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THE NEW MARVEL IN PHOTOGRAPHY.

A VISIT TO PROFESSOR ROeNTGEN AT HIS LABORATORY IN WUeRZBURG.—HIS OWN ACCOUNT OF HIS GREAT DISCOVERY.—INTERESTING EXPERIMENTS WITH THE CATHODE RAYS.—PRACTICAL USES OF THE NEW PHOTOGRAPHY.

BY H.J.W. DAM.

In all the history of scientific discovery there has never been, perhaps, so general, rapid, and dramatic an effect wrought on the scientific centres of Europe as has followed, in the past four weeks, upon an announcement made to the Wuerzburg Physico-Medical Society, at their December meeting, by Professor William Konrad Roentgen, professor of physics at the Royal University of Wuerzburg. The first news which reached London was by telegraph from Vienna to the effect that a Professor Roentgen, until then the possessor of only a local fame in the town mentioned, had discovered a new kind of light, which penetrated and photographed through everything. This news was received with a mild interest, some amusement, and much incredulity; and a week passed. Then, by mail and telegraph, came daily clear indications of the stir which the discovery was making in all the great line of universities between Vienna and Berlin. Then Roentgen's own report arrived, so cool, so business-like, and so truly scientific in character, that it left no doubt either of the truth or of the great importance of the preceding reports. To-day, four weeks after the announcement, Roentgen's name is apparently in every scientific publication issued this week in Europe; and accounts of his experiments, of the experiments of others following his method, and of theories as to the strange new force which he has been the first to observe, fill pages of every scientific journal that comes to hand. And before the necessary time elapses for this article to attain publication in America, it is in all ways probable that the laboratories and lecture-rooms of the United States will also be giving full evidence of this contagious arousal of interest over a discovery so strange that its importance cannot yet be measured, its utility be even prophesied, or its ultimate effect upon long-established scientific beliefs be even vaguely foretold.

The Roentgen rays are certain invisible rays resembling, in many respects, rays of light, which are set free when a high pressure electric current is discharged through a vacuum tube. A vacuum tube is a glass tube from which all the air, down to one-millionth of an atmosphere, has been exhausted after the insertion of a platinum wire in either end of the tube for connection with the two poles of a battery or induction coil. When the discharge is sent through the tube, there proceeds from the anode—that is, the wire which is connected with the positive pole of the battery—certain bands of light, varying in color with the color of the glass. But these are insignificant in comparison with the brilliant glow which shoots from the cathode, or negative wire. This glow excites brilliant phosphorescence in glass and many substances, and these "cathode rays," as they are called, were observed and studied by Hertz; and more deeply by his assistant, Professor Lenard, Lenard having, in 1894, reported that the cathode rays would penetrate thin films of aluminium, wood, and other substances and produce photographic results beyond. It was left, however, for Professor Roentgen to discover that during the discharge another kind of rays are set free, which differ greatly from those described by Lenard as cathode rays The most marked difference between the two is the fact that Roentgen rays are not deflected by a magnet, indicating a very essential difference, while their range and penetrative power are incomparably greater. In fact, all those qualities which have lent a sensational character to the discovery of Roentgen's rays were mainly absent from these of Lenard, to the end that, although Roentgen has not been working in an entirely new field, he has by common accord been freely granted all the honors of a great discovery.

Exactly what kind of a force Professor Roentgen has discovered he does not know. As will be seen below, he declines to call it a new kind of light, or a new form of electricity. He has given it the name of the X rays. Others speak of it as the Roentgen rays. Thus far its results only, and not its essence, are known. In the terminology of science it is generally called "a new mode of motion," or, in other words, a new force. As to whether it is or not actually a force new to science, or one of the known forces masquerading under strange conditions, weighty authorities are already arguing. More than one eminent scientist has already affected to see in it a key to the great mystery of the law of gravity. All who have expressed themselves in print have admitted, with more or less frankness, that, in view of Roentgen's discovery, science must forth-with revise, possibly to a revolutionary degree, the long accepted theories concerning the phenomena of light and sound. That the X rays, in their mode of action, combine a strange resemblance to both sound and light vibrations, and are destined to materially affect, if they do not greatly alter, our views of both phenomena, is already certain; and beyond this is the opening into a new and unknown field of physical knowledge, concerning which speculation is already eager, and experimental investigation already in hand, in London, Paris, Berlin, and, perhaps, to a greater or less extent, in every well-equipped physical laboratory in Europe.

