The Invisible Light

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Editorial.

Apologies for the gap since the previous issues of The Invisible Light. I hope to produce the next issue this autumn and we should be back to our usual pattern of two issues per year. Please could you send me contributions - anything interesting will be considered.

It is hard to believe that we are now on the 41st issue. There have been many interesting contributions over the years, and we really should produce an index so that past articles of interest can be identified.

BSHM.
Please note that registration for the British Society for the History of Medicine, Edinburgh Congress, 13th -16th September is now open at: http://bshm.org.uk/congress/congress-registration/. You can book now to take advantage of the early bird rates. BSHM members and members of BSHM affiliated societies such as the BSHR enjoy a further discount - and if you book now the 3 day delegate rate for the Conference is only £180.
Keynote speakers will include Philippa Langley , who led the successful search for the remains of Richard III, and the Guthrie lecture will be delivered by Professor David Watters from Melbourne. The Congress is being held in association with the Society for the Social History of Medicine whose sponsored keynote speaker is Professor Malcolm Nicolson.
Please note that abstract submission is also open via: http://bshm.org.uk/congress/congress-registration/ and will close on May 31st 2017. The congress has approval for up to 20 hours of CPD.

The BSHR has a stand at UKRC in the summer in Manchester. Do come along and visit us!

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Interesting Web Sites.

The British Association of Urological Surgeons: Virtual Museum.
http://www.baus.org.uk/museum
This is a brilliant virtual museum and perhaps the sort of thing we should be aiming for as a radiological community. The curator is Jonathan Goddard who says that the BAUS virtual museum is devoted to the history of urology. Each area of the museum displays a different aspect of the specialty, ranging from the History of Urology in pre-surgical times to recent advances in surgery and in urological instrumentation.

100 years of radiotherapy in the Netherlands Cancer Institute: The Radiotherapy Timeline documents the evolution of radiotherapy in the NKI.
www.historad.nl/EN/welcome
This good web site examines the history of radiotherapy at the Netherlands Cancer Institute (NKI) in Amsterdam, The Netherlands, They have designed a website describing 100 years of development of Radiotherapy (1913-2013). The original was published in the Dutch language in 2013, but is now an English version is available. The site focuses on the developments at the NKI, but is of a broader interest, as it covers many aspects of Radiotherapy in general.

Elizabeth Fleischmann-Aschheim.
http://hekint.org/index.php?option=com_content&view=article&id=1367
Elizabeth Fleischmann-Aschheim (1865-1905) opened California's first X-ray photography laboratory in 1896, and this was only one year after Roentgen's discovery. She was able to examine casualties from the Spanish American War. As was the case for so many of the early workers she was injured by radiation and was an early X-ray martyr.

Kelvedon Hatch Secret Nuclear Bunker.
http://www.secretnuclearbunker.com
Come and witness the three lives of the bunker starting with its role as an RAF ROTOR Station, then a brief period as a civil defence centre through to its most recent life as a Regional Government HQ. Designed for up to 600 military and civilian personnel, possibly even the Prime Minister, their collective task being to organise the survival of the population in the awful aftermath of a nuclear war.
This website offers a brief insight into the working life of the bunker. To get the whole story, a tour of the bunker is absolutely necessary. For more information, please visit the Admission Details page.

Faraday's notebooks inscribed on the UNESCO UK Memory of the World Register
The Royal Institution's collection of Michael Faraday's laboratory notebooks have been inscribed on to the UNESCO UK Memory of the World Register.
http://rigb.org/about/news/summer-2016/faraday-notebooks-added-to-unesco-register
Liz Beckmann brought this site to my attention. The Royal Institution's unique collection of Michael Faraday's original laboratory notebooks in which he charts some of the most important physical and chemical discoveries made during the nineteenth century, have received international recognition as one of the latest additions to the UNESCO UK Memory of the World Register. These laboratory notebooks are the only science representation out of the list of seven items added this year. Without Michael Faraday we would not have had radiology.

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Dental Radiography in 1961.

This interesting photograph from 1961 shows apparatus designed to simplify radiography of the teeth. This new apparatus was developed by Dr. Sydney Blackman of the Royal Dental Hospital in London, and produced a complete image of the state of the mouth. Sidney Blackman was a pioneer of panoramic dental radiography, and he may be seen behind the apparatus centrally. I knew his daughter Rita Mason who was a radiographer, and she wrote a piece for *The Invisible Light* about her father. Rita Mason was an active member of the RHHCT, which became the BSHR.

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Recent Publications in Radiology and Radiation Physics History.

Nuclear Medicine.
Three interesting books have been produced in the last few years on the subject of Nuclear Medicine. The subjects covered are quite complementary.

History of Nuclear Medicine in Europe.
Field Michael, De Roo Michel. Stuggart: Schattauer; 2003.

This is a very good book coming out of the European Association of Nuclear Medicine. It is an excellent account of the development of Nuclear Medicine and all areas are covered. There are good historical overviews, and included are accounts of the development of the specialty in individual European countries. There are good appendices including an excellent tabular overview of important developments.

A History of Radionuclide Studies in the UK.
McCready Ralph, Gnanasegaran Gopinath, Bomanji Jamshed (eds.). Switzerland: Springer; 2016.

This book was written for the 50th Anniversary of the British Nuclear Medicine Society. The book has chapters on the development of Nuclear Medicine in the UK, including physics as applied to Nuclear Medicine, the evolution of training, and radiopharmacy. There are reviews of Nuclear Medicine as applied to individual organ systems, and the contributions of selected departments are recounted. I am left wanting to know more, for example about figures such as Valentine Mayneord and the role of the Radiochemical Centre in Amersham.

A Personal History of Nuclear Medicine Wagner
Henry N. London: Springer-Verlag; 2006.

This is a well-written personal account of a life in Nuclear Medicine. The author was associated with Johns Hopkins University for 56 years, and he made major contributions to the development of Nuclear Medicine. It is beautifully illustrated with many photographs of those involved in the development of the discipline. The book comes accompanied by an attached DVD.

Nikola Tesla (1856-1943).

I find the figure of Nikola Tesla interesting and somewhat curious. His supporters make many extravagant claims about his scientific contributions, and it's difficult to determine precisely where the truth lies about this remarkable man.

(Book) The Truth About Tesla: The Myth of the Lone Genius in the History of Innovation. Cooper, Christopher. New York: Race Point Publishing; 2015.

