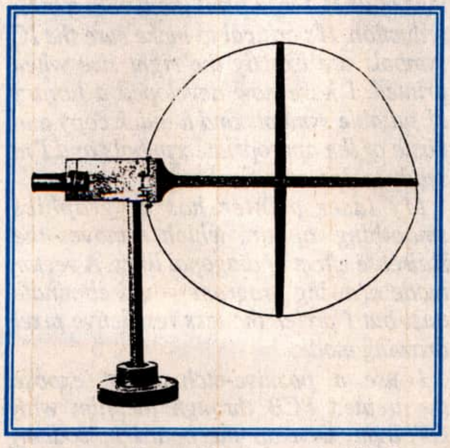
Hertz's transmitter: a dipole antenna with capacitive loading balls at each end — driven by an induction coil.

Not surprisingly, to modern eyes at least, when Hertz increased the frequen-cy at which he was transmitting, his results became more consistent. He was able to observe this result and draw the correct inferences from it.

Up until the experimental work of Hertz, it was common to load a Leyden Jar capacitor across the spark gap of the Induction Coil, and this had the effect of keeping the frequency of operation of a radio frequency wave generator at a relatively low value. As noted, Hertz was to discard the conventional Leyden Jar in favour of his own radiator, in the form of an end loaded dipole. This had the effect of very substantially in-creasing the frequency of the radio wave and no doubt it contributed to his suc-cess, where other experimenters had failed at longer wavelengths.

While there may well have been an element of luck in the changes that were made to the operating charac-teristics of the apparatus Hertz employed, he was able to overcome its remaining limitations and derive elegant and conclusive results. Perhaps more im-portantly, they were results that were able to be duplicated by others sub-sequently. His work established the reality of Maxwell's elusive 'displace-ment current' and the electro-magnetic field, through which waves of radio fre-quency energy would flow.

While his untimely and premature death prevented any further personal ex-ploration of the new domain that he had charted, it was not long before other workers would see the implications and start the procession of events which have continued to the present day.



For a receiver, Hertz used this loop antenna with a tiny spark gap 'detector' — viewed with a microscope.

There is little doubt that one of the most important of these later arrivals in the new field of electro-magnetic energy was a young man of mixed Italian and Irish descent who read a description of the work of Hertz in an obituary, some time in the autumn of 1894. This was Guglielmo Marconi. He was to pick up the baton dropped by Hertz and not immediately retrieved by the scientific community, and carry it forward into the history that we now remember.

The enormous contribution of Hertz's experimental work was reflected in the short term by the work of others. In the longer term it lead to electro-magnetic radiation being known for a while as Hertzian radiation. This did not persist. However, by contrast the decision of the scientific community to abandon the term 'cycles per second' in favour of 'Hertz' as the unit of frequency has clearly become completely established. It is certainly a fitting and lasting tribute to a fine scientist, tragically cut short in the prime of life. ❖

STOP PRESS:

NEW KITS FOR EA PROJECTS

Just as this issue was going to press, we received the following advice from Dick Smith Electronics regarding their release of a new kit for an *Electronics Australia* construction project:

Improved DSO Adaptor for PC's (May 1994): The DSE kit is complete with case, punched and silk-screened front panel and punched rear panel, PCB, transformer, all specified electronic components (including the fast ADC 08061 converter chip) and a copy of the latest version of David Jones' software. It carries the catalog number K 7346 and is priced at $199.00.

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