The Invisible Light

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Contents.

Editorial.

It's been a busy time in the world of radiology history since the last appearance of this publication. We are now in 2023, and are celebrating the centenary of Wilhelm Conrad Röntgen's death in 1923. The image on the front page is a cigarette card showing Röntgen at the time of the discovery in 1895. The world continuously changes. We had the Röntgen Centenary Congress and celebrations back in 1995, and the radiological world has changed dramatically since that time. We now are on the verge of another revolution with the introduction of Artificial Intelligence (AI). Who now knows what the future holds? And yet when Röntgen discovered X-rays in 1895 who would have correctly predicted that future? And when Röntgen died in 1923 the future was again uncertain. The future is always uncertain.

What I always find difficult is finding out about new books and articles. The main method would seem to be serendipity – essentially just coming across something of interest. And so the paper by Hsabo, Aneke, Tuck, and Middela on 'Scrotal kidney' as a BJR Case Report with its historical review was a great find. So, and again, please send me anything that you come across.

I like the article by Edwin Aird giving a history of low energy X-rays as used in radiology and radiotherapy, and including his personal history of this subject. Edwin's personal history is particularly valuable. Please send me your articles for the next edition.

So I hope to see you all in Liverpool for UKIO, and in Cardiff/Caerdydd for BSHM. We really must present radiology history papers at meetings to keep a high profile for our subject.

Adrian Thomas.
adrian.thomas@btinternet.com

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BSHR Spring update.

Our Chairperson Michael Jackson gives an update on some forthcoming events activities of interest:

John Clifton Essay Prize.
The BSHR has recently launched the John Clifton Essay Prize, a new initiative to promote research and insight into the history of radiological sciences (including medical imaging, radiotherapy & nuclear medicine). A £250 first prize is up for grabs, and we are keen to receive entries from trainees and undergraduates, so please spread the word. Closing date is 8th September, more information can be found at:
http://www.bshr.org.uk/

UKIO 2023, Liverpool.
Adrian Thomas and Arpan Banerjee will both be presenting papers at UKIO in June: Tuesday, June 6, 2023 (11:10 am to 11:40 am), don't miss these presentations if you are at the meeting, and also be sure to pay the BSHR stand a visit.

The British Society for the History of Medicine.
The British Society for the History of Medicine will be hosting their 2023 Congress in Cardiff in September:
https://bshm.org.uk/congress-2023/
The themes of the congress are:
- Medicine in War and Conflict
- Literature and Visual Art as Historical Resources
- Medicine in the Age of European Colonialism

Which offers plenty of scope for papers which also have a radiological flavour as well – abstracts are currently being accepted - deadline for submissions is 31 May 2023. It would be fabulous to have BSHR members in attendance and presenting work.

The International Society for the History of Radiology.
A little further afield, the International Society for the History of Radiology will be hosting their 12th Symposium at Remscheid-Lennep, Germany, from Friday 27 to Sunday 29 October 2023. More information can be found at:
12th Symposium of the International Society for the History of Radiology | ISHRAD

BSHR online lecture.
Finally, remember to keep November 8th in your diary for the BSHR online lecture, celebrating World Radiography Day and International Day of Radiology – further details to follow.

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Recent Books and Articles:

Paul Langevin, my father: The man and his work [Print Replica] Kindle Edition.
ASIN : B0BPQVS8VD
Publisher : EDP Sciences; 1st edition (8 Sept. 2022)
Language : English
File size : 11033 KB

This book is by André Langevin, and is translated by Francis Duck.

The 150th anniversary of Paul Langevin's birth was in 2022 has brought Francis Duck back to his roots in ultrasonics Somewhat curiously I found the kindle version available at both £69.27 and £20.99 so do be careful. There is a paperback available at £43.33.

André Langevin (1901-1977) was the second son of Paul Langevin (1872-1946) and his wife Jeanne Desfosses (1874-1970). Langevin was a student of physics at the École Supérieure de Physique et Chimie Industrielle where he became head of works in applied electricity in 1938. He was married to Luce Dubus (1899-2002), a physicist, a teacher at Fénelon High School in Paris and a communist activist, who assisted in writing this biography. He published on piezoelectricity and petrography, completing his doctorate in 1942. During the post-war period Langevin was active in the National Union of Scientific Researchers and the National Education Federation. This biography of his father was written by André Langevin after his retirement in 1965. The life of Paul Langevin is fascinating and his work was a major contribution to our modern discipline of ultrasound. The book is warmly recommended.

The blurb states:

> PAUL LANGEVIN (1872-1946) was a renowned French physicist, humanist, and educationalist. This biography by his son André, originally published in French in 1972 and here translated into English for the first time, is enhanced by numerous quotations from his friends, scientific and political colleagues, family and by Paul Langevin himself. Close to the Curies, Einstein, and Rutherford, this is a vivid account of a life lived at the core of physics turned upside down by the discovery of radioactivity and X-rays, by the theory of quanta, by relativity and by wave mechanics. Langevin himself was the originator of ultrasonics, a profound theorist of magnetism and of statistical mechanics and an evangelist for relativity. His utter commitment to rational science was equally applied to social justice. His life was deeply affected by both world wars and the political turmoil between them, during which he publicly opposed fascism and supported communist principles. In this personal, intimate account of his life, we find a generous, courageous, loving, brilliant human being. There is much in his understanding of humanity and the resolution of conflicts that remains relevant today.

How We Got Here: The Legacy of Anti-Black Discrimination in Radiology.

Julia E. Goldberg, Vinay Prabhu, Paul N. Smereka, Nicole M. Hindman
RadioGraphics 2023; 43(2):e220112 https://doi.org/10.1148/rg.220112

This is a review article in RadioGraphics. It notes that anti-black discrimination has existed in the United States of America within the field of radiology and associated professional organizations since their inception. The authors believe that it is critical to understand this history and the resultant structural racism to address the current race-based disparities within the practice of radiology for patients and radiologists alike. From slavery to "Jim Crow" laws, legalized racism in the United States complemented the scarcity of medical ethical guidelines during the 19th and 20th centuries.