This is the present scientific aspect of the discovery. But, unlike most epoch-making results from laboratories, this discovery is one which, to a very unusual degree, is within the grasp of the popular and non-technical imagination. Among the other kinds of matter which these rays penetrate with ease is the human flesh. That a new photography has suddenly arisen which can photograph the bones, and, before long, the organs of the human body; that a light has been found which can penetrate, so as to make a photographic record, through everything from a purse or a pocket to the walls of a room or a house, is news which cannot fail to startle everybody. That the eye of the physician or surgeon, long baffled by the skin, and vainly seeking to penetrate the unfortunate darkness of the human body, is now to be supplemented by a camera, making all the parts of the human body as visible, in a way, as the exterior, appears certainly to be a greater blessing to humanity than even the Listerian antiseptic system of surgery; and its benefits must inevitably be greater than those conferred by Lister, great as the latter have been. Already, in the few weeks since Roentgen's announcement, the results of surgical operations under the new system are growing voluminous. In Berlin, not only new bone fractures are being immediately photographed, but joined fractures, as well, in order to examine the results of recent surgical work. In Vienna, imbedded bullets are being photographed, instead of being probed for, and extracted with comparative ease. In London, a wounded sailor, completely paralyzed, whose injury was a mystery, has been saved by the photographing of an object imbedded in the spine, which, upon extraction, proved to be a small knife-blade. Operations for malformations, hitherto obscure, but now clearly revealed by the new photography, are already becoming common, and are being reported from all directions. Professor Czermark of Graz has photographed the living skull, denuded of flesh and hair, and has begun the adaptation of the new photography to brain study. The relation of the new rays to thought rays is being eagerly discussed in what may be called the non-exact circles and journals; and all that numerous group of inquirers into the occult, the believers in clairvoyance, spiritualism, telepathy, and kindred orders of alleged phenomena, are confident of finding in the new force long-sought facts in proof of their claims. Professor Neusser in Vienna has photographed gall-stones in the liver of one patient (the stone showing snow-white in the negative), and a stone in the bladder of another patient. His results so far induce him to announce that all the organs of the human body can, and will, shortly, be photographed. Lannelougue of Paris has exhibited to the Academy of Science photographs of bones showing inherited tuberculosis which had not otherwise revealed itself. Berlin has already formed a society of forty for the immediate prosecution of researches into both the character of the new force and its physiological possibilities. In the next few weeks these strange announcements will be trebled or quadrupled, giving the best evidence from all quarters of the great future that awaits the Roentgen rays, and the startling impetus to the universal search for knowledge that has come at the close of the nineteenth century from the modest little laboratory in the Pleicher Ring at Wuerzburg.

On instruction by cable from the editor of this magazine, on the first announcement of the discovery, I set out for Wuerzburg to see the discoverer and his laboratory. I found a neat and thriving Bavarian city of forty-five thousand inhabitants, which, for some ten centuries, has made no salient claim upon the admiration of the world, except for the elaborateness of its mediaeval castle and the excellence of its local beer. Its streets were adorned with large numbers of students, all wearing either scarlet, green, or blue caps, and an extremely serious expression, suggesting much intensity either in the contemplation of Roentgen rays or of the beer aforesaid. All knew the residence of Professor Roentgen (pronunciation: "Renken"), and directed me to the "Pleicher Ring." The various buildings of the university are scattered in different parts of Wuerzburg, the majority being in the Pleicher Ring, which is a fine avenue, with a park along one side of it, in the centre of the town. The Physical Institute, Professor Roentgen's particular domain, is a modest building of two stories and basement, the upper story constituting his private residence, and the remainder of the building being given over to lecture rooms, laboratories, and their attendant offices. At the door I was met by an old serving-man of the idolatrous order, whose pain was apparent when I asked for "Professor" Roentgen, and he gently corrected me with "Herr Doctor Roentgen." As it was evident, however, that we referred to the same person, he conducted me along a wide, bare hall, running the length of the building, with blackboards and charts on the walls. At the end he showed me into a small room on the right. This contained a large table desk, and a small table by the window, covered with photographs, while the walls held rows of shelves laden with laboratory and other records. An open door led into a somewhat larger room, perhaps twenty feet by fifteen, and I found myself gazing into a laboratory which was the scene of the discovery—a laboratory which, though in all ways modest, is destined to be enduringly historical.

