

W. C. ROENTGEN AND THE DISCOVERY OF THE ROENTGEN RAYS

OTTO GLASSER

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Thirty-five years ago, on November 8, 1895, Wilhelm Conrad Roentgen made the revolutionary discovery of a mysterious new kind of ray which he called the "x-ray." Thirty-five years is too short a period of time in which to obtain the proper perspective by which to judge the significance of this revelation or to appreciate fully the genius of the man who made this remarkable discovery and beneficently gave it to the world. On the other hand, thirty-five years is so long ago that it is difficult to obtain authentic facts from original sources bearing directly upon the manner in which the existence of the roentgen rays was first revealed to their discoverer. Fortunately, however, there are some persons still living who had personal and intimate contact with Roentgen and can relate their experiences with authority, and who can also vouch for the veracity of the early reports of the discovery.

According to the statements made by these persons, this peculiar and inexplicable phenomenon was first manifested by the fluorescence of a small barium platinum cyanide screen under the influence of the penetrating rays emitted from an excited Crookes tube. A detailed description of Roentgen's discovery was given by Sylvanus P. Thompson, a well-known English physicist, himself an enthusiastic x-ray research worker and president of the newly founded British Roentgen Society, at a meeting held on Friday, November 5, 1897, at St. Martin's Town Hall in London. Roentgen had modestly declined an invitation to address this historic meeting. Thompson's report of the discovery agrees with many others, and according to our studies, must have related the events as they actually occurred. Sylvanus P. Thompson said in this address:

"November the eighth, 1895, will ever be memorable in the history of Science. On that day a light which, so far as human observation goes, never was on land or sea, was first observed. The observer, Prof. Wilhelm Conrad Roentgen. The place, the Institute of Physics in the University of Wurzburg in Bavaria. What he saw with his own eyes, a faint flickering greenish illumination upon a bit of cardboard, painted over with a fluorescent chemical preparation. Upon the faintly luminous surface a line of dark shadow. All this in a carefully darkened room, from which every known kind of ray had been scrupulously excluded. In that room a Crookes' tube,

stimulated internally by sparks from an induction coil, but carefully covered by a shield of black cardboard, impervious to every known kind of light, even the most intense. Yet in the darkness, expressly arranged so as to allow the eye to watch for luminous phenomena, nothing visible until the hitherto unrecognized rays, emanating from the Crookes' tube and penetrating the cardboard shield, fell upon the luminescent screen, thus revealing their existence and making darkness visible.

"From seeing the illumination by the invisible rays of a fluorescent screen, and the line of shadow across it, the work of tracing back that shadow to the object which caused it, and of verifying the source of the rays to be the Crookes tube, was to the practiced investigator but the work of a few minutes. The invisible rays — for they were invisible save when they fell upon the chemically painted screen — were found to have a penetrative power hitherto unimagined. They penetrated cardboard, wood, and cloth with ease. They would even go through a thick plank, or a book of 2000 pages, lighting up the screen placed on the other side. But metals such as copper, iron, lead, silver and gold were less penetrable, the densest of them being practically opaque. Strangest of all, while flesh was very transparent, bones were fairly opaque. And so the discoverer, interposing his hand between the source of the rays and his bit of luminescent cardboard, *saw* the bones of his living hand projected in silhouette upon the screen. The great discovery was made."

This report, given here in the exact words of the great English scientist, was published in November, 1897, in the second volume of the world's first journal of roentgenology the English *Archives of Skiagraphy*, or as it was afterwards called, the *Archives of the Roentgen Ray*.

Inevitably many stories and fables are spun about discoveries and inventions of great significance and the birth of the x-ray did not escape this fate. The most popular story, perhaps, is the myth of the book and the key. It is repeated from time to time and recently again made the rounds through the newspapers in the following form:

"Prof. Roentgen once placed an experimental electric tube upon a book beneath which was a photographic plate holder, loaded. Some time later he used the plate in his camera and was puzzled, upon developing it, to find the outline of a key on the plate. He investigated and discovered a key between the pages of the book on which the experimental lamp had rested. The strange 'light' from the electrical discharge in the glass tube had penetrated the covers

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and pages of the book and the shield of the plate holder. Thus the x-ray was discovered.”

