I. Wilhelm Conrad Röntgen

"Der Kürze halber möchte ich den Ausdruck "Strahlen" und zwar sur Unterscheidung von auderen den Namen "X-Strahlen" gebrauchen." (1895)

Wilhelm Conrad Röntgen was born March 27, 1845 in the lower Rhine town of Lennep, the only child of Friedrich Conrad Röntgen, a well-to-do textile merchant, and of his Dutch wife, and cousin, Charlotte Constance Frowein. When Wilhelm was three years of age, his parents moved to Apeldoorn in Holland, the home of his maternal grandparents, and became Dutch citizens. He attended primary school in Apeldoorn and boarding school at Middelaan. At age 17, he registered at a private Technical School in Utrecht. He lodged in the home of one of his professors, Dr. Jan Willem Gunning, a fine scholar who became his tutor, guide, and mentor; Wilhelm was to remain loyal and affectionately devoted to him ("...your place in my heart never became empty"). Wilhelm served as instructor in chemistry and wrote a section in the professor's textbook. Towards the end of his studies at the technical school, a disparaging caricature of one of the teachers appeared on a blackboard. Because Wilhelm refused to reveal the name of the mischievous artist, he was expelled from the school as an accomplice. As the only alternative he audited courses and was privately tutored but he failed to gain admission at the University of Utrecht. His lofty dream of higher education had vanished.[216] (Figs. I-1 and I-2.)

In 1865 Röntgen learned that the Zürich Polytechnikum accepted students without the customary credentials, provided they passed a stiff entrance examination; he applied for admission and, upon consideration of his documents and letters, the examination was waived. Röntgen was a tall, slender, and broad-shouldered young man with distinguished facial features: ample forehead, deep-set brown eyes, thick and wavy black hair, and well-groomed sideburns. He dressed impeccably: he wore a soft wing collar with a large bow cravat and a gold chain across his vest. He was reserved and rather shy but very friendly; his eyes betrayed both his determination and his kindness. (Fig. I-3.)

At age 23, Röntgen finished his studies on mechanical engineering with excellent grades, and in June 1869, after acceptance of his dissertation, "Studien Uber Gase," *Guilielmo Röntgen, Apledoornensi*, received his diploma of *Doctoris Philosophiae* from the University of Zürich. On the evening of his graduation he eagerly hiked the steep *Leiterlei* up to the Uetliberg "to meet and share his joy with an admired friend at a health resort: she was Anna Berta Ludwig (1839–1919), the daughter of a German political refugee and innkeeper. She was tall and slender and possessed unusual charm. She lacked formal education but had been brought up to be orderly, "sincere" and morally

Fig. I-1. Wilhelm C. Röntgen, age 17 (1862).

Fig. I-2. Modern photograph of Röntgen's home in Apledoorn, Holland.

upright. Berteli and Willi often sailed on the blue waters of Lake Zürich. Their tenderness for each other grew from the vastness of their mutual interests and the intensity of their intellectual interchange.

August Edward E. Kundt, an experimental physicist, known for his work on sound, offered Röntgen an assistantship ("Kundt...introduced me to physics and thus removed the doubt and uncertainty regarding my future"). In 1870, Kundt accepted the chair of physics at the University of Würzburg and Röntgen went along as his assistant. On January 19, 1872, Berta and Wilhelm were married and moved into an apartment in Heidingsfelderstrasse; she assumed all of the household chores and he faced the demands of his exacting position. His early failure to obtain the Abitur proved to be an academic obstacle.[288]

In April 1872, Röntgen followed Kundt to the Kaiser-Wilhelms University at Strassburg where in March 1874, he became a *Privat Dozent*. With no further obstacles to his academic career, he undertook to do fundamental research. He proved himself a serious experimental physicist, conducting well conceived experiments and reporting them in a precise manner. Kundt became the most important scientific influence on Röntgen's life; together they studied piezoelectric properties and thermal conductibility of crystals. Röntgen responded to the lure of a professorship of his own at the Agricultural Academy of Hohenheim, Württemberg, but after 18 months he accepted Kundt's offer to return to Strassburg as an associate professor of theoretical physics. A passionate hiker, he enjoyed the Alsatian forests and the Vosges mountains ("If I ever should be missed, never look for me on the main road").