There was a wide table shelf running along the farther side, in front of the two windows, which were high, and gave plenty of light. In the centre was a stove; on the left, a small cabinet, whose shelves held the small objects which the professor had been using. There was a table in the left-hand corner; and another small table—the one on which living bones were first photographed—was near the stove, and a Rhumkorff coil was on the right. The lesson of the laboratory was eloquent. Compared, for instance, with the elaborate, expensive, and complete apparatus of, say, the University of London, or of any of the great American universities, it was bare and unassuming to a degree. It mutely said that in the great march of science it is the genius of man, and not the perfection of appliances, that breaks new ground in the great territory of the unknown. It also caused one to wonder at and endeavor to imagine the great things which are to be done through elaborate appliances with the Roentgen rays—a field in which the United States, with its foremost genius in invention, will very possibly, if not probably, take the lead—when the discoverer himself had done so much with so little. Already, in a few weeks, a skilled London operator, Mr. A.A.C. Swinton, has reduced the necessary time of exposure for Roentgen photographs from fifteen minutes to four. He used, however, a Tesla oil coil, discharged by twelve half-gallon Leyden jars, with an alternating current of twenty thousand volts' pressure. Here were no oil coils, Leyden jars, or specially elaborate and expensive machines. There were only a Rhumkorff coil and Crookes (vacuum) tube and the man himself.

Professor Roentgen entered hurriedly, something like an amiable gust of wind. He is a tall, slender, and loose-limbed man, whose whole appearance bespeaks enthusiasm and energy. He wore a dark blue sack suit, and his long, dark hair stood straight up from his forehead, as if he were permanently electrified by his own enthusiasm. His voice is full and deep, he speaks rapidly, and, altogether, he seems clearly a man who, once upon the track of a mystery which appealed to him, would pursue it with unremitting vigor. His eyes are kind, quick, and penetrating; and there is no doubt that he much prefers gazing at a Crookes tube to beholding a visitor, visitors at present robbing him of much valued time. The meeting was by appointment, however, and his greeting was cordial and hearty. In addition to his own language he speaks French well and English scientifically, which is different from speaking it popularly. These three tongues being more or less within the equipment of his visitor, the conversation proceeded on an international or polyglot basis, so to speak, varying at necessity's demand.

It transpired, in the course of inquiry, that the professor is a married man and fifty years of age, though his eyes have the enthusiasm of twenty-five. He was born near Zurich, and educated there, and completed his studies and took his degree at Utrecht. He has been at Wuerzburg about seven years, and had made no discoveries which he considered of great importance prior to the one under consideration. These details were given under good-natured protest, he failing to understand why his personality should interest the public. He declined to admire himself or his results in any degree, and laughed at the idea of being famous. The professor is too deeply interested in science to waste any time in thinking about himself. His emperor had *feted*, flattered, and decorated him, and he was loyally grateful. It was evident, however, that fame and applause had small attractions for him, compared to the mysteries still hidden in the vacuum tubes of the other room.

"Now, then," said he, smiling, and with some impatience, when the preliminary questions at which he chafed were over, "you have come to see the invisible rays."

"Is the invisible visible?"

"Not to the eye; but its results are. Come in here."

He led the way to the other square room mentioned, and indicated the induction coil with which his researches were made, an ordinary Rhumkorff coil, with a spark of from four to six inches, charged by a current of twenty amperes. Two wires led from the coil, through an open door, into a smaller room on the right. In this room was a small table carrying a Crookes tube connected with the coil. The most striking object in the room, however, was a huge and mysterious tin box about seven feet high and four feet square. It stood on end, like a huge packing-case, its side being perhaps five inches from the Crookes tube.

