Chapter 2

Francis Henry Williams

(1852–1936)

"It is universally acknowledged that the most important step towards an intelligent use of x-rays as a therapeutic agent is the ability to give a definite dosage: this may be done by means of the fluorometer." (1902)[667]

Francis Henry Williams was born in Uxbridge, Massachusetts, on 15 July 1852. He was the second son of Elizabeth Dewe, who in 1848 married Dr. Henry Willard Williams (1821–1895), a pioneer ophthalmologist. His paternal grandparents were Elizabeth Osgood and Willard Williams (1788–) of Salem, Massachusetts (subj. note 2.1). Francis had an older brother, Charles Herbert (1850–1918). When Francis was eight, his father married Elizabeth Adeline Low, and this union produced six younger siblings.

Francis received his initial schooling during the years of Civil War austerity. He had his secondary, or college preparatory, education in the aftermath of the conflict. In 1869, a Peace Jubilee was celebrated in Boston with great enthusiasm and a frenzy of patriotism. The affair was held in a specially built coliseum with the attendance of the Grenadiers Band of London and the Bande de la Garde Republicaine of Paris. That same year young Francis applied for admission at the Massachusetts Institute of Technology. The young institution looked for maturity of character in its applicants. It aimed to transform students into future leaders with a mastery of science and technology, balanced with insights into history, literature, and art.

From its puritan origins, Boston was being transformed into a cosmopolitan conglomerate. Then, as now, the Italian North End and Irish Charlestown occasionally clashed, while an infusion of radical Russian Jews added new political zest to the mix. Boston was also on the way to justifying its title as the Athens of America, a cultural capital for the United States. In American literature a new movement was afoot in the language of the mother country, but with unmistakable influences from German, French, and Italian. The limpid prose of Ralph Waldo Emerson (1808–1882), the incandescent logic of James Russell Lowell (1819–1891), and the nimble wit of Oliver Wendell Holmes (1809–1894) were receiving wide attention. Nathaniel Hawthorne (1804–1894) and Henry David Thoreau (1817–1862) were being posthumously recognized. In November 1872 an extensive fire that started on Summer Street destroyed 770 buildings and devastated 65 acres in downtown Boston. A lifetime of toil and considerable wealth went up in smoke. It was in this atmosphere of social change, intellectual achievement, and civic rebuilding that Williams came of age.

Francis Williams presented his thesis on "The Synthesis of Hydrocarbons by the Treatment of Cast Iron with Acids," and received from M.I.T. his degree of Science Bachelor in chemistry in 1873. He was a lanky youngster with a long face and nose, a full lower lip, large deep-set brown eyes, and sea-shell ears (Fig. 2-1). He was the president of his class. Following graduation he took part in an expedition to Japan to observe the solar eclipse by Venus (called the Transit of Venus Expedition). He continued on a tour around the world and, on his return in 1875, entered the Harvard Medical School. His father, an 1849 graduate who had lectured at the school since 1869, had been appointed Harvard's first Professor of Ophthalmology in 1871. Francis's elder brother, Charles, received his M.D. from the school in 1874, and entered the specialty of his father, becoming a noted ophthalmologist. Francis Williams received his degree in 1877 and, as his father had done, went to Europe for postgraduate studies, spending two years in Vienna and Paris.

In 1879, Dr. Williams started to practice medicine in Boston. In 1882 he was elected a life member of the M.I.T. Corporation. He joined the staff of the

Fig. 2-1. Francis H. Williams, M.I.T. Bachelor of Sciences and president of the class of 1873.

Outpatient Department of the Boston City Hospital in 1883, and the following year was appointed Instructor in Materia Medica at Harvard. After a year he was promoted to Assistant Professor of Materia Medica and General Therapeutics.

In 1891 Dr. Williams married Anna Dunn Phillips, granddaughter of John Phillips, Boston's first mayor. From their home at 505 Beacon Street, they could walk leisurely to where, in the words of Santayana, "the street consents to bend" then runs downhill to the grassy shoulder of the Commons slopes and to the Frog Pond. The excellent concerts offered by the Municipal Band on the Commons were a pleasant attraction. In 1891 Williams was elected Secretary of the M.I.T. Corporation, on the Executive Committee of which he was to serve for twenty-five years.

An earnest clinical researcher, Dr. Williams wrote a paper on the intermittent administration of quinine for the treatment of malaria. In 1894 he was the first in his medical community to use the diphtheria antitoxin, which had just been produced by the Pasteur Institute of Paris. Within a year he reported results in the first eighteen cases treated. Edward Russell Williams (1872–1921), Francis's half-brother, graduated from Harvard Medical School in 1894. He, too, chose to be an ophthalmologist. Their father died in 1895.

Announcements of Röntgen's discovery of "a new kind of ray" appeared in U.S. newspapers in early January 1896. The *Boston Globe* reported the successful experiments of Professor John Trowbridge (1843–1923) at Harvard and Amos Emerson Dolbear (1837–1910) at Tufts. The Rogers Laboratory of Physics at M.I.T. had the wherewithal to reproduce Röntgen's experiments. Charles Robert Cross (1848–1921), Professor of Physics, authorized Williams to

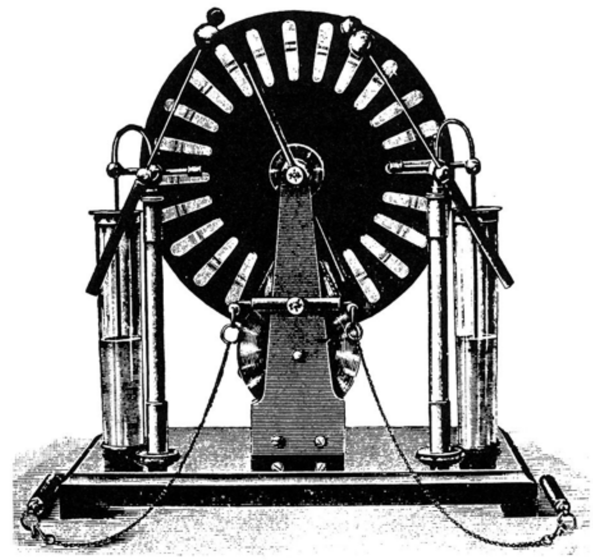


Fig. 2-2a. Standard model of the Wimshurst static machine.

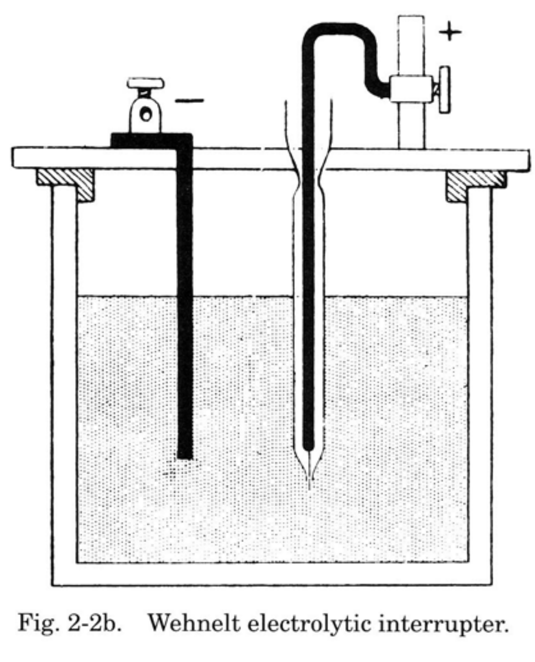


Fig. 2-2b. Wehnelt electrolytic interrupter.