I have found this story to be unknown outside of the United States, and it certainly did not originate in Germany, but it is one which appeals to the imagination of the general public. It seems to be traceable to an account of a Chicago scientist by the name of T. S. Middleton who in 1895 was a student at the Wurzburg University and who incorrectly placed the date of the discovery in the Spring of the year 1895.

This story contains some inaccuracies even in its original form. The incident might have taken place after the discovery of the rays and if it did occur it might have directed Roentgen to the study of the photographic effect of the rays, but there are many reasons for questioning the veracity of this tale. Roentgen never spoke of any observations which might have had anything whatever to do with such an experiment. If this observation had been made in April, 1895, Roentgen would certainly have been the first to refer to it because he was always most conscientious and accurate in recording his data. Even Roentgen's two assistants, one of whom helped him to operate the vacuum pump with which the Hittorf and Crookes tubes were evacuated, did not know about the discovery of the x-ray until it was publicly announced late in December. If these co-workers who were in rather intimate touch with Roentgen's work did not know about the discovery until it was announced publicly, how much less insight must the students at the University have had into the work of their Professor! One of the few persons who knew about the discovery before the announcement was made was Roentgen's wife, Bertha. One evening in November, 1895, she became very angry with her absent-minded husband because he did not comment upon the excellent dinner she had prepared for him, and he did not even notice that she was angry until she asked him what was the matter. He finally took her downstairs to his laboratory, which was in the same building, and for the first time presented to her astonished eyes the wonders of the x-ray. We have in our museum a letter which Mrs. Roentgen wrote in March, 1896, to Prof. Roentgen's cousin, Mrs. L. R. Grauel, of Indianapolis, in which she relates how her husband told her of the discovery for the first time in November, 1895. This statement is, therefore, of great significance as it fixes the date of the discovery.

Another fable connected with the discovery, which occasionally emerges from oblivion and which was even recently broadcast by radio from Hamburg, is the story that the first observation of the fluorescent light was made by Roentgen's laboratory servant. It is



Fig. 1. Photograph of Wilhelm Conrad Roentgen taken at the time of his discovery of the x-rays. (From "Les Prix Nobel en 1901," Norstedt, Stockholm, 1904.)

perhaps of psychological interest that envious or ignorant individuals often repeat such stories in spite of well-founded historical facts to the contrary.

Roentgen's adopted daughter, who now lives in Hanover, Germany, but who at the time of the discovery was living with her foster parents in the Wurzburg Institute, states in a letter of April 2, 1930, that she remembers very distinctly that on the evening in which her father discovered the rays he was alone in his laboratory. Roentgen himself wrote a letter to Mrs. Boveri on April 28, 1921, in which he says in his characteristic manner: "Do you know that now Zehnder also heard the story that I did not make the first observation of the effects of the x-rays, but that an assistant or servant discovered them. What miserable envious man has invented this story?"

Was Roentgen's discovery of the roentgen rays accidental? Popular opinion would have us believe that it was! However, a careful study of the personality and the scientific background of Roentgen himself, as well as the events which led up to the actual discovery, and of the published comments of contemporary scientists, should emphatically disprove this theory. Roentgen was undoubtedly one of the outstanding physicists of the nineteenth century, even without taking into consideration his discovery of the roentgen rays. He began to experiment with cathode rays in October, 1896, because he was interested in many riddles which still existed in spite of valuable contributions to the subject which had been made by other investigators. Like all research scientists he was on the lookout for new phenomena, and was following in the path of all his illustrious predecessors from von Guericke to Lenard when he discovered "a new kind of ray." Roentgen's discovery was the final step in a brilliant and logical correlation of a multitude of facts which had been disclosed by many scientists. His glance at the fluorescent screen may be said to be the only accidental incident connected with the discovery. But how well Roentgen knew the explanation of this almost insignificant phenomenon! Many scientists before him — Crookes, Goodspeed, Goldstein, Lenard, and others — had made similar observations but had entirely forgotten about them until Roentgen's announcement was made. It was his keen observation and the accuracy of his critical judgment, together with his great experimental skill which made his discovery of such tremendous significance.

