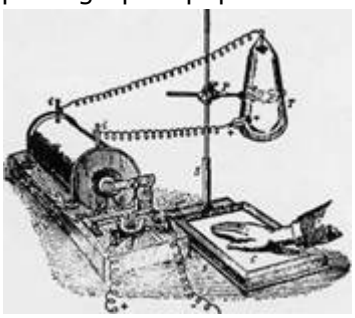
X-RAYS IN MEDICINE - THE FIRST CENTURY

Each man, woman and child is a potential beneficiary from W C. Rontgen's discovery of x-rays in 1895, through the two medical sciences which it created. The modern hospital cannot function without a diagnostic radiology department, and therapeutic irradiation remains a mainstay of cancer treatment.

Discovery, 1895

Wilhelm Conrad Rontgen, head of the physics institute in Wiirzburg, Bavaria, was the first man to realise that invisible rays are produced when an electrical current is passed across a vacuum. He performed the crucial experiments in the last 3 months of 1895 with the following equipment:

vacuum glass tube (Crookes' type), induction coil with interrupter, wet-cell batteries and sensitized photographic paper.



Experiment apparatus used by Rontgen

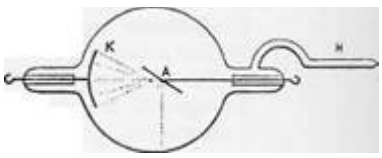
A simple mechanical switch is mounted on the same block as the induction coil, connected by electric cables to the battery (not shown). The patient's hand rests on the cassette containing the film, positioned beneath a glass Crookes tube

Britain, 1896

The first x-rays in Britain were made early in 1896 by enthusiastic amateurs operating fragile home-made apparatus.

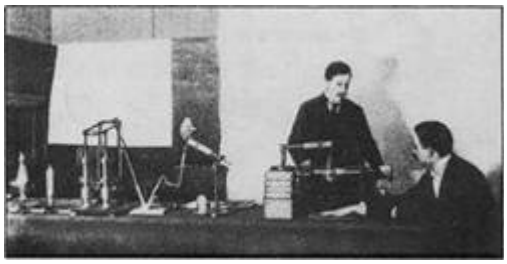
They included academics like Professor Henry Jackson, commercial photographers, and amateur scientists such as Archibald Campbell Swinton. Soon they were joined by doctors. The curiosity of the public about the invisible rays knew no bounds, and crowds flocked to lecture-demonstrations and public displays of x-rays. There were cartoons in Punch and music hall jokes about "Mr Rontgen's naughty rays" Before the end of 1896 x-ray sets were installed in most hospitals. Medical pioneers such as Thurstan Holland (Liverpool), John Hall-Edwards (Birmingham) and John Macintyre (Glasgow) had commenced their careers as the world's first radiologists.

Punch cartoon of 25 January 1896 expressing British resentment at German intervention in colonial affairs by alluding to Rontgen's discovery.



An early advance in apparatus construction —Jackson's focus tube.

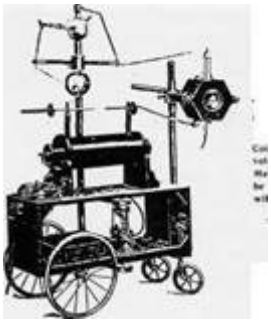
A curved or dished aluminium cathode K focussed the cathode stream on the platinum anode A The anode, angled at 45 degrees, deflected the resulting x-rays emitted from the wall of the tube in a more concentrated beam. The side arm H was used to reduce tube damage by heating.



Archibald Campbell Swinton (1863-1930) and an assistant demonstrating x-rays before the Royal Photographic Society on 11 February 1896.

The Barts medical student, Sydney Rowland, shown x-raying an ankle in 1896 (British Medical Journal, 29 February 1896). The table-top apparatus is similar to Rontgen's could be moved.

Medical enthusiasts in London were led by a 24-year-old medical student at St Bartholomew's Hospital, Sydney Rowland (1872-1917), who described advances in the British Medical Journal and himself experimented with x-rays. In April 1896 Rowland was appointed editor of a journal, Archives of Clinical Skiagraphy - the first radiological journal published in the English language. (The word "skiagraphy" was soon abandoned in favour of "radiography" or "roentgenography".) Archives survives to the present day, after four changes of title, as the British Journal of Radiology.



Made to the design of Dr. W. Stewuart, for use in the Wards of St. Bartholomew's Hospital, (for radiographing patients unfit to be moved.)

Oak Trolley Price £75LESLIE MILLER 66, HattonGarden, London, E.C.

Early advertisement for mobile x-ray apparatus

Archives of Clinical Skiagraphy.