Radium City, A History of America's First Nuclear Industry,
by Joel O. Lubenau and Edward R. Landa - change in URL link.

In the Spring 2020 Western Pennsylvania History “the Senator John Heinz History Center” announced it would publish online the book, "Radium City, A History of America’s First Nuclear Industry” by Joel O. Lubenau & Edward R. Landa. The book is well worth downloading, and the story is remarkable.

The book remains available online but the URL link has changed to https://www.heinzhistorycenter.org/wp-content/uploads/2022/08/Radium-City.pdf .
A notice about the new URL was published in the Fall 2022 Western Pennsylvania History.

Happily, the cost of downloading the book in a pdf format remains the same – it is free!

More than a hundred years ago, a Pittsburgh, Pennsylvania based enterprise, Standard Chemical Company, became the first American company to produce radium. In fact, it produced more radium than any other company in the world. In 1921, Marie Curie, co-discoverer of the element, received a gift of one gram of radium from the Women of America costing $100,000. It was made by the company and, after it was presented to her by President Harding at the White House, she travelled to western Pennsylvania to visit the company’s plants. The company was founded by two brothers, James J. and Joseph M. Flannery, undertakers-turned-industrialists.

Radium City, A History of America’s First Nuclear Industry, by Joel O. Lubenau and Edward R. Landa, is the story of how the Flannery brothers utilized science, technology, engineering, and medicine in an innovative enterprise to produce and promote radium for medical and commercial purposes. It is an account of the first use of radioactive material in medicine, the role of scientific and medical research to promote its utilization, the effects of radiation on worker health and the environment, and the government’s role in these matters. It is about a time when Pittsburgh was — briefly — nicknamed, “Radium City.”

Scrotal kidney: a gross case of “nephroptosis”
Hsabo EA, Aneke IA, Tuck J, and Middela S. Scrotal kidney: a gross case of “nephroptosis”. BJR Case Rep 2023; 9: 20220054.
Published Online: 8 Mar 2023 https://doi.org/10.1259/bjrcr.20220054

This is a most Interesting historical review of nephroptosis with references. They radiologically illustrate a case of nephroptosis (floating kidney) in an 82-year-old male whose right kidney had progressively descended into the right hemi-scrotum. They detected this condition upon a recent visit to the accident and emergency department where a computed tomography demonstrated the right kidney within the scrotum with a degree of hydronephrosis yet a stable renal function. The patient was managed conservatively as per the multidisciplinary team meeting advice.

The authors comment that nephroptosis, which is also known as ‘wandering’ or ‘floating’ kidney, is a condition where the kidney descends by more than 5 cm (or the length of two vertebral bodies) when moving from the supine to the upright position. They say that while the true incidence of this condition is still unknown, intravenous urogram or IVU studies showed a slight female preponderance as compared to males. Furthermore, it has been postulated that the lack of adequate perinephric support might be a key factor contributing to this excessive range of kidney mobility.

What I particularly like about this paper is that a modern publication is accompanied by a historical review. So many modern articles ignore any history or prior art and present the topic as somehow isolated in the present moment and devoid of any context.

Claims of priority – The scientific path to the discovery of X-rays☆ Uwe Busch
Zeitschrift für Medizinische Physik [Claims of priority – The scientific path to the discovery of X-rays - ScienceDirect]
Available online 19 April 2023
https://doi.org/10.1016/j.zemedi.2022.12.002

This is an excellent review by our friend Uwe Busch who is Director of the German Roentgen Museum. As he explains, shortly after Röntgen's publication about a new kind of rays, a dispute about the priority claims began. Röntgen was not the first researcher to produce X-rays nor was the first to take X-ray images. An analysis of the history of cathode ray research in the 19th century reveals ample evidence that researchers before Röntgen had already produced X-rays, albeit without knowing this. Most of them, for their part, did not claim any priority, some did so rather casually. The German-Hungarian physicist Philipp Lenard, a co-founder of German Physics, considered himself a 'true discoverer'. It remains to be said, however, that he, like many others before him, failed to recognize the character of the new radiation. It was Wilhelm Conrad Röntgen, with his three scientific publications on X-rays, who laid the foundations for their physical clarification and paved the way for the success story of their application in a variety of fields that continues to this day. We should thank Uwe for making such a clear presentation of a complex and confusion subject.

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The Udo Radtke Tube Collection, Germany.

Udo Radtke has been collecting all kinds of electronic tubes for 45 years. The museum can be found at:
www.tubecollection.de/ura/museumfotos.htm

Presently Udo Radtke is collecting the ion-type X-ray tubes. What he has is:
www.tubecollection.de/ura/roentgen-ionenroehren.htm

Udo Radtke notes that for many tubes, the manufacturer is not recognisable. Only comparisons with well-known tubes in collections, museums and the literature will be of help here. Probably the most important work on ion tubes is the classic:

'The Development of the Ion-X-Ray Tube' by Paul Ronne and Arnold B.W.Nielson.

In his collection there are many different ion X-ray tubes whose manufacturers are known, but also those whose origins are unknown. It may be possible to display them on the basis of existing catalogues, photographs, and various links.

In this respect, Udo Radtke limits himself for the time being, only to the publication of the photographs and information on the sizes in terms of the diameter and total length. As soon as he has further information on individual tubes, and will add them accordingly.