It is interesting to note that one year before Roentgen made his discovery he gave an address as the President of the Wurzburg University and in this speech quoted some of the thoughts of one of his

predecessors in the chair of Physics and Philosophy, Prof. P. A. Kircher, who as early as 1602 made the following statement: "Nature often reveals the most astonishing phenomena by the simplest means, but these phenomena can only be recognized by persons who have sharp judgment and the investigative spirit, and who have learned to obtain information from experience, the teacher of all things." How applicable this centuries-old assertion



Fig. 2. First x-ray picture of a hand taken by Roentgen in November, 1895. (Courtesy of the Physical-Chemical Institute of the University of Vienna, Prof. Dr. E. Haschek.)

was destined to become in the case of Roentgen's own discovery and how strange that he should have quoted it a year before the great event! Very similar in spirit was that short comment which was made by the philosopher, Münsterberg, of Harvard University, shortly after the announcement of the discovery when he refused to subscribe to the idea that it was entirely accidental by saying, "Suppose chance helped, there were many galvanic effects in the world before Galvani saw by chance the contraction of a frog's leg

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on an iron gate. The world is always full of such chances, and only the Galvanis and Roentgens are few."

After the first observation of the fluorescent effects of the unknown rays, Roentgen feverishly followed the clue and in the next few weeks performed an astonishing number of carefully planned experiments. We know from his wife's story that Roentgen seldom emerged from his laboratory during these weeks, that he had his meals there, and that he even slept there part of the time in order to be undisturbed and to be ready day or night to try out any new ideas that might come to him in the course of his work. Such new ideas certainly must have been numerous. Today it is difficult to imagine the multitude of unknown and complicated phenomena with which the scientist had to wrestle during those first days. The replacing of the fluorescent screen by the recording photographic plate was one of his first important successful steps. Many of his first pictures which show the varying absorptibility of many materials were produced in this way. His first roentgenograms of the hand of his wife (Fig. 2), a compass, metal weights in a wooden box, and so forth, have come to have historic significance. At first the photographic plate became more popular as a method of demonstrating the effects of the new rays, and for a time this method overshadowed the use of the fluorescent screen to such a degree that the latter almost faded into oblivion, reappearing, however, many months later under the name of the Edison Fluoroscope, Salvioni cryptoscope, and so forth, when it was hailed enthusiastically as another new discovery which made the rays visible to the eye. It seems that the significance of this supposed improvement almost eclipsed that of the discovery of the rays. Essentially, however, these improvements were only slight modifications of Roentgen's original experiment.

By means of his screen and plates Roentgen made all of the fundamental observations which he reported in his first two classical communications with such accuracy and thoroughness that other physicists and investigators could add nothing new to the master's original work until many years later. Roentgen showed the propagation of the rays in straight lines. He observed that they were not reflected or refracted or deviated by the influence of magnetic fields. He investigated the penetration of the rays through different materials which are entirely opaque to ordinary light. He made observations on the hardening of the rays by absorption, the creation of secondary radiation and the conductivity of air when traversed by the rays, and recorded many other properties.