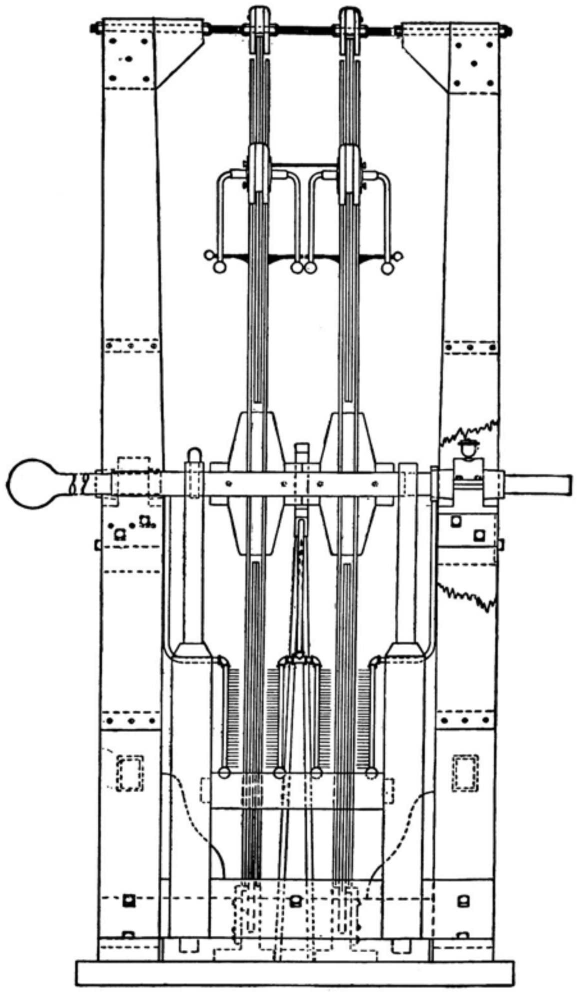


Fig. 2-3. Cross-section of static unit showing rotating and fixed disks. (From Williams, F.H., *The Roentgen Rays in Medicine and Surgery,* New York, McMillan and Co., 1901.)

use the laboratory's equipment for trials of fluoroscopy and radiography. With the assistance of Ralph Restieaux Lawrence (1873–1946+) and Charles Ladd Norton (1870–1939), both of the physics department at M.I.T., he was able to do fluoroscopic examinations of patients. In the evenings, he transported patients from the Boston City Hospital to the M.I.T. Physics Department, then on Boylston Street in Boston proper. Radiographs of the chest could require forty-five minute exposures; Williams naturally favored fluoroscopy. He soon found radiological advantages in the diagnoses of incipient tuberculosis and pleural effusions. Said he, "We may now look where we have previously only been able to listen."

News of the discovery of X rays resulted in worldwide speculation on the "photography of the invisible." In addition, interesting biological effects were soon observed and investigated. In Chicago, Emil Herman Grubbé (1875–1960) suffered a radioepidermitis of his hands and used these effects as a rationale to irradiate a patient with a cancer of the breast. In Nashville, Professor John Daniel made radiographs of his minister's hand and persuaded the dean of Vanderbilt's Medical College to pose for a radiograph of his brain. Nothing came out of the necessarily long exposure except Dean Dowell's hair![666]

Various types of static, or frictional, generators of electricity were in general use at this time. Because of its simplicity the most favored was the Wimshurst type influence machine, popular in Europe (Fig. 2-2a). The prototype had two inversely revolving sixteen-inch (forty centimeter) glass disks, mounted one-eighth of an inch apart, and powered by a hand crank or motor. This type of machine was reliable, but the charge generated was weak. Drs. Norton and Lawrence developed a larger Wimshurst machine consisting of twelve disks, twenty-six inches (sixty-five centimeters) in diameter. They also worked with a Ruhmkorff induction coil which, although it provided greater energy, required troublesome interrupters (Fig. 2-2b).

The Board of Trustees of the Boston City Hospital appointed Dr. Williams as a Visiting Physician and granted him $1100 and the use of a basement room for his continued clinical investigations. The space at first accommodated a borrowed Wimshurst machine, and was enlarged in 1898. It would become the Department of Radiology of the City Hospital in 1905, when it was moved to Ward A Building. During the first few years, Williams had four successively larger static machines. The energy produced was in direct proportion to the size and number of disks as well as to the speed of their revolution. Seeking greater power, Williams had machines of the Holtz type specially built, again with the help of Norton and Lawrence. This equipment featured four six-foot (183 cm) diameter glass disks rotating at 250 revolutions per minute. Four slightly larger (193 cm) concentric disks were fixed at one-half inch (1.2 cm) distances from the rotating ones (Fig. 2-3). A system of brushes and collectors of current led to the insulated terminals. The whole machine weighed about twelve hundred pounds.[662] Dr. Williams developed a system of multiple adjustable spark gaps, permitting a steady output and hence the use of tubes of lower resistance. Insulation was of the greatest importance: moisture severely reduced the output. The machine was enclosed in a moisture-proof varnished cabinet with glass panels (Fig. 2-4). The initial charge had to be given by the smaller Wimshurst machine. He also experimented with several increasingly larger coils (Fig. 2-5). Williams preferred the static generator, but for house calls, a portable induction coil unit, energized by storage batteries transported on the physician's horse carriage, proved practical (Fig. 2-6).