Gundelach Gehlberg.
For 2 years Udo Radtke has been working in the Glasmuseum Gehlberg, which is in the original building of Emil Gundelach. He digitalized everything that was there, and prepared many things for display. They are beautifully illustrated.

www.tubecollection.de/ura/gundelach.htm

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Majesty by Ernesto Romano.
https://ernestoromano.com

Ernesto Romano's new work follows on from the sad passing of Her Majesty Queen Elizabeth II, and explores symbols that are deeply rooted in British history, for example the Crown Jewels.

Ernesto Romano wrote that: 'The sad passing of HM The Queen left a void in my inspiration as she has been my muse for so many years. It was a loss that we all were prepared to feel at some point but nevertheless when it happened it was a shock.

I decided to explore an incredible symbol which is the Coronation Crown and to symbolise the void that The Queen left, this time the crown has no skull X-Ray associated but it is just the crown, a symbol and all that comes with it.

I use my imaginary X-ray machine to explore the beauty and complexity of St. Edwards crown, which is the crown used at the moment of the coronation, and which will be used in May 2023 for the coronation of Charles III.'

St Edward's Crown is the crown that is used at the moment of coronation. It was made for Charles II in 1661, and was a replacement for the medieval crown which had been melted down in 1649 at the time of the Commonwealth. The original was thought to date back to the eleventh-century royal saint, Edward the Confessor , who was the last Anglo-Saxon king of England.

The crown was commissioned from the Royal Goldsmith, Robert Vyner, in 1661. Although it is not an exact replica of the medieval design, it follows the original in having four crossespattée and four fleurs-de-lis, and two arches. It is made up of a solid gold frame set with rubies, amethysts, sapphires, garnet, topazes and tourmalines. The crown has a velvet cap with an ermine band.

Majesty, a unique commissioned piece for the Bankside Hotel, 2023.
Digital print on brushed gold aluminium (140 x 115 cm)

The Bankside Hotel commissioned Ernesto Romano to make this large piece beautifully finished on gold aluminium, in collaboration with Degree Art.
This work dedicated to the Coronation Crown and follows on the sad passing of Her Majesty Queen Elizabeth II and explores symbols deeply rooted in British history like the Crown Jewels.

The artist uses his imaginary X-Ray machine to explore the beauty and complexity of St Edward's crown, which is the crown used at the moment of the coronation, and which will be used in May 2023 for the coronation of Charles III. The work is an homage to the legacy of HM The Queen and her cultural influence during her 70 years of reign and a celebration of continuity with King Charles III.

Commissioned to mark the coronation of King Charles III, this original piece is accompanied by a limited edition set of 25 miniature versions gifted, at random. to guests to celebrate the momentous year.

“My work with X-rays is free from any social connotation,
any prejudice or stereotype and often free from gender and ambiguous
and eventually the most judgemental free angle from which a person can be looked at.”
Ernesto Romano

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A history of low energy X-rays used in radiology and radiotherapy; including a personal history of this subject.

By: Edwin Aird PhD, FIPEM, MRCR (Hon.).

The early history of radiotherapy

It is possible by looking through the early issues of British Journal of Radiology (BJR) for the years 1910-1935 to find articles, many from clinicians and surgeons, that describe their use of radium and X-rays to treat various disease; and Richard Mould (1980) has written extensively about the use of radium from 1985 to 1937.

All medical Radium 226 sources (needles and tubes) were removed from hospitals in the UK by 1995.

There are several papers in both BJR and the Achieves of the Roentgen Ray (1897-1915) that describe some to the uses of radium and x-rays 1900-1920. Most of these are from a surgeon's perspective, so give little in terms of the equipment used and their characteristics.

For example: the use of 200kV X-rays in lung is described in 1928 (R. Paterson BJR 1928;1:90); and in the breast in 1931 (J.E.A. Lynham BJR 1931;4:534). But there is no definite foundation for radiotherapy given; particularly because there was no system for measuring the "dose" given. There were the beginnings of the use of the Roentgen as a unit of exposure (formally in 1928); but many clinicians were using "skin erythema" as a means of deciding when to stop treatment. There is an interesting paper from the Middlesex Hospital in 1935 (HT Flint and CW Wilson BJR 8:426) describing the use of the Radium bomb, which contained 2gram radium. They measured dose rates of 18.3R/min at 3cm (as well as and other distances); and stated: "It appears that at a radium to skin distance of 3cm a skin erythema appears after 6 hours (6600R), and that skin peeling occurs after 7 hours(7700R)". Interestingly, they also quote Ralston Paterson and H.M. Parker (BJR 34;7:592 and authors of the Manchester Radium Dosage System) as having found only 3000R for erythema and 4000R for skin peeling.

This demonstrates how uncertain skin erythema was as a measure of dose.

The links with radiobiology in those early days are interesting: Dr Neville S Finzi (MacKenzie Davidson Memorial Lecture 1933 BJR 7:9-20) and at a meeting of the Section of Radiology of the Royal Society of Medicine states: " ….in his practice the main principle in treating any form of malignant disease had been to give sufficiently large dose to every malignant cell. It was now agreed by the majority of radiologists that the alliance of the recuperative powers of the body, with the depressing effect of the rays on malignant cells , should be the aim in view. That part of the body outside the treated areas should receive as small a dose as possible" This principle has not changed to the present day. The major mechanism by which ionising radiation causes permanent damage to living tissue is the inhibition of the ability of cells to divide and their consequent death when division is attempted. With increasing radiation dose, a progressively higher proportion of both tumour and normal tissue is deprived of reproductive capacity.

Fractionation schemes to give tumoricidal doses, but allowing preservation of normal tissue, particularly critical organs was an extremely important part of the development of radiotherapy. To increase local control while using dose and careful planning which produces an acceptably low incidence of normal tissue complications has become the main aim of modern radiotherapy. Various formulae have been developed to compare fractionation schedules ; but the work of Jack Fowler and the use of the linear quadratic formulae are now widely accepted as the most useful method (particularly the Biological Effective Dose, the BED).