Christopher Cooper is described as an expert in energy policy and is a Senior Research Fellow at Vermont Law School's Institute for Energy & the Environment. He has traveled the globe analyzing the most effective methods of harnessing the sun's energy -- from solar towers in South Korea to massive photovoltaic arrays in Mongolia's Gobi Desert. He has written extensively on solar power and the effects of solar activity on electrical systems, including designing a comprehensive plan to protect the North American electricity grid from impending solar storms. This is a profusely illustrated and beautifully produced book. As it says, the myth of Tesla as the lone-genius inventor, created with inventing everything from radar to the microwave oven, continues to be perpetuated. Cooper's contention is that a false history has been crafted; where publicity and patent law crown winners and losers, and that the true collaborative and incremental process of invention is ignored. Tesla's three most inventions are described (the Tesla coil, alternating current, and wireless transmission), and a more accurate history is presented. This book is warmly recommended.

(Book) The Inventions Researches and Writings of Nikola Tesla.
Tesla, Nikola. New York: Barnes and Noble; 2014.

This is a charmingly produced book in a mock leather-bound style, with gilt page edges and silk-ribbon marker. It gives a record of the inventions, researches and writings of Nikola Tesla, who is described as one of one of the modern world's most groundbreaking inventors, and the blurb states that during the early Twentieth Century, Nikola Tesla 'blazed the trail that electrical technology would follow for decades afterward.' Tesla pioneered inventions like alternating current (AC), radio, wireless transmission, and X-rays, and worked with innovators like George Westinghouse and Thomas Edison, the once celebrated Tesla 'was later largely forgotten by history.' I don't think that Tesla has been forgotten. The book has many illustrations and diagrams of many of Tesla's early patents and inventions, as well as dozens of thought-provoking lectures and articles.

(DVD) Let There Be Light. A 'what if' drama about the amazing inventor, visionary and eccentric Nikola Tesla.
Director: Michael Politis. Actors: Michael Politis, Robert Goss, Marina Seretis, & Carolle Bright.
Studio: TMW MEDIA GROUP. Release date: 14-Apr-2011

This film is very much in the genre of Tesla as the lone-genius inventor. The conflict between Tesla and Edison is covered. Tesla is shown at a crucial turning point after he had been banished from mainstream science into a life of obscurity and poverty. As one of the most eccentric, misunderstood and humanistic physicists of the 19th and early 20th Century, he was a prolific inventor but got credit for virtually none of his world changing technological ideas as his competitors and the world ignored, ridiculed and did whatever they could to discredit, humiliate and steal from him. Nicola Tesla who is 'inventor of most everything electrical, has been discredited by mainstream science.' Tesla's ides are 'stolen from by his competitors, led by 'All American hero' Thomas Edison. With no one to listen to, understand, or fund his new ideas, his creative mind stops, redirecting its intensity into an agonizing depression that can be only result in suicide.' So we are told that to this day, Tesla's inventions remain years ahead of 'modern' science. Many of his inventions are reportedly under lock and key by governments on both sides of the former Iron Curtain. Tesla's inventions include a car that runs without engines, wireless transmission of electricity on a world scale and a machine that can (and did) make the earth shake. Nikola Tesla (1856-1943) was a Serbian-American physicist, inventor, mechanical and electrical engineer. He was one of the most important contributors to the birth of commercial electricity and is best known for his many revolutionary developments in the field of electromagnetism in the late 19th and early 20th centuries.

(DVD) Nikola Tesla: The Genius Who Lit the World.
Director: Dr. Ljubo Vujovic, Prof. Aleksandar Marincic, & Henry Jesionka.
Actors: Spiro Guberina, Rade Serbedzija, Mustafa Nadarevic, Miodrag Radovanovic, & Radmila Radovanovic.
Studio: UFO TV. Release date: 17-Feb-2004.

This program reveals the discoveries of a forgotten genius, many of which went virtually unnoticed for nearly a century. Nikola Tesla is considered the father of our modern technological age and one of the most mysterious and controversial scientists in history. How did this obscure visionary from what is now Yugoslavia lay the foundation for modern communications and energy research? Nikola Tesla's contributions to science and technology include the invention of radio, television, radio-astronomy, remote control and robotics, radar, medical x-ray and the wireless transmission of electricity. Many of Nikola Tesla's inventions were and in some cases still are considered a little too revolutionary by government agencies and the power brokers of the time and are discussed in detail in this program.

Encyclopedia Britannica lists Nikola Tesla as one of the top ten most fascinating people in history. So why is he virtually unknown to the general public? This program is a penetrating study of the life and mind of a "scientific superman" who, against all odds, dedicated his life to the task of designing and improving technology for the service and advancement of humanity.

The Radium Girls: They paid with their lives. Their final fight was for justice.
Kate Moore. Simon & Schuster; 2016.

Kate Moore is a writer with the Sunday Times. She was the director of the critically acclaimed play about The Radium Girls called 'These Shining Lives'.

Atlas of Postmortem Angiography.
Eds.: Silke Grabherr, Jochen M. Grimm, Axel Heinemann.
Switzerland: Springer; 2106
This atlas of postmortem angiography provides a summary of modern techniques.
The atlas has been edited and written by members of an international working group created in 2012, “Technical Working Group Post-mortem Angiography Methods” (TWGPAM). There are two chapters of historical interest:
Postmortem Imaging: Development and Historical Review. pp. 3-33. Adrian MK Thomas.

This chapter looks at the origins of angiography and forensic radiology. The origins of angiography in post-mortem studies is described, and the need to define the normal is discussed in detail.

Postmortem Angiography: A Historical Review. pp. 53-70. Silke Grabherr, Hugues Cadas, Beat M Riederer, Phillipe Charlier, & Valentin Djonov.

The classic techniques are described, including specimen radiography with vascular injections and castings and radiography.

William Henry Fox Talbot: Dawn of the Photograph.
Roberts, Russell & Hobson, Greg. London: Scala Arts & Heritage Publishers Ltd; 2016

This excellent book was published as a catalogue to accompany an exhibition at the Science Museum in London in the spring of 2016, and features 100 high-quality reproductions of Talbot's work. Approximately 30 per cent of the material in the had been unavailable in print or previously unpublished

There are two interesting introductory essays which examine how Talbot's invention of photography in the 1830s, evolved to establish the artistic, scientific and industrial possibilities for photography. Talbot demonstrated how the medium of photography had the ability to open up the visual world to a different kind of scrutiny, as well as to reaffirm what was considered to be real.