-the first radiological journal in the English language -

Archives Clinical Skiagraphy

In 1897 the Rontgen Society was founded with only one requirement for membership, namely, a scientific interest in x-rays. Its early meeting were social events open to the public, but soon it became the meeting place for doctor-users, apparatus makers and experimenters. In the 1920s the Rontgen Society merged with a medical body that had been formed in 1917 to supervise the training of radiologists. The merger created the British Institute of Radiology, which then assumed teaching and organizational functions. The B.I.R. is the oldest radiological society in the world and remains one of the pillars of British Radiology.

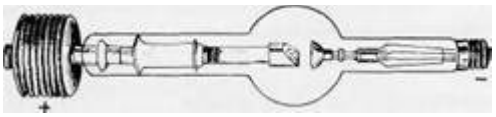
The makers of traditional scientific instruments in the alleys off Fleet Street marketed the first x-ray sets, and Britain was one of the first countries to export x-ray apparatus

The Greatest Early Advances

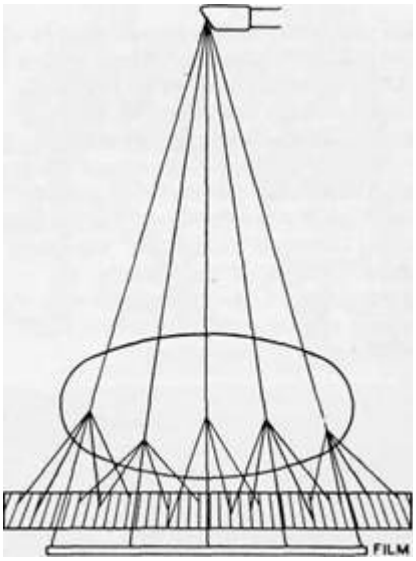
All four elements of Rontgen's table-top apparatus were modified within 30 years. These improvements heralded the first Golden Age of Radiology.

1. Rectifying Transformer. Despite larger induction coils and mechanical interrupters, discharge from the coil remained too low. Homer Snook of Philadelphia solved this problem in 1907 with his transformer and motor-driven rectifier, which delivered 100 kilovolts at over 100 milliamperes

2. Hot Cathode Vacuum Tube. Glass tubes were too fragile for long life, and a more robust vacuum tube was required. Another serious drawback was the fact that there was no way of independently regulating the tension and current of the tube. All these problems were met in 1912 by the American scientist, William Coolidge who, having invented a ductile form of tungsten and learnt from Edison's invention of the electric light bulb, built a tube with a very high vacuum and a cathode consisting of a tungsten filament. He then showed that the current could be increased across this tube by heating the tungsten filament. In practice it was found that a resistor placed across the cathode circuit enabled the operator to vary the current at will. This advantage of Coolidge's tube, as well as a steady action at tensions as high as 150 kilovolts due to its high vacuum, sounded the deathknell of the Crookes tube.



Hot cathode vacuum tube



The Potter-Bucky diaphragm, consisting of slats of wood interleaved with strips of lead foil.

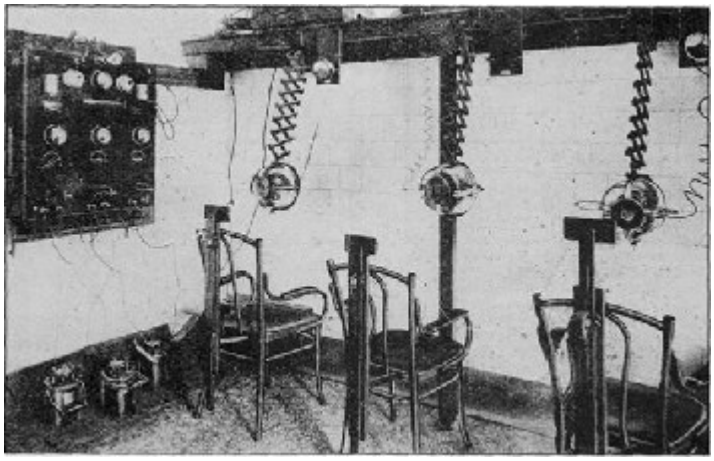
3. X-Ray Sensitive Emulsion. An image may be viewed on a barium platinocyanide screen (fluoroscopy) or it may be recorded photographically on paper, glass or film (x-ray photograph or radiograph). Emulsion-coated glass plates were cumbersome and damaged easily. Eastman-Kodak's cellulose acetate safety film was marketed only in 1924.

4. Potter-Bucky Diaphragm. This device, an arrangement of parallel metal strips which permits the primary x-ray beam to pass but blocks out secondary radiations, was hailed in 1924 as a major forward step in image enhancement. The diaphragm is assembled so that the plane of each slat allows the rays from the focus to pass through the grid. Radiation scattered by the patient's body is deflected by the lead strips.