In 1879, Röntgen was appointed Professor of Physics at the Hessian University of Giessen and there he lived contentedly for nearly a decade. He lectured five hours and offered two practical exercises weekly during both semesters. He improved the University laboratories, continued his studies on the properties of crystals and of the absorption of heat by water vapor, and wrote 15 additional papers. His parents moved to Giessen and shortly afterwards his mother died: he strongly identified with her and was grieved for a long time ("... how far does motherly love reach beyond the grave"). His father died also in Giessen. Not having children of their own, the couple decided to adopt Berta's niece, who became their legal heir. The Röntgens enjoyed spending their *grosse Ferien* in the Swiss peak of Pontresina in the Engadine.

Röntgen acquired a reputation as an investigator with his study of electrical effects of moving dielectrics, a work which coordinated to perfection his genius as a theorist and his ability for experimentation. The "Röntgen current," his colleagues called the electro-dynamic force essential to the concept. His fame brought him offers from the Universities of Jena and of Utrecht, both of which he declined. Then the Königliche University of Würzburg offered him the chair of physics plus the directorship of the new Physikalische Institut. The position entitled them to spacious living quarters above the laboratories in Pleicher Ring. Thus, in 1888, he returned to the University where, 16 years previously, he had not been able to become *Privat Dozent,* and to the beautiful city on the River Main where he and his bride had made their first home. His teaching schedule was as full as at Giessen. He lectured in a black cutaway coat. He had allowed his mustache and beard to grow freely, acquiring a patriarchal appearance that matched his demeanor. (Fig. I-8.) His lectures were meticulously prepared but monotonously delivered in a fast, deep voice which was difficult to follow.[231] His examinations were comprehensive, difficult, and dreaded ("Don't pamper the students.... Let each find his own way out of difficulties"). Despite his classroom commitments, he did research on the compressibility of liquids, the conductibility of electrolytes, and the thermal coefficient of expansion, and he published 17 additional papers. Röntgen enjoyed the social graces as well as the scientific brilliance of his faculty colleagues at Würzburg. An outdoor enthusiast, he often went hunting in the Rimparer Wald.

Röntgen was 49 years of age when he was elected Rector. Upon assuming the highest office of the Julius–Maximilian University of Würzburg, he quoted Werner von Siemens:

> If some phenomenon which has been shrouded in obscurity suddenly emerges into the light of knowledge...if the missing link of a chain of thoughts is fortuitously supplied, this then gives to the discoverer the exultant feeling that comes with a victory of the mind...which lifts him to a higher plane of existence.

The new Rector, *Wilhelm Conrad Röntgen,* had served for six years as Professor of Physics and Director of the Physical Institute at the Bavarian Universi-

ty. Already a well known and respected teacher and researcher, he had yet to face his own fateful challenge, to prove his mettle by his ingenious response, and to experience the exultation of original intellectual achievement. "The University is a nursery of scientific research and of mental education," he said, "a place for cultivation of ideals for students as well as for teachers. Its significance as such is much greater than its practical values... . Every genuine scientist...is an idealist in the best sense of the word... ."

"Only gradually," he insisted, "has the conviction gained importance that experimentation is...the most reliable lever enabling us to extract secrets from nature, and that the experiment must constitute the final judgment as to whether a hypothesis should be retained or discarded."

Early in 1894, Röntgen's attention had been caught by the work on *cathode rays* of Philipp Lenard (1862–1947).† When engaging in a new line of research, he usually repeated the precedent experiments. He corresponded with Lenard and purchased tubes, photographic plates, and fluorescent materials. There is evidence that, in March 1894, he had started some work. Probably because of the added academic obligations thrust upon him, he was unable to devote enough time to experiments or publications for several months. In the fall of 1895, he resumed his work but no longer with Lenard type tubes or other equipment; he adopted the arrangement of a condenser and transformer between the coil and the tube, as suggested by Nikola Tesla (1856–1943).