On December 28, 1895, Roentgen handed his "preliminary" com-

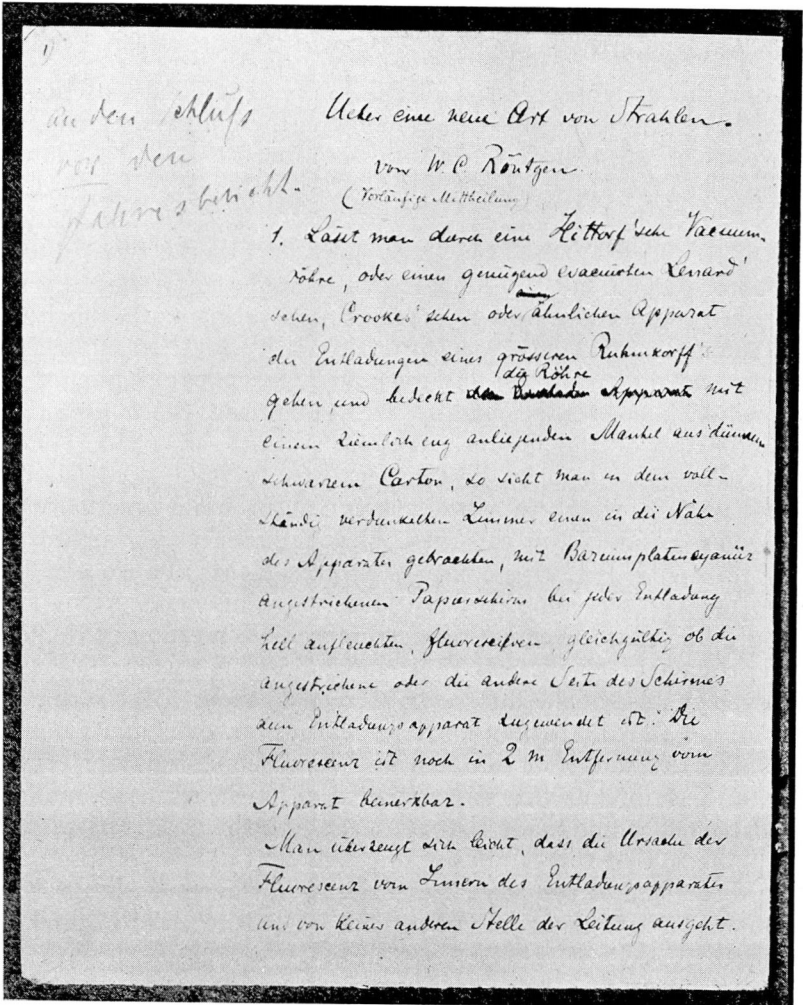


Fig. 3. Original manuscript of Roentgen's first paper "On a New Kind of Ray." (Courtesy of the Physical Institute of the University of Wurzburg, Director, Prof. Dr. Harms.)

munication, "On a New Kind of Ray," to the President of the Wurzburg Physical Medical Society (Fig. 3). It was accepted for publication in the Annals of the Society for the year 1895, although he had not yet lectured on the subject. No meetings or lectures are given in German universities during the Christmas vacation, therefore Roentgen waited until the 23rd of January, 1896, before he spoke publicly on the subject of his discovery for the first and apparently the only time.

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During this month the news of the discovery travelled with almost unbelievable rapidity from the quiet laboratory of the sleepy little town on the river Main to the four corners of the world. The public press in the capitals of Europe and America printed the news even before the Wurzburg newspaper, the *General Anzeiger*, printed its first report. This sudden world-wide publicity was not entirely to the liking of the modest discoverer, and the earliest reports went to press without his consent. He had sent some of his first x-ray pictures to a few friends, before the news of the discovery was published. One of these was Prof. F. Exner, in Vienna, who had been a friend of Roentgen since their college days in Zurich. One evening Exner showed the pictures to a little gathering of fellow scientists. They naturally created quite a sensation and some heated comments were made. Prof. Ernst Lecher, of Prague, asked Exner to let him have the prints until the next morning. Late at night Lecher hastened to bring the good news to his father, Z. K. Lecher, who was then the publisher of the *Wiener Presse*. Even in those days newspaper men had their uncanny sense for news, and the next morning edition of the *Presse* contained an elaborate article on the revolutionary discovery by the "Wurzburg Professor." The news was quickly copied by other continental papers and on the evening of January 6, 1896, it was cabled from London to all of the civilized countries of the world in the following words: "The noise of war's alarm should not distract attention from the marvellous triumph of science which is reported from Vienna. It is announced that Prof. Routgen of the Wurzburg University has discovered a light which for the purposes of photography will penetrate wood, cloth and most other organic substances." A more detailed report of the discovery followed the next morning, and in a few days the almost unbelievable story of the "all-penetrating rays" had found its way not only into the newspapers but also into the scientific journals.

The *Electrical Engineer*, *New York*, reported the discovery on January 8, 1896 (Vol. 21, p. 51), under the title, "Electrical Photography through Solid Matter;" the *Electrician*, *London*, followed with an article on January 10, 1896 (Vol. 36, p. 334), under the headline "Sensational Worded Story." A detailed article also appeared in the January number of the Italian *Il nuovo cimento*, while the French *L'eclairage electrique* published its first comments on the discovery on February 6, 1896. The *London Nature*, and the *New York Science* had somewhat more elaborate articles in their issues of the 16th and 25th of January.

