PART I – RÖNTGEN AND HIS DISCOVERY OF X RAYS

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The year 1995 marks the centenary of the discovery of X rays. Radiologists, radiological organisations, para-radiological bodies and the medical industry all over the world are celebrating Wilhelm Conrad Röntgen's momentous discovery.

THE DISCOVERY

The discovery of X rays came about through an incidental observation on 8th November, 1895 by Röntgen (Fig 1), who was then Professor of Physics at the University of Würzburg. On that fateful Friday afternoon, Röntgen was investigating the phenomenon caused by the passage of an electric current, produced by an induction coil, through a partially evacuated glass tube. Although the glass tube was covered in black cardboard and the room darkened, towards the conclusion of his experiment, he suddenly noticed a flickering glow from a nearby bench. This strange light appeared from a paper screen covered with barium platinocyanide, a fluorescent substance, whenever electrical charges were passed through the glass tube. Röntgen realised that he was dealing with something previously unknown and reasoned that if this new type of invisible rays could escape from a light-proof cardboard box, then perhaps it could penetrate other substances as well. He soon discovered that these rays could pass through all sorts of objects. Moreover, Röntgen could see the shadow of the bones and soft tissues of his own hand on the fluorescent screen, when his hand was placed between the glass tube and the screen. To document these rays, he replaced the fluorescent screen with a photographic plate and was able to make a photographic record of an object sited between the vacuum tube and the plate.

Fig 1 – Professor W.C. Röntgen (1845 – 1923)

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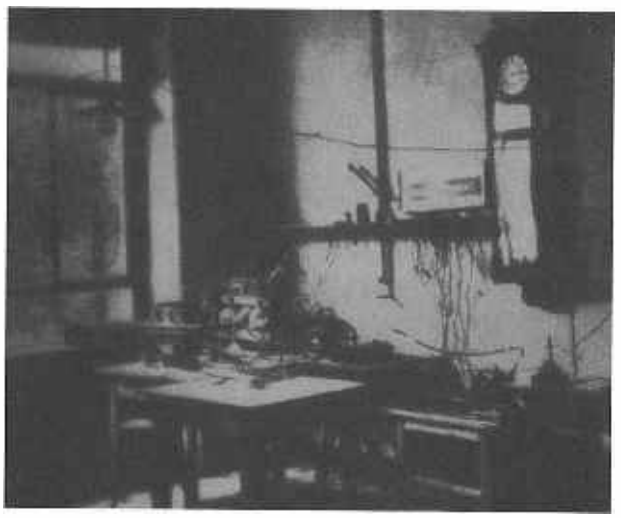
Fig 2 – Old photograph of Röntgen's laboratory in the original Physical Institute, University of Würzburg

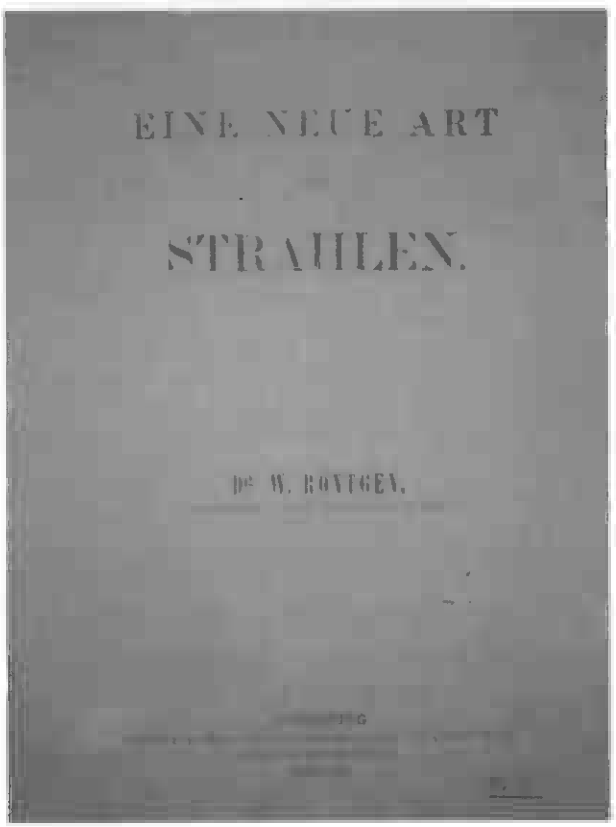


For the next seven weeks, Röntgen kept his great discovery a secret and practically locked himself in his laboratory (Fig 2), conducting a series of meticulously planned experiments aimed at validating his observations. One evening, Röntgen asked his wife to put her hand on to a light-proof cassette containing a photographic plate and made an exposure using the new rays that he had discovered. The resultant photograph, when developed, was widely believed to be the first ever radiograph of a human. In this original radiograph, the bones of her fingers were clearly seen together with the metallic rings that she was wearing (Fig 3).