This is the first of possibly several articles, to describe the history of x-rays and gamma rays in radiotherapy.

This one will deal with the low energy X-rays, that in the first half of the 20th century was all that were available. Cobalt 60 machines (with an average photon energy on 1.25MeV came to UK in 1950s. Linear accelerators (4-20MV) came into radiotherapy in the UK in 1954 onwards.

History (1950-1970s) of low/medium energy x-rays in radiotherapy.

Low (SXT)/medium (DXT) energy X-rays and their production.

In this article I want to describe SXT and DXT only and their radiotherapeutic use. It is possible to summarise in a table (Table 1) the properties of the equipment used in the range of X-ray peak voltages for 10-400kV. I shall refer to these as: Grenz rays (10kV); Superficial rays (50-140kV; and Deep Therapy X-rays (150-400kV).

Table 1.

Name	Energy	HVL	% depth dose
Grenz	10kV	<0.03mmAl	100% at surface
SXT	50-140kV	0.5-5mmAl	80%-95% at 5mm
DXT	150-400kV	7mmAl - 4mmCu	50% at 60-80mm
Contact/Papillon	50kV	0.6-1.3mmAl	100% at surface

Grenz rays have been used for benign conditions of the skin (see Stewart and Jones BJR 1964; 37:79, using the “Dermopan” at Mount Vernon Hospital).

SXT . Many of these sets in 1950s and 1960s were provided with a range of “energies”, from very light filtration (HVL 1mm Al) to high filtration (140kV HVL 5mmAl). But, in my experience radiotherapists at this time (1970-1980) would use only a standard energy that gave a typical HVL of 2mmAl.

Short distance (“Contact”; very high dose rate, 1940s/1950s. See figure 1) low energy X-ray sets have been used based on similar designs. More recently a new form of brachytherapy (originally using radioactive sources of radium) has been developed, known as electronic brachytherapy (D Eaton 2015:88) using a very small X-ray tube, almost in contact with the tissues to be treated . Also the “Papillon” unit using an end-window similar to the contact set has now been used routinely in the last 20 years (Fig 2), but was first used by Papillon in 1974 (Endocavitary irradiation in the curative treatment of early rectal cancer, Diseases Colon Rectum 17: 172).

By the 1950s X-ray tubes were sealed and well established producers of X-rays in two energy ranges for radiotherapy: 50-140kV and DXT 200-300kV.

Fig 1: An old "contact" X-ray set (3-10kV) . Distance to outer surface from x-ray target 18mm.

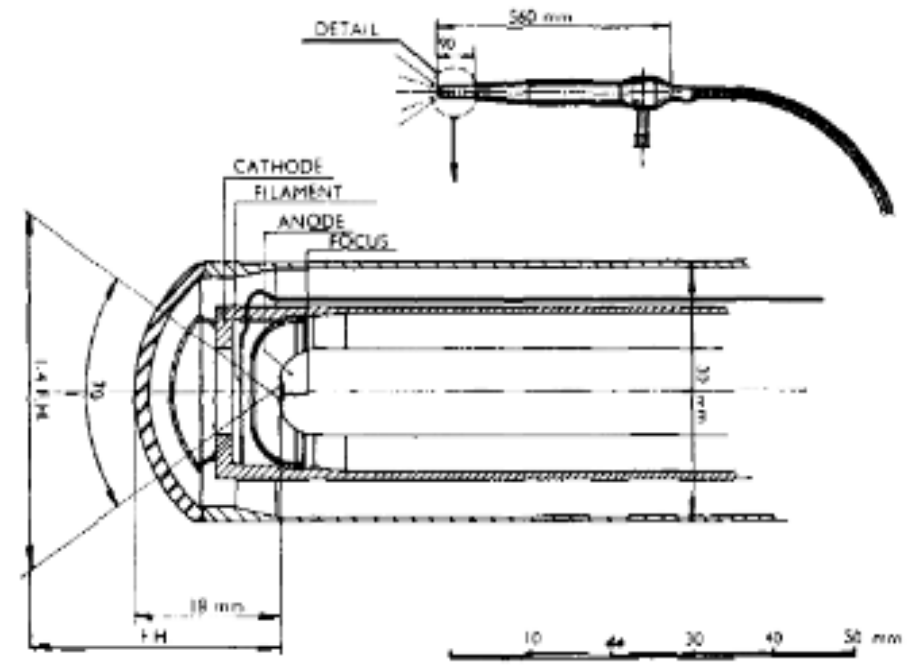

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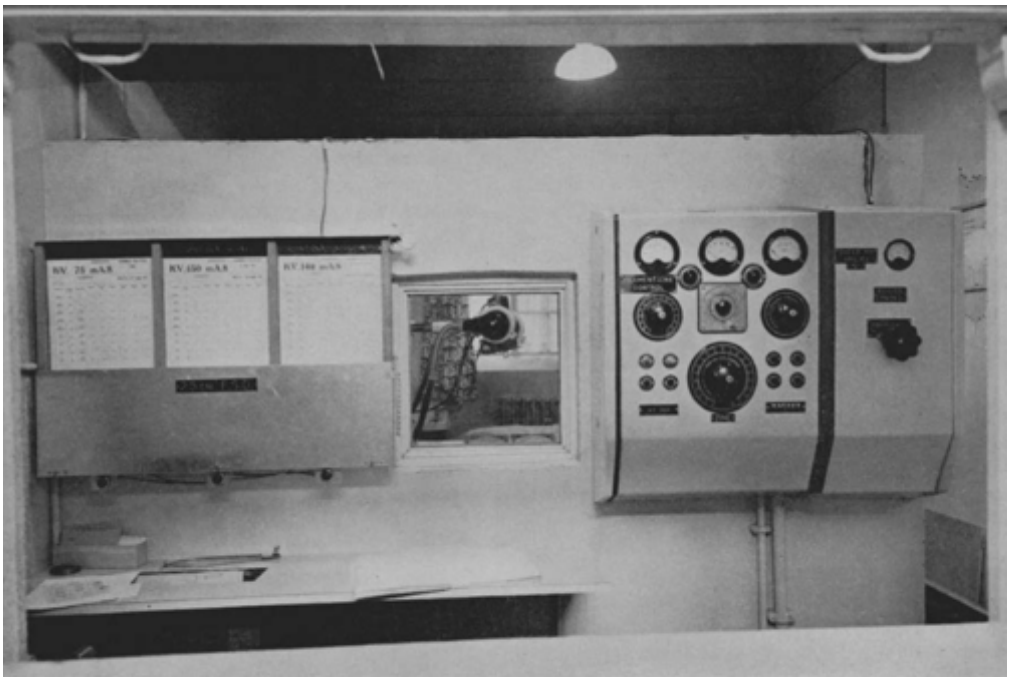
Fig 2: The modern Papillon low energy X-ray machine.

