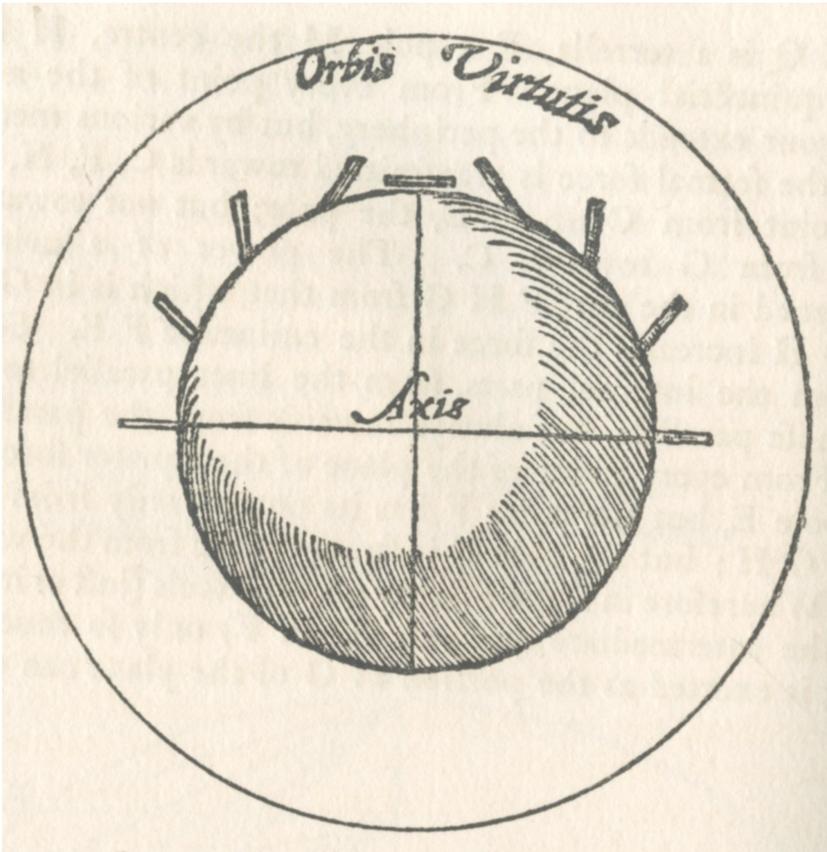
The Invisible Light



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Contents:

Editorial.

The items in this issue of The Invisible Light are all of interest. I have again been mining the papers of the late Derek Guttery and hope you find his words and thoughts of interest. Derek's untimely death was a great loss to the radiology history community in general and to the British Institute of radiology in particular. Part of his collection is in the John Ryland's Library in Manchester.

MRIS History UK / History of MRI/S in the UK (Vol. 1) (eBook) (Eds.) (2019). There is an interesting web site dedicated to charting the history of the development of Magnetic Resonance Imaging and Spectroscopy in the UK over the last 45 years in which I have been involved. The eBook, which can be download for free, contains a number of personal historical accounts as well as obituaries of some of the key researchers who helped introduce NMR/MRI/MRS. A number of links to other relevant history accounts can be found on the Links page, e.g. the new historical Picker and Philips picture archive. It is edited by the trio of Grahame Bydder, Martyn Paley & Ian Young and may be found at https://mrishistory.org.uk. This will be a major Internet resource for the history of NMR/MRI. You are able to submit chapters and there is an 'Author Template' page you can visit. I wrote a piece 'NMR and MRI: Historical Reflections', and would encourage others to offer work. For example an article on what it was like to operate an early MRI scanner would be useful. Even though the story of MRI is short it is surprisingly complex.

The cover illustrates a terella with magnetic pieces of iron: 'How magnetick pieces of iron and smaller lodestones conform themselves to a terella & to the earth itself, and by them are disposed,' and is from "William Gilbert of Colchester, Physician of London, on the Magnet, Magnetick Bodies also, and on the great magnet the earth." (Translated SP Thompson)(1900) London: The Chiswick Press

For those who are coming to Liverpool I look forward to seeing you at out BSHR stand. Please send me articles and pieces for the next journal.

Adrian

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Reality is stranger than Fiction: The Life of Carl Tanzler (1877-1952).
Do you believe in Undying love?

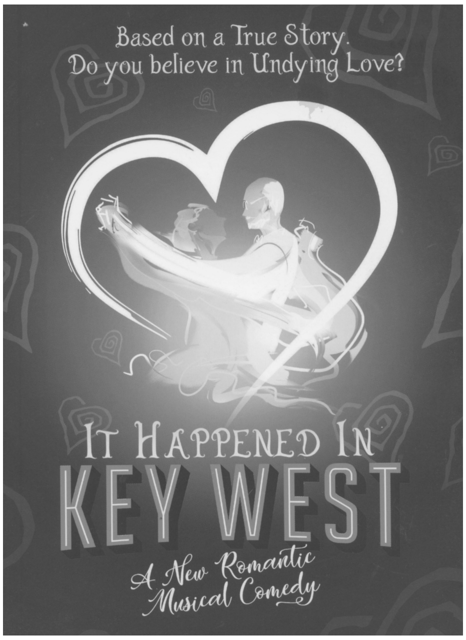
Adrian M K Thomas

Real life can be so very odd; so that if it were to be made into a story our response would be that surely the author has an overly fanciful imagination. Such is the case with the true story of Carl Tanzler, who was a German-American radiographer/radiology technician.

Carl was born as Karl Tänzler or Georg Karl Tänzler on February 8th 1877 in Dresden in Germany. He married and his wife was called Doris.

In 1927 Karl left his family in Zephyrhills in Florida, and was appointed as a radiology technician at the US Marine Hospital in Key West, which is also in Florida. At this point he was calling himself Carl von Cosel or Count Carl von Cosel. Carl met a young Cuban-American patient Maria Elena Milagro de Hoyos (1909-1931), and this meeting was the major event of his life. Unfortunately Elena suffered from tuberculosis, like so many of her family. Carl was completely smitten by the young woman, and unfortunately his infatuation continued long after Elena had sadly succumbed to the disease in 1931. In 1933, which was almost two years after her death, Carl removed Elena's corpse from its mausoleum. The living Carl and the dead Elena then 'lived' together in Carl's home for seven years. However by October 1940 Elena's sister Florinda had heard rumours that Carl was living with, and sleeping with, the disinterred body of her sister. Florinda therefore went to Carl's house and there confronted him, and so the body of Elena was discovered.

There was a preliminary legal hearing on October 9,1940 at the Monroe County Courthouse in Key West. Carl was held in custody to make an answer to the charges, however the case was ultimately dropped and Carl was set free, since the statute of



limitations for the crime had expired. Carl was made a US citizen in Tampa FL in 1950. Finally separated from his obsession, Tanzler used a death mask to create a life-sized effigy of Hoyos, and lived with it until his death on July 3, 1952 in Pasco County, FL.

Carl's story has recently been told as a musical "It Happened in Key West", written by Jill Santoriello and Jason Huza, and conceived and produced by Jeremiah James. The musical was presented in Lancaster, Pennsylvania in 2017, before moving to London, England in the summer of 2018 where I was able to see it. We were asked, "Do you believe in Undying Love?" as we attended this new romantic musical comedy. Certainly the love affair between a radiographer and a deceased patient in an unusual topic, however if is produced again it might provide for a romantic evening.