Although at first it appeared as if the technical journals would claim the discovery, the valuable medical possibilities of the use of

the x-ray for diagnostic purposes immediately became apparent and the *Münchener medizinische Wochenschrift* of January 14, 1896, reported a meeting of the Berlin Society of Internal Medicine, which took place on January 6, 1896, at which the neurologist, Dr. Jastrowitz, spoke on Roentgen's discovery. Further comments appeared in the same journal the following week. On January 16 the *Wiener klinische Wochenschrift* (Vol. 96, p. 48), reported Prof. S. Exner's talk on the x-ray. The English *Lancet* and also the *British Medical Journal* contained the first news in their issue of January 11 under the title, "The Searchlight of Photography;" the French *Comptes rendus* of January 20, and the Italian *La settimana medica* of January 25, under the title "Experiences with the Roentgen Light," *Medical Record*, New York, January 11, 1896, under the title "Illuminated Tissues," and the *Journal of the American Medical Association* on February 15, 1896. These early communications show the alacrity with which the medical profession accepted the new weapon and promptly used it to good advantage, at the same time anticipating the vast possibilities of improving diagnosis by improving the new tool. Even the fondest hopes of those first days following the discovery were soon surpassed in the romantic development of roentgenology.

Roentgen's name and the news of his discovery thus became known throughout the whole world, and much progress had already been made even before the modest discoverer spoke for the first and only time on his "New Kind of Ray." The lecture was given before the Physical Medical Society of the University of Würzburg on January 23, 1896, in the auditorium of Roentgen's Physical Institute. Long before the meeting began every seat of the large room was occupied. Professors of the University, high officials of the city, representatives of the Army, and many students, filled the room. With great excitement and enthusiasm the crowd was waiting for the discoverer, and when he entered a veritable storm of applause arose which was repeated many times during the evening. Roentgen modestly expressed his thanks and just as modestly began to talk about his work. He emphasized first that on account of the general interest he thought it his duty to speak publicly about his "Arbeit," although the experiments were still in the course of development. He then mentioned the investigations with cathode rays made by Hertz, Lenard, and others, and said that his own observations had led him to make experiments along the same lines which resulted in his discovery. He related how he first observed the fluorescence of a small piece of paper painted with barium platinum cyanide and how he quickly found out that the cause for

this fluorescence came from the carefully covered Hittorf tube itself, and not from any other part of the high tension circuit. "I found by accident," the discoverer said, "that the rays penetrated black paper. I then used wood, paper, books, but I still believed I was the victim of deception. Then I used photography and the experiment was successful."

Roentgen demonstrated numerous successful experiments with the x-rays and also mentioned his well-known earlier attempts to make photographs through a door in his laboratory with the result that he found light strips on the exposed plate which were unexplainable. Upon dismantling the door he found that the strips of white lead which held the panels of the door together were responsible for the increased absorption of the rays and caused the light strips on the plate. He then exhibited various x-ray pictures and they, of course, excited the greatest interest. After the demonstration Roentgen asked the famous anatomist of the University, His Excellency von Kölliker, to permit him to photograph his hand (Fig. 4). Von Kölliker eagerly complied with this request and when the excellent picture was shown a little later there was tremendous applause and all present felt that this was a moment of real historical significance. Von Kölliker said feelingly that in his forty-eight years of membership in the Physical Medical Society he had never attended a meeting at which a subject of such great significance had been presented. He finished with three cheers for the discoverer and proposed that henceforth the x-rays be called roentgen rays. This suggestion was adopted amid renewed applause for Roentgen. The general optimism was again expressed in a short discussion and only one of those present, the surgeon, Prof. Schoenborn, warned against too much optimism since the method hardly promised to be of much if any value in diagnosing internal disturbances.

Prof. Lehman, who was then President of the Physical Medical Society and now is Professor of Hygiene at the Wurzburg University, has related part of the story given above and substantiated some of the early reports of this meeting which appeared in various journals. He stated recently that many of those present at the meeting met afterwards and had a glass of beer, and that they looked with keen optimism into the future, but "whatever our dreams then expected, they have been far surpassed by the actual facts."

From then on a veritable flood of articles on the new "wonder rays" appeared in rapid succession in the press of the whole world. I have been able to collect over a thousand articles on x-rays which appeared in scientific journals during the year 1896. Over fifty books on the same subject were published in the same year, not to mention

the innumerable comments which appeared in some of the popular and semi-scientific journals.