X-rays In Treatment

X-rays were first used to treat patients in 1896. Initially there was uncertainty about their indications and benefits, and the earliest treatments were applied to disorders of the skin and other superficial lesions. Many of these were non-cancerous conditions, such as scalp ringworm, which was common in Victorian cities.

The irradiation of deep-seated lesions became possible only after Coolidge tubes became available, enabling doses to be delivered with higher kilovoltages, which penetrate the tissues.



Radiotherapy room at The London Hospital, IS use of x-rays in ringworm of the scalp.

Landmarks on the road to supervoltage x-ray therapy were:

1925 300 kV Coolidge's sealed tube 1927 400 kV continuously evacuated tube 1939 1,000 kV treatment with continuously evacuated steel tube and Cockcroft-Walton generator

1945-53 Development of supervoltage apparatus for routine therapy

electrostatic generators - 2MV

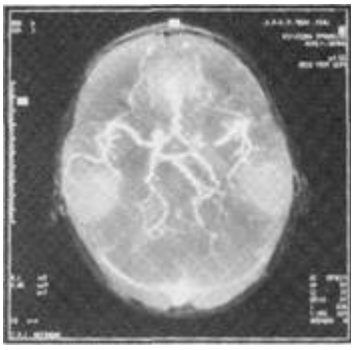
betatrons, up to — 20MV

linear accelerators, up to 8MV

Computers and Diagnostic Imaging

The marriage between computers and x-rays in the 1970s heralded a work pattern revolution, because of the enormous increase in anatomical information provided by computerized x-rays (computer-assisted tomography, CT scanning). This invention of the English scientist, Godfrey Hounsfield, has been hailed as the greatest in the field of radiology after Rontgen's, as well as the most important British contribution to science since the Second World War. Hounsfield earned the Nobel prize for his work. Modern imaging techniques also utilise other sources of energy, such as isotopes, ultrasound waves or an electromagnetic field (magnetic resonance imaging, MRI). They require the same computer software and often share terminals in the modern radiology department. Computer techniques have simplified the imaging of blood vessels. Digital subtraction angiography is the computer technique which enables any part of the circulation to be pictured, silhouetted like the branches of a tree against a blue sky. The same picture can now be made without the injection of an iodine substance into the body, i.e. non-invasively, by MR angiography.

Magnetic resonance angiogram of the arteries of the brain.



MR image of the brain and spinal cord. These pictures are obtained without the use of x-rays or the injection of chemical substances into the bloodstream.

The X-ray Professions

The Doctors Until the First World War the term "radiologist" was applied to anyone who could operate an x-ray set and produce x-rays. Most of the battlefield radiographs were made by untrained persons. In 1916 the Liverpool radiologist Thurstan Holland protested at this unsatisfactory situation, and declared that a radiologist must be "a doctor trained to interpret x-rays". In 1919 CambridgeUniversity offered a training course and a Diploma in Medical Radiology (D.M.R.), which immediately established the radiologist as a qualified medical specialist.

Charles Thurstan Holland of Liverpool (1863-1914), the father of British Radiology.

By the early 1930s radiodiagnosis and radiotherapy were already separate professions. Their 2 organizations amalgamated in 1939 to form the Faculty of Radiologists. It became in 1975 the Royal College of Radiologists. Faculty and RoyalCollege for 50 years have exercised professional control over radiologists and radiotherapists, and served as the profession's voice to the government and the public.

The Radiographers Early equipment was operated by untrained persons, usually called "x-ray assistants". After 1903 the British Army Medical School at Netley Southampton ran a course of x-ray instruction — the first school of radiography in the world. In 1920 the 20 x-ray assistants working in the London teaching hospitals formed the Society of Radiographers. The Society became the arbiter of professional status of the radiographer, and its examination the sole test of knowledge.The College of Radiographers, which represents the interests of all diagnostic and therapeutic radiographers, was created from the Society of Radiographers. Membership grew from the original 20 seventy years ago and now exceeds 10,000.

Royal Victoria Hospital on Southampton Water. Designed by Florence Nightingale, it housed for many years the home of the Royal Army Medical School and the first school of radiography in the world.

The Physical Scientists The first hospital physicist was probably the 1896 experimenter, C.E.S. Phillips, who soon after 1900 was appointed honorary physicist at the CancerHospital, Fulham (now The Royal Marsden Hospital). Another pioneer and teacher of medical physics was Professor Sidney Russ, who joined the MiddlesexHospital in 1910, and served it for 36 years. Gradually other hospitals appointed staff physicists. The Hospital Physicists Association (HPA) had 30 members when founded in 1943; by 1990 there were over 1,200 physical scientists engaged in clinical work. The HPA still exists, but now the scientific aspects of the application of physics in medicine is controlled by IPSM (The Institute of Physical Sciences in Medicine).