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Non-Medical Practitioners offering Radiographic Services.

Based on notes found in the papers of the late Derek Guttery.

THE NON-MEDICAL PRACTITIONERS NAMED BELOW WERE OFFERING AN X RAY EXAMINATION SERVICE FROM 1896. SOME WERE IN BUSINESS FOR ONLY A SHORT TIME, WHEREAS OTHERS SUCH AS E.L.GLEW AND W.A.COLDWELL CONTINUED OPERATING UNTIL THE MID AND LATE 1920s. TYPICAL X-RAY EXAMINATIONS WOULD HAVE BEEN LIMITED TO DEMONSTRATING FRACTURES AND DISLOCATIONS IN HANDS, FEET, ARMS AND LEGS AND DETECTING FOREIGN BODES SUCH AS NEEDLES AND BULLETS AND SWALLOWED OBJECTS SUCH AS COINS:

"A.A.Campbell Swinton informs us that he is going to arrange a special laboratory for the purpose of the medical applications of the Röntgen photography.
The laboratory will be at his address, 66 Victoria Street, London, S.W., and is expected to be opened early next week."
The Photogram, III, 105b (April 1896)

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". . . The announcement [of the discovery of X-rays] was in The Standard on January 7, and my brother, Mr. Alan Swinton, afterwards F.R.S., and now dead – to whom you often gave hospitality in your columns on scientific subjects – having fortunately a Crookes' tube, experimented on the 7th., and got results which I myself saw, I think, that day. He wrote, confirming Röntgen's discovery, to The Standard on January 9, his letter appearing on the 10th, and on the 13th he produced a photograph showing the bones of his own hand, which was exhibited at a lecture he gave at the Camera Club on January 16th.

I am quoting from the cuttings in his scrap-book, which include one from The Times of the 17th, and the photograph of his hand lies before me. In a very short time his office was besieged by doctors, and he set up a special laboratory. On my brother's death, 15 months ago, his first radiographs were deposited by his executors at the British Institute of Radiology."
From a letter to The Times from George S.C. Swinton, Monday, February 15, 1932, p.8c.

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". . . Soon after the discovery of the Röntgen rays, there sprang up a demand for Röntgen-ray photographs – or radiographs as they cam to be called later – for surgical purposes, and I set up what was, I believe, the earliest laboratory in this country to which medical men were able to send their patients to be photographed by these rays. . .
. . . Many distinguished people visited my laboratory in those days to see photographs taken by the Röntgen rays, and on one occasion Lord Salisbury, at that time Prime Minister, visited us, when we did a photograph of the bones of his hand, which photograph was a particularly good one."

– A.A.Campbell Swinton: Autobiographical and other Writings, 43 (1930).

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Professional Radiography is undertaken by W.E.Gray, F.R.P.S., 92 Queen's Road, Bayswater; by G Ridsdale Cleare, 97 Lower Clapton Road, N.E.; by Friese Greene, and by Appleton & Co., Manningham Lane, Bradford. Messrs. Leo Atkinson & Co., 193 Greenwich Road, S.E., also inform us that they have fitted up a laboratory for the production of radiograms for medical man and others.
The Photogram, III, 131a (May 1896)

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THE NEW PHOTOGRAPHY. A Practical Remonstration by Mr.H.H.Powles [at the Camera Club, Wednesday, March 25, 1896] . . . SURGICAL POSSIBILITIES. It will be gathered from what has gone before that surgeons are only too glad of this new method of seeing the bones, to help them come to a decision in cases difficult of diagnosis. It will certainly prove invaluable in cases of necrosis and other diseases affecting the bone structure. Laboratories for the investigation of such cases by the Röntgen method are now being established, and one of them is under the supervision of Mr.Powles at Faraday House. Here already several obscure cases have been investigated with satisfactory results. — The Journal of the Camera Club, X, 73-74 (April 1896)

The experiments were made at Mr.Friese Green's "New Photography" laboratory, 39, King's Road, Chelsea . . . — THE PHOTOGRAPHIC NEWS, XL, 210 (April 3, 1896)

William Friese Green (1855-1921) was a British pioneer of cinematographer who saw X-rays as a means of making money. In 1896 he applied for a provisional patent (9,919) for "Producing X-rays and Light". One of his ventures involved Matinée X-ray Exhibitions at the Old Oxford Music Hall in London during which he would invite members of the audience to have their hands and arms radiographed and see the results displayed on photographic plates.

In 1896, he established a laboratory for radiography at 39, King's Road, Chelsea in 1896 where the X-ray examinations were undertaken by a young man called Forrest Barnes. An account of the sort of work he undertook is given in Ray Allister's FRIESE-GREENE: Close-up of an Inventor (1948):

A carriage arrived at 39, King's Road, and the coachman delivered a note. Sir Pierce Gould, the well-known surgeon . . . would be obliged if Mr Friese-Greene would come at once to Sir Pierce's house, bringing his X-ray apparatus. . .

Sir Pierce's nurse-receptionist lay on the couch, obviously in pain. The surgeon explained that last night she got a needle into her foot. She knew where it had entered. This morning it was not in the same place and the foot was so swollen it was impossible to find the needle by feeling for it. The X ray found it. It had "walked" almost to the ankle during the night.

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Messrs R.J.Appleton & Co., photographers of Bradford, are prepared to treat medical cases with the Röntgen rays. This firm has been successful in photographing portions of the backbone, the arm and other parts of the body. — The Practical Photographer, VII, 152. (May, 1896)

The Roentgen Rays and Surgical Operations. — Dr.Moorhead, of Tong [a village near Bradford, West Yorkshire], has had a somewhat peculiar experience in connection with the X rays. A lady patient of his having got a portion of a needle into her foot, he took her to Messrs. Appleton of Bradford, where the X-rays were applied, and the needle localized. The following morning, with the aid of a life-size tracing of the negative, the doctor attempted to cut out the needle, but, to his surprise, it was not where it should have been. On the photograph the needle was in a horizontal position, but it was found in a vertical position, and was extracted from the dorsal surface of the foot instead of the planter surface. The needle extracted was 1.1/8in. in length, and had struck the bone with such force as to bend the point. Surgeons resorting to the X rays will, therefore, have to devise some means of operating immediately a negative has been obtained. English Mechanic and World of Science, LXVI, 504a (January 14, 1898)

THE ROENTGEN RAYS AND SURGICAL OPERATIONS. [40761.] — My attention has been called to an account of the experiences of Dr.Moorhead, of Tonge [sic], on the X-rays, and which was published in these columns about a fortnight ago. A lady having a needle in her foot was radiographed by a firm in Bradford, and the needle shown to be in a horizontal position. The following morning, aided by a tracing from the X rays negative, an attempt was made to remove the needle, but to the doctor's surprise the needle was now in a vertical position, it was 1.1/8in. long with a bent point, and it had to be removed from the dorsal surface instead of the plantar surface, and the conclusion arrived at from this experience was that "surgeons using the X rays will therefore have to devise some means of operating immediately after the negative has been obtained."