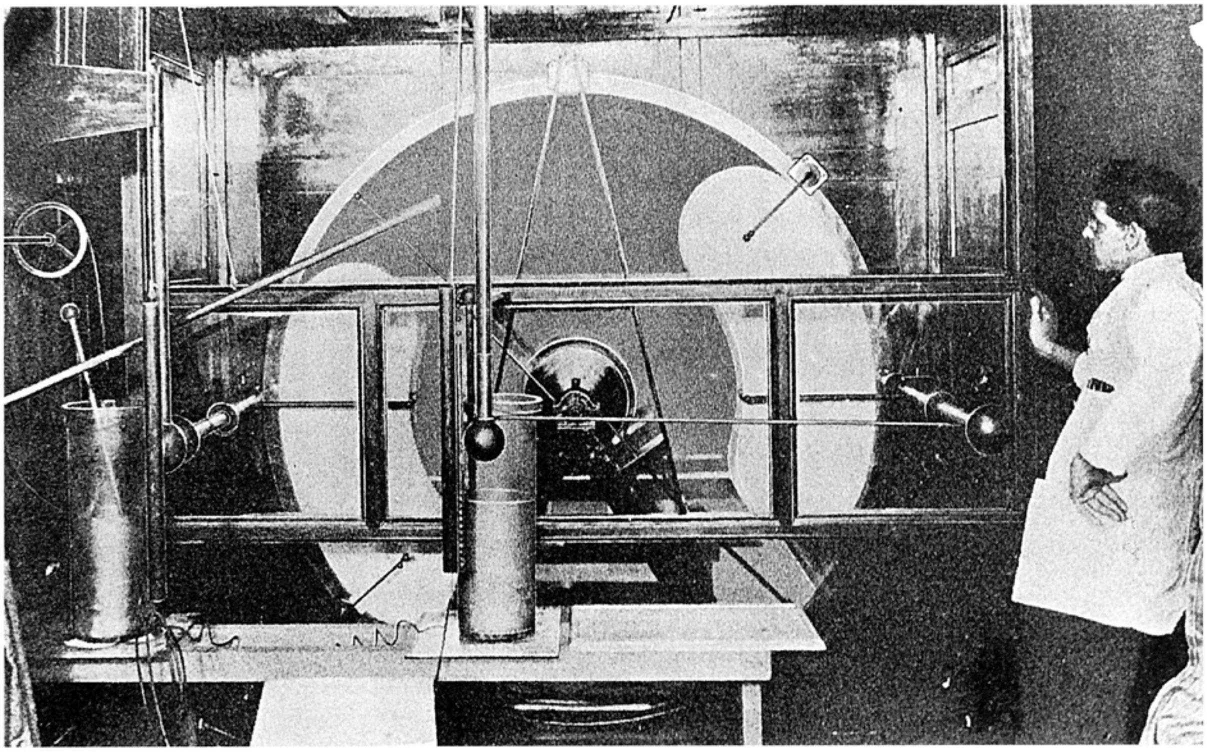


Fig. 2-4. Large static machine of the Holtz type with front panel removed. (From Williams, F.H., *The Roentgen Rays in Medicine and Surgery,* New York, McMillan and Co., 1901.)

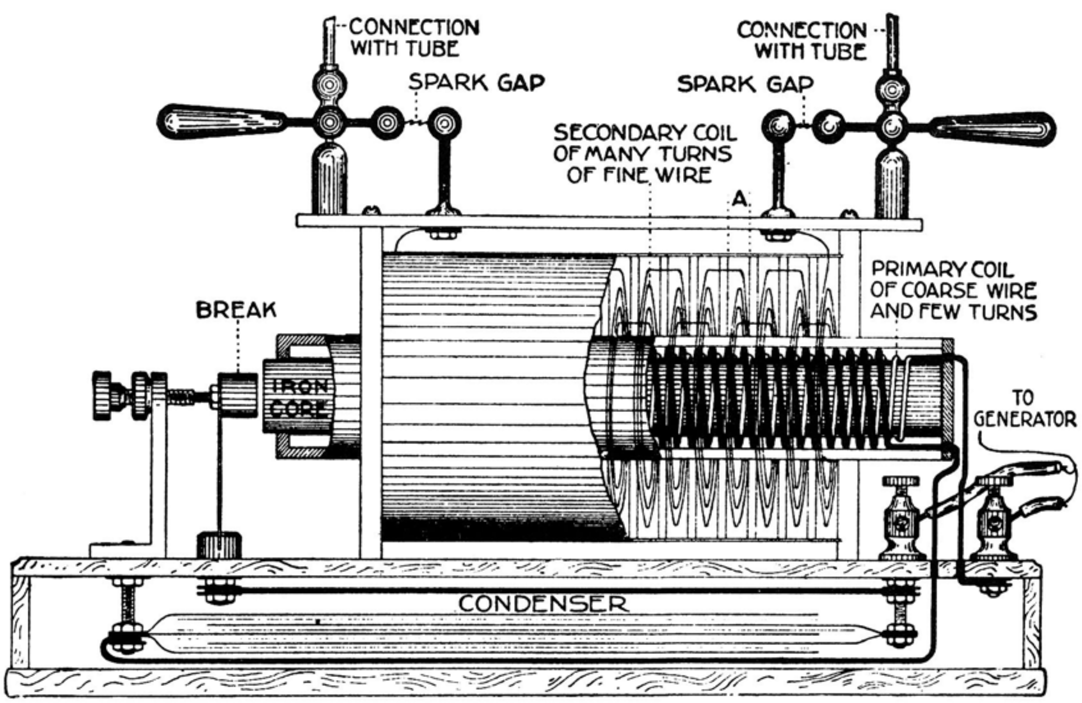


Fig. 2-5. Induction coil with condenser designed by Rollins.

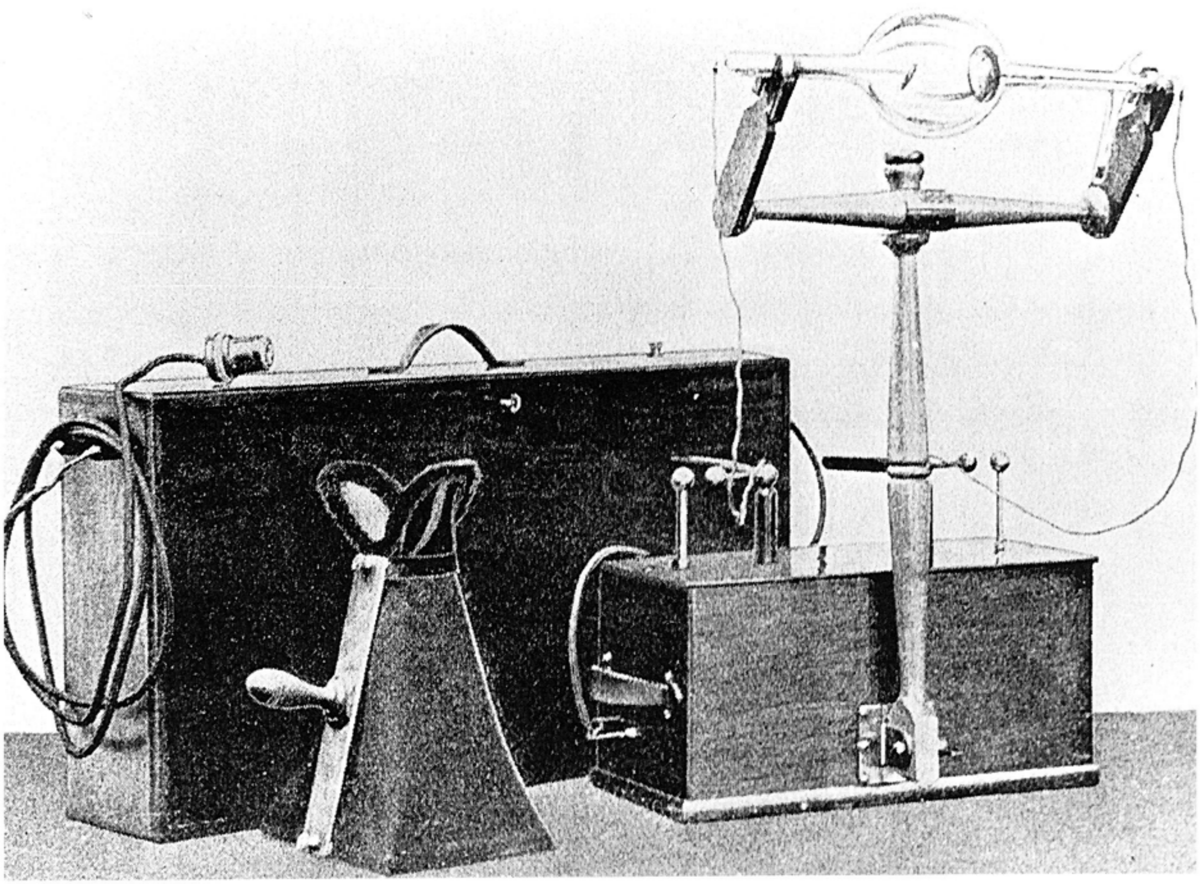


Fig. 2-6. Early portable X-ray unit. The smaller box contains the coil; the larger, the electrolytic interrupter. The hand fluoroscope and open tube as generally used are shown.