SXT (see figure 3).

Fig 3: SXT control unit . View through lead glass window to SXT head and cables.



The equipment I became familiar with in 1967 was the Philips KX10 unit. (See also the Watson ST 150 at that time PG Orchard BJR 1963; 36:535) It could produce X-rays in the range 50-140kV at currents from 5-10mA. The target (tungsten) angle was much shallower than that used in radiology since there was no need for “sharpness”. Cooling was achieved using forced oil.

Perspex applicators were used to define the field size and distance from focal spot to skin. Looking through the literature (primarily the BJR) I have found a few historic articles describing equipment.

Lillicrap and Wilson (1974) describe a new SXT set to be used at the RMH in 1974. : a modified Pantak 150 with a Thermax SLT/T tube (150kV 9mA; target angle 45 deg; 4mm focal spot size ; forced oil cooling. Alternative energies from 50kV 19mA could be used , giving a range of HVL; 0.7mmAl to 0.25mmCu.

A comparison with X-ray tubes used in Radiology.

These tubes were very different in design, but with similar high potential difference: 70-140kV and 1-100mA. Target (tungsten, except for mammography) angles were typically 19-20 degrees-to give a small focal spot of 1-2mm; and the target structure needed to rotate to prevent any part of target overheating.

Standard exposure settings are chosen depending on the site to be imaged, the mA and time will be varied to give the correct exposure: for example: simple abdomen 64-70kVp 50-60 mAs. Modern systems will use automatic settings of exposure based on the radiation received at the imaging plate. Focal spot to patient skin varied with type of examination: typically 70-120cm. Undercouch tubes would have a fixed source to couch surface distance.

The heel effect: the sharp target angle results in a non-uniform intensity across the X-ray beam, not found with the shallower target angle used in therapy tubes.

Older tubes would be 50-120kV and maximum mA of 100. A timer would determine the exposure for fractions of seconds to several seconds. For fluoroscopy a typical current would be 1-2mA.

Fig. 4: An X-ray set and image plate mounted at right angles to the main radiotherapy beam on a Varian True Beam Linear Accelerator.

It is interesting to note that modern high power X-ray tubes have found a vital place in radiotherapy in the form of equipment used for CBCT, where fan beams of diagnostic quality are rotated around the patient to give a very fast 3D scan prior to radiotherapy; a role used in “Adaptive Radiotherapy”. [See fig. 4.]

The use of SXT for Radiotherapy.

An early paper: Dr GJ van der Plaats…"X-ray Caustic Method " June 1939; BJR 12:353. Using a 50kV set with an HVL of 0.3 mmAl at a very short distance he was able to get 8000R/min (see discussion of unit below); which gave 3000R at 5mm depth in tissue in 56sec. "The single-treatment caustic X-ray dose means a vital blow to the affected region……. (but with)…….enormous local inflammation" [Note: at that time there was no consensus on the use of fractionation of dose]. No mention in this paper of atrophy, telangiectasis. But another paper (Z.A. Leitneer from Berlin in 1938 11: 586) refers to "ulceration at doses greater than 5000R.

The main use of SXT was and is now still in use: (see recent survey : D. Eaton in Phys and Eng Sci in Med 2021;44:341 showing, in a 2015 survey, that 73% of UK centres are still using SXT for skin cancers: basal (BCC) or squamous cell (SCC)). Although this equipment was provided with a choice of filters most clinicians used only one HVL. In radiobiology terms the BED (P Prior, Front. Oncol. 11 May17th 2021) required for BCC and SCC is 60-70Gy: this corresponds to typical treatment schedules: 2Gyx25fr; 4Gy x 15fr; 3Gy x 30fr (see also Royal College of Radiologist's (RCR) recommendations below). Applicators were used to fix the distance between the focal spot and the skin. Lead masks-typically only 0.5mm lead was needed-would provide very good shaping of the X-ray beam to the shape of skin to be treated.

DXT (fig. 5a and 5b).

The equipment I was familiar with in 1960s to the 1970s was the Marconi: 250kV 15mA. This continuous current produced an enormous amount of heat in the target, so continuous oil cooling was necessary (oil, not water since the oil came into contact with the high voltage in the target). The target angle was 45 degrees; focus to skin distance 50cm (using rectangular and circular Perspex applicators). Filtration could be varied; but on the equipment in Newcastle, Frank Farmer had increased the filtration to give a half-value layer of 3.5mmCu. This gave more penetration of the x-rays into the body: an HVL in tissue of about 70mm was achieved at this energy/filtration); but meant that the dose rate was not very high: only 32cGy/min (see a more recent DXT machine specification: Xtrahl 300kV , 10mA, HVL 3mm. Cu, 84cGy/min.