Now, the inference of all this is that the needle had moved during the few hours only before the operation. Well, I do not intend to discuss this point; but I desire to point out that if the plate was under the plantar surface, and the Crookes tube over the dorsal surface, the needle could only be shown as a line or as a dot; in the latter case it would have to be perfectly vertical to the plane of the plate, and directly under the central rays of the tube, which is a ten thousand to one chance; if the needle was a little inclined out of the perpendicular, or the tube a little to one side, the image by projection would have been shown as a line, and may have led to the misconception that the needle was in a horizontal position. Of course, radiography is not to blame for this. What should have been done was to have taken a second radiograph at right angles to the first, and the two would have more correctly located its position. In my own practice it sometimes happens that a second radiograph reveals conditions that make it advisable to take a third, and abandon the first. — W.I. Chadwick. English Mechanic and World of Science, LXVI, 577c-578a (February 4, 1898)

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Radiographic Studios appear to be opening everywhere. One of the latest is at the London Stereoscopic Co.'s premises in Regent-street. Jones & Scott, of Exeter, have fitted themselves very completely, under the advice of J.W.Gifford, for all classes of surgical work. Unfortunately, some of those who have gone into the line are already working at ridiculous prices – an original surgical for half-a-crown, for instance – but our own experience of the uncertainty of the subject, and the skill necessary to ensure any regular success, makes us think that these people will not long keep to such prices, or anything approaching them. — The Photogram, III, 156b (June 1896)

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X RAYS IN THE COURT . . . Mrs Wills was walking up Bridge Street, Exeter, and when opposite Mr.Pike's premises a man, carrying sacks, came out suddenly and ran against her with such violence that she was knocked down. Her arm was badly injured and sprained, as was seen by the X-ray photographs produced, and it was doubtful whether she would ever thoroughly recover the use of the limb. — Mr.Andrew, surgeon, said he had attended Mrs.Wills, and was inclined to think the injury to the arm was permanent. He had the X ray photographs taken by Scott and Son, thinking there might be other injuries besides the sprain, and these showed there was no fracture, but that the arm was twisted. That he attributed to the hand being doubled up under the arm in the fall. — Judgment (sic) for plaintiff for £15, and half a guinea was allowed for the photographs. — THE PHOTOGRAPHIC REVIEW, II, 18 (January 1897)

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Radiography as a business is being taken up all over the country. Not only are professional photographers going into it, but some amateurs also. V.E.Johnson, M.A., F.R.M.S., Alderley Edge, near Manchester, asks us to intimate that he is prepared to lecture and demonstrate, and to undertake surgical cases. — The Photogram, III, 202b (August 1896)

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Photographer and Radiographist is the style and title of Jas. Dickinson, who has removed from Grainger-street to new premises in Neville-street and Pink-lane, Newcastle-on-Tyne. — The Photogram, III, 253 (October 1896)

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Instruments for taking Roentgen's photographs are lent out with all the required accessories. The prices depend on the size and number of plates required, and the length of time for which they are wanted, and vary from £1 1s. to £5 5s. Damaged tubes and coils will be charged for. Skilled assistants can be sent to take these photographs. Terms on application. — Preface to 5th. edition (October. 1896) of K.Schall's Electro-Medical Instruments and their Management . . .

A radiographic laboratory which has turned out some excellent work and the proprietor of which is prepared to lecture and demonstrate upon the subject, has been recently opened by F.H.Glew, 156 Clapham-road, London W. — The Photogram, IV, 154a (May 1897)

Glew advertised his radiographic services in London local newspapers —

F.H.Glew/ Surgical Radiographer/ the/ Radiographic Laboratory/ 156 Clapham Road/ London S.W. — Advertisement on front page of The Brixton Free Press, No.883, Friday, August 4, 1899.

F.H.Glew was a chemist and electrical engineer and one of the earliest members of the Röntgen Society (1898). He had an experimental laboratory behind his chemist shop in Clapham Road. where he developed – sometimes in association with R.S.Wright of Newton & Co. – a number of pieces of X-ray equipment including a rectifier, a motorised mercury interrupter (patented), and a "vacuum regulating" X-ray tube (1896) now in the Science Museum, London. As a result of his later work with radium, he received severe radiation injury to his fingers. He died in September 1926. His name was added to the Hamburg Radiation Martyrs' Memorial in 1956. For Glew's spirited defence of the important work done by non-medical radiographers, see Journal of the Röntgen Society, XIV, 110–115 (October 1918) (Copy enclosed with my letter of 22 May, 1996).

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Allen & Hanbury, Chemists, London. Operated an X-ray service for General Practitioners from about 1896. The radiographer was W.A.Coldwell (q.v.) who left in about 1906 to establish his own radiographic service.

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Walter Augustus COLDWELL (1864-1929) Originally worked for the London chemists Allen & Hanbury. Following the discovery of X-rays, Coldwell ran Allen & Hanbury's X-ray examination service for general practitioners until 1906 when he left to establish his own radiographic service at 62 Welbeck Street, London W. In 1907-08 he moved to 6, Mandeville Place, Manchester Square, London W.

Coldwell was elected to membership of the Röntgen Society in March-April 1898. He suffered severe radiation injures to both hands with consequential amputation of several fingers and eventual death in 1929 from axillary metastases. His name was added to the Hamburg Radiation Martyrs' Memorial in 1956.

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Frank Simpson PEPPERDENE (1862-1933) – or Dr Pepperdene as he preferred to be called – was, according to his own statement, involved with X-rays from 1897:

I commenced lecturing and demonstrating . . . in 1897. Since then I have been experimenting with the X-rays — interview with Pepperdene quoted in The Daily Mail, July 22, 1910.
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Pepperdene was proposed for Membership of the Röntgen Society on 5 April 1898 and elected on 10 May. At the time of his application for membership, he described himself as "Analytical Chemist" and claimed to hold the degrees of M.A. and PhD. There is no evidence that he was entitled to either qualification. He later became a member of Council of the Röntgen Society. Despite his friendship with A.W.Isenthal, there is no doubt that he was a charlatan or, at least, a clever opportunist.

At the end of 1898, Pepperdene approached the City Orthopaedic Hospital in Hatton Garden with an offer to set up an X-ray department at his expense subject to his being appointed to the staff. This arrangement seems to have continued until about 1901-02 when he moved his family to Bexhill-on-Sea. In the meantime, he had established a private radiographic practice in rented rooms at 68 Wimpole Street. From about 1900, his hands had been effected by X-ray dermatitis and by 1902 this was seen to be serious. The condition worsened until February 1910 when his left arm was amputated just below the elbow. A public appeal was made to raise funds as it was thought that Pepperdene might never be able to work again. Pepperdene emigrated to Canada with his family in early 1911 and appears to have continued his work with X-rays until his death in 1933.

Pepperdene was interviewed in July, 1910 "in his London operating room" by a reporter from the London Daily News and is quoted as saying:

I think I may claim to have been one of the earliest to experiment in radiography and radiotherapy, and I introduced the treatment into the City Orthopaedic Hospital. It is quite true that in those days, even in the hospital, I had to use my own instruments. They are those you see around you, and cost over £1,000. — interview with Pepperdene quoted in the Bexhill Observer, July 23, 1910.