The professor explained the mystery of the tin box, to the effect that it was a device of his own for obtaining a portable dark-room. When he began his investigations he used the whole room, as was shown by the heavy blinds and curtains so arranged as to exclude the entrance of all interfering light from the windows. In the side of the tin box, at the point immediately against the tube, was a circular sheet of aluminium one millimetre in thickness, and perhaps eighteen inches in diameter, soldered to the surrounding tin. To study his rays the professor had only to turn on the current, enter the box, close the door, and in perfect darkness inspect only such light or light effects as he had a right to consider his own, hiding his light, in fact, not under the Biblical bushel, but in a more commodious box.

"Step inside," said he, opening the door, which was on the side of the box farthest from the tube. I immediately did so, not altogether certain whether my skeleton was to be photographed for general inspection, or my secret thoughts held up to light on a glass plate. "You will find a sheet of barium paper on the shelf," he added, and then went away to the coil. The door was closed, and the interior of the box became black darkness. The first thing I found was a wooden stool, on which I resolved to sit. Then I found the shelf on the side next the tube, and then the sheet of paper prepared with barium platino-cyanide. I was thus being shown the first phenomenon which attracted the discoverer's attention and led to the discovery, namely, the passage of rays, themselves wholly invisible, whose presence was only indicated by the effect they produced on a piece of sensitized photographic paper.

A moment later, the black darkness was penetrated by the rapid snapping sound of the high-pressure current in action, and I knew that the tube outside was glowing. I held the sheet vertically on the shelf, perhaps four inches from the plate. There was no change, however, and nothing was visible.

"Do you see anything?" he called.

"No."

"The tension is not high enough;" and he proceeded to increase the pressure by operating an apparatus of mercury in long vertical tubes acted upon automatically by a weight lever which stood near the coil. In a few moments the sound of the discharge again began, and then I made my first acquaintance with the Roentgen rays.

The moment the current passed, the paper began to glow. A yellowish-green light spread all over its surface in clouds, waves, and flashes. The yellow-green luminescence, all the stranger and stronger in the darkness, trembled, wavered, and floated over the paper, in rhythm with the snapping of the discharge. Through the metal plate, the paper, myself, and the tin box, the invisible rays were flying, with an effect strange, interesting, and uncanny. The metal plate seemed to offer no appreciable resistance to the flying force, and the light was as rich and full as if nothing lay between the paper and the tube.

"Put the book up," said the professor.

I felt upon the shelf, in the darkness, a heavy book, two inches in thickness, and placed this against the plate. It made no difference. The rays flew through the metal and the book as if neither had been there, and the waves of light, rolling cloud-like over the paper, showed no change in brightness. It was a clear, material illustration of the ease with which paper and wood are penetrated. And then I laid book and paper down, and put my eyes against the rays. All was blackness, and I neither saw nor felt anything. The discharge was in full force, and the rays were flying through my head, and, for all I knew, through the side of the box behind me. But they were invisible and impalpable. They gave no sensation whatever. Whatever the mysterious rays may be, they are not to be seen, and are to be judged only by their works.

I was loath to leave this historical tin box, but time pressed. I thanked the professor, who was happy in the reality of his discovery and the music of his sparks. Then I said: "Where did you first photograph living bones?"

"Here," he said, leading the way into the room where the coil stood. He pointed to a table on which was another—the latter a small short-legged wooden one with more the shape and size of a wooden seat. It was two feet square and painted coal black. I viewed it with interest. I would have bought it, for the little table on which light was first sent through the human body will some day be a great historical curiosity; but it was "nicht zu verkaufen." A photograph of it would have been a consolation, but for several reasons one was not to be had at present. However, the historical table was there, and was duly inspected.

"How did you take the first hand photograph?" I asked.

The professor went over to a shelf by the window, where lay a number of prepared glass plates, closely wrapped in black paper. He put a Crookes tube underneath the table, a few inches from the under side of its top. Then he laid his hand flat on the top of the table, and placed the glass plate loosely on his hand.

"You ought to have your portrait painted in that attitude," I suggested.

"No, that is nonsense," said he, smiling.

"Or be photographed." This suggestion was made with a deeply hidden purpose.

The rays from the Roentgen eyes instantly penetrated the deeply hidden purpose. "Oh, no," said he; "I can't let you make pictures of me. I am too busy." Clearly the professor was entirely too modest to gratify the wishes of the curious world.

"Now, Professor," said I, "will you tell me the history of the discovery?"