By 1895 when Röntgen discovered the X-rays the science of photography was well developed. If there had not been photography then radiography could not have developed, and indeed radiography was called *The New Photography*. Röntgen and many of the pioneer radiographers were keen amateur photographers.

10 Physicists who Transformed our Understanding of Reality.
Evans, Rhodri & Clegg, Brian. London: Robinson; 2015.

This is a good little book of short biographies based on the authors personal choice. Their top 10 transforming physicists are Galileo, Newton, Faraday, Maxwell, Marie Curie, Rutherford, Einstein, Bohr, Dirac and Feynman. The scientific breakthroughs that these physicists made are discussed, and also an account of their lives is given. Many of their lives are quite fascinating. I especially enjoyed the chapter on James Clerk Maxwell who is not as well known as he should be.

Cold War Secret Nuclear Bunker: The Passive Defence of the Western World During the Cold War (Pen & Sword Military Classics).
Nick McCamley. England: Pen & Sword (Military); 2002 (reprinted 2016)

That this book which was published in 2002 has been reprinted 5 times says a great deal about its value.

"Nuclear Bunkers" tells the previously undisclosed story of the secret defence structures built by the West during the Cold War years.

The book describes in fascinating detail a vast umbrella of radar stations that spanned the North American continent and the north Atlantic from the Aleutian islands through Canada to the North Yorkshire moors, all centred upon an enormous secret control centre buried hundreds of feet below Cheyenne Mountain in Colorado. This is complemented in the United Kingdom with a chain of secret radars codenamed 'Rotor' built in the early 1950's, and eight huge, inland sector control centres, built over 100' underground at enormous cost.

The book reveals the various bunkers built for the U.S Administration, including the Raven Rock alternate war headquarters (the Pentagon's wartime hideout), the Greenbrier bunker for the Senate and House of Representatives, and the Mount Weather central government headquarters amongst others. Developments in Canada, including the Ottawa 'Diefenbunker' and the regional government bunkers are also studied.
In the UK there were the London bunkers and the Regional War rooms built in the 1950's to protect against the Soviet threat, and their replacement in 1958 by much more hardened, underground Regional Seats of Government in the provinces, and the unique Central Government War Headquarters at Corsham.
Also included in the UK coverage is the UK Warning and Monitoring Organisation with its underground bunkers and observation posts, as well as the little known bunkers built by the various local authorities and by the public utilities.
Finally the book examines the provision, (or more accurately, lack of provision), of shelter space for the general population, comparing the situation in the USA and the UK with some other European countries and with the Soviet Union.

Opera: Doctor Atomic, by John Adams.
Studio: Opus Arte DVD Release Date: 2 Feb. 2009

The longing to overcome human boundaries led the physicist J. Robert Oppenheimer to begin an experiment that formed a threat to the whole of humanity, and whose scientific results still do today. The question of the moral implications of the atomic bomb is raised in John Adams' opera, just as much as that of the influence on the private lives of the main characters. Doctor Atomic is the fifth work to result from almost twenty years of collaboration between the American composer and his fellow American director and Erasmus Prize-winner Peter Sellars.

Film: Et soudain, tout le monde me manque [Original french version,no english] The Day I Saw Your Heart (2011)
Actors: Mélanie Laurent, Michel Blanc, Florence Loiret Caille, Claude Perron, Guillaume Gouix
Directors: Jennifer Devoldère

A delightful French film with a radiographer as the lead character. She makes artistic use of radiographs. A charming film.

X-ray guided surgery in the First World War: the Hirtz compass.
Francis Duck. IPEM Scope, March 2016: 52-54.

An interesting illustrated paper on localization of foreign bodies in WW1.
IPEM Scope is to be congratulated in publishing articles with a historical content.

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Early Radiology in Bath

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This article recounts a parochial story from the early days of radiology. Radiological histories have commonly, perhaps exclusively, concentrated on the pioneer centres, first publications and the public and medical euphoria following the first announcement of x-rays in January 1896. This story tells a different tale, of the slower and more uneven introduction of radiology into hospital practice, and how this developed in one provincial town, Bath. Historical sources that give evidence for such local stories are not, usually, to be found in the academic literature and books published at the time. They are to be found, rather, in newspaper reports, minutes of hospital boards and committees, and other local documents. Much of the evidence compiled here has been found in such sources.
From my home in Bath I can look out on the ornate gables of late Victorian homes, characteristic of the middle-class affluence of the time. It was the professional owners of such houses and their families who packed the Literary Institution, in the shadow of Bath Abbey, on 7th February 1896, to learn about the 'New Photography'. The Bath Chronicle reported that 'Not for a long time has there been such an audience which assembled at the Literary Institution on Friday' [1]. The speaker was Mr (later Colonel) James W Gifford, well-to-do owner of a lace-making factory from Chard, Somerset, and amateur scientist [2]. He had already given one of the earliest public demonstrations of x-rays to the Royal Photographic Society in London two weeks before, and had been invited to speak again under the

auspices of the Bath Photographic Society. The following evening he was in Bristol to give a similar lecture at the Merchant Venturers' Technical College.
There was applause when the chairman remarked that they might consider 'Somerset very much honoured that (the speaker) belonged to our county'. Gifford had a good speaking style. As part of his warm up, he remarked that he had received many requests to take portraits with the "new photography". These included one from a lady who thought her daughter would make a good subject, adding that her room 'was most favourable, as it had a south-west aspect with a sea view for the background (laughter)'. Turning to the more serious business of the lecture, Gifford remarked on the difficulty in such a crowded room of operating the induction coil safely. He proceeded to demonstrate the procedure on a lad from the Royal United Hospital with a malformed hand. The boy placed his hand on a photographic plate, with a sheet of celluloid to prevent moisture affecting the film. The pear-shaped 'Crookes radiant matter tube' was mounted about a foot above it. When the current was turned on (accumulators supplied by Mr A McTavish of Green Street) the audience observed a 'beautiful greenish light'. During the 15-minute exposure, Gifford explained that the sharpness of the image could have been improved by using a lead diaphragm, but at the expense of a much longer exposure time. He showed many lantern slides showing his own shadowgrams of hands, feet and arms, demonstrating how even in a few weeks from Rontgen's announcement the image quality had been improved.
Gifford never demonstrated any deep understanding of x-rays, which he believed were electrical vibrations, likening them to the action of a tuning fork. He stated in his lecture that Rontgen had only rediscovered Philipp Lenard's earlier observation, and had then used journalists to publicise his own work. Gifford also reported that he had tried and failed to focus x-rays using ebonite lenses and he attributed this failure to variable attenuation across the lens.