Fig 5 a): A typical DXT tube showing the heavy copper enclosure of the tungsten target at 45 degrees to the electron beam.

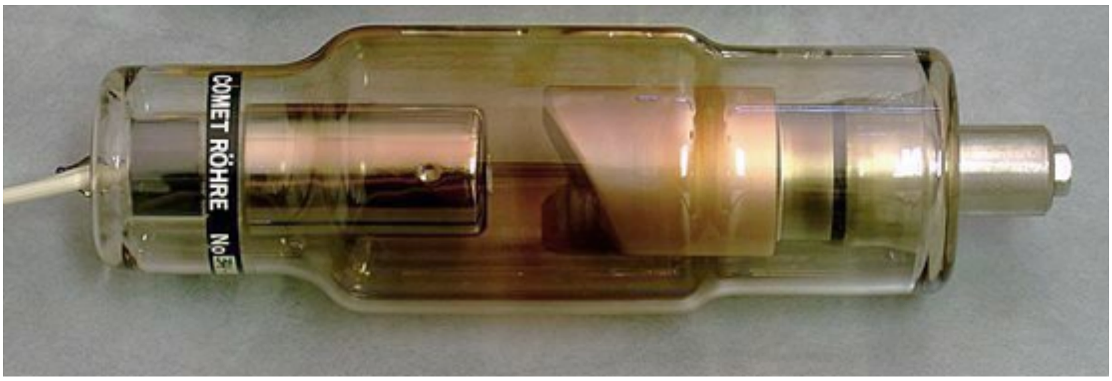


Fig 5 b): A modern DXT head in use.

In the 1930s to the 1950s DXT equipment was used, before higher energy equipment became available, for all deep-seated tumours. But multiple fields were required to give a high dose at the tumour (see figure 6 a & 6b.). After the advent of high energy treatment machines (Cobalt 60 and Linear Accelerators, which could penetrate much further into tissue with 50% depth doses for 70mm to 130mm), DXT was only used for palliative treatment in the lungs and for deeper superficial cancer not suitable for SXT.

Fig 6a: Showing DXT fields added together for treatment of the bladder.
See George Innes Proceedings of the Royal Society. Vol XLI page 691. Presented May 21, 1948.

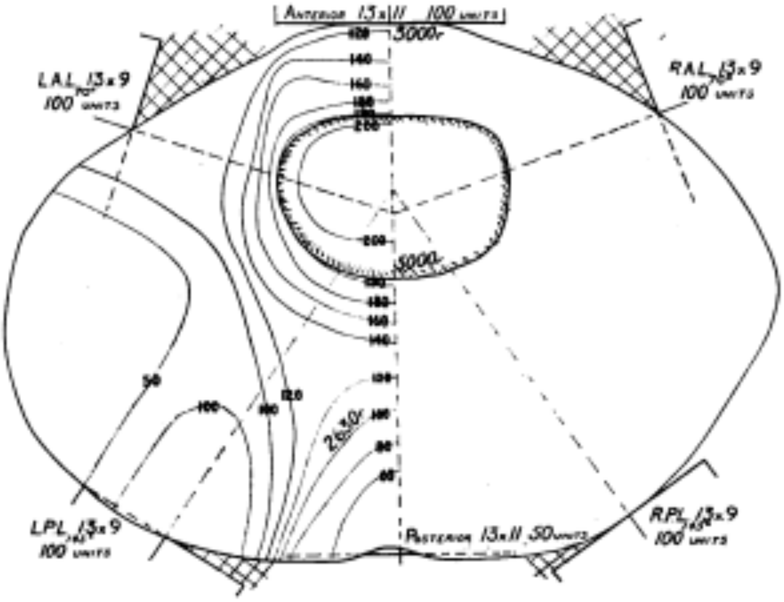


Fig. 13.—Ca. Bladder. Treated by 10^6 V, 9·3 mm. Cu H.V.L., 100 cm. F.S.D.

Fig 6b: Showing DXT fields added together for treatment of the oesophagus.

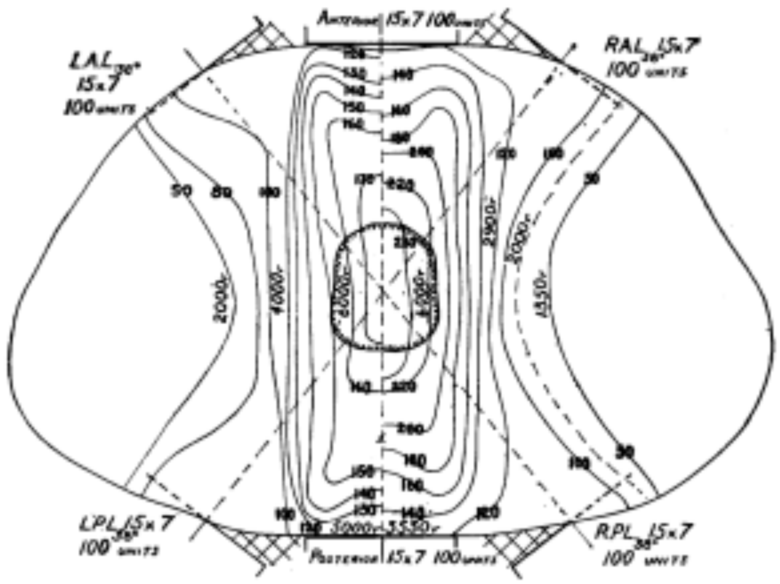


Fig. 10.—Ca. Œsophagus.
Left: Treated by 250 kV, 1·5 mm. Cu H.V.L., 50 cm. F.S.D.
6,000 r $D_T \equiv$ 4,000 r/field $\equiv$ 5,000 r D_S.
Right: Treated by 10^6 V, 9·3 mm. Cu H.V.L., 100 cm. F.S.D.
6,000 r $D_T \equiv$ 2,760 r/field $\equiv$ 3,530 r D_S.
(Maximum possible = 7,600 r D_T.)