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Isenthal, Potzler & Co. have opened handsome premises at 85 Mortimer-street, W. (close to Regent-street), where they stock every possible kind of radiographic instrument, as well as a very large selection of other electrical-surgical apparatus. They are the sole British agent of the Voltholm Company of Munich, and are also importers of all novel and really special patters in Continental radiographic apparatus. They have a convenient radiographic laboratory under the charge of A.W.Isenthal, F.R.P.S., etc., who is well known as one of our best practical radiographers, a member of the Council of the Röntgen Society, and joint author of Practical Radiography. — The Photogram, V, 300a (September 1898)

Radiographic Outfits of the most perfect kind are a special feature of the business of Isenthal, Potzler & Co., just opened at 85 Mortimer-street, Cavendish-square, London, W. An examination of some of the special lines will fully prove how great has been the progress in radiography since those early days of '96 when Röntgen's discovery was received with semi-incredulity. By Isenthal, Potzler & Co., two large floors are almost entirely devoted to radiographic apparatus, and to a model radiographic studio, in which radiography is undertaken for physicians and surgeons. The studio and dark-rooms may also be used by experienced operators. The fixed installation includes a twenty-inch spark coil, with all the most perfect accessories in the way of electrically-driven and controllable interrupter, driven from separate batteries, volt-meters,
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ammeters, etc., and with complete outfits of intensifying screens, exposing and examining table for patients, etc., etc. . . . — The Photogram, V, 333b (October 1898)

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Radiographic Services listed in [Kellys] Post Office London Directory from 1900 until 1916 [later volumes were not surveyed] show the following names:

APPLETON & Co.
ATKINSON, Messrs Leo
CLEARE, G.Ridsdale
COLDWELL, W.A.
COXETER & Son
DAVIS, Harry & Walter
DICKINSON, James
FOWLES, H.W.
GLEW, F.H.
GRAY, W.E.
GREENE, William FRIESE-
ISENTHAL & Co.
ISENTHAL, POTZLER & Co.
JOHNSON, V.E.
JONES & SCOTT
LONDON STEREOSCOPIC COMPANY
SCHALL, K
SCOTT & Son
SWINTON, A.A.Campbell
THATCHER, Cyril Frederic
GRAY, W.E.

Typical entries in the Directory were:

Coxeter & Son, improvements & complete apparatus for examination & difficult radiography; examinations made & radiographs taken at patients' residences or at 4 & 6 Grafton Street, Gower Street, London W.C. — [Directory entries from 1900 to 1903].

Frederick H.Glew, 156 Clapham Road, S.W. TN 1787 HOP; silver medalist, Paris Exhibition 1900. — [Listed in Directory from 1900 to 1916].

Harry & Walter Davis, 52 Grafton Street, Gower Street, London W. — [Listed in 1904 Directory only.]

Walter Augustus Coldwell, 62 Welbeck Street, London W. Late operator [radiographer] to Allen & Hanbury's Limited. TN 2430 MAYFAIR; TA "Skiagraphy London". [From 1914 onwards called "Laboratory of Radiographic Research"]. — [Listed in Directory from 1906 to 1916].

Cyril Frederick Thatcher, 35 Harley Street, London W. — [Listed in 1915 and 1916 Directory only].
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[Verbatim transcripts of the relevant pages of [Kellys] Post Office London Directory from 1900 until 1916 are shown on attached green pages]

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THE PHOTOGRAM.

(Edited by H.Snowden Ward & Catherine Weed Ward) Published under this title from January 1894 to December 1905. 12 vols. (I - XII) London, 1894-1905.

Continued as:

THE PHOTOGRAPHIC MONTHLY (THE PHOTOGRAM) (Editors H.Snowden Ward, Catherine Weed Ward) Vols.XIII – XVIII, January 1906 – October, 1911.

B.L. press mark for both titles: P.P. 1912. eb. (1.) [British Library set is lacking vol.15, No.180.]

NOTE: From March onwards, the 1896 volume contains a considerable number of references to "The New Light" or the "New Photography" and this interest in X-rays continued to a lesser degree during 1897 and 1898 but by the 1899 volume had diminished to three short entries (all at p.281 of the September issue.); four entries during 1900 and three during 1901.

The founder and chief editor of THE PHOTOGRAM, H.Snowden Ward (died New York, December 6, 1912), took a great interest in Röntgen's discovery and was one of the original members of the Röntgen Society and a very energetic member of Council. In late January, 1896 he published an illustrated 15-page special supplementary number of THE PHOTOGRAM under the title "The New Light and the New Photography" (price 3d.) containing "Full particulars popularly written, of Prof. Röntgen's Discovery" including "Early Work on Invisible Rays, and a Popular Exposition of the Subject" by E.J.Wall and H.Snowden Ward; "The 'X-rays'" translated [by C.M.Stanton] from Röntgen's "First Communication" and "The Work of A.A.Campbell Swinton, and J.W.Gifford". The supplement was obviously well received by the readers of Snowden Wards's journal as it reached a third edition – containing additional material and illustrations – by 5 February and thereafter went into a least one further edition. It was followed in ?July# 1896 by Snowden Ward's book Practical Radiography (price 1s., paper; 1s. 6d. cloth) which the author claimed to be "so far as we are aware, the first practical handbook of the applications of the X-rays published in any language". A second and virtually re-written edition of 158 pages produced in collaboration with A.W.Isenthal appeared in April 1898 and a third edition of 198 pages by the same co authors in 1901. ["Practical radiography is again coming to the front with the commencement of the autumn season, and the little practical handbook, which we published under this title a year ago, is almost entirely out of print." — The Photogram, IV, 275, September 1897]

#reviewed in The Photogram, August 1896.

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PUBLIC DISINTEREST IN X-RAYS:

By the end of 1896, the educated public began to lose interest in X-rays which had received excessive attention in the press:

Tired as we are of the X-rays, they appear to be doomed, like the poor to be always with us — The Photographic News, XL, 482 (July 31 1896)

THE X RAYS. The Middlesborough Gazette, speaking of a lecture by Mr.Campbell Swanson [sic – Swinton], makes him say:

"That while six months ago everybody was excited with the subject, it has now become so stale that it was difficult to galvanise it into any sort of interest. The fact thus stated is another illustration of how soon we nowadays cease to wonder at anything. That all our ideas of photography should be reversed, and that interiors should be revealed and surfaces not, that the bones of the hand should be photographed and the skin and the flesh left out of the picture , was certainly a discovery that startled the world into the belief that anything was possible. But it has now taken its position among the commonplaces of existence, and people talk of the new photography as they do about the new woman. It is a pity that things capable of maintaining the feeling of healthful wonder should be permitted to lose their interest and settle down into the trivialities of everyday life." — quoted in The Photographic Review, I, 346b (November 1896)

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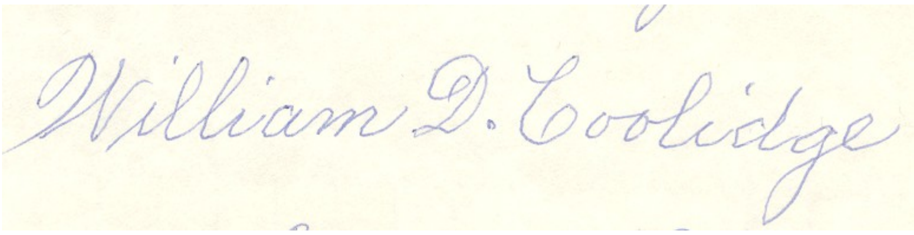
The Coolidge "Universal" pattern X-ray tube.
William Coolidge (1873-1975).