Röntgen communicated his discovery in the form of a short manuscript entitled "On a new kind of rays" (Fig 4) (Ueber eine neue Art von Strahlen), which he submitted for publication on 28th December, 1895. This was subsequently published in the 1895 volume of the *Annals of the Würzburg Physical Medical Society* (Sitzungs berichte der Physikalisch-Medizinischen Gesellschaft zu Würzburg). He named the new rays "X rays" to distinguish them from other known types of rays. Röntgen

Fig 3 – Radiograph of Frau Röntgen's hand

Fig 4 – Cover of a reprint of Röntgen's 1895 paper, translated "On a New Kind of Rays"



demonstrated that almost all materials were transparent to X rays, although to different degrees. He listed different substances which fluoresced when exposed to X rays. He showed that the X rays travelled in straight lines, were not reflected or refracted, and that the intensity of X rays varied inversely with the distance from its source. Röntgen then sent copies of his original article and examples of X ray pictures to a number of well-known scientific colleagues in several countries.

The news of the discovery of X rays quickly spread and was first announced to the public on the front page of *Die Presse*, a Vienna newspaper, on 5th January, 1896. Two days later, on 7th January, the Frankfurt *Zeitung* together with the London morning paper, *The Standard*, reported the potential applications of these new rays in the diagnosis of diseases and injuries of bones, and also the help that these rays could provide to surgeons confronted with complicated bone fractures and bullets inside the body. Many practitioners, both medical and non-medical, were able to repeat Röntgen's experiments and to test the applications, medical and non-medical, of X rays.

Röntgen gave his first and only formal lecture on the subject of the discovery of X rays on 23rd January, 1896, at a meeting of the Würzburg Physical Medical Society (Fig 5). Before an

Fig 5 – Painting by Robert Alan Thom of Röntgen's presentation before the Würzburg Physical Medical Society, where he is shown taking radiograph of von Kölliker's hand (from the cover of the 1992 Annual Report of the British Institute of Radiology).

enthusiastic audience, he presented the results of his experiments and gave a demonstration of the new rays by producing a radiograph "live" of the hand of the famous anatomist, Professor Albert von Kölliker. At the end of the lecture, von Kölliker proposed that the new rays be named "Röntgen's rays". This was unanimously approved by the distinguished audience.

Following his discovery of X rays, Röntgen received numerous decorations and honours from all over the world. In 1901, Röntgen was awarded the first Nobel Prize for Physics (Fig 6). Röntgen donated the accompanying prize money to the University of Würzburg to support further scientific research. He was also a recipient of the Royal Order of Merit of the Bavarian Crown, which carried the status of nobility. It was characteristic of Röntgen to decline this personal nobility, which would have allowed him to use the prestigious prefix "von" before

Fig 6 – The first Nobel Prize for Physics awarded to Röntgen in 1901.

Fig 7 – Painting by von J. Steib (1898-1957) of the house where Röntgen was born, as shown on a postcard bought in Lennep in 1994.

Fig 8 – Röntgen as a young man

his name. Röntgen belonged to that special breed of pure scientists who refused to exploit their discoveries for personal gains. He was of the opinion that discoveries and inventions belonged to humanity, hence they should not be hampered by patents, licences and contracts or be controlled by any one group.

Röntgen's original communication was very quickly translated into several languages. Within two months, almost all the major medical and scientific journals had commented on the value of the medical applications of **X** rays with the appearance of numerous articles illustrated by **X** ray pictures. By May 1896, the medical uses of radiology were sufficiently established to warrant the establishment of a dedicated radiological journal, *Archives of Clinical Skiagraphy,* the forerunner of the present *British Journal of Radiology.* Over one thousand papers relating to **X** rays were published in 1896 alone. The new field of radiology was hence established. Röntgen himself wrote only 2 further papers on the subject of **X** rays, both of great scientific merit. In 1897, Professor Sylvanus P. Thompson, the eminent British physicist, said: "Röntgen had so thoroughly explored the properties of the new rays that by the time his discovery was announced, there remained little for others to do beyond elaborating on his work".

RÖNTGEN – A BRIEF BIOGRAPHY

Wilhelm Conrad Röntgen was born on 27th March, 1845 at Gänsemarkt 1 in Lennep, a small town in the Rhine region of Germany. His father, Friederich Conrad Röntgen, was a textile merchant while his mother, Charlotte Constance Frowein, hailed from a Dutch family prominent in industrial and shipping circles. Wilhelm was the only child of his parents, who incidentally were closely related (first cousins). When he was three years old, the

Röntgen family moved to Apeldoorn in the Netherlands, where his mother's parents lived. Young Wilhelm received his initial education here and on 27th December, 1862, at the age of 17 years, he entered the Utrecht Technical School.