On Friday, November 8, 1895, Röntgen was experimenting with a Hittorf-Crookes high-vacuum tube covered with a cardboard and tinfoil jacket. To test that the jacket was lightproof, he connected the electrodes of his Ruhmkorff coil and passed a high tension discharge through the tube. In the dark, he noticed a shimmering light ("Leuchtschirm"), as a reflection on a mirror, coming from a point on a work bench about one yard away. Lighting a match, he identified the shining object: a piece of paper painted with barium platinocyanide. Obviously, something excited the fluorescence at much greater distance than it was possible for cathode rays to do. Absorbed in his work, Röntgen delayed responding to his wife's summons for dinner in their adjoining quarters; when he finally sat at the table, he failed to appreciate her culinary offering, returning promptly to the laboratory. Early the next day and in subsequent days and weeks, Röntgen devoted all his attention to the study of the observed phenomena, eating his meals, and sometimes sleeping, in the laboratory. He spoke to no one about his work; his assistants found him irritable and less approachable than usual.

Four days were required to achieve the desired vacuum in his tube. Having repeatedly verified his experiment, he noted that an interposed wire projected a shadow on the fluorescent paper but a book of 1000 pages was no obstacle, and the same was true of blocks of wood and sheets of rubber. He compared the relative "transparency" of various thicknesses of aluminum, silver, copper, zinc, platinum, and found 1.5 cm of lead

Fig. I-3. Röntgen with members of his family (about 1875).

† See Biographical Notes on page 171.

Fig. I-4. Artist's conception of the moment of discovery. (Courtesy of General Electric Co.)

to be entirely opaque; lead, in paint and glass, also caused relative opacity. He measured the intensity of the fluorescence to be inversely proportional to the square of the distance from the tube. He noticed that the fluorescence of the barium platinocyanide was visible on both sides of the paper on which it was painted. Placing a piece of metal in front of the paper screen, he noted the shadow of his fingers and the darker image of the bones within; thus, the *first fluoroscopy* took place. It occurred to him that many of these phenomena could be recorded on photographic plates; thus, he made radiographs of several objects. On December 22nd, he asked Berta to lend him a hand and took of it the first clinical roentgenogram; he suggested to her that others could probably say he had gone crazy ("Der Röntgen ist wohl verrükt geworden").

On December 28, 1895, Röntgen delivered to the Secretary of the Würzburg Physical and Medical Society, a handwritten paper entitled, "Ueber eine neue Art von Strahlen," on a new kind of rays. In a footnote, he explained that "to differentiate them from others" he would call them x rays ("...und zwar zur Unterscheidung von anderen den Namen 'X-Strahlen' gebrauchen"). On New Year's day, Röntgen sent printed copies of his article (the word *Ueber*, was now omitted) and prints of his radiographs to a few colleagues. The historically privileged recipients were: Jules Henri Poincaré (1854–1912) of Paris; Lord William Thomson Kelvin (1824–1907) of Glasgow; Sir Arthur Schuster (1851–1934) of Manchester; Hendrick Antoon Lorentz (1853–1928) of Leiden; Otto Lummer (1860–1925) of Berlin; August Voller (1842–1920) of Hamburg; Frederich Wilhelm Kohlrausch (1840–1910) of Strasbourg; Ludwig Louis Albert Zehnder (1854–1949) of Freiburg; and Franz Serafin Exner (1849–1926) of Vienna. It was through Exner that the news of the discovery found its way to the lay press: on Sunday, January 5, 1896, the Vienna *Freie Presse* (the "Reklametrompete," Röntgen called it) carried the front page news which rapidly spread worldwide. Kaiser Wilhelm con-

gratulated him and requested a private lecture; on the afternoon of January 14, Röntgen made a demonstration before the august audience in Berlin: he was given the Prussian Order of the Crown. It was not until January 23rd that Röntgen was called to make the formal presentation of his paper before the Physicalisch-Medizinische Gesselschaft. The reception given him by his colleagues and students was heart-warming. During the presentation he took a radiograph of Albert Rudolf Köhllicker (1817–1905), Professor of Anatomy. As the developed plate was shown, the audience broke into applause; von Kölliker proposed that thereafter the rays be called *Röntgen's rays.* (Fig. I-7.)