John Arthur Roebuck Rudge

The venue for Gifford's lecture no longer graces the centre of Bath. The Royal Literary Institution, with its columned entrance and galleried hall and library, was demolished in the 1930s to make way for a new road and a public toilet. Much of its valuable fossil collection was disbursed and many books were sold.
Gifford left the citizens of Bath to work out their own radiological future. The venue for the next demonstration of x-rays in Bath still stands, on the right-hand side at the top of Broad Street. On Wednesday February 26 1896, John Arthur Roebuck Rudge gave two practical demonstrations of 'electrical shadow photography' at the Jubilee Hall, in the YMCA building, admission 6d [3] (figure 1). This was a different affair, aimed at the general public, and intended to make a profit.

Figure 1. Jubilee Hall, Broad Street, Bath where the instrument maker John A R Rudge gave two lectures on the "New Light"on 26th February1896.

Rudge (figure 2), a lifelong bachelor, had been working in Bath as a scientific instrument maker for over 30 years. With his own creative interest in photography he surely would have attended Gifford's lecture. He had the understanding, skill and workshop facilities for glass-blowing, coil-winding and battery construction which allowed him to investigate x-ray imaging as soon as he learned of it. Like Gifford, Rudge also recruited a lad for his lecture demonstration, this one with a hand 'cramped by rheumatism'.

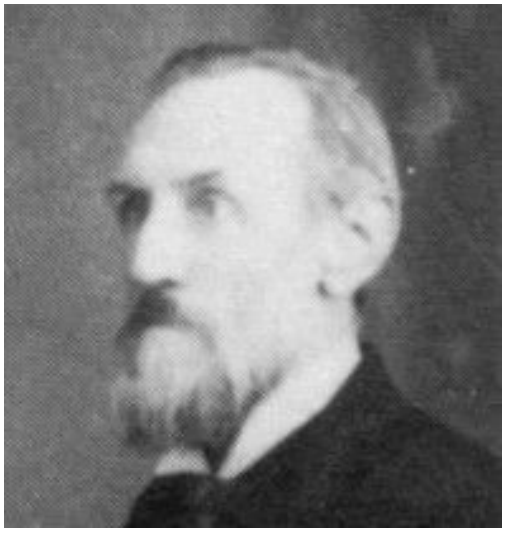

Figure 2. The only known portrait of John Rudge

His well-publicised inventions had already earned him a special place within Bath society. By the mid 1860's he had been entertaining juvenile audiences with his electric model railway, in which the power was supplied by stationary batteries connected to the rails rather than mounted on a carriage and as a result, being lighter, travelled faster. At about the same time he demonstrated his 'aurora-borealis connected with the air pump' showing that even then he had the means to create vacuum tubes. By the early 1870s he was supplying electrical lighting for outdoor events, using his own design of carbon arc lamp. In public lectures he was able to compare its spectrum with those from other forms of lamp. Other inventions were given evocative names: the photodromic wheel, the chromo-electric star and the electric bagpipe. He was both a skilled and knowledgeable instrument maker and an enthusiastic publicist.

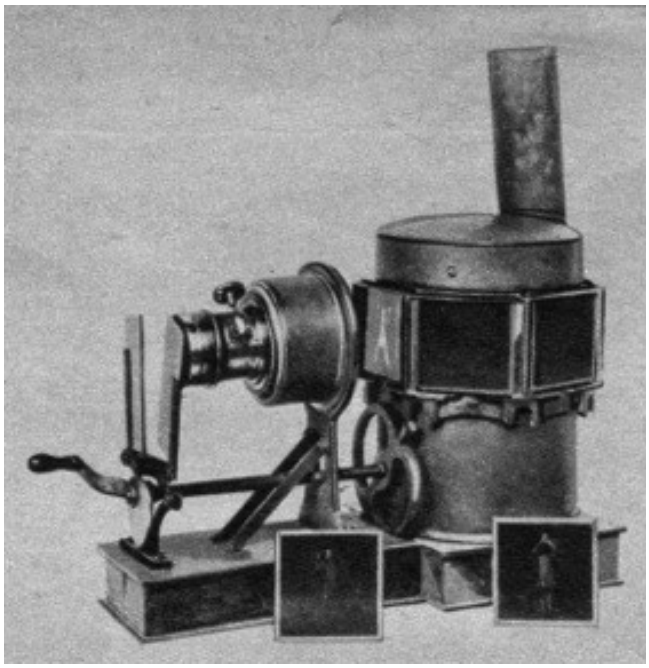

Figure 3. John Rudge's Biophantascope.

Of all Rudge's inventions, the only one that has stood the test of history is the Biophantascope (figure 3). Two plaques are now mounted on the wall of his home and workshop at 1 New Bond Street Place. One, with raised metal lettering, says: 'Here lived, worked and died Rudge inventor of the Biophantascope the precursor of the kinematograph B.1837 D.1903'. The second plaque associates Rudge with William Friese-Greene, the Bath pharmacist whose kinematograph used celluloid ribbon to enable true cine-photography to be carried out (figure 4). In truth, the design of Rudge's biophantascope, with its seven glass plates mounted to spin horizontally around a central spindle, was always too clumsy and limited to achieve true cine-photography, but nevertheless impressed those who saw it. In particular it came to the notice of a local doctor, Dr Preston King, who was responsible, together with Rudge, for later introducing the first hospital-based x-ray department in Bath. King was interviewed by a reporter from the Bath Chronicle in February 1892, when he described how the image

of a face seemed to smile, then frown, and 'takes on in turn expressions of anger, merriment, disgust and astonishment' [4].

In 1913, some years after Rudge had died, his contributions were reported locally through slightly rose-tinted spectacles. A friend described him as 'the best technical photographer I have ever known' which we have no reason to doubt. However, the assertion that 'Mr Rudge had also conceived the idea of X Rays before many other scientists' must be put down to overenthusiastic parochialism [5].

