HOM 019
Bernard S. Wolf, MD: "History of Radiology"
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Albert S. Lyons, MD: There have been a number of exceptionally important discoveries and contributions which have so changed the face of medicine each time that afterward it has been difficult to understand how people could practice before these introductions. As examples, for instance, I can mention the circulation of the blood, the invention of the microscope, the proof of the bacterial origin of disease, blood transfusion, anesthesia, the use of antibiotics.

In fact, each generation in which these are introduced always finds the generation before where it was not present, as antediluvian. And we shouldn’t stop there, because we now ought to consider, in our own minds, since we are part of a whole dynamic flow, what is apt to develop in our time to make modern medicine seem obsolete?

Well, none of us is a soothsayer. Once can use as an example, for instance, an assumption that in the transplantation of organs, the problems in relation to the acceptance and rejection of tissues will be solved, and then, of course, medical practice will bear only a slight similarity to present practice.

Those outstanding contributions I mentioned may be challenged by some, and of course there are many others, but I think everybody will agree that the discovery and the use of X-rays in medicine is one of those revolutionary advances. It’s been rather recent, too. In the lifetime of some who are still alive, there were no X-rays and they were practicing medicine.

Let me read a few sentences from a personal recorded interview which I had with Dr. Harry Wessler, in his eighties, just before he died a few years ago. He was one of the pioneers in this institution, and many of the things that he stimulated, which later were taken up by other men, he did not have his name associated with. He was, however, for instance, very influential in the development of—as an example—the bronchopulmonary segment.

He said, “You know, in those days, before the X-ray, nobody had the slightest idea what a lung looked like. They died with cavities. When you have X-rays, we began to see what the lesions were: small lesions, infiltrations, tiny cavities and so forth. It was a revelation. And don’t forget, I was the first one to do this, because the first X-ray of the lung was made when I was a house physician. I was the first one here, is what I mean. There was no one here to teach me that. You know, at Mount Sinai, we were way ahead of the rest of the country at the time. At the time when we were X-raying, people like those down at Johns Hopkins thought it was a waste of time. Honestly.”

If his recollection is correct, it's rather startling to realize in what state both medical practice and medical knowledge, as well as medical acceptance, was in those times.

Dr. Bernard Wolf will tell us today how this now virtually indispensable tool, irreplaceable tool, came upon the scene, and he is especially fitted to tell us. He is, of course, head of the [Mount Sinai] Department of Radiology. But his background was also in physics, and I can remember in college days, he was a major in physics, and I daresay there was considerable soul searching before he entered the career of medicine, as to whether he should go on to medical school or to stay in graduate school in physics.

He was a surgical intern at Mount Sinai. Then he went into radiation therapy, and in the Army, his job had to do with setting up standards for protection and safety in radiation. In all, his whole background had to do with physics and radiation.

When Dr. Marcy Sussman, who was head of the Department of Radiology moved from New York to the West, there was an opening, and Dr. Wolf was appointed head of the Department of Radiology, and that was a great chance that the institution took—as well as the fact that he took a chance, too—because he had only really just the merest brush with diagnostic radiology, and had had very little background and training in the field. But he has that kind of mind and talent, which I think is possessed by very few, and in short order, he telescoped years in experience in such a way so that he became not only a highly competent radiologist, but in a very small time thereafter, he became an outstanding radiologist. Now, of course, I would say he is considered as one of the most brilliant in the world. Dr. Wolf.

Bernard S. Wolf, MD: Al and I go back a long way. He didn't mention to you that we were classmates, but we even went to camp together, I guess before we entered our teens, Al.

Lyons: I don't want everybody to know how old I am. [laughter]

Wolf: Also when you said that I was well equipped to do this, I assumed you were talking about our progressive aging process. I don't really go back to the origin of X-rays. I also am not a historian, so what I have to say is no news to any of you who have read the history of medicine, history of radiology.