"There is no history," he said. "I have been for a long time interested in the problem of the cathode rays from a vacuum tube as studied by Hertz and Lenard. I had followed theirs and other researches with great interest, and determined, as soon as I had the time, to make some researches of my own. This time I found at the close of last October. I had been at work for some days when I discovered something new."

"What was the date?"

"The eighth of November."

"And what was the discovery?"

"I was working with a Crookes tube covered by a shield of black cardboard. A piece of barium platino-cyanide paper lay on the bench there. I had been passing a current through the tube, and I noticed a peculiar black line across the paper."

"What of that?"

"The effect was one which could only be produced, in ordinary parlance, by the passage of light. No light could come from the tube, because the shield which covered it was impervious to any light known, even that of the electric arc."

"And what did you think?"

"I did not think; I investigated. I assumed that the effect must have come from the tube, since its character indicated that it could come from nowhere else. I tested it. In a few minutes there was no doubt about it. Rays were coming from the tube which had a luminescent effect upon the paper. I tried it successfully at greater and greater distances, even at two metres. It seemed at first a new kind of invisible light. It was clearly something new, something unrecorded."

"Is it light?"

"No."

"Is it electricity?"

"Not in any known form."

"What is it?"

"I don't know."

And the discoverer of the X rays thus stated as calmly his ignorance of their essence as has everybody else who has written on the phenomena thus far.

"Having discovered the existence of a new kind of rays, I of course began to investigate what they would do." He took up a series of cabinet-sized photographs. "It soon appeared from tests that the rays had penetrative power to a degree hitherto unknown. They penetrated paper, wood, and cloth with ease; and the thickness of the substance made no perceptible difference, within reasonable limits." He showed photographs of a box of laboratory weights of platinum, aluminium, and brass, they and the brass hinges all having been photographed from a closed box, without any indication of the box. Also a photograph of a coil of fine wire, wound on a wooden spool, the wire having been photographed, and the wood omitted. "The rays," he continued, "passed through all the metals tested, with a facility varying, roughly speaking, with the density of the metal. These phenomena I have discussed carefully in my report to the Wuerzburg society, and you will find all the technical results therein stated." He showed a photograph of a small sheet of zinc. This was composed of smaller plates soldered laterally with solders of different metallic proportions. The differing lines of shadow, caused by the

difference in the solders, were visible evidence that a new means of detecting flaws and chemical variations in metals had been found. A photograph of a compass showed the needle and dial taken through the closed brass cover. The markings of the dial were in red metallic paint, and thus interfered with the rays, and were reproduced. "Since the rays had this great penetrative power, it seemed natural that they should penetrate flesh, and so it proved in photographing the hand, as I showed you."

A detailed discussion of the characteristics of his rays the professor considered unprofitable and unnecessary. He believes, though, that these mysterious radiations are not light, because their behavior is essentially different from that of light rays, even those light rays which are themselves invisible. The Roentgen rays cannot be reflected by reflecting surfaces, concentrated by lenses, or refracted or diffracted. They produce photographic action on a sensitive film, but their action is weak as yet, and herein lies the first important field of their development. The professor's exposures were comparatively long—an average of fifteen minutes in easily penetrable media, and half an hour or more in photographing the bones of the hand. Concerning vacuum tubes, he said that he preferred the Hittorf, because it had the most perfect vacuum, the highest degree of air exhaustion being the consummation most desirable. In answer to a question, "What of the future?" he said:

"I am not a prophet, and I am opposed to prophesying. I am pursuing my investigations, and as fast as my results are verified I shall make them public."

"Do you think the rays can be so modified as to photograph the organs of the human body?"

In answer he took up the photograph of the box of weights. "Here are already modifications," he said, indicating the various degrees of shadow produced by the aluminium, platinum, and brass weights, the brass hinges, and even the metallic stamped lettering on the cover of the box, which was faintly perceptible.

"But Professor Neusser has already announced that the photographing of the various organs is possible."

"We shall see what we shall see," he said. We have the start now; the developments will follow in time."

"You know the apparatus for introducing the electric light into the stomach?"

"Yes."

"Do you think that this electric light will become a vacuum tube for photographing, from the stomach, any part of the abdomen or thorax?"