William Coolidge was a remarkable man and he lived through dramatic times. 1913 marked the centenary of the development of the hot cathode or Coolidge X-ray tube. All of our modern X-ray tubes are based on this design and on variations of it.
The early X-ray tubes were gas or ion tubes in which the cathode was a simple cup and the anode was set at an angle, hence the name of the focus tube. The working of these X-ray tubes depended of the ionisation of the gas remaining inside the evacuated glass bulb. They worked well, however their function was unpredictable and the radiographer needed to know the individual tube, and how a particular tube functioned in use. The function of the tube varied with its use and before use the tube needed to be seasoned. It was not uncommon for one tube to be reserved for extremity work and the other for chest radiography.



William David Coolidge (1873-1975) was born in Hudson, Massachusetts, on 23 October 1873. In 1905 he joined the General Electric Company Research Laboratory and he worked there until he retired in 1944.

In 1906 Coolidge made a major contribution when he discovered how to make molybdenum and tungsten ductile. Prior to this, these metals were thought of as being unworkable because they were far too brittle. The ductile tungsten was now useful since it could be made into incandescent lamp filaments replacing the earlier carbon filaments.
It was when working with x-ray tubes that Coolidge found a particular tube that worked well when the cathode became heated. Coolidge then collaborated with Irving Langmuir who was studying electron emissions from hot tungsten filaments. It was found that even in the highest vacuum that the electron emission was stable and reproducible. It occurred to Coolidge that this could be adapted for use in an x-ray tube. In his notebook of 12 December 1913 Coolidge wrote that, “I L (Langmuir) tells me that in his study of the Edison Effect, current from the hot cathode is greater with vacuum of .01 or .02 micron than at higher pressure (except in case of argon). I will try this at once in an x-ray tube in which I can heat the cathode.”
The Edison effect (also known as thermionic emission) is the emission of electrons from a hot cathode within a vacuum tube. This effect had initially been reported in 1873 by Frederick Guthrie in Great Britain. Guthrie was working with electrically charged objects. He found that a positively charged red-hot iron sphere would discharge, but that this did not happen if the sphere had a negative charge. This effect was rediscovered by the American Thomas Edison on the 13 February 1880 when he was trying to find why the filaments in his incandescent lamps were always breaking.
The team at GE then developed a high-vacuum tube with a heated tungsten filament acting as the cathode, and a tungsten disc as the anode. The tubes were evacuated and initially the green fluorescence of glass that always took place when x-ray tubes

operated was observed. As the vacuum increased the fluorescence disappeared and the tube became stable and controllable. The ions in the tube that were previously needed became unnecessary. The limitations of the older gas tubes were largely secondary to the presence of these ions.
The first of these new tube with a heated cathode was used by the well-known US radiologist Lewis Gregory Cole from New York. The new tube was first demonstrated at a dinner in a New York hotel on 27 December 1913. The new tube was enclosed in an open-topped lead glass bowl for radiation protection. Up to this point the x-ray generators had an output considerably higher than the older x-ray tubes could endure and this was changes at a stroke. With his characteristic modest William Coolidge wanted to call the new design of tube the "GE Tube" however Lewis Cole proposed the name of "Coolidge Tube" and this is the name that stuck.
Coolidge wanted to test his new tube designs on human subjects and decided rather unwisely to use himself as a test subject as so many had done before him with disastrous effects. Whilst this went well initially Coolidge became concerned when the hair on his started to fall out. Coolidge therefore obtained an embalmed leg from a local physician to use as a phentom. When Coolidge had finished his experiments he took the leg to the company's incinerator for disposal. Coolidge threw the leg in to the incinerator with no explanation. The operator did not know much English and opened the incinerator, and as the covering came apart he was horrified to see a human leg! He was convinced that he had come across a dreadful crime and so he called the company police. A detective then visited Coolidge and he had to give a very lengthy explanation!
Further experiments by Coolidge and his team on the new tube resulted in the observations that the radiographic contrast deepened on the tube voltage and that the resolution depended on the size and position of the focal spot.
During the First World War Coolidge became involved in producing a dependable portable radiographic unit for military use. The individual elements were of necessity simple and light and easily transportable. There was attached petrol driven generator to provide the current. The new tube had many benefits for military use and could be operated for long periods of time without over-heating.
It might be imagined that the new Coolidge tube would rapidly sweep away the old ion/gas tubes. In fact the gas tubes survived for a considerable period of time. The older designs were readily available and also quite cheap. So as an example, in GC Aimer's catalogue a standard gas tube retailed at £7 15s 0d (£7.75p), whereas the Coolidge tube sold at £40, which was more than four times the cost. Aimer was forced however to admit that "the Coolidge tube has certain advantages over the gas tube" (!).
Coolidge continued to work in x-rays and in the 1930s developed a 900,000-volt tube. He was also deeply involved in non-destructive testing and industrial radiography.

Coolidge received many honours and was personally very modest. He said "such honours as this I accept only if I can some-how share them with many others, since the entire staff of our research laboratory contributed to the success of this work."

The section below is based on a letter found in the papers of the late Derek Guttery. The history of the cathode ray tube is very interesting and also complex. A good web resource is *The Cathode Ray Tube Site* https://www.crtsite.com/index.html , which details the complete cathode ray tube evolution over the past 150 years starting with

Geissler and Crookes tubes in the 19th century and all the various spin-offs. It is a unique collection of historic tubes and background information. Derek had an immense knowledge of the developmeny of the X-ray tube. Unfortunately the documents and pictures associated with this letter are not available, but would be reasonably easy to reconstruct with a little effort.

The letter starts ……………..

Dear xxxxxx

Further to my letter of 7 November (possibly 1996), I am now able to forward the promised collection of documentary material and comments relating to the Coolidge family of X-ray tubes:

- U.S. Patent No. 1,211,092, January 2, 1917: W.D. Coolidge – X-ray tube. [Application filed June 5, 1916] Coolidge's patent for the original "Universal" pattern X-ray tube announced in December 1913: the first X-ray tube successfully to employ thermionic emissions as a source of electrons.

- "The Coolidge Focus-Tube": announcement of "A demonstration . . . in New York on December 27, 1913 of a new form of Roentgen tube invented by Dr. Coolidge . . . of Schenectady" — Archives of the Roentgen Ray, February 1914.

- W.D. Coolidge: "X-ray Work at Schenectady" — Journal of the Röntgen Society, January, 1921, pp.23-29. An important retrospective account of the development of ductile tungsten at G.E.'s research laboratories in Schenectady and Coolidge's subsequent invention of what he described in his first paper on the subject as "A Powerful Röntgen Ray tube with a pure electron discharge" [Physical Review, II, 6, pp.409-430, December 1913]

- The Economy of Coolidge Tubes — full-page page advertisement by the British Thomson-Houston Co. (Holders of the Coolidge British Patents] published in the Journal of the Röntgen Society, October 1918.

- Perfect Control; Making Allowances; and You are Sure of the results when you use a [Coolidge tube] — three of a series of full-page advertisements for Coolidge tubes published by Watson & Sons in the British Journal of Radiology. The chosen examples appeared in the January, July and October, 1927 issues.