Interlock Systems.

Many of the first SXT and DXT machines were not fitted with any interlock systems to ensure that the correct kV/filter combination were used. It was obvious that this was an essential part of the equipment. Following an incident in Germany it also became mandatory to provide a back-up timer for the primary timer that controlled the total exposure time (see PM77 1977, 3rd edition HSE 2006).

Modern Recommendations for use of SXT(dose/fractionation) by RCR (Radiotherapy dose fractionation, third edition 2019).

For both SCC and BCC SXT radiotherapy is the modality of choice.

In the elderly: 18-20Gy (single fraction, (fr)) for areas less than 3cm

Other ages:

Range from : 45Gy/10fr over 2-3 weeks; 50Gy/15-20fr over 3-4 weeks; 55Gy/20fr over 4weeks. (see also A.J.M. Partlin et al BJR 2014;87. Christie survey of 43 centres)

It is interesting to note that in the latest edition of the RCR report the use of electrons for superficial therapy is mentioned (since many centres in UK no longer have SXT equipment. "RBE of electrons is about 10% less than for SXT….although this is not often considered in practice" (Why not? – *author's comment*)

For Rectal Cancer.

There has been an interesting development in recent years.
In the RCR document a "Contact RT boost is recommended as 90Gy in 3Fr over 4weeks (See the OPERA trail 2015 described by Prof Sun Myint and Papillon technique …figure 7 below)

Dosimetry.

In the early years of radiotherapy the "exposure" to the skin was determined by the amount of erythema, viz:

Measurements began to be introduced in 1928 with the adoption of the official definition of the Roentgen: a measurement of exposure made by an ionisation chamber in air. This was used in radiotherapy until 1953 when the rad was defined as a measure of absorbed dose. The unit we use today is the Gray (1975), which is 100rad. The mGy and cGy are also used.

In radiation protection: effective dose (the tissue-weighted sum of equivalent doses in all tissues and organs irradiated by a particular exam) is used to be able to express the risk to the patient from stochastic cancer induction. Effective dose is measured in Sieverts and mSv.

For example: a standard chest CT gives a dose of 1.5mSv; but a simple chest radiograph is only 0.1mSv;
Larger doses are given by :

Coronary CT angiography : 12mSv.

Modern mammography gives a dose of 0.4mSv

Medical Physics Experts in radiology are expected to ensure that any department that they work in keeps to the National DRLs

ADDENDUM:

SXT/DXT A brief History of my involvement.

My own experience coincides with this period, starting in 1967 at Newcastle General Hospital (NGH) with Prof Frank Famer as Head Of Medical Physics, and William Ross FRCR and FRCS (Newcastle 1953-1987) and C.J.L. Thurgar as senior Radiotherapists. Although I was initially employed on a grant to study for an MSc by thesis, I was also expected to spend time learning about Radiotherapy generally. The equipment at that time at NGH was: 1 Philips KX10 (50-140kV); 2 x 250kV Marconi X-ray sets; 2 x Mobaltron Cobalt 60 unit; 2 Linear Accelerators ; one of these: the Mullard 4MV (MJ Day and FT Farmer BJR 1958;31),was the first in UK with an iso-centric mounting; it continued treatments for 25years …see BJR letter 25 years later: W.M. Ross and M.J. Day BJR 1981;54:819. Another particularly interesting machine at Newcastle was the simulator. With the advent of high energy radiotherapy it became evident that very good systems of identifying the target and check the beams to be used, so that the optimum beam directed plan could be chosen. This introduced the concept of "the simulator".

Fig. 7: The Newcastle Simulator (with its original small image intensifier).

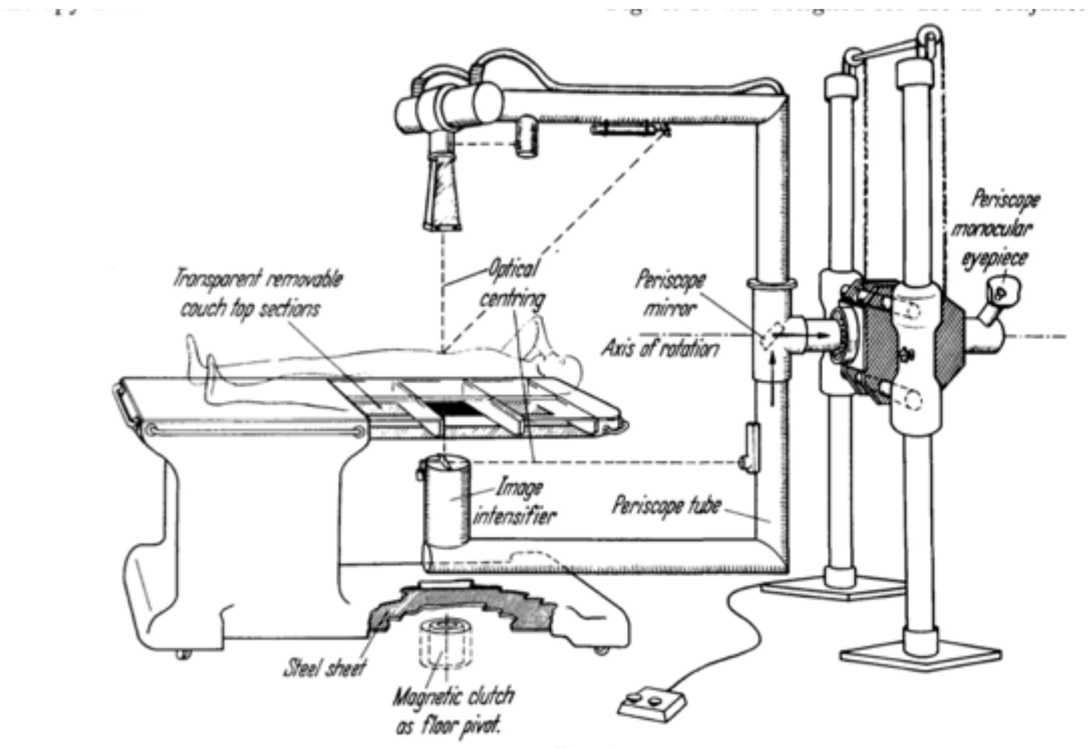


FIG. 1.