Figure 4. One of two plaques at 1 New Bond Street Place, Bath commemorating the contributions of John Rudge and his friend William Friese-Greene to cinephotography.

The first clinical x-rays in Bath

For the Bath doctors who had any interest in x-rays, it was natural that they would approach Rudge for help. The first report, on March 19 1896, describes how Rudge photographed the hand of a woman patient at the Royal United Hospital that had been pierced by a needle. 'Its position was so clearly defined that Mr Freeman was enabled to cut down to and take out the needle without any difficulty'. The wording suggests that Rudge visited the hospital, although since his workshop was close by, she may have visited him there. On Wednesday 25th March 'Rudge took a photograph of the left hand of a gentleman in Bath with the object of detecting a bullet in the middle joint of the first finger'. This seems to have been a self-referral, as the newspaper report added that the bullet had been there for 13 years, and two doctors were previously unsuccessful in finding it [6]. But then the public interest began to wane, and after a further short report of a visit to Rudge's workshop in June 1896 at which he demonstrated a fluoroscopic screen of his own devising [7], local journalists from the Bath Chronicle lost interest. Perhaps Rudge continued to carry out the occasional radiograph when called upon to do so, but any record of such events has been lost. Throughout the country the interest of the press in x-rays soon waned. The evidence for this comes from the on-line Newspaper Archive (figure 5). In order to learn of the next phase of the history of Bath radiology, therefore, it was necessary to consult other sources, in particular the minutes of the Royal United Hospital Board.

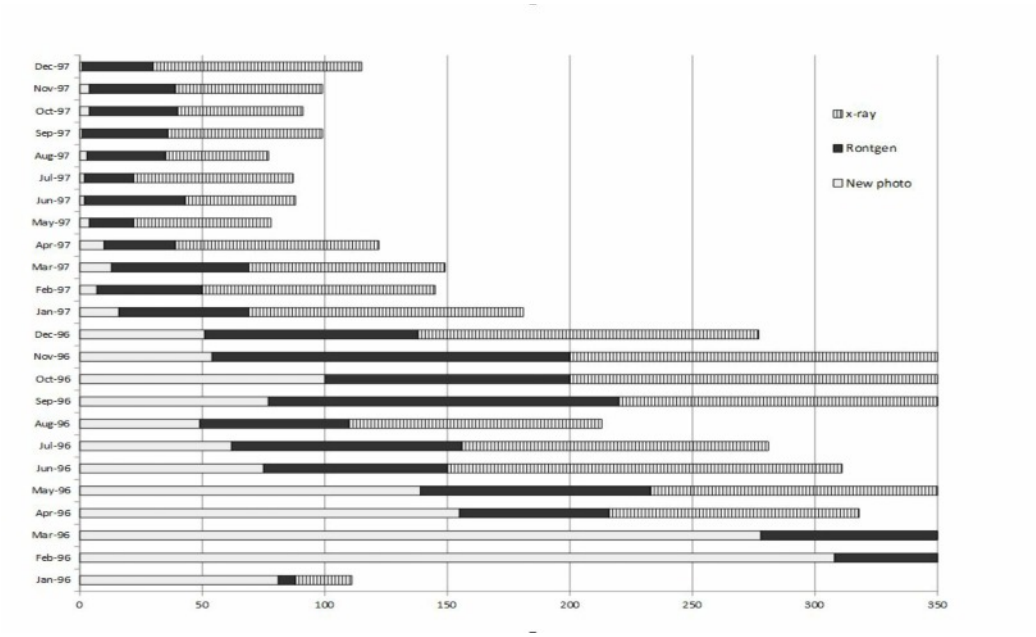

Figure 5. A count of the total number of times that the phrases 'New photography', 'x-rays'and 'Rontgen rays' were used in British newspapers during 1896 and 1897 .www.britishnewspaperarchive.co.uk

Preston King

Dr Preston King (1863-1943) (figure 6) had only been a Bath physician for a few years when he publicised Rudge's biophantascope. A farmer's son from Great Barton in Suffolk, educated at Bury St Edmunds Grammar School, he gained entrance to Cavendish Hall Cambridge in 1881 (BA 1884, MB 1888, MD 1892). After clinical training at St Thomas's Hospital London, (MRCS 1887), and a brief spell as a ship's surgeon, he was appointed in Bath as resident medical officer at the Mineral Water Hospital. He was also appointed as assistant physician at the Royal United Hospital (RUH), the local general hospital (figure 7). He married Margaretta Bond in 1898, the couple living first in Gay Street and then in The Circus.

In 1900, moves were finally made to explore investment in a hospital x-ray facility at the RUH, apparently led by Preston King. Politically, a major challenge was to make a sufficiently strong clinical case to the hospital board to finance the enterprise at a time when the RUH had its own financial problems. A planned bacteriological laboratory had been put on hold: consideration was being given to a reduction in the number of beds from 120 by closing wards: government stocks were sold to cover expenses: a new public appeal for subscriptions was launched. Certainly x-ray images were dramatic, but would the change in patient care be cost-effective? The first step, in May 1900, was to gain formal permission from the board to obtain x-rays for 'two cases under Mr Scott and Mr Lace, during the next fortnight, the secretary was empowered to order the same on the requisition of the staff'. Further permission was granted for three more cases in the wards in July [8]. That there were costs involved indicates that an outside agent, presumably Rudge, provided the radiological service. This initiative coincided with a renewed interest by the Bath Chronicle, after several years of silence. Headlined 'A Curious Shooting Incident', a report on 7 June told how Ernest, young son of Mr Camden of the Locksbrook Cycle Works, had shot himself in the right hand whilst cycling, accidentally firing his friend's pistol which he was holding in his other hand. 'The Rontgen rays were brought into requisition', but the surgeons failed to remove the bullet [9].

Figure 6. Preston King during one of his two terms of office as Mayor of Bath.

Undeterred by this particular failure, a request was made to the RUH Hospital Board on October 16th that a sum not exceeding £70 should be expended to purchase 'a Rontgen Rays', being a portion of a recent £300 donation [10]. The terminology suggests that the board members had no clear idea what was being requested. Finally, on January 3rd 1901, Preston King took the initiative. He knew that he was not the Board's favourite doctor. There were regulations about taking leave, and King had incurred the Board's wrath for taking sick leave without seeking permission when he contracted measles earlier in the year, having to apologise before being reinstated. Using the Medical Committee to present his case, he recommended that a coil, capable of giving a 15-inch spark, should be purchased from Mr Rudge for £30, together with a set of accumulators for £8-5s and a fluorescent screen [11]. This proposal was accepted a few days later by the Board.