The idea of swallowing a Crookes tube, and sending a high frequency current down into one's stomach, seemed to him exceedingly funny. "When I have done it, I will tell you," he said, smiling, resolute in abiding by results.

"There is much to do, and I am busy, very busy," he said in conclusion. He extended his hand in farewell, his eyes already wandering toward his work in the inside room. And his visitor promptly left him; the words, "I am busy," said in all sincerity, seeming to describe in a single phrase the essence of his character and the watchword of a very unusual man.

Returning by way of Berlin, I called upon Herr Spies of the Urania, whose photographs after the Roentgen method were the first made public, and have been the best seen thus far. The Urania is a peculiar institution, and one which it seems might be profitably duplicated in other countries. It is a scientific theatre. By means of the lantern and an admirable equipment of scientific appliances, all new discoveries, as well as ordinary interesting and picturesque phenomena, when new discoveries are lacking, are described and illustrated daily to the public, who pay for seats as in an ordinary theatre, and keep the Urania profitably filled all the year round. Professor Spies is a young man of great mental alertness and mechanical resource.

It is the photograph of a hand, his wife's hand, which illustrates, perhaps better than any other illustration in this article, the clear delineation of the bones which can be obtained by the Roentgen rays. In speaking of the discovery he said:

"I applied it, as soon as the penetration of flesh was apparent, to the photograph of a man's hand. Something in it had pained him for years, and the photograph at once exhibited a small foreign object, as you can see;" and he exhibited a copy of the photograph in question. "The speck there is a small piece of glass, which was immediately extracted, and which, in all probability, would have otherwise remained in the man's hand to the end of his days." All of which indicates that the needle which has pursued its travels in so many persons, through so many years, will be suppressed by the camera.

"My next object is to photograph the bones of the entire leg," continued Herr Spies. "I anticipate no difficulty, though it requires some thought in manipulation."

It will be seen that the Roentgen rays and their marvellous practical possibilities are still in their infancy. The first successful modification of the action of the rays so that the varying densities of bodily organs will enable them to be photographed, will bring all such morbid growths as tumors and cancers into the photographic field, to say nothing of vital organs which may be abnormally developed or degenerate. How much this means to medical and surgical practice it requires little imagination to conceive. Diagnosis, long a painfully uncertain science, has received an unexpected and wonderful assistant; and how greatly the world will benefit thereby, how much pain will be saved, and how many lives saved, the future can only determine. In science a new door has been opened where none was known to exist, and a side-light on phenomena has appeared, of which the results may prove as penetrating and astonishing as the Roentgen rays themselves. The most agreeable feature of the discovery is the opportunity it gives for other hands to help; and the work of these hands will add many new words to the dictionaries, many new facts to science, and, in the years long ahead of us, fill many more volumes than there are paragraphs in this brief and imperfect account.

THE ROeNTGEN RAYS IN AMERICA.

BY CLEVELAND MOFFETT.

At the top of the great Sloane laboratory of Yale University, in an experimenting room lined with curious apparatus, I found Professor Arthur W. Wright experimenting with the wonderful Roentgen rays. Professor Wright, a small, low-voiced man, of modest manner, has achieved, in his experiments in photographing through solid substances, some of the most interesting and remarkable results thus far attained in this country. His success is, no doubt, largely due to the fact that for years he had been experimenting constantly with vacuum tubes similar to the Crookes tubes used in producing the cathode rays.

When I arrived, Professor Wright was at work with a Crookes tube, nearly spherical in shape, and about five inches in diameter—the one with which he has taken all his shadow pictures. His best results have been obtained with long exposures—an hour or an hour and a half—and he regards it as of the first importance that the objects through which the Roentgen rays are to be projected be placed as near as possible to the sensitized plate.

It is from a failure to observe this precaution that so many of the shadow pictures show blurred outlines. It is with these pictures as with a shadow of the hand thrown on the wall—the nearer the hand is to the wall, the more distinct becomes the shadow; and this consideration makes Professor Wright doubt whether it will be possible, with the present facilities, to get clearly cut shadow images of very thick objects, or in cases where the pictures are taken through a thick board or other obstacle. The Roentgen rays will doubtless traverse the board, and shadows will be formed upon the plate, but there will be an uncertainty or dimness of outline that will render the results unsatisfactory. It is for this reason that Professor