In his first ten-page report, subtitled as preliminary (Vorläufige Mitheilung) and divided into 17 numbered sections, Röntgen discussed the properties of the new rays as different from light and from cathode rays. Defining them as a thing in themselves, he admitted that their true nature was not known, that they originated on the tube's glass wall (Fig. I-6) at the site of impact of cathode rays, that they could not be reflected, refracted, or deflected.

A second communication followed shortly with five additional sections in seven pages. He reported (March 1896) that the rays were capable of discharging an electrometer and, likewise, to discharge insulated dielectrics; he gave a scale for measuring x-ray intensity by fluorescence and by photographic means; he also recommended the use of a concave aluminum cathode and of a platinum anode placed at its focus in a 45° angle. (Fig. I-9.) A year later, he made a third communication, with 17 pages and 11 sections in which he enumerated eight variables affecting the intensity of x-ray emission. He classified tubes as "hard" and "soft" and indicated that they became harder with use, that the harder the rays, the greater their penetration. He left little for others to add about the new rays.

There is now little doubt that for at least 20 years previously, experimental physicists, including Sir William Crookes (1832–1909), Johann Wilhelm Hittorf (1824–1914), and Philipp Lenard had failed to recognize their identity. This, of course, should add to, rather than detract from, Röntgen's credit. "The physicist," Röntgen wrote, "must start with certain resignation...that his work will be superseded by that of others...that his methods will be improved upon, more accurate results obtained and that the memory of his life and his work will gradually disappear." This certainly applied more to his predecessors than it did to himself, mostly due to the thoroughness of his inquiry.

"As soon as the paper was published," wrote Berta to a cousin in Indianapolis, "our domestic peace was gone": the pain of fame! Public speculation on the "*photograph of the invisible*" was rampant. In England newspapers carried advertisement of *x-ray proof undergarments* for ladies. In New Jersey, an assemblyman introduced legislation to forbid the use of x-ray opera glasses! Even today it is difficult to imagine the extraordinary interest and vertiginous activity motivated by Röntgen's discovery: over 1,000 scientific papers and 50 books were written on the use of the newly discovered rays during 1896.

The news of the discovery appeared in the Chicago newspapers on January 9, 1896. Emil Herman Grubbé (1875–1960), a student instructor at the Hahnemann Medical College who made a living manufacturing vacuum tubes for laboratories, promptly proceeded to experiment with a coil and tube.[232] On January 27th just four days after Röntgen's official presentation in Würzburg, Grubbé† exhibited his reddened hands to members of his faculty. As a consequence, one of his professors referred to him a patient with recurrent cancer of the breast; two days later, Grubbé started a series of fractionated irradiations that lasted over

Fig. I-5. Reproduction of the original roentgenogram of Frau Röntgen's hand (December 1895).

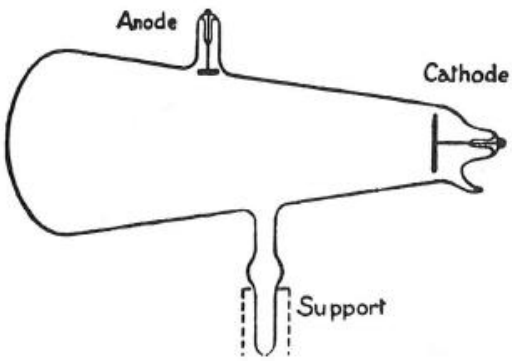

Fig. I-6. Tube of the type used by Röntgen in his discovery.

† See Biographical Notes on page 171.

Fig. I-7. Artist's reconstruction of the historic presentation in Würzburg and the taking of a radiograph of Professor von Köhllicker's hand (January 23, 1896). (Courtesy of Parke Davis Co.)

three weeks. Within days, John Daniel, a professor of physics at Vanderbilt University, was making radiographs of his minister's hands; Daniel conceived the idea of a radiograph of the brain. He talked Dr. William L. Dowell, Dean of the Faculty of Medicine, to pose for a long exposure: nothing came out of it except Dean Dowell's hair, the first observed and published radiation epilation.[147]