It's hard for me, not being a professional historian, sometimes to separate the wheat from the chaff, because stories that are presented in one way in one of the history books may be presented another way in a second one. Apparently, it also turns out that you have to be careful if you add autobiographies, because you sometimes distort the facts yourself, because memory sometimes apparently doesn't serve you too well, and this has happened in the field of radiology. There have been a substantial number of, as my British friends would say, 'controversies' over who did what first, and a lot of it goes back to the very early two months after the discovery of radiology. But we won't get into that because that seems to be kind of a blind end.

The various specialties—I was looking at Ed Weinstein—I guess psychoanalysis is probably the only one that is a couple of years younger than radiology. I'm told by some friends of my friends that psychoanalysis is on its way out. And curiously enough, many radiologists and many laymen look forward to the time when radiology will be on its way out. X-rays, as you're well aware, are not entirely harmless, and we have to use them for a purpose. This is an area, too, that I really don't want to get into—the problems with protection from X-rays were realized very promptly after their discovery, but often not given enough attention, and it should be mentioned that there are, I guess, now about 400 people who have their name inscribed on a monument in the garden of the St. George's Hospital in Hamburg as martyrs to radiation. Most of those developed skin cancer, for reasons that we may be able to go into, and died as a result of that.

At any rate, the story of radiology goes back only to November 8, 1895. Apparently in the late afternoon of a Friday, the story goes, Wilhelm Conrad Roentgen, working in his laboratory in Wurzburg, he was professor of the department of physics and also rector of the university, enclosed a Crookes tube in cardboard—I guess it was black cardboard, some kind of a box—put out the lights, turned on the induction coil, and discovered to his surprise, apparently purely inadvertently, that there was still, when he pressed the switch, some light flickering a few feet away. It was this that led to the discovery of X-rays, but it requires a little background to understand what he had in mind.

Gas tubes, Crookes tubes, [Hickox] tubes, had been studied prior to that for about 35 years. This was one way that physicists were able to study in a somewhat evacuated glass envelope the characteristics of electrical discharges, and they did a lot of work, but all of it was done within the tube. If they wanted to do an experiment, they had to do the experiment within the glass enclosure of a so-called Crookes tube.

And it was known that in this tube there were rays, cathode rays, and it was known that these were electrically charged particles, electrons, and that they went from the negative electrode, the cathode, to the anode, the positive charged side. These cathode rays, they were able to demonstrate, had mass, because in one experiment, Crookes put a kind of a little windmill in the course of the cathode rays and the windmill turned. He also put an electromagnetic field across it and could demonstrate that the shadow of an object moved. So they knew that these were charged particles.

A student of Hertz, whose name I think is familiar to you, by the name of Philip Lennard, used one of Hertz's experiments, which was the fact that these cathode rays could traverse a thin foil of aluminum. He got the idea that he could get these cathode rays out of the tube and really go to work on studying them if he made a window in the tube of aluminum foil. He required some way of demonstrating that the cathode rays came out of the tube. And he found two ways of doing that. He darkened the room. He enclosed a Crookes tube with an aluminum window in cardboard, and then he took a fluorescent screen. They didn't use the term fluorescent screen at that time particularly, but this was crystals of barium platinum cyanide, pasted onto cardboard, and he could demonstrate when he brought it up in the darkness to the aluminum window of the Crookes tube that the cathode rays were coming out because the barium platinum cyanide crystals fluoresced.

He also used a photographic plate, again in total darkness, and demonstrated that beyond the window, for about no more, however, than a couple of inches, he could obtain blackening of a silver bromide photographic emulsion.

Apparently, it occurred to Roentgen, and as far as I can see this is partly reading his mind, that maybe this aluminum window in Lennard's experiment, wasn't necessary, that maybe these cathode rays were coming through the glass and people had never noticed it. Apparently on that afternoon, he repeated Lennard's experiment, but without an aluminum window, and that's what he was about when he darkened the room, darkened the enclosure, and then purely inadvertently, because he happened to have this barium platinum cyanide screen sitting on his work bench, noticed that this was fluorescing.