One is left wondering who was funding the rest of the equipment including cables, x-ray tube and stand. The revenue consequences, too, were largely ignored, which would have included replacement tubes and chemicals. Always cautious about new technology, there was a condition that the coil should be supplied on a 1-month's trail and carry a 2-year guarantee.

One matter that was considered was space. Where would the new x-ray equipment be placed? Elsewhere, typically, the medical electricity department played host to new x-ray equipment. Unlike the Mineral Water Hospital, there is no evidence that the RUH had such a department at this time. Instead, it was recommended that the anaesthetics room be fitted up to receive the apparatus. This suggests a close association with surgery, to assist with the planned removal of foreign bodies, but the wisdom of generating a large spark in a room designated for the use of inflammable gasses does not seem to have been considered.

Figure 7. The original Royal United Hospital building, Beau Street, Bath as it appears now. It is now a 5-star hotel. The Cross Bath and the new Bath Spa are in the foreground.

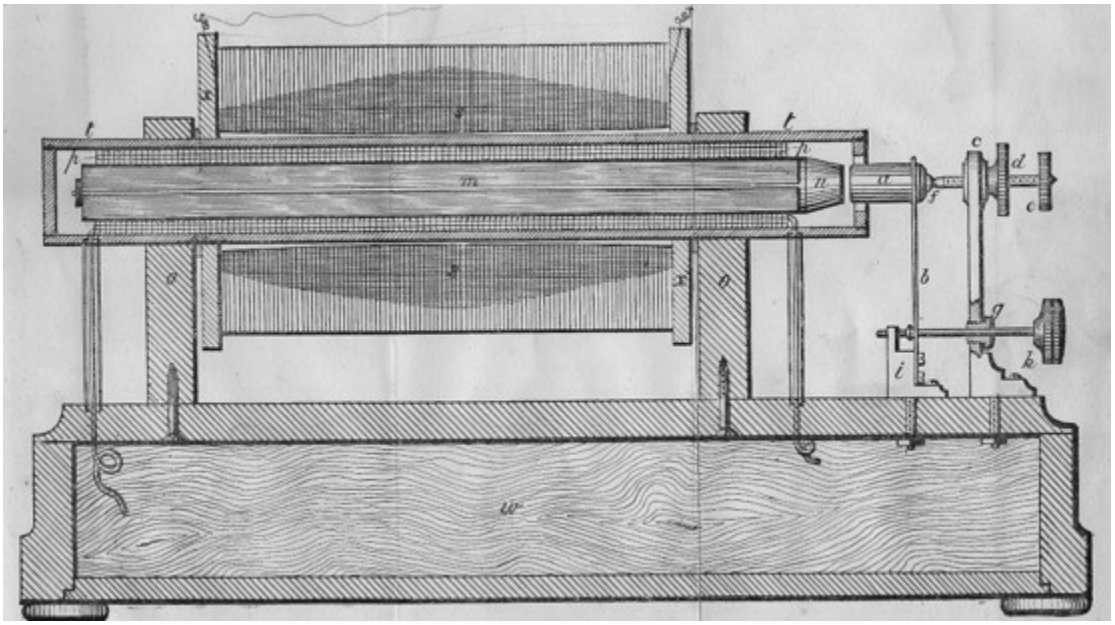

Figure 8. Sectional drawing of a 12-inch spark coil [12, p108]

The induction coil

The purchase of an induction coil and accumulator shows that these, rather than x-ray tubes, were the most expensive, and the most important, items to be bought. The coil ordered by the RUH from Rudge would have been hand-built either by Rudge himself or by his nephew, Edgar Rudge, who worked as his partner and later took over the business when John died. The third edition of F.C. Allsop's book, *Induction Coils and Coil Making* [12], published in 1899, described in great detail what the Rudges would have had to do. Allsop, a London 'manufacturing electrician', advised that a coil giving a 4-inch spark should allow a clear x-ray image (presumably of an extremity) to be achieved in 3 to 4 minutes exposure. In opting for a more powerful coil, Preston King clearly intended to ensure that his x-ray equipment was capable of working at the clinical cutting edge.

Allsop gave 14 pages of instructions for the construction of a 12-inch spark coil, of which he observes 'There are probably few persons of an electrical turn of mind who have not wished to be the possessor of a large coil, with which so many interesting and instructive experiments can be performed'. Preston King was clearly such a person. Allsop estimated that such a coil could be purchased for about £50, of which the materials might cost a quarter of that price. Thus the £30 paid by the RUH was a good deal (perhaps provincial rather than London prices) and Rudge would have received some income for the considerable amount of time he would have had to spend in the coil's construction. Allsop emphasised that 'the main requirements for success are patience and a determination to construct each part thoroughly', clearly Rudge's most notable characteristics.

Figure 8 shows a sectional drawing of the coil construction. The core, *m*, consisted of lengths of highly annealed charcoal iron wire No 22 gauge, packed around a 1/8 inch soft iron rod with an iron extension piece, *n*. The complete bundle, 1.5 inches in diameter, impregnated with melted paraffin wax, weighed about 8 lbs. The primary winding, *p*, consisted of three layers of double silk-covered copper wire 0.11 inch (2.8 mm) diameter, each layer insulated from the next with wax-impregnated paper. Allsop suggested that wire winding should be carried out by two people, so that the wire could be as close packed as possible. It was then impregnated in melted paraffin wax, before being inserted into an insulated tube, *t*, made of ebonite, which served to prevent sparking between the windings. The whole was mounted on a hollow mahogany base, *w*, with two wooden coil supports, *oo*, on which the ebonite bobbin cheeks, *xx*, are mounted. The overall length was about 70 cm.