Dr. William Herbert Rollins (1852–1929),[B] Williams's brother-in-law, became a valuable colleague. A dentist as well as a physician, Rollins was remarkably ingenious in the development of innovative X-ray tubes. Early tubes were mostly of the Crookes type (Fig. 2-7) where X rays emanated mainly from the glass walls. Later, the concept of a target was adopted, eventually becoming part of the anode, while cathodes were made concave for a tighter focus of the beam (Fig. 2-8). Rollins placed the cathode at twice the distance of the cathode concavity radius. He provided Dr. Williams with a variety of tubes (Fig. 2-9) including water-cooled and rotary targets. At a time when practitioners of radiology liberally exposed themselves and their patients to open X-ray tubes without protection, Rollins introduced the use of lead glass on the operator side of hand-held fluoroscopes.[538,642] Rollins also developed a containing tube box lined with several coats of lead paint (Fig. 2-10). The considerable protection afforded by these measures was not appreciated until much later. The record of freedom from radiation injury in Williams's staff and patients was eventually evident and exemplary.

On 25 April 1896, Williams made a demonstration of X rays at a meeting of the Suffolk Medical Society held in Walter Hall at M.I.T. With the room darkened his audience was able to see the bones of a hand and wrist. He also recounted his experiences with fluoroscopy of the chest.[642] The same month he reported to the Association of American Physicians his results of the past three months, demonstrating radiographs of the chest, a bullet in the forearm, and a case of splenomegaly. He also reported the localization of a piece of metal in the orbit. In addition, he gave an account of the negative results of irradiation of bacteria *in vitro*. George Miller Sternberg (1838–1915), Surgeon General of the U.S. Army, a notable bacteriologist, participated in the discussion. Professor Harold Clarence Ernst (1856–1922), who had read an account of Dean Dowell's epilation, inquired if this were true. Dr. Williams replied that he had not personally noticed any loss of hair.[660]

In September 1897, at the meeting of the British Medical Association held in Montréal, Williams di-

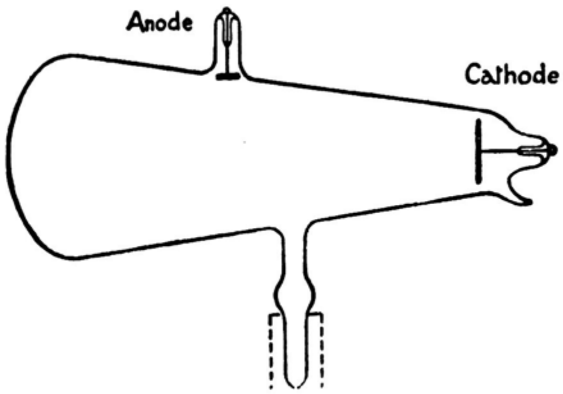


Fig. 2-7. Early Crookes tube like those used by Röntgen.

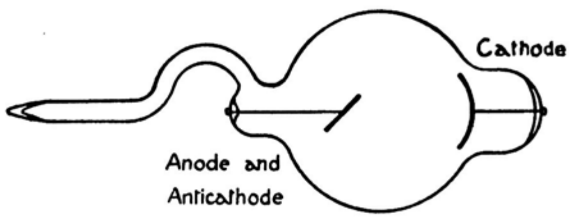


Fig. 2-8. Concave cathode and target-anode combined.

rected attention to fluoroscopy findings in emphysema, pneumonia, and tuberculosis.[681,663] In October he described a technique for delineation of the heart in fluoroscopy.[659] He had already fluoroscoped forty patients with pulmonary tuberculosis. He pointed to the retraction of the heart to the affected side and the diminished excursion of the diaphragm.

Two years after the discovery of X rays Dr. Williams had publicly discussed their application to the diagnosis of thoracic aneurysms, pericardial effusion, pneumothorax, and pulmonary tuberculosis.[92] He also demonstrated the usefulness of X rays in showing renal stones.[646] His background as a capable internist and skillfully trained technologist gave him an advantage he put to good use. He experimented with a "see-hear": a fluorescent screen combined with phonendoscopic diaphragm for noting intrathoracic signs and sounds simultaneously. This was also one of Rollins's inventions.

Walter Bradford Cannon (1873–1945), then a medical student at Harvard, made fluoroscopic observations of the cat's stomach in 1897.[96] Cannon assisted Dr. Williams in similar studies of the esophagus and stomach of young children using bismuth subnitrate for contrast. They demonstrated radioscopically and radiographically the varying position of the viscus, its excursion during respiration, and its changes of shape during digestion. At that early date, Dr. Williams described the use of air for contrast in the stomach and large bowel.[664]

Mr. Earnest E. Fewkes was appointed to do radiographic work at the hospital. His twelve years of experience as a photographer and his marked mechanical ability made him a valuable assistant. Appointments were set for fluoroscopy to be done by Dr. Williams and "x-ray photography" (radiography) by Fewkes, the earliest of radiologic technologists.

Surgeon General Sternberg had been impressed by the localization of projectiles demonstrated by Williams. As the country engaged in the Spanish-American War in 1898, he ordered an x-ray unit as part of the medical equipment of the first hospital ship, the *S.S. Olivetti,* brought to serve the U.S. armed forces in Cuba.