The cartoons and poems appearing in many popular magazines and newspapers form a most interesting part of the early printed records of the discovery and give us a good idea of its reception by the general public (Fig. 5). Not infrequently they express a certain



Fig. 4. Roentgenogram of von Kölliker's hand, taken by Roentgen after his first lecture on the x-ray on January 23, 1896.

fear of the ghastly skeletal pictures which was voiced also in many publications. As an example we may quote from the London *Pall Mall Gazette*:

“We are sick of the roentgen rays. It is now said, we hope untruly, that Mr. Edison has discovered a substance — tungstate of calcium is its repulsive name — which is potential, whatever that means, to the said rays. The consequence of which appears to be that you can see other people's bones with the naked eye, and also

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Fig. 5. Two early cartoons of Roentgen's discovery of a "New Photography." (From "*Punch*" and "*Life*.")

see through eight inches of solid wood. On the revolting indecency of this there is no need to dwell. But what we seriously put before the attention of the Government is that the moment tungstate of calcium comes into anything like general use, it will call for legislative restriction of the severest kind. Perhaps the best thing would be for all civilized nations to combine to burn all works on the roentgen rays, to execute all the discoverers, and to corner all the tungstate in the world and whelm it in the middle of the ocean. Let the fish contemplate each other's bones if they like, but not us.¹

This same ignorance and pessimism found expression in jokes and poems as well as in everyday life. On February 19, Assemblyman Reed, of Somerset County, New Jersey, introduced a bill into the House at Trenton, New Jersey, prohibiting the use of x-rays in opera glasses at theaters,² and in London, England, a firm "made prey of the ignorant women by advertising the sale of x-ray proof underclothing."³ Numerous poems were published, one of which reads:

O Roentgen, then the news is true
 And not a trick of idle rumor,
 That bids us each beware of you
 And of your grim and graveyard humor.

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We do not want, like Dr. Swift,
To take our flesh off and to pose in
Our bones, or show each little rift
And joint for you to poke your nose in.

We only crave to contemplate
Each other's usual full dress photo
Your worse than "Alltogether" state
Of portraiture we bar in toto!

The fondest swain would scarcely prize
A picture of his lady's framework;
To gaze on this with yearning eyes
Would probably be voted tame work.

No, keep them for your epitaph,
These tombstone souvenirs unpleasant;
Or go away and photograph
Mahatmas, spooks and Mrs. Besant.*

— *From London "Punch," Jan. 25, 1896.*

*In this connection, it is interesting that a recent number of *Time* (February 9, 1931) contained a review of a biography just published of Mrs. Besant—"The Passionate Pilgrim" by Gertrude Marvin Williams. The first paragraph of this review is as follows: "Annie Wood Besant (rhymes with either incessant or pleasant) is an old woman (83) popularly associated with occult ritual and mystic robes. She is still president of the Theosophical Society, but perhaps you didn't realize she was once a parson's wife, an atheist, a Socialist, a beautiful spellbinder." And the review concludes: "At present she is a still energetic old woman who stands as temporal Head to some 43,000 scattered Theosophists."—Ed.

However, this scattered opposition could by no means stop the triumphal course of events. The hopeful individuals by far outnumbered the fearful ones, some of them even believing that with the new knowledge all the age-old problems of spiritualism, soul photography, vivisection, temperance movements, Philosopher's stone would be solved. The New York newspapers actually reported that at the College of Physicians and Surgeons the roentgen rays were used to reflect anatomical diagrams directly into the brains of the students, making a much more enduring impression than the ordinary methods of learning anatomical details.⁴

A romantic chapter in the history of science is the story of the feverish activities which were in progress in laboratories all over the world during the first weeks following Roentgen's great discovery. Many prior claims were made and many attempts were made to find a better name for the new phenomenon. In rapid succession

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came suggestions for technique and for practical uses for the rays in medicine, and efforts were made to solve the secret of the essential character of these rays. First observations of the physiological effects of the rays, especially on the human skin, were soon reported. It would lead much too far, however, to discuss at this time all the fascinating phases of Roentgen's discovery. They have been dealt with in detail in my book.⁵

Very quickly Roentgen's work received proper recognition. Emperor Wilhelm invited him to Potsdam to give a demonstration of his discovery and conferred a decoration upon him. The Prince Regent of Bavaria, Luitpold, bestowed upon him the "Verdienst Orden" of the Bavarian crown with which the coveted "von," the sign of nobility was connected. Roentgen declined to accept this latter honor. His University gave him an honorary degree of M.D., and his birthplace, Lennep, made him an honorary citizen. Italy decorated him with the Order of the Italian Crown, and England gave him the Rumford Medal. He was honored by the whole world as hardly any scientist had been before, but still he remained a modest, industrious man. In spite of all the excitement about him he continued his work after his first publication was printed, and as early as March, 1896, he was ready to give his second communication to the press, this being an important addition to his first paper.