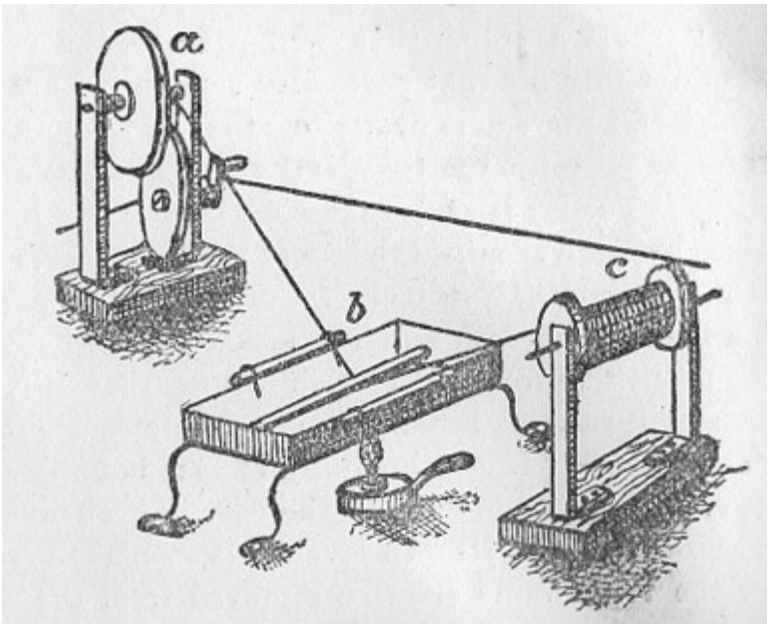

Figure 9. The method used for winding one of several secondary coil sections, passing the wire from the feed spool (c) through a heated wax bath (b) on to the secondary winding spool(a).

Winding the secondary was the most time-consuming and difficult part of the construction. With coils of this size, the secondary was constructed in sections or flat rings, *s*, 96 of them in this case, separated by insulating discs of paraffined paper. Figure 8 also shows that the windings were deeper in the middle, and shallower towards the ends of the coil, following the pattern of the magnetic lines of force. In total, 12 lbs of No.36 (appr. 0.2 mm diameter) silk-covered copper wire was used, a length of almost 20 km. To improve insulation, the wire was fed through a bath of warmed paraffin wax as each section was wound (Figure 9). The sections were then slotted one by one onto the insulating tube, electrically connected, and impregnated with more hot wax. Further layers of paraffined paper, an ebonite sheet, or varnished thread would have been added for final external insulation. Additional electrical elements

were the contact breaker (*afb*) at the end of the coil, and a condenser made of insulated sheets of tinfoil mounted within the wooden base (not shown).

Radiology established at the Royal United Hospital

After Rudge had received the order for the coil, further delays followed, partly because Rudge himself was hospitalized following injury early in 1902. Nevertheless, by 1903, the RUH x-ray department was fully established, with Preston King appointed as honorary physician in charge of the electrical department. He also introduced ultraviolet light therapy with the installation of a Finsen lamp at around the same time. In response to increased workload, King made a request for a nurse to assist him with some of the x-ray cases [13]. This request was kicked into the long grass by referring it back to Matron. By 1905 the workload had increased further, and he suggested that his part-time commitment to x-rays should be endorsed officially, reporting that 'it is difficult to give proper attention to the work of the x-ray department, whilst still retaining the post of assistant physician' [14].

Preston King also retained an honorary position at the Mineral Water Hospital. This hospital, with its specialist emphasis on neurological and dermatological diseases, seems not to have invested in x-ray equipment in its medical electricity department, presumably taking any patients in need of x-rays round the corner to the RUH. Eventually, in 1911, X-ray apparatus was installed here too, at a cost of £40-6s-10d, and placed under the care of the pathologist, James Lindsay. His report for 1913 says that over 300 x-ray examinations and several x-ray treatments had been carried out, and that the running costs were about £50, equally shared between chemicals and x-ray apparatus [15].

In January 1916, almost exactly 20 years after Gifford's lecture, Preston King gave his own lecture on x-rays, again at the Royal Literary Institution, also at the invitation of the Bath Photographic Society [16]. Unlike Gifford, King was able to give a clear description of the physics of x-rays. Using a fluoroscopic screen, he allowed some members of the audience to inspect their own bones. Perhaps he mentioned John Rudge and the essential part he had played in establishing medical radiology in Bath. If so, the reporter for the Bath Chronicle failed to notice. Life moves on. By 1916, more important events were occupying everyone's attention. King's emphasis was now on the use of x-rays for military casualties returning from the trenches, noting particularly the challenge of the exact localisation of foreign bodies before surgery. When, in April of the same year, the Bath War Hospital was opened, Preston King was appointed as one of the 'radiographers'.

Overview

The negotiations used by Preston King and his colleagues to introduce radiology into the Royal United Hospital Bath in 1900 will be familiar to anyone today who has tried to persuade cash-strapped managers to introduce new and expensive technology. First, a formal request was made to the hospital board for modest funds for a sample of 5 patients. This demonstrated the clinical purpose of x-ray imaging, involved medical colleagues, and made managers partners in the process. Having initiated the process, another request was made for partial funding of the equipment, identifying a particular donation that was more than enough to cover the cost. Creation of new space would always be a problem, so first placing the x-ray equipment near the operating theatre in the anaesthetics room, rather than distantly in a medical electricity department, gained the surgeons' support, no matter how impractical or dangerous it was. Once this agreement was gained, and the ball was rolling, it would have been easier to procure further funds from other undocumented sources. Patience and persistence was needed too, and it may well have been a year or more before everything was in place. Promoting the RUH at a meeting at the Guildhall in October 1904, the Board made much of the recent introduction of 'a bacteriological laboratory, the Rontgen ray, Finsen light and other electrical apparatus' [17]. This suggests a fairly long lead time from the original discussions in 1900 and 1901, but also a great pride in having invested in the latest medical technology.

This present article gives a different perspective on the early days of radiology, and in particular raises the practical issues around the introduction of radiology, with its capital expense, running costs, and need of trained personnel, into the day-to-day clinical operation of a general hospital. In the case of Bath, the persistence and focus of Dr Preston King, and the technical skill and experience of John Rudge combined to facilitate this introduction. Whilst the story is local to Bath, it can be imagined that it was being duplicated in some form throughout the country, with local enthusiasm and skills combined to persuade both sceptical managers and inertial colleagues of the potential importance of this new x-ray technology to clinical care.

Acknowledgement

I wish to record my sincere thanks to the staff at the Bath Records Office for making available to me the Bath hospital records and access to the on-line newspaper archive.