A constellation of dedicated workers joined in the vertiginous efforts to exploit Röntgen's and the Curie's discoveries in the field of medicine. Hermann Heineke (1873–1922), Jean Alban Bergonié (1867–1926), and Claudius Regaud (1870–1940) were among those investigating radiobiologic mechanisms. William Duane (1872–1935), Louis Frederic Wickham (1861–1913), and Henry Harrington Janeway (1873–1921) contributed to the development of *curietherapy*. Antoine Louis Gustave Beclère (1856–1939), Francis Henry Williams (1852–1936), Guido Holtzknecht (1872–1931), Gösta Forssell (1876–1950), and countless others sought to utilize the possibilities of *radiodiagnosis*. Leopold Freund (1868–1943), William Allen Pusey (1863–1940), Robert Kienböck (1871–1954), George Clemens Perthes (1869–1927) aided the first steps of *roentgentherapy*. Friedrich Dessauer (1882–1963), Eugene Wilson Caldwell (1870–1915), Henri Dominici (1867–1926), and a number of others contributed to the early development of *medical physics*.

Antoine Henri Becquerel (1852–1908), a professor of physics at the Paris Sorbonne, was motivated by Röntgen's discovery when he reported the x-ray-like property of uranium to fog photographic plates and to incite fluorescence. His observation led Marie Sklodowska (1867–1934) and Pierre Curie (1869–1906) to a pursuit that brought forth their transcendental discoveries. The door was opened for theoretical physicists to consider conceptual revisions. Max Karl Ernest Planck (1858–1947) developed a new theory of the nature of radiations that was to be the basis of revolutionary new concepts. Ernest Rutherford (1871–1937) conceived a revised structure of the atom, and Niels Henrick David Bohr (1885–1962) reinforced it with quantum support. Albert Einstein (1879–1955) gave thoughtful support to Planck's theory in the interpretation of the phenomenon first observed by Lenard[16] as photoelectric effect. The basis was laid for the eventual development of quantum mechanics.

Röntgen received the Royal Order of Merit of the Bavarian Crown, but deliberately forfeited the right to the name *von Röntgen* by not making the required application. Yet he was thrilled by a *Fackelzug* on Pleicher Ring organized in his honor by the students. "Few among you," he told the torch paraders, "might be so fortunate as to receive this rare distinction, but all of you may enjoy the inner satisfaction that will come with your successful efforts." In 1900, he was appointed Professor of Physics at the Ludwig-Maximilians University of Munich. In 1901, chosen among twelve candidates, he received the first Nobel Prize for Physics. At the Nobel Banquet, Röntgen spoke eloquently of Northern mythology and of his own saga come true. He turned over the rich cash prize to the

Fig. I-8. Röntgen at the time of his discovery; facsimile of his signature.

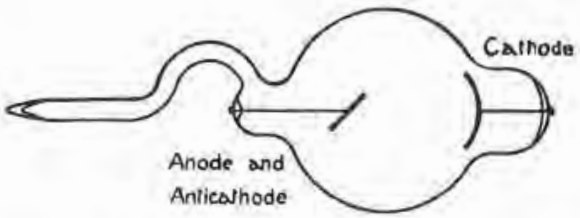

Fig. I-9. Type of tube recommended by Röntgen with concave cathode and angled anode target.

University of Würzburg. A grace of six months was granted for the delivery of his formal lecture. He worried about the preparation of the text, about technical details of its presentation, admitted to "stage fright," obtained a postponement and finally, seized upon a polite statement of the Nobel Committee and declined to return.[251] Röntgen was a very poor public speaker and at least on one occasion he brought considerable embarrassment upon himself and others because of it (Grundsteinlegung of the Deutsches Museum of Munich). In 1905, to celebrate the tenth anniversary of the discovery, the Deutsche Röntgen Gesellschaft called a congress in Berlin. Röntgen protested the use of his name, refused to attend but sent a letter of thanks. Radiologists in England and in the United States had also adopted his name for their societies.