Mrs. Roentgen gives us a good insight into the strenuous life which Roentgen led during this time in the letter to her cousin which we mentioned earlier in this paper. She wrote on March 6, 1896:

"It is not easy to be a famous man, and very few people have any conception of how much work and how much excitement it carries with it. Our quiet home life was gone as soon as my husband had published his paper. Every day I must admire anew his enormous capacity for work and how he keeps his thoughts together in spite of the thousand and one small things with which he is annoyed. It is however high time now that he should take a rest and I am preparing everything for a few weeks' trip to the south where he can spend some time in the open. We are of course grateful that we are privileged to enjoy these wonderful times. How much recognition my husband gets for his untiring researches! Sometimes it would seem that all the praise and honors would make a person dizzy. It would be serious indeed if the man thus honored were conceited. You know my good husband very well and you surely can realize that his greatest recompensation lies in the fact that he could find something valuable in the field of pure science."

A few days after this letter was written Roentgen and his wife started on their trip south. They spent several restful weeks in beautiful Sorrento near Naples, where they stayed at the Hotel Victoria, and there Roentgen found his well-deserved rest. While he was in Italy he saw a note in the papers to the effect that "Prof. Roentgen the famous discoverer of the Roentgen rays was in Italy



Fig. 6. Photograph of Roentgen as a young student.

and had been seen in Rome in a dark brown suit." He immediately packed that brown suit at the bottom of his trunk because he was very shy, and did not want to be famous. He always tried to avoid publicity.

Upon his return from his vacation he continued to work on the x-rays throughout the year. The results of his investigations were published on March 10, 1897, under the title: "Further Observations on the Properties of the X-rays." This work rounded out his fundamental series of experiments on the x-rays.

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After the news of Roentgen's discovery had been published, the general public wanted to know more about the man who was successful in opening the door to new wonderlands of science. Naturally the first newspaper accounts of Roentgen himself were rather meager. His name was misspelled "Routgen" through an error in transcription and was reprinted incorrectly in most of the early reports. He was said to be an Austrian professor and the place of the discovery was given as Vienna; this error was probably due to the fact that the first published news of the discovery came from Vienna, as has been previously explained. Soon, however, the clever reporters were able to find out more about his personal affairs and presented their readers with rather good biographies of the great scientist.

Wilhelm Conrad Roentgen was born on March 27, 1845, in Lennep, a little town on the Lower Rhine, in the heart of the industrial section of that part of Germany. His father, Friedrich Conrad Roentgen, a manufacturer and cloth merchant, had also been born in Lennep on January 11, 1801. The Roentgens came from an old Rhenish merchant family which can be traced back to the seventeenth century. Roentgen's mother, Charlotte Constance Frowein, was born in Amsterdam on February 25, 1806. She came from a Dutch family well known in industrial and shipping circles. Her father also was born in Lennep. Two of Roentgen's grandparents were cousins. Mrs. Roentgen's mother, Sussanna Marie Moyet, had also been born in Amsterdam. Her family originally came from Italy and emigrated to Holland in the seventeenth century.

Wilhelm Roentgen was an only child although his father and his grandfathers came from families of many children. Young Roentgen grew up in very happy surroundings. His mother had brought beautiful furniture, pictures, and china from Holland to their Lennep home and the boy early acquired a taste for art and beauty which he never lost throughout his life. Part of his childhood was spent in Holland with his mother's relatives in Utrecht and Apeldoorn. Later the Roentgens moved to Apeldoorn and their son attended the schools in Utrecht. He was not a particularly brilliant student, always preferring a hike through the fields and woods to dull and uninteresting lessons at school. His happy school days were suddenly interrupted. After a harmless student prank he was found to be guilty and since he did not wish to divulge the names of his accomplices he was expelled from the school. This was a severe blow to his ambitions. However, a great consolation in those dark days was the complete understanding of his beloved mother. He entered the school for machinists in Apeldoorn in order to prepare himself for the profession of his father. A little later he tried again