Original simulator design, using image intensifier and periscope system running through the main bearing to the eyepiece behind stand. The magnetic clutch in the floor provided for rotation of the couch about a vertical axis through the isocentre.

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My own intensive experience at this time (1968-1971) was the use of SXT sets for 3 different purposes:

At Newcastle a special piece of equipment had been developed (see F. Farmer, J.F. Fowler, J.W. Haggith, BJR 1963;36:426 and figure 7) with two particular features: The X-rays were provided by an SXT tube (instead of a diagnostic tube); and the imaging system used initially was a small image intensifier; it was soon realised that on rotation of the gantry the image could not be understood. A completely new idea was to use a Xerox system (fig. 8). This was particularly useful since it gave an immediate image for the radiotherapist to read; its disadvantage was that it gave poor images through large body parts such as the abdomen.

Fig. 8: A Head and Neck radiograph taken on the Newcastle simulator using Xero-radiography.

1) to re-design the Farmer ionisation chamber (used throughout radiotherapy to measure exposure dose) to ensure it had a very consistent energy response (Aird and Farmer BJR 1972;17:169);
2) to perform the in-vivo measurements with equipment (developed by others and refined by me) to measure antimony dust in workers lungs by differential X-ray absorption (Underhill et al Inhaled Particles 1970;2:611);
3) to develop equipment to measure bone mineral in the femur, particularly in the elderly and renal patients, using 2 X-ray energies (E. Aird BJR 1977;50:350 and E. Aird, A.M. Pierides, 1980 Proceedings of 4th Int Conf Bone Meas NIH Publications 80-1938:217).

1) Farmer dosemeter: I spent many hours altering the design of the Farmer chamber and then testing it at various x-ray energies) in the range 50-250kV, using different filtrations to obtain different HVLs in Aluminium) this also gave me a much better understanding of the x-ray energies used in Radiology.
2) The equipment to measure Antimony dust in-vivo was very sophisticated. The primary source of X-rays was an SXT tube. But the beam from this was directed onto one of two targets. These targets produced characteristic X-rays (Kα and Kβ just below and just above the absorption edge of Antimony. By additional filtration of the Kβ X-rays , this method was very accurate. 1mg/cm2 could be detected in a chest thickness of 20cm.
3) The endocrinology and geriatric departments at Newcastle General were very keen to develop means of measuring bone mineral sequentially as well as absolute. I developed a dual energy x-ray system using a combination of low and high energy characteristic X-rays from targets bombarded with primary X-rays from an SXT set.

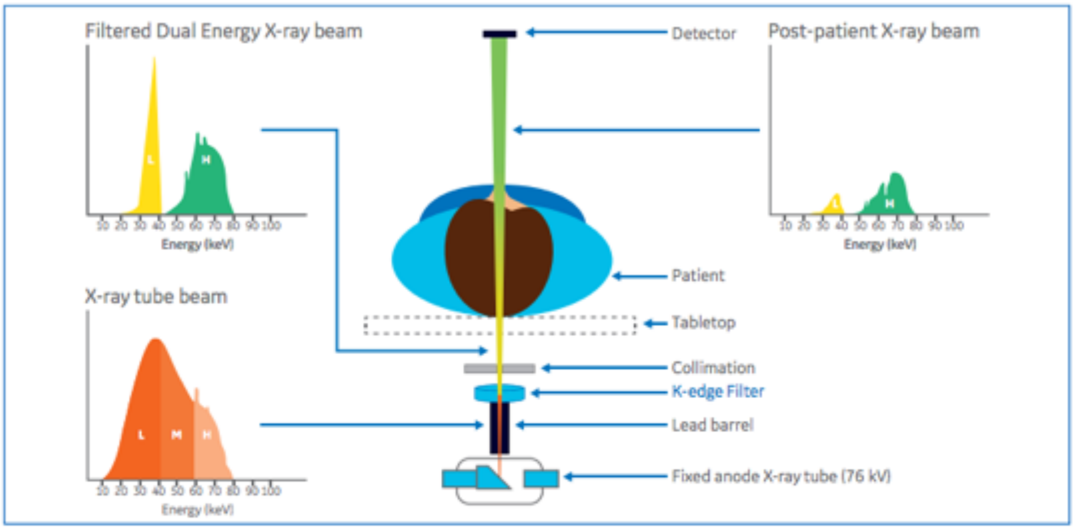

Fig. 8: A diagram to show the X-ray set of the Lunar Dexa equipment; together with the x-ray spectra filtered to give two different mean x-ray energies.

Interestingly, Richard Mazess (of Lunar Systems, Madison, Wisconsin) developed a dual energy X-ray bone mineral device which used the primary beam heavily filtered by two different filters to perform dual energy absorptiometry (reference/diagram 8). This was a much more efficient use of X-rays than my use of characteristic rays. However, even the most recent of these machines: GE Lunar Prodigy DXA and GE Lunar iDXA do no give absolute bone mineral content result; so this type of equipment is very good for following changes in an individual, but not very good at identifying weakness in an individual's bone mineral content. (IAEA 14 Human Health Services 2010).

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