Williams gradually developed an interest in the therapeutic possibilities of the roentgen rays. He presented to the Medical Society of the Boston City Hospital the patients whom he had successfully treated for superficial forms of cancer. In published articles, he presented illustrations of the results of roentgentherapy of basal cell carcinomas (rodent ulcers) of the eyelids (Figs. 2-11a and 2-11b) and squamous (epidermoid) carcinomas of the lower lip (Figs. 2-12a and 2-12b).[665,666] In each case the histopathologic diagnosis had been made by Frank Burr Mallory (1862–1941) of the City Hospital, who achieved fame as a tumor histopathologist. Technical details were carefully given, emphasizing adequate protection of non-affected structures, well-collimated and filtered beams, and prolonged fractionation. Patients were treated daily or on alternate days for five or more weeks. He insisted that "healing takes place without any caustic action," that is, without intense reactions of the tissues exposed. His excellent esthetic results were unquestionably due to appropriate fractionation, a point

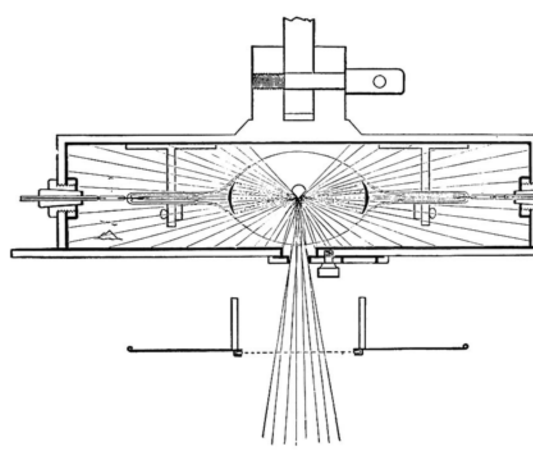


Fig. 2-9. Model of Rollins's double cathode tube to be used with his high frequency coil. Note protective encasement.

lost on others. His contemporaries, like him, were obliged to fractionate because of the low output from the tubes. It is our contemporaries who have failed to understand the process. His results were all the more remarkable in that dosimetry was lacking and irradiation was measured arbitrarily by time of exposure. He reported beneficial effects of irradiation in cases of Hodgkin's disease for which there had been no remedy, although manifestations of the disease would recur in non-irradiated areas.[669] He became enthusiastic over the results of irradiation of eczema, psoriasis, lupus, and various inflammatory conditions of the skin, as well as the anodyne effects of the X rays in the treatment of these and other diseases. In 1905 over twenty-three hundred patients were irradiated at City Hospital. Williams wrote "the x-rays have opened to us ... a method for the treatment of disease more comprehensive than any other remedy we have hitherto possessed."[669] He also foresaw the value of radiation in the study of physiology and pathology.

The information written and circulated about X rays in the earliest days came from numerous sources, not all responsible or genuinely authoritative. Much of radiology practice was conducted on a basis of day-to-day empiricism. Tubes, for instance, became hardened by use and developed lower (and unpredictable) outputs. A contemporary encyclopedia on electrotherapeutics offered this advice: "A tube ... can best be tested by the operator's own hand. In fact the hand is a better indicator than any artificial skiameter, as it contains many types of bones, from the massive carpal end of the radius to the delicate third phalanx of the little finger."[23] Unlike many of his contemporaries, Williams did not develop lesions of the skin of his hands: he had greater respect for radiations.

The first edition of Williams's book, *The Roentgen Rays in Medicine and Surgery*, appeared in 1901 (Fig. 2-13a).[668] It was widely welcomed by physicians who had depended on purely physical information. Williams's background as a competent clinician allowed him to present the medical significance of the new technology. The subtitle of his book emphasized the role of the X ray as a therapeutic agent (Fig. 2-13b), revealing his early experience with radiotherapy. In Paris, Antoine Béclère was greatly impressed with the book and translated it himself into French. The book, updated in 1902 and 1903, marked the beginning of respected American roentgenologic literature.[280]

In an effort to differentiate the output of various tubes, Dr. Williams invented an apparatus that may be considered one of the first to approach, in a primi-

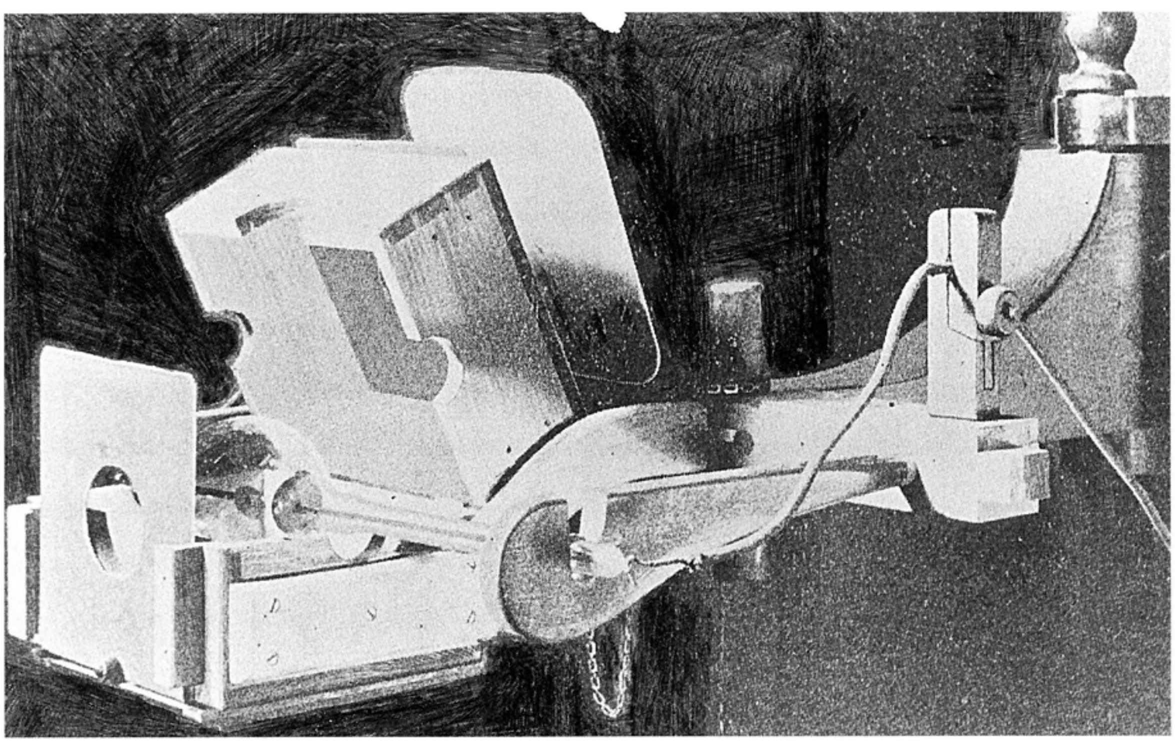


Fig. 2-10. Early model of Rollins's tube holder shown open. The inside of the box was coated with several layers of lead paint, adequate for low voltage radiations. Lead plates were put, in addition, on all sides of the tube. A lead diaphragm with a circular opening of various diameters regulated the exit beam.