Wilhelm was not a particularly brilliant student while at the Utrecht school and was unfortunate enough to be expelled over a harmless prank by a fellow student. Apparently, this other student drew a caricature of an unpopular teacher on the stove in the classroom. Wilhelm was caught looking intently at it and was assumed to be the culprit. Wilhelm however steadfastly refused to reveal the name of the guilty person, took the blame and was expelled for his loyalty. As his chances of entering University via the Dutch education system seemed remote, he enrolled at the Federal Polytechnical School (Eidgenössische Technische Hochschule) in Zürich, Switzerland on 16th November, 1865. He was known to be serious in his chosen course of Mechanical Engineering, interested enough to attend extra-mural lectures for his own further education, and to be fun-loving in nature. It was in Zürich that he met his future wife, Anna Bertha Lugwig, (Fig 9) daughter of the owner of "Zum grünen Glas", a cafe that he used to frequent.

Röntgen graduated with a Diploma in Mechanical Engineering on 6th August, 1868. He stayed on in the Polytechnical School to work with August Kundt, Professor of Physics and a brilliant experimental physicist, who was to be Röntgen's mentor. Less than a year later, on 22nd June, 1869, he received his doctorate in philosophy (Ph.D.) from the University of Zürich for his thesis entitled "Studies in Gases" (Studien über Gase), a treatise about problems in thermodynamics.

When Professor Kundt moved to the University of Würzburg, Germany, in 1870, Röntgen followed him as his assistant. As Röntgen did not fulfill the strict traditional criteria laid down by this institution, namely that of having a formal high school matriculation diploma as well as training in the classical languages, he was not allowed to take the title of "privat-dozent" or honorary lecturer, which represented the bottom rung on the academic ladder. Röntgen continued to work hard in the fields of thermo- and electrodynamics, and on 19th January, 1872, he married Anna Bertha in Apeldoorn, the Netherlands. As the Röntgens did not have any children of their own, they eventually took care of Josephine Bertha, Frau Röntgen's niece, subsequently adopting her as their own daughter when she turned 21. Later in 1872, the newly-wed couple relocated to Strassburg when both Röntgen and Professor Kundt accepted appointments at the newly established university there. Röntgen's parents joined them in Strassburg in October of the following year. On 13th March, 1874, Röntgen was finally apponted "privat-dozent" in physics at the University of Strassburg. From this point of time, his academic career really started to take off.

Röntgen became Professor of Physics and Mathematics at the Agricultural Academy at Hohenheim in Wurtemberg in April 1875, before returning to the University of Strassburg as an Assistant Professor of Theoretical Physics in October 1876. On 1st April, 1879, Röntgen accepted the post of Professor of Physics at the Hessian Ludwigs University in Giessen. He was only 34 years old when he was appointed to this important chair. Röntgen was to remain in Giessen for the next nine years, establishing himself as an authority on electromagnetic and gas phenomena, piezoelectric properties of crystals and surface phenomena of liquids. He demonstrated the "Röntgen current", the magnetic effects resulting from movement of a dielectric between two electrically charged condenser plates, hence proving Maxwell's theory of electromagnetic forces. This experiment made Röntgen world-famous among physicists and was rated to be of equal, if not greater, importance than his subsequent discovery of X rays, even by Röntgen himself.

Fig 9 – Anna Bertha Lugwig, later Frau Röntgen

Fig 10 – Professor and Mrs Röntgen being driven in a horse-drawn carriage while on vacation.

Life turned a full circle for Röngten on 1st October, 1888, when he was offered the prestigious post of Professor of Physics and Director of the new Physical Institute of the University of Würzburg. It was this same University which had denied him a lowly academic post 18 years previously! During this period, Röntgen's work was concentrated mainly on the effects of pressure on the physical properties of liquids and solids. In 1894, Röntgen became Rector of the University of Würzburg. In his inaugural speech as Rector, Röntgen quoted from one of his predecessors, Athanasius Kircher (born 1602): "Nature often reveals astounding marvels in even the most unremarkable things, but they can be recognised only by those who, with sagacity and a mind created for research, ask counsel from experience, the teacher of all things". These words proved to be prophetic for in

Fig 11 – 1984 postage stamp from Transkei in Africa commemorating Röntgen as the discoverer of X rays

the following year, he discovered X rays, soon after he started experimenting with cathode rays, the electric discharge produced in evacuated glass tubes.

Many honours were bestowed upon Röntgen after his discovery but he remained very much a private person, declining to attend the numerous awarding and dedication ceremonies as a rule. On 1st April, 1900, at the special request of the Bavarian government, he accepted the Professorship of Physics at the University of Munich. He continued his research, principally on the conductivity and the effects of irradiation upon crystals, until he retired in 1920. The remaining few years of his life were lonely, as he missed his beloved wife who had passed away in 1919 after a long and happy marriage. Röntgen died from bowel carcinoma on 10th February, 1923, in Munich. He was buried at the family grave in the Old Cemetry in Giessen. Most of his scientific papers were destroyed, according to the terms of his last will, and were hence lost forever to future researchers.

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