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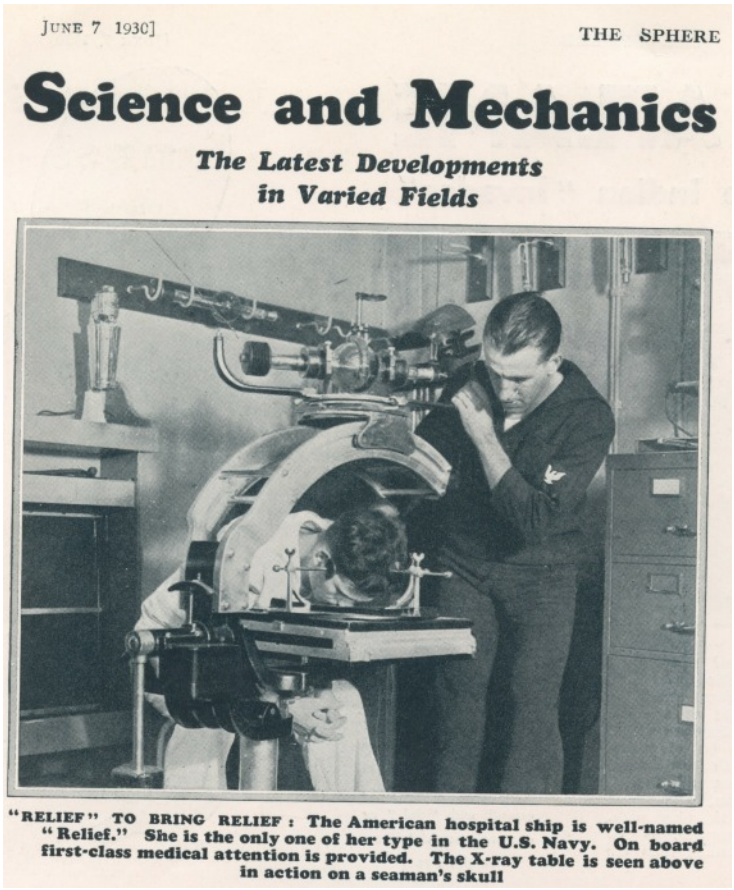
American Naval Radiography in 1930.

This interesting clipping from 1930 gives a good view of the apparatus in use.
The patient is held in a specialised skull table with the head immobiised.
The X-ray tube is shown well. It is a Coolidge type tube and is air cooled using the fins on the left. By 1930 the ion or gas tube had passed out of use.
The apparatus is not shockproof and the cable passing to the anode via the fins is shown clearly. A selection of other tubes that can be used are seen in the rack on the wall behind.



JUNE 7 1930] THE SPHERE

Science and Mechanics

The Latest Developments in Varied Fields

"RELIEF" TO BRING RELIEF: The American hospital ship is well-named "Relief." She is the only one of her type in the U.S. Navy. On board first-class medical attention is provided. The X-ray table is seen above in action on a seaman's skull

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The Lady with the X-Ray Eyes.

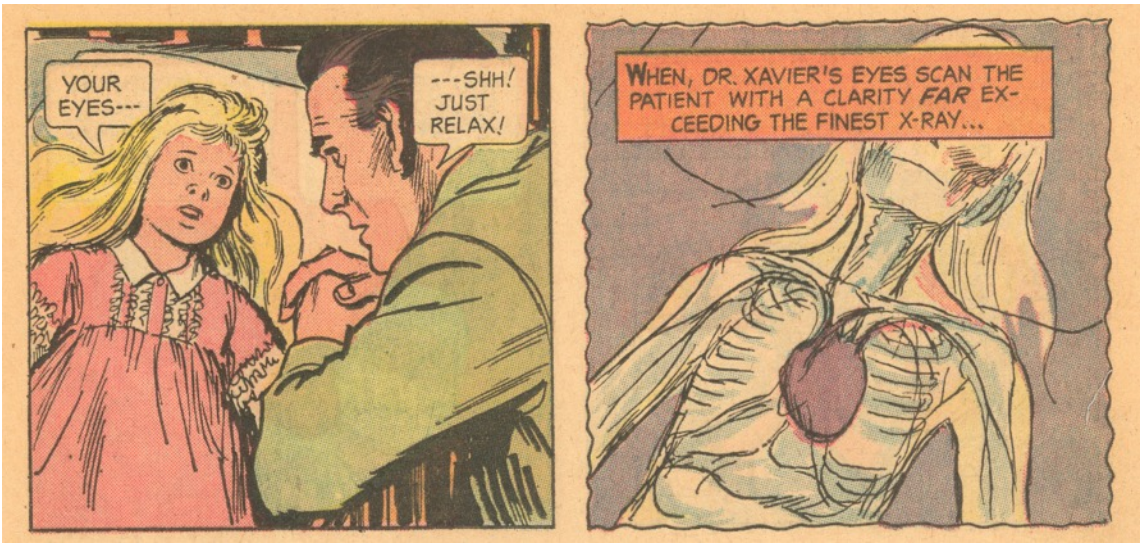
This is an interesting image from *The Sketch* of the 7 March 1906. There have been a number of instances of individuals claiming to see inside the body under either hypnotic or Mesmeric trances. The Okey sisters from Tottenham Court Road were apparently able to see inside the body under a Mesmeric trance as demonstrated by John Elliotson, who was the inaugural Professor of Medicine at my old medical school at University College Hospital in the early 19th Century.

This newspaper clipping describes the activities of the Frenchwoman Louise Bar. As it says, she was being prosecuted for the illegal practice of medicine!

***FRANCE.*—MLLE LOUISE BAR, "THE LADY WITH THE X-RAY EYES."**

Mlle. Bar is the young lady of St. Quentin who claims that, under the influence of hypnotism, she can see into the human frame and diagnose illness of any kind. Her father puts the "'fluence" on her, and she is given the patient's hand while she describes the disease and prescribes the remedy for it--the latter being written down and signed by a Dr. Hamand. Mlle. Bar is being proceeded against for illegal practice of medicine.

The image below is from a cartoon based on the cult film 'The Man with the X-Ray Eyes', and shows Dr Xavier examining a child with a thoracic tumour. Dr Xavier has given himself X-ray vision by using special eye drops. The idea of X-Ray vision is a popular one, whether as seen in Dr Xavier below, or in Clark Kent who was otherwise known as Superman!



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