Fig. 7. W. C. Roentgen with his parents and other relatives. (Courtesy of the Physical Institute of the University of Wurzburg, Director Prof. Dr. Harms.)

to pass the examinations which would have given him the same credits as would graduation from the Utrecht school, that is, the right to enter college, but he failed and again had to return to the Apeldoorn school. It is doubtful whether these repeated attempts of fate to bar Roentgen from the regular scholastic courses were really a disadvantage. It would seem that freedom from the strict and often dry scholastic burden permitted the budding genius to develop along lines that later bore the finest of fruit. As often happens a happy coincidence threw new light into the darkness of young Roentgen's student experiences. A Swiss friend of the Roentgens, by the name of Thormann, told the young student that the Zurich Technical High School accepted students for matriculation without the usual credentials. So in the Spring of 1865 we find Roentgen in the beautiful city on blue Lake Zurich and on the road which led him to the highest peak of academic honors. The

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well known Clausius, Professor of Theoretical Physics, and Kundt, the experimental physicist, awakened such a love for the physical sciences in the heart of the young student that he soon devoted himself entirely to this subject. His brilliant career subsequent to this time is so well known that we will only cite a few of the important incidents of his life.

On June 22, 1869, he was graduated as Doctor of Philosophy and remained as assistant to his teacher, Kundt. Two years later he followed Kundt to Wurzburg where the former had accepted the offer of the chair of physics. In Wurzburg the two were forced to work under rather unfavorable circumstances in a poorly equipped "physical cabinet." While in Wurzburg, Roentgen married (on July 7, 1872) Bertha Ludwig, of Zurich, with whom he lived very happily for nearly fifty years. The Roentgens had no children but later adopted and raised a young niece of Mrs. Roentgen.

Once more a dark cloud crossed Roentgen's path. Since he had not the required credentials from Utrecht, the strict old traditions of the Wurzburg University would not permit him to become "Privatdozent" and thus to reach the first step of his academic career. However, at that time Kundt was called to the newly-founded German University in Strassburg and Roentgen went with him. Here in the newly-acquired Provinces was an atmosphere free from hampering traditions and after a short time (on March 13, 1874) Roentgen became Privatdozent of Physics at the Strassburg University. A year later (April 1, 1875) he was offered the chair of physics and mathematics at the Academy of Hohenheim which he accepted. However, as he was accustomed to the rather large and well-equipped laboratories of the University at Strassburg he did not feel very happy in the poorly equipped institute at the Hohenheim Academy. At Kundt's request he returned to Strassburg a year later and accepted the Associate Professorship of Theoretical Physics. Alone and also in collaboration with his teacher he published a series of excellent treatises on the merit of which he was offered the chair of physics at the Giessen University. He accepted this appointment on April 10, 1879, and stayed for almost ten years in the old Hessian city. Many of his most valuable researches were carried on in Giessen and here he spent some of his happiest hours and made some of his best friends. In later years he often recalled his pleasant trips from Giessen to the Rhine at the season of the wine festivals.

In 1888 Roentgen was called to the University of Wurzburg, the institution which a few years previously had refused to give him his academic standing. Here he succeeded the brilliant Kohlrausch

who had gone to Strassburg. It was in Wurzburg that he made the discovery of the x-rays in November, 1895.

We have already spoken of the many honors and compliments which were showered upon Roentgen after his discovery. Various institutes made efforts to obtain his services but he stayed in Wurzburg until April 1, 1900, when he accepted the call of the University of Munich and moved to the Bavarian capital by special request of the Bavarian government. In 1901 he was awarded the first Nobel prize. The years in Munich were filled with successful work and happy vacations. When the world war broke out times changed and Roentgen, who always loved his Fatherland, suffered from the hardships of the great conflict. In his loyalty he gave his gold and some of his valuable honorary medals to the government. The tragic results of the war weighed very heavily upon him and his hopes that the broken morale of the German people could ever be regained were almost gone. His beloved wife died on October 31, 1919, after a long illness and Roentgen was a very lonely and unhappy man. He died in Munich on February 20, 1923, of carcinoma of the intestines at the age of seventy-eight years, and his ashes were laid to rest in Giessen. His name and his work will live forever.

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