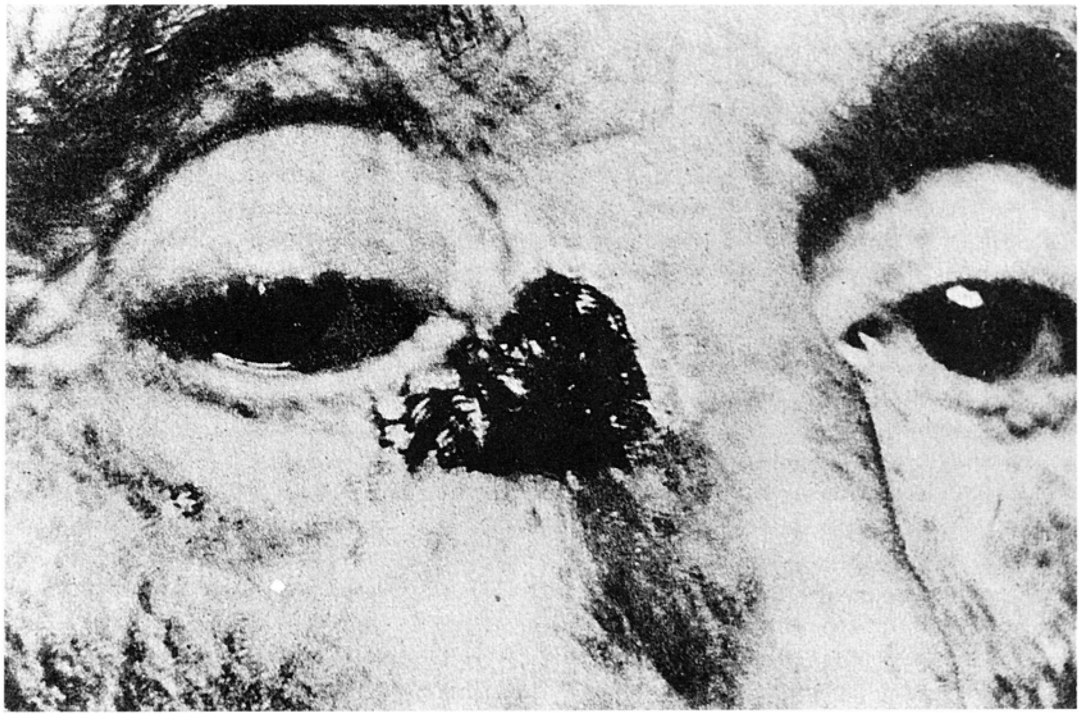


Fig. 2-11a. Patient with basal cell carcinoma of the eyelid, extending over the infraorbital skin.

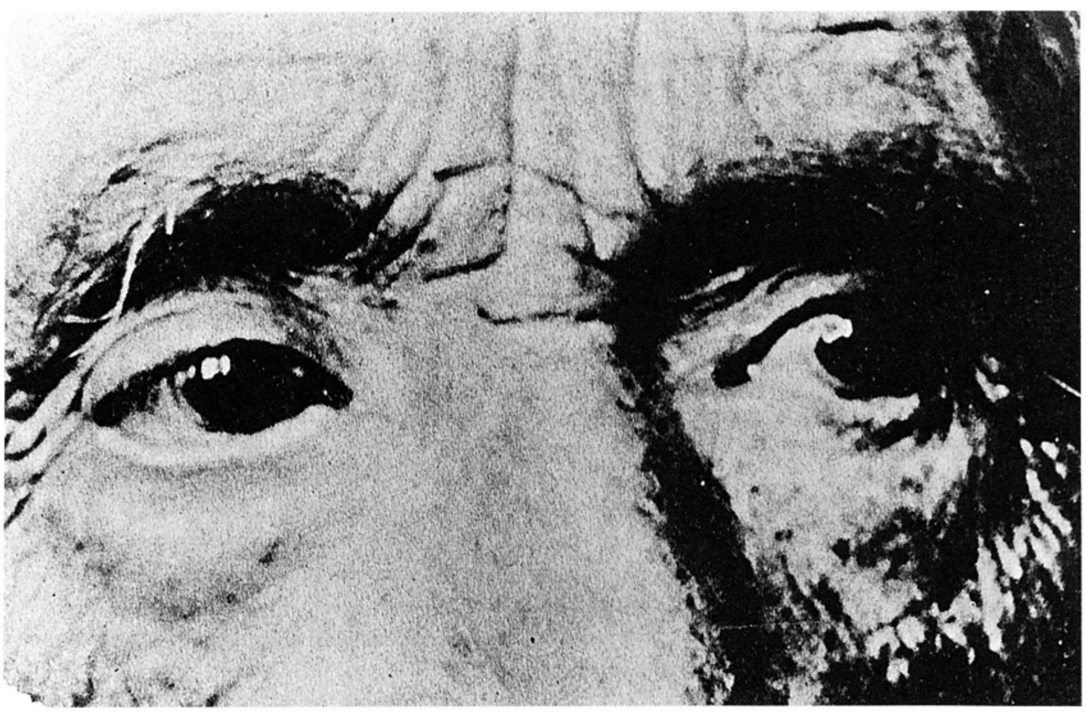


Fig. 2-11b. Same patient with area healed, following fractionated roentgentherapy.

Fig. 2-12a. Squamous cell carcinoma of the lower lip.

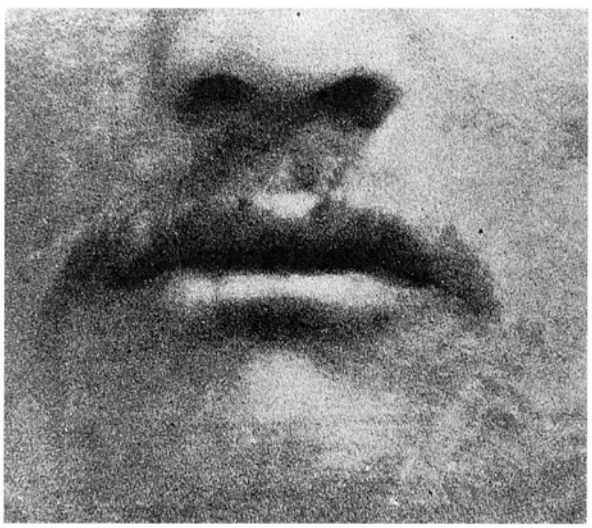


Fig. 2-12b. Same patient with lower lip healed after fractionated roentgentherapy.