In 1912, working in Röntgen's physics laboratory, Max Theodor Felix von Laue (1879–1960) studied diffraction of light in crossed gratings and suggested to Walter Friedrich (1883–1971) and Paul Knipping (1883–1935) the experiments with narrow beams of rays and copper crystals, resulting in remarkably important new avenues of research in x-ray diffraction.[87]

Despite persistent attempts, Röntgen refused all suggestions that he profit by his discovery ("I am of the opinion that...discoveries and inventions belong to humanity..."). This unselfish attitude was enough to make him unpopular among industrialists. Moreover, in order to retain his dignity and to carry on work he was obliged to refuse, indiscriminately, a flood of honors offered to him. He developed a reputation as inapproachable, intolerant and gruff, yet he continued to teach and experiment.

Mrs. Röntgen's health declined; she required time and attention which he devotedly gave ("Ich wunschte... . Sie hatten so einen guten Mann wie ich"). Their daughter married and they were again alone, with their trusted housekeeper. The years of the first World War were hard on them: a reduced circle of friends, food shortage, and their inability to travel, in addition to the anxiety produced by the war news, took a great deal out of both. On October 31, 1919, Berta, six years his senior died at the age of eighty. For years, she had required five or more daily injections of morphine which he administered personally. ("I want to help and console my poor wife in her dark hours".) Röntgen resigned his position at the University and, in the inflation that followed the war, he found his savings of a lifetime wiped out; even his foreign securities had to be turned over to the authorities. Loneliness weighed heavily on him ("I try to live as I imagine my wife would find satisfactory").

To celebrate the 50th anniversary of Röntgen's doctorate, the Prussian Academy of Sciences sent him a letter in which his scientific contributions were enumerated, then added:

> Probably never has a new truth from the quiet laboratory of a scientist made triumphal progress so quickly and universally as has your epoch-making discovery of those wonderful rays. The expectations as to the technical and practical value of the new discovery...have been far surpassed by the actual developments.

The postwar implementation of William D. Coolidge's hot cathode tube became a most important stimulus to the development of radiology. With better control of intensity and penetration and the advent of a catholic dosimetry, roentgentherapy was ready for greater utilization. Claudius Regaud's momentous contribution and the subsequent understanding of the protracted fractional application of radiations brought about better results and wide appreciation and acceptance of radiotherapy in a variety of malignant tumors.

Fig. I-10. Bust of Röntgen by N. I. Altmann, at the Leningrad's Institute of Röntgenology and Oncology.

Through the kindness of a friend, in 1922, Röntgen spent a vacation in the Swiss mountains. It was a journey full of memories; it was "as a pleasant dream" ("How much that is good and beautiful do I have to thank [Switzerland] for"). Then he returned to his solitude, visited occasionally by close friends. He was weakened by cancer of the rectum which was only diagnosed in its terminal stage.* On February 10, 1923, he expired with only his devoted housekeeper nearby. His ashes were given a place beside his wife in the Alte Friedhof of Giessen.

Wilhelm Conrad Röntgen was not an ordinary man. German by birth and breeding, he was educated and inspired by Dutch and Swiss masters. Giving no signs of genius in his childhood and adolescence, he rose to be one of the outstanding experimental physicists of his time. Treading on territory that had been explored by his most notable contemporaries, he observed and discovered what they had obviously overlooked; he was remarkably prepared to exploit the unanticipated phenomenon and thoroughly analyzed and defined the newly discovered radiations, leaving little for others to add.

Röntgen's experiments were simple and brilliantly conceived; his papers are examples of comprehensive yet succinct presentations of thought. An indefatigable worker, he expected a similar dedication in his associates ("Es muss einem in Blut Fliessen"); he treated them cordially but remained formal and authoritative. Privately, he displayed loving kindness, great sensitivity, and a sense of humor. He was a devoted teacher who detested pretense and tolerated no frivolities, but he was a dull lecturer; he was attentive to the eager student but had no patience with the dabbler.

For all his greatness, Röntgen was also the subject of inscrutable pathos. His emotional lifetime was the eminent domain of two women, his mother and his wife. Genuinely shy and admirably modest, he was diffident towards strangers and could not differentiate the opportunist from the honest dissenter, the importune from the genuine admirer. He disdained honors but was not above being mortified by envious gossip; he was capable of vehement quarrels and of breaking up friendships over trifles. But above these petty details of character towered a genial experimental scientist of outstanding integrity and exemplary unselfishness.