- For Every Critical X-ray Requirement there is a Coolidge Tube that Answers Ideally — full-page advertisement published by the London branch of the Victor X-ray Corporation in the British Journal of Radiology, December, 1927. Victor had been wholly owned General Electric of U.S.A. since 1920. The advertisement illustrates the entire range of Coolidge X-ray tubes then available, including the "Universal".

- X-ray Technique for Standard Coolidge Tubes (7" Diam. Bulb) — single sheet issued by The British Thomson-Houston Co., in about 1925 indicating exposure conditions for various parts of the body.

- Facsimile of a letter of thanks from W.D. Coolidge, July 15, 1970 accepting Honorary Membership of the Society of Radiographers – Radiography, January 1971.
- "Dr William D. Coolidge: a pioneer celebrates 100th birthday" — tribute in Radiography, December, 1973.
- Obituary: William David Coolidge 1873-1975 — British Journal of Radiology, 48, 1975.

Derisive cartoon "The Cool-Edge Tube" commissioned from the Punch artist George

The Cool-Edge Tube.

Morrow by Cuthbert Andrews for inclusion in the Andrews' anonymous 24-page jeu d'esprit A CATALOGUE OF NEXT-RAY TUBES mailed to every London radiologist on April 1, 1919. Cuthbert Andrews actively promoted a "Buy British" policy in his advertisements in radiological journals and strongly, but unsuccessfully, disputed General Electric's efforts to extend the original and heavily enforced Coolidge patent when it expired in 1929.

I have included a duplicate copy of the George Morrow cartoon and also of a couple of the advertisements as I thought you might like to give them to your father. As a retired General Practitioner he might also be amused to have the enclosed anonymous cartoon "Medical Remuneration" taken from an 1878 copy of Punch. I have just restored it for another purpose and happen to have a few spare copies left over.

The Coolidge tube that you described when you 'phoned last week is the "Universal" pattern and differs little from the original design described by the inventor in his classic paper "A Powerful Röntgen Ray tube with a pure electron discharge" first published in the December 1913 issue of the Physical Review [II, 6, pp.409-430]. The fact that the Edison-screw fitting at the cathode end on your tube is chromium-plated indicates a date of manufacture between 1925 – when this type of plating was first introduced commercially – and 1930, when production of the "Universal" finally ceased. Earlier examples have a nickel-plated screw. I have checked my own collection of Coolidge tubes from 1914 to 1930 and found one with a chromium screw still bearing the original purchase label dated "May 1927". The serial number is A 2267. Unfortunately, my tube is a BTH [British-made] version so the serial number will be from a different series to the [?]American-made example that you possess. Etched identification markings on the envelope should establish whether your tube was made in the United States or Britain.You also mentioned that the target-face of your tube shows evidence of damage in the focal area. If the tube suffered gross thermal overload during its working life, this will almost certainly be confirmed by the presence of a fine tungsten "bloom" deposited overall on the anterior hemisphere of the glass envelope and its boundary sharply defined in line with the angle of the target face. The "bloom" may only become discernible by rotating the tube through various angles while viewing in daylight; the posterior hemisphere will be entirely clear. Evidence of very severe thermal overload will be indicated by heavier, but more localised deposits of "spatter" or tungsten "mirror" on the glass. The swaged union between the tungsten anode and molybdenum supporting stem should be clearly visible by the subtle difference in colour of the two metals. Molybdenum was chosen to support the anode because of its poor heat conductivity.
In 1913, W.D.Coolidge, a research scientist at General Electric's Research Laboratories at Schenectady, introduced a totally new and revolutionary type of X ray

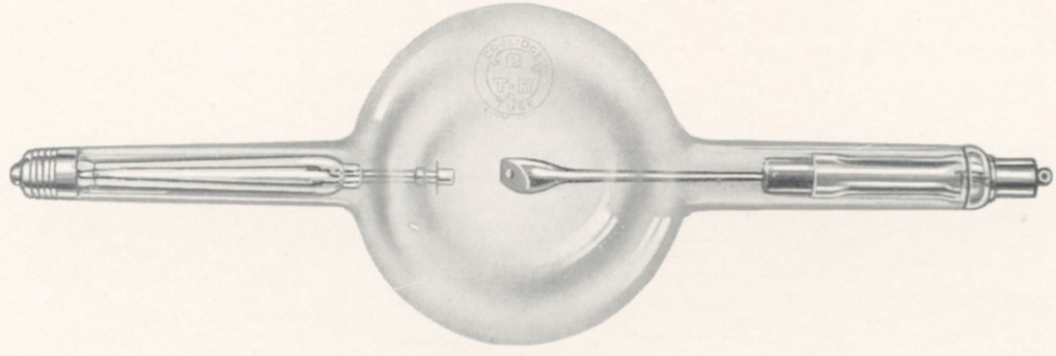


Fig. 5.12 (*see* p. 105).
Original Coolidge Tube.

tube embodying the results of his research on the development of ductile tungsten for incandescent lamp manufacture. In it, a beam of electrons (or cathode rays) was produced by thermionic emission from a heated tungsten filament coiled into a flat spiral like a watch spring and mounted within a tungsten or molybdenum focusing cup. The opposing anode (on subsequent production versions) was a solid piece of sintered and forged tungsten swaged on to the end of a slender molybdenum stem. The focal spot was circular as dictated by the coiled shape of the filament. As the tube demanded a very high degree of vacuum for successful operation, it was exhausted to approximately one ten-millionth of an atmosphere whereas the existing method of generating electrons in an "gas" or ionic tube entirely depended upon the presence of a certain level of residual gas to function. Self-rectification was completely precluded with the Coolidge tube as the anode quickly reached red to white incandescence during operation. The tube was primarily intended for operation in conjunction with closed-circuit or "Snooks" mains-energized transformer incorporating full-wave or half-wave rectification. The filament could be energized either by a mains-operated step-down transformer or a secondary battery. In either case, the filament supply had to be absolutely insulated from earth (and from the operator too!).

Considerable interest was aroused with the announcement of Coolidge's invention of the hot cathode tube in the Times newspaper on 31 December 1913 and technical accounts of the new design were soon widely reported in the British medical and technical press. Commercial examples of the tube were not available in Britain until about March 1915. The U.K. outlet and owner of the British patent was the British Thomson-Houston Company (the X-ray part of which was absorbed by equipment maker Watson & Co. in late 1927). The majority of British equipment at the time was still based on the induction coil. Initially, the 12-volt supply for the Coolidge filament had to be obtained either from a secondary (accumulator) battery standing on an insulated table or wall bracket or – in those parts of the country where an A.C. mains supply was available – from an insulated step-down transformer. Many British radiologists continued using low-cost induction coil equipment until the late 1920's as the "Snook" or closed-circuit high-voltage transformer first introduced to the U.K. from Philadelphia in 1908 by R.S. Wright of Newton & Co. had not met with the rapid acceptance that it achieved in America, Germany and certain other countries. Apart from the conservatism of the British radiologist of the time, another reason for retaining the low-cost induction coil – whether used in conjunction with a "gas" or a Coolidge tube – could have been that many parts of Britain had a D.C. mains supply requiring the additional purchase of an expensive alternator to operate equipment fitted with closed-circuit transformers. [1]

Introduction of the Coolidge tube – when used in combination with a closed circuit high-voltage generator – presented the radiologist with a completely stable and versatile source of X-rays in which adjustment of tube voltage and tube current were not interdependent. For the first time, it was possible to employ one tube for all application without the necessity to interchange between a battery of "gas" tubes of different degrees of "hardness. However, acceptance of the new type of tube was slow to be adopted in Britain for a number of reasons apart from the intervention of the Great War and the high monetary cost of re-equipping. It is also relevant that b-y

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1 An example of the conservatism of the period is illustrated by a Canadian-based radiologist's recollection of a visit to Thurstan Holland's department in Liverpool in 1910. Thurstan Holland was one of the pioneer architects of British radiology and was then using an X-ray apparatus energised by a 12-inch induction coil:

"I saw some beautiful radiographs by Mr Thurstan Holland who showed me his apparatus. He got beautiful radiographs, but had to expose quite a long time. I said I was using a four kilowatt transformer. He asked why. I said that there was no reason, except that I got the pictures more quickly. He said that he did not need to get them more quickly [!!]." — Lieut.-Colonel Robert Wilson, Canadian Army Medical Corps, reported in Journal of the Röntgen Society, October 1917, p.98.