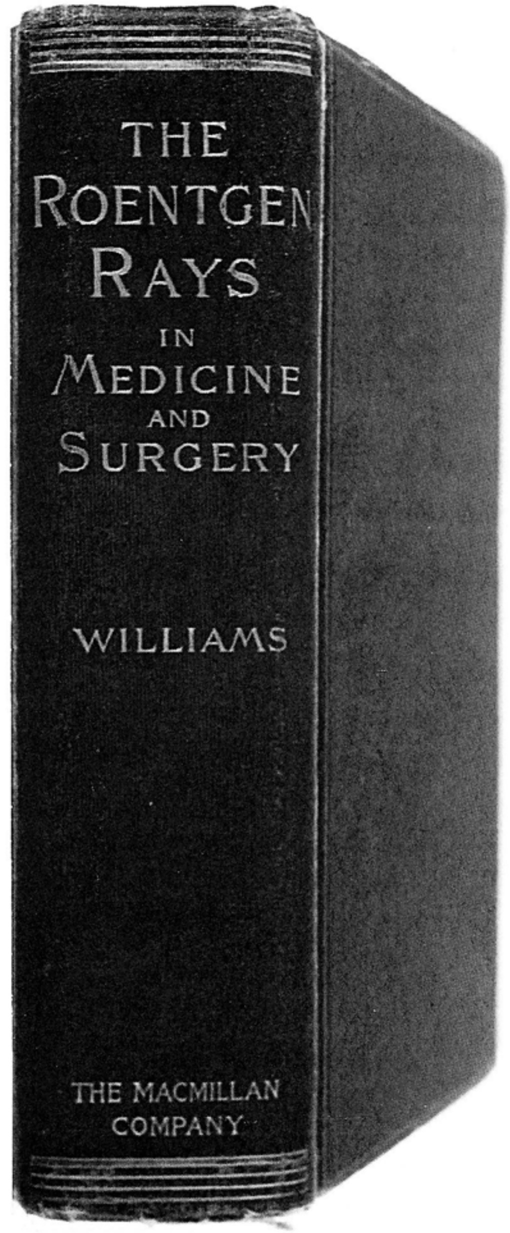
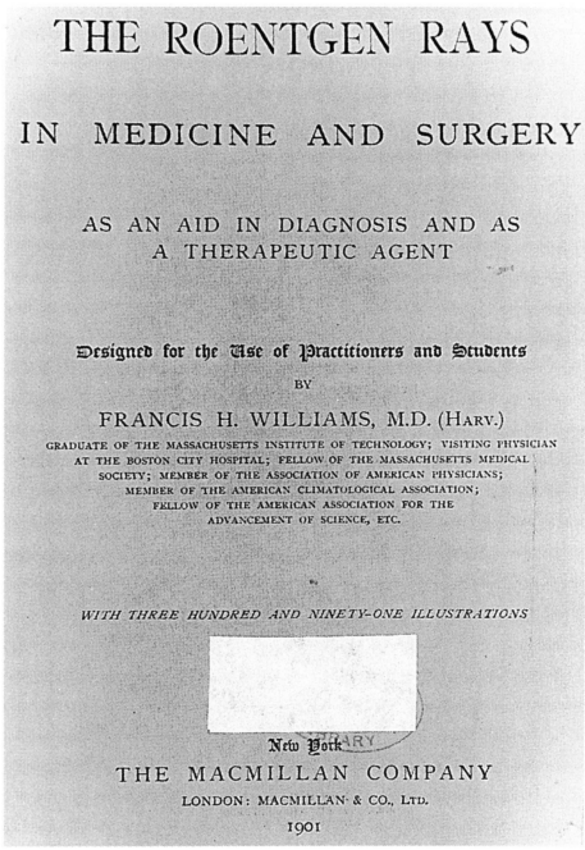


Fig. 2-13a. Spine of 1901 edition of Williams's textbook.

tive manner, the important problem of dosimetry. His gadget, which he called a fluorometer, consisted of a screen of fluorescent calcium tungstate in the middle of which was placed a small source of radium producing a certain fluorescent brightness.[667] The screen was brought closer to the operating tube until it became brighter than when exposed to radium alone. The distance at which the two brightnesses became equal was different for the various tubes, and was taken as a relative measure (Fig. 2-14).

In 1900, Rollins obtained a small amount of radium chloride. He encased it in a metal capsule and entrusted it to Williams who used it first as a standard for his fluorometer, but later became interested in the therapeutic uses of this weak source.[538B,538C] In 1903, Williams went to Paris. Informed of his visit, Béclère interrupted his summer vacation and returned to Paris to greet the admired American. Through Béclère, Williams was able to observe and obtain firsthand information on therapeutic work recently initiated by Henri Alexander Danlos (1844-1922), who worked with radium loaned to him by Pierre Curie.[495] He was also able to purchase one hundred milligrams of radium bromide. In addition, he visited and observed the work of Guido Holzknecht (Chapter 3) in Vienna and of Sir James McKenzie Davidson (1856–1919) in London.


THE ROENTGEN RAYS

IN MEDICINE AND SURGERY

AS AN AID IN DIAGNOSIS AND AS A THERAPEUTIC AGENT

Designed for the Use of Practitioners and Students

BY

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WITH THREE HUNDRED AND NINETY-ONE ILLUSTRATIONS

New York

THE MACMILLAN COMPANY

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1901

Fig. 2-13b. Title page of the 1901 edition of Williams's book.

Within months of his return from Paris, Williams reported to the Massachusetts Medical Society his experience in the radium treatments of forty-two patients. He dismissed the use of radium for radiodiagnostic purposes and attempted to compare the effects of roentgen rays and radium in the treatment of tumors, irrespective of dosimetry. He concluded that radium had definite advantages for intracavitary application.[670] At the same time, in 1903, Margaret Cleaves,[B] of New York, was pioneering the vaginal application of radium for cancer of the cervix. In collaboration with his brother Charles, Williams investigated the possibilities of the use of radium in the treatment of inflammatory diseases of the eye.[671] He also turned the X rays on prostatic hypertrophy[672] and suggested irradiating early cases of cancer of the breast.[673]

In 1908, the Department of Radiology was moved to the basement of the Burnham or Peabody Building and given larger space at Boston City Hospital. In collaboration with the hospital's pathology department, Williams undertook a systematic comparison of radiographs of cadavers and autopsy findings.[674] Just before the start of the first World War, the department acquired its first Coolidge tubes to replace the old gas tubes. Shortly afterwards glass plates were replaced by films.

Williams served the Boston City Hospital as a Visiting Physician until 1915, when he retired as chief of the Department of Radiology, but remained as a consultant. For the greater part of these years Dr. Samuel Walker Ellsworth (1870–1942) was his associate and became his successor. In 1918 Williams was president of the Association of American Physicians, giving an address emphasizing the importance of bedside teaching.[675] He also developed an intraoral instrument for the application of radium to hypertrophic tonsils.[676] The Executive Committee of the American Radium Society chose him as one of its earliest honorary members. He became a member of the American Roentgen Ray Society in 1921. At the twenty-fifth annual meeting of that society in Swampscott, Massachusetts, in 1924, he reported his reminiscences and his continued work in stereo-fluoroscopy and radium therapy.[677] Primarily a radiodiagnostician, Dr. Williams was also unquestionably a true pioneer of radiation oncology. In 1924 the Department of Radiology of the Boston City Hospital was moved to the first floor of the newly erected Thorndike Building. The modern facility was named the Francis H. Williams Memorial X-Ray Laboratory, and Williams was honored by an appropriate memorial wall panel.

Little has been recorded of Dr. Williams's later years. Mrs. Williams died in 1935; the couple had no children. Dr. Williams's life ended on 22 June 1936, in the Phillips House of the Massachusetts General Hospital.[471] The funeral took place at the Mount Auburn Crematory. Dr. Williams made a bequest of $100,000 to be known as the William Barton Rogers

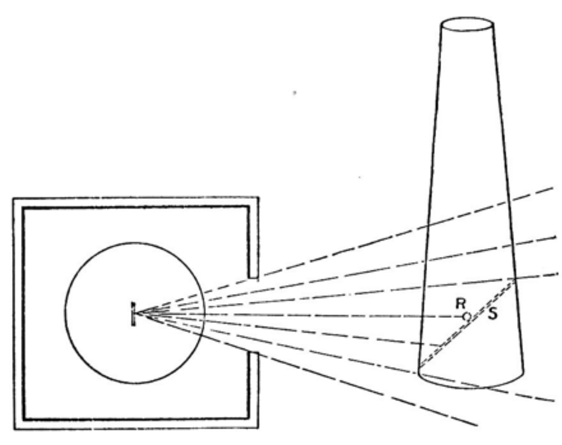

Fig. 2-14. Sketch of Williams's fluorometer to measure difference in output of X rays from various tubes. Small radium source (R) on fluorescent screen is observed through the closed tube until it is equaled by the X-ray beam.