In the winter of his life, Röntgen suffered the repeated rumors that the discovery was not really his, that he could not help to have made it, that he was a bystander. Most of these rumors lacked legitimate paternity, except those originated by Lenard and some of his associates; the rumors grew to be not only baffingly unrelated to the facts but also mercilessly cruel. Lenard's enmity was apparently initiated by the award of the first Nobel Prize for Physics to Röntgen: "In recognition of the extraordinary services he has rendered by the discovery of the remarkable rays which have subsequently been called after him."[290] Two years later, Lenard was also awarded the Nobel

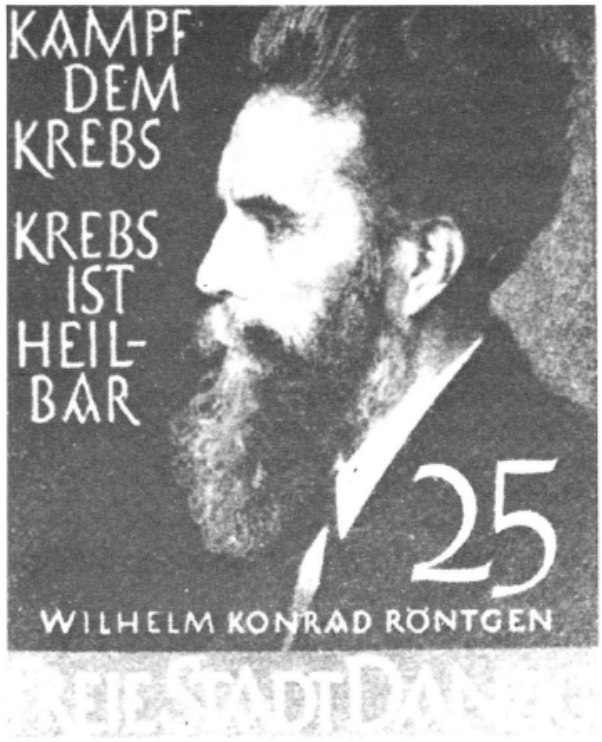

Fig. I-11. Postage stamp of the formerly Free State of Danzig, honoring Röntgen.

Prize for his work on cathode rays. In his Nobel Lecture, Lenard related the evolution of his own discovery; then he added slyly: "...it seems to me that the discovery (of x rays) at this stage appeared to follow *automatically*." There started his long yarn, which became worse with the long years of his life. Lenard became openly antisemitic: at a meeting of the *Naturs-forscher Gesselschaft*, called at Bad Nauheim near Frankfurt, under the chairmanship of Max Planck, Lenard lent the prestige of his position as professor at Heidelberg to an impassioned attack on Einstein with unmistakable antisemitic undertones.[325] In his books, he repeatedly presented Röntgen as a midwife, present but not responsible for the birth: he further referred to Röntgen as an opportunist, conveniently overlooking that Röntgen not only had observed the presence of the rays that so many others had failed to identify, but had also thoroughly studied the new rays and created order in a sphere that was entirely outside all previous human experience.[290]

Röntgen had requested in his will that all his papers and correspondence be burned; this was later used to imply that he was trying to cover up something. However, rather foresightedly, he made an exception for certain letters that were jealously kept in a safe at the Würzburg Institute. One of these letters was written by Lenard on May 27, 1897, over a year after the discovery but before the Nobel award. With candor and truthfulness later abandoned, Lenard had written:

> "Because your great discovery caused such swift attention in the farthest circles, my modest work also came into the limelight, which was of particu-

* See Subject Notes on page 183.

lar luck for me, and I am doubly glad to have had your friendly participation...especially through the presence of the ray discovered by you..."[173]

In September 1945, Lewis Elmer Etter (1901–1979), an American radiologist, visited occupied Würzburg and had two interviews with octogenarian Lenard. Asked about his early candid recognition of Röntgen's merit, he replied that he had been too modest and that he had expected Röntgen to reply that "he owed it all to me." Asked if Röntgen was a Jew, he said, "No, but he was a friend of Jews, and he acted like one."[173] Disappointed in himself for not having made the discovery, rancor and bigotry had corroded a brilliant mind and maimed Lenard's character.