1915, the formerly unpredictable and unreliable "gas" tube had developed into a fairly sophisticated piece of equipment with a long and dependable service life.

One significant prejudice against earlier versions of the Coolidge tube was the image quality. Many users of the first "Universal" tubes were disappointed with the poor diagnostic image definition resulting from the initially unsuspected "extra-focal" radiation emitted by the unhooded one-piece tungsten anode:

“. . . As one of the first users of Coolidge tubes, I cannot say my enthusiasm was very great when in 1914 I got my first tube of this kind. Not only were the electrical phenomena governing hardness and milliamperage rather difficult to understand at that time, but the radiographs lacked definition. The reason was not very clear, the focal spot visible on the target did not seem to be very large. Very soon after our first experiments, we tried to get a more accurate idea of the focus by means of a pinhole camera. Many such pictures were published afterwards by others in various periodicals, showing that the whole of the target, even the stem, irradiated X-rays.”
— L.G.Heilbron: "Modern Radiographic Technique" in British Journal of Radiology (Röntgen Ray Section) April, 1924, p.53.

Even as late as 1922, Schall's equipment catalogue X-ray Apparatus and their Management comments:

“Coolidge tubes cannot yet be made with a fine focus. They can be used for showing fractures of legs or arms, and foreign bodies like rifle bullets; but for producing negatives with fine detail, gas tubes with a sharp focus are infinitely better.”

A similar – if somewhat prejudiced – comment about the early Coolidge tubes is made by Cuthbert Andrews in a privately printed version of an Address to the Society of Radiographers:

“. . . Whatever people may say or think, one cannot get away from the fact that the hot-cathode tube has drawbacks which are inherent in its constitution, and that cannot be altered. For instance, its greater inefficiency, electrically speaking, its lack of focus, and its production of scattered or secondary radiation. . . .” — Cat and Kittens Radiography, 1926, p.16.

For a number of years, the main application for the Coolidge tube was X-ray therapy where the significantly greater output and higher stability justified the cost of either modifying existing generating equipment or designing new high-voltage generators incorporating a filament-heating system. The poor image definition must have deterred diagnostic users in other countries too. Strangely, the Coolidge "Universal" tube retained a helical filament and round focal spot throughout its lifetime whereas all later hot filament tubes adopted the Goetze line focus principle.

The German Lilienfeld hot-cathode tube of the same period (1913) as the Coolidge never came to Britain because it was too expensive and too complicated and also because it's importation could have resulted in patent litigation.

Declaration of war meant that almost the entire supply of X-ray tubes was diverted to military applications and led to serious shortages for civilian use [2]. The non-availability of suitable glass for tube envelopes presented an immediate problem to British tube makers and obliged the Secretary of State for War to establish various technical committees to sponsor experimental work developing formulae for the special glasses used for X ray tubes, miners' safety lamps, chemical apparatus, thermometers and various other specialist products – all of which had formerly been imported [3]. The general shortage of tubes was especially worsened by the non-availability of tubes from German makers who, pre-war, had been a major and strongly favoured source of supply [4].

The war certainly made Britain realise the folly of allowing foreign countries to hold a virtual monopoly of many commodities essential to the survival of the country. For example, the manufacture of chemical and laboratory glassware was virtually non-existent in Britain before 1914 making it necessary to create a whole new industry.

When the war ended, the only British companies still making ["gas"] X-ray tubes were A.C.Cossor, Newton & Wright, A.E.Dean, G.C.Aimer and Cuthbert Andrews.

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2 Editorial [by W. Deane Butcher] in the October 1914 of the Archives of The Roentgen Ray (XIX, 159-160:

THE SHORTAGE IN X-RAY TUBES. One of the minor complications of this terrible war is a threatened shortage of X-ray tubes. For many years past we have insisted, in season and out of season, on the desirability of being entirely independent of the Continent for our supply of X-ray material, and representations have been made to Parliament and the Government, but without success. At the present moment the case stands thus:– There are, in England some three or four manufacturers of X-ray tubes but these depend almost entirely on Germany for the supply of the soda glass required for their construction, and the same may be said of the American focus-tube makers, from whom it was hoped we might obtain an additional supply. At the present moment we must get our X-ray tubes where we can, and we need not enquire too closely as to the exact nationality of those who may be able to manufacture an X-ray bulb in England.

3 With the exception of a very few outstanding companies, the British glass industry was then in a particularly parlous, depressed and disorganised condition. The methods of manufacture were mystical, secret, traditional and empirical. Scientists were seldom employed, silicate chemistry was not understood, and rule of thumb prevailed. The composition of glass was a precious secret handed down from father to son. Foreign manufacturers enjoyed cheaper raw material, cheaper labour, Government subsidies and tariff protection:
The unfortunate condition of the glass trade was attributed by men of science to ignorance and want of initiative on the part of the manufacturer, but by the manufacturer it was attributed to free trade, unfair trading conditions, and to the gulf dividing industrial from academic chemistry... French and German soda glass could be purchased at 3¾ pence per pound [£0.0035 per kilo.] [before 1914] . . .
In justice to the English manufacturers it must be remembered that the German and Austrian furnaces and pots were and are adapted for melting a leadless glass, whereas the English furnaces and pots were adapted for melting a glass containing lead . . . — H.J.Powell Glassmaking in England (1923) chapter XV: "Glassmaking during the War, 1914-18".
“. . . There was a desire amongst manufacturers everywhere for closer association with one another and for contact with science and men of science, by which means alone the deadening influences of generations past could be overcome . . .” — Opening address by at the inaugural meeting of the Society of Glass Technology, November 9, 1916.

4 The shortage of tubes appears to have persisted throughout the War and orders placed with suppliers for tube for civilian use were subject to the Glass Control (Consolidated) Order 1917 and had to be approved and certified by the Ministry of Munitions of War, optical and glassware supply, 22-23 Hertford-street, London. W1.

The Americans were represented by Machlett (who had first come into the country during the war), G.E.Coolidge (by then, manufactured under licence by B.T.H.) and Macalister-Wiggin (first distributed and subsequently manufactured under licence by Newton & Wright).