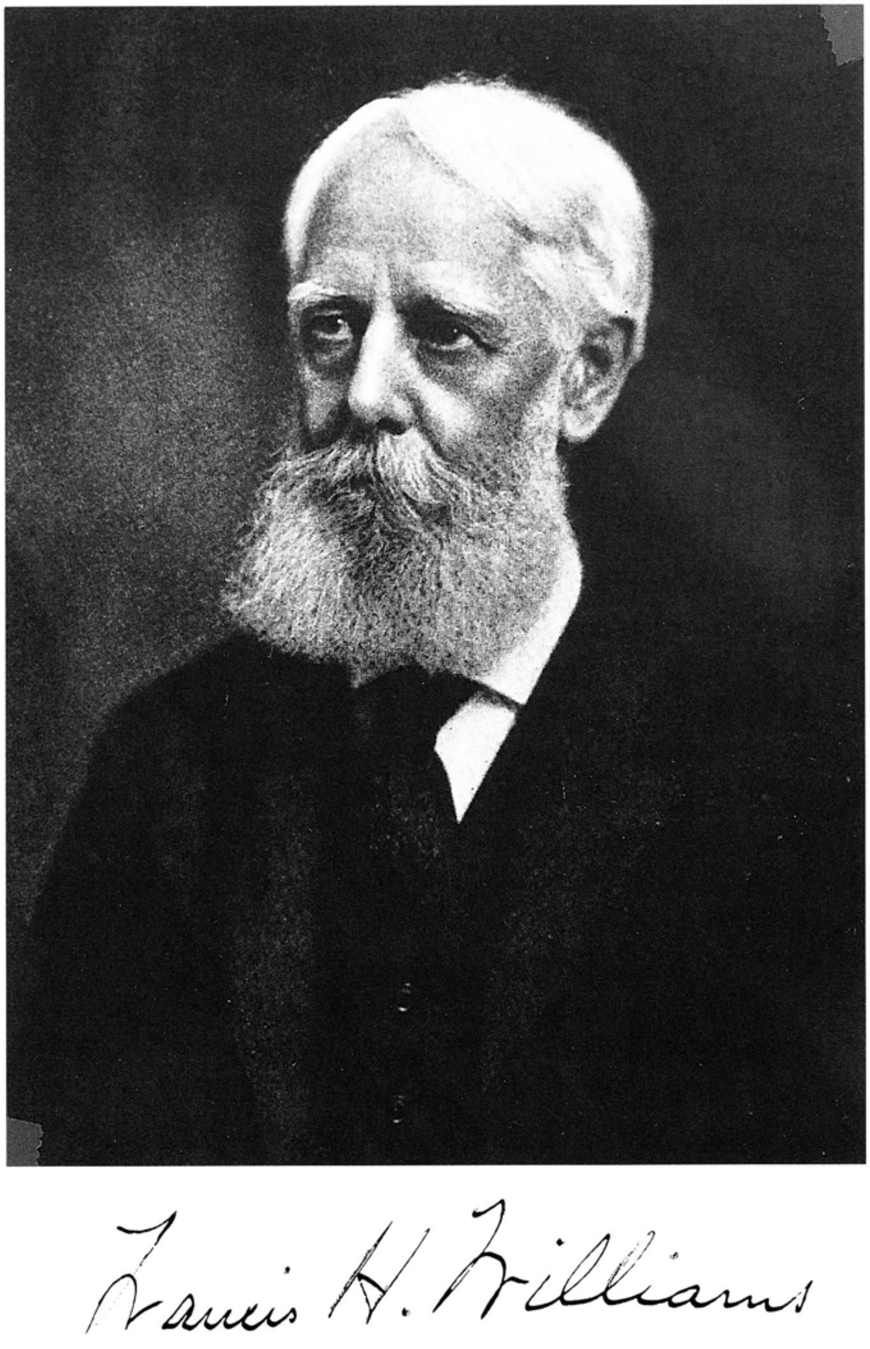

Fig. 2-15. Dr. Francis H. Williams, 1924.

and Emma Savage Rogers Fund at M.I.T. He wrote "I make this bequest for the promotion of pure science because I believe that pure and applied science should work together since they not only assist but stimulate each other." He stipulated that for the first twenty years the interest should accrue to the capital, and thereafter eighty percent of the annual interest should be granted for research. By 1971 the fund had grown to over two million dollars.

Francis Henry Williams was a tall gentleman of sedate and dignified bearing with the least touch of diffidence, wrote Percy Brown (1875–1950). He moved with a gracious stride through the patient wards and made a lasting mark in the minds of his contemporaries.[92] From a distance, we gather that he was a cultured man of wealth and position, original but not eccentric, humble but not sanctimonious, aloof but not snobbish, nursing his privilege with a romantic sense of honor and inner elegance—in short, a model Boston Brahmin (Fig. 2-15).

The valuable work of Dr. Williams in the early period of roentgen ray investigation, wrote Preston Manasseh Hickey (1865–1930), distinguished him as one of the pioneers of American roentgenology. His work constitutes a considerable part of the foundation of our knowledge.[280] Williams was the first to prove that cancer of the lower lip could be cured by the X rays, wrote Frederick William O'Brien (1881–1965).[449] His early recognition of the importance of protection of patients and personnel, and his persistent practical efforts in this respect distinguish him from the majority of his contemporaries.

The fifth International Congress of Radiology was held in Chicago in the summer of 1937, under the presidency of Arthur Carlisle Christie (1879–1956). Unable to attend, Antoine Béclère, former president and member of the Executive Committee, sent a sound film of himself to be shown at the inaugural session of the Congress. Appearing on the screen, the venerable eighty-one-year-old master said:

> My gratitude to the radiologists of the United States is of long standing. In 1901 ... an admirable book ... was published in this country ... on the services rendered by Röntgen's discovery regarding both diagnosis and treatment of the sick .... I read it avidly and was amazed at the therapeutic successes ... obtained at a time when there was no means of measuring radiations. But my experience with my own patients was to prove them right. I met the author, Dr. Francis Williams, two years later when he came to Paris to procure some radium. I admired the man, as I did his book, and soon a friendship was set up that lasted until his recent death. All the physicians who since have entered the new pathway of roentgentherapy owe a deep debt of gratitude to this great pioneer of medical radiology.[71]

Subject Notes

2.1 The direct line of Dr. Francis Williams's paternal ancestors reveals a succession of freemen of Salem, Massachusetts. George Williams, a wealthy cooper, married Marie and died in 1654. Their son, John Williams (1636–1697), married Elizabeth in 1665. Their son, John Williams, Jr. (1664–1732), was also a cooper. He married Sarah Manning in 1686. Their son, Henry Williams (1704–1756), a boat captain, married Mary Waters in 1727. Their son, Henry Williams, Jr. (1744–1814), a master mariner, married Abigail Russell from Andover in 1770. They became the parents of Willard Williams, Dr. Francis Williams's grandfather.