It was really no Nobel Prize winning discovery, as described in this fashion. This did not require any highly sophisticated physics or mathematics. What it did require was a prepared mind. And that's what Roentgen had, and that's why he did get the Nobel Prize, the first one in physics in 1901, because he knew that there was something different going on here, that this was something that had never been described. The cathode rays could not go several feet in air, and if something was fluorescing over here as a result of something coming out of a tube, this had to be a new kind of ray. And that's what he called it, a new kind of ray. He coined the term X-rays.

Apparently, he didn't sleep much for the next two months, investigating the properties of X-rays, because this prepared mind knew that he had something really hot. This was a great discovery that nobody had described.

Actually it's a very curious thing that it took so long to discover that Crookes tubes emitted X-rays because they'd been used for 20 or 30 odd years. And the story does go that Sir William Crookes himself periodically had to return fogged film to the Ilford Co., which is still a very busy photographic company in England, complaining to them that they were giving him fogged film. Apparently, nobody really pursued it to find out where the fogging was occurring, but obviously it was the result of X-rays that he was totally unaware of.

He [Roentgen] worked apparently very hard. He even worked through the Christmas holidays. He, as I said, knew that he had something really hot. So apparently he decided to be a little spectacular, and his wife was worried about him, it seems, because he didn't return home too often. So he invited her down, and took the first X-ray apparently that's ever been taken, of Mrs. Roentgen's hand. May we have the first slide?

This is dated December 22, 1895. It is not recorded how long an exposure was required. This is the direct action of X-rays on photographic plate, originally presumably a glass plate. There's Mrs. Roentgen's ring, I'm not so sure it's a marriage ring but I assure you they were married. This was the quality that he achieved. It probably took an exposure of about an hour, and there were many, as you'll note in a moment, pictures of hands taken throughout the world in the next two months. One of the things that surprises me is that people could keep their hands still for this period of time. At any rate, this is the historical picture of Mrs. Roentgen's hand. May we have the lights again?

On December 28, again trying to speed things up, he went to the secretary apparently of the Wurzburg (curiously enough to me) Physical Medical Society. Just how they happened to have a physical medical society, I don't really know, but apparently it was quite active. I guess in those times, physics and medicine were pretty closely allied. And he asked the secretary to publish his article, promptly. He went to him apparently on December 28th.

This was very unusual, because it seems that the society ordinarily had the paper presented to them before it got into their transactions, but he said that he wanted it printed promptly before he gave his lecture, which happened. And New Year's Day he got his reprints. He'd also prepared copies of this radiograph. And he chose New Year's Day to send to about seven or eight physicists on the Continent and Great Britain copies of his article and in addition, copies of Mrs. Roentgen's hand.

Everything was prepared, you see, in laboratories throughout the world, to do exactly what Roentgen did, and this promptly happened. In fact, the speed of things here is extraordinary to me, because I don't think our communications these days, compared to what it was then—because apparently his physicist friend in Vienna, a gentleman called Exner, as far as I know not known for anything else except his role in this, went to, I guess, a cocktail party and spoke to somebody there about Roentgen's picture, and the somebody happened to be the son of the editor of the *Vienna Press*. So the next morning apparently, on the front pages of the Sunday *Vienna Press*, was Roentgen's great discovery of invisible rays.

This was January 5th. A London correspondent, apparently of the *London Chronicle,* must have been at the same party, because on January 6th it was published in London. On January 7th, I think it was, yeah, it was published in the *St. Louis Dispatch*. January 12, *The New York Times*. January 13, *Le Matin* of Paris. So this really spread like wildfire.

And in the next year, apparently about a thousand articles were written on X-ray, and it occurred very promptly, not only to the physicists but to the reporters, that this new invisible ray, which could show bones through hands, which could show—this was another famous roentgengram of Roentgen—could show weights in a closed wooden box, and coins in purses that were closed and so forth, had tremendous potential medically.