Cuthbert Andrews had experimented making a hot cathode tube as early as 1914 (in conjunction with the physicist C.L.Lindemann) but realised that it was too crude to be successful. When he reconsidered the idea after the war ended, he was faced with two obstacles –

“. . . first, the virtual impossibility of obtaining certain essential materials; and second, the existence of a patent, which, we were advised on high legal authority, was unassailable. We were, therefore, reduced to the necessity of looking forward to the expiration of the patent in 1927, meanwhile carrying on experimental work with the object of discovering an alternative basic principle – an apparently hopeless task. Then came the 'war extension' of patent validity, which added a further two years' life to the patent in question, bringing the date of expiration to [June] 1929 . . .”

Andrews and his British-based competitors therefore had no alternative but to continue the profitable but slowly declining business of producing "gas" tubes. In May 1921, Andrews introduced the LEVIATHAN, a completely new design of heavy anode gas tube in 7-inch and 8-inch versions which he claimed was the "best X-ray tube which has ever been constructed in this or any other country". The LEVIATHAN was very successful and continued in production until about 1929-30. The fact that Andrews made or repaired a combined total of nearly 1500 (mainly 8-inch/200 mm.) gas tubes during 1922 gives some indication of the continuing demand. The "Buy British" policy actively promoted by Andrews in his advertisements combined with his persuasive personality and close personal contact with the radiological world during the following three decades also greatly assisted the success of his products.

The Cambridge D.M.R.E. examination for radiologists still included questions about gas tube operation as late as 1925 and, in May, 1927, the Society of Radiographers debated a motion that

“. . . the hot cathode tube is not always conducive to the best radiographic results; and that to allow the gas tube to be entirely superseded by the hot cathode tube would be definitely injurious to the interests of radiography.”

The debate is reported in full in ten closely printed pages of the Society's JOURNAL. Although several speakers at the debate condemned the "gas" tube as an antique instrument, the report concludes – "There seems to be a general feeling that results with gas tubes were better." A vote taken at the end of the debate resulted in a majority in favour of the motion supporting the gas tube.

Those people who had condemned the gas tube at the debate were afterwards criticised by Stanley Melville – one of the leading pioneers of British radiology – in a letter to the British Journal of Radiology ending:

“. . . In chest work particularly, I am certain that the gas tube has not its equal, and it is an interesting fact that, in this, I am supported by no less authorities than the American writers, Wesseler and Jaches, in their standard work on Chest Radiography. The work of the Radiologist is diagnosis, rather than the making of pretty pictures.”

The debate also seems to have been the inspiration for a half-page Newton & Wright advertisement in the April 1927 issue of B.J.R. endorsing its famous HERCULES gas tube with the statement:

“The controversy as to the merits of 'Gas' or 'Hot Cathode" Tubes has not yet been settled, the truth being that both have their advantages and both have their drawbacks.”

In a January 1928 review of the annual Exhibition of X-ray and electro-medical apparatus held in the Central Hall, Westminster – at which G.C.Aimer and Cuthbert Andrews showed various models of "gas" tubes – the writer comments that their presence would "serve to reassure those workers who have been inclined to lament prematurely [their] demise." [British Journal of Radiology, N.S., 1, No.1 January 1928, p.16]. In October of the same year, Karl Schall's son, William, following a visit to the International Congress at Stockholm, commented about the situation then current in Britain:

“. . . the general interest in radiological matters and the design of apparatus has been severely hampered by the Coolidge patents. These established a virtual monopoly which kept the coil and gas tube alive beyond their natural span, and prevented that development of hot cathode tube design which has so obviously resulted from the conditions of healthy competition in Germany.” — W.E. Schall: "Some Impressions of the International Congress at Stockholm” British Journal of Radiology, N.S., 1, No.10, (October, 1928), p.369.

In July 1929, B.T.H. applied for a further extension to the Coolidge patent but on the basis of vigorous opposition from Newton & Co., A.E.Dean and Cuthbert Andrews – backed by moral and material support from large numbers of radiological workers – the Chancery Court agreed an extension of only one more year (Electrical Review, 2 August, 1929, p.201). Thereafter, the field would be re opened to other tube-making participants.

Meanwhile, five years earlier, in 1924, Andrews had became aware of the work done by Dr. Bouwers of Philips Lamp Works developing a hot cathode self-protected or radiation-shielded "low vacuum" tube – the METALIX – and this turned his attention to the development of a similar tube radically different from the original Coolidge type and thus a way of overcoming the patent problem. The first Philips METALIX tube was installed in St. Bartholomew's Hospital in mid-1924 and thereafter extensively advertised in the radiological press and by 1926 was included in the catalogues of most of the equipment suppliers especially after the range was extended to include the Goetze line-focus. Siemens (S.R.W.) introduced its equivalent self-protected MULTIX tube to London in July 1930 although it had been available in Germany since 1926. By 1927 Andrews' own hot-cathode, self-protected PROTEXRAY tube had begun to take practical form and in May, 1929 he was able to show a completed example at the British Institute of Radiology. By June, 1930 it was in regular production and fully protected by patents. The designer was Andrews cousin, J.D.Frye.

So far as Britain was concerned, successive improvements to the Coolidge tube, together with introduction of the Philips METALIX, Siemens MULTIX and Andrews PROTEXRAY tubes during the second half of the 1920's finally signalled the beginnings of the end of the gas tube and induction coil era and by 1930 only the smaller hospitals and private practitioners were still so equipped. At about the same time, X-ray equipment began to improve in other ways and especial attention was paid to radiation-shielding so that X-rays did not escape in unwanted directions. The introduction of shielded all-enveloping tub shields by various tube makers towards the end of the decade played a crucial part in ensuring greater safety for both patient and operator. In about 1929-30, A.C. Cossor, Newton & Wright and A.G. Aimer finally withdrew from "gas" tube production. A.E. Dean had ceased making tubes in about 1927. None of them – apart from Cossor – possessed the technical resources to undertake the development of a hot-cathode tube. From then on, Andrews was the sole remaining X ray tube maker in the British Empire and when he sold the manufacturing part of his business to General Radiological in 1946 could boast of having produced a combined total of more than 30,000 ionic and hot-cathode tubes of 75 different ratings during his long X-ray career, commencing in 1910 in a small basement workshop at 35 Hatton Garden as Manager of the London branch of the Hamburg tube maker, C.H.F. Müller.

These hurried notes have quite a few loose ends, but I think I've correctly indicated what happened with the X-ray tubes in the U.K. between the invention of the Coolidge "Universal" tube in 1913 and its demise in about 1930 and why the "gas" version persisted for so long. In retrospect, the reluctance to adopt the hot-cathode tube sooner seems quite extraordinary.

Incidentally, the highly revered William David Coolidge – who came from a poor and almost "hillbilly" background – continued his brilliant career and went on to become Director of Research at General Electric, Schenectady and author of many other epoch-making technical discoveries and inventions. He was elected an Honorary Member of the Röntgen Society in 1918 and of the Society of Radiographers in 1970. He died at the age of 101 in February 1975. After Röntgen, his achievements – with those of John Wesley Coltman (builder of the first successful image intensifier tube) and Godfrey Hounsfield – are indisputably the greatest in the technical history of X-ray.

Apologies for rambling on longer that I intended: at least, I can now spell Schenectady without recourse to my notes.

Yours sincerely
D.R. Guttery.

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“History does not repeat itself, but historians repeat each other.”

George C Herring