The story of what happened in this country is of some interest because it does show again the fact that, at least to that time, there were a fair number of professors of physics who were interested in this area. It is said that the professor of physics at Yale, Arthur Williams Wright, was the first one to reproduce Roentgen's experiments in this country in the physics laboratory at Yale. But within a few days, and this was the end of January and the first part of February, 1896, the professor of physics at Harvard wasn't too far behind, John

Tolbridge, and he did the same thing. And the professor of astronomy at Dartmouth was only a few days behind, apparently about February 8th, 1896, this historic scene took place. Can we have the lights off again? Maybe we don't need them off.

This apparently was at Dartmouth. The gentleman on the left is said to be Dr. Edwin Fort, professor of astronomy, who however had been trained in physics. It's hard to tell that the gentleman sitting on the chair apparently was a young boy named Eddy McCarthy who had fractured his ulnar. Dr. Edwin Fort's brother was Eddy McCarthy's physician. And, apparently as a result of the fact that the brothers were talking to each other, he knew about this, and he brought this boy in to have an X-ray of his broken forearm, and the picture apparently hasn't been preserved, but this scene is supposed to demonstrate the first roentgengram taken on a patient for a purpose in this country.

OK, can we have lights again? That was at Dartmouth. Princeton, a few days later, Professor William Francis McGee got films of hands, and incidentally also designed a hand fluoroscope of a type.

Then the interesting story was that in February 21st, the professor of physics at the University of Pennsylvania, Dr. Arthur W. Goodspeed, gave a lecture to the American Philosophical Society, I think meeting in Philadelphia, about similar experiments as those you've just seen. But he added something. Apparently about six years before, he, and a photographer friend of his by name of Jennings, were experimenting on what photography might be with sparks, and somehow they were using a Crookes tube as well, and just playing around. Mr. Jennings had some unexposed plates sitting on the bench. History doesn't relate why he developed them but when he did, he got this. And in 1890, Jennings looked at this apparently and didn't make any sense about it, but somehow preserved the picture.

When Dr. Goodspeed heard about Roentgen's discovery, he knew about this picture apparently, he dug it up, and it does show the shadow of two coins. He actually went through the experiment again of what they'd done that particular night, to demonstrate that these were shadows of coins produced by X-rays. Why the coins were sitting on the photographic place isn't clear either. But this historical picture indicates supposedly the first X-ray film of any kind that anybody ever took. Now, again, this is a demonstration that Dr. Goodspeed's and Mr. Jennings' minds were not prepared, and they did not claim any credit for having discovered X-rays.

It's curious that Lennard, however, apparently felt bad about Roentgen's discovery and descriptions and all of the credit that Roentgen was getting, because they ceased to be friends shortly after Roentgen published his work. May we have the lights again?

This is some of the early history of it. One of the curious things about what happened in this country was the role of Thomas Edison. He isn't spoken about much these days, but you probably are aware that he had something to do with developing movie cameras and incandescent bulbs. He also took this discovery of Roentgen's up, apparently at the behest of William Randolph Hearst, because Hearst, I guess, attempting to get a scoop telegraphed Edison in West Orange, New Jersey and said, “Could you deliver to me in a week or so a picture of man’s brain with Roentgen’s X-rays?”. Edison said, “Yes.” Hearst apparently published this in his papers that Edison was going to get an X-ray picture of a man’s brain in a week or so. The story goes that three dozen or three score reporters descended on West Orange, New Jersey, and waited day after day after day for Edison to produce a picture of a man’s brain. Edison never did. But apparently it was a very exciting time in West Orange at that time.

What Edison did do, though, was to put a number of people at work. He was an extraordinarily methodical fellow and he had a whole team there, in fact. His laboratory there is known as the first example of applied research in an industrial laboratory for development and research. He had somebody working on chemical materials. He had somebody work on blowing tubes, testing tubes, all kinds of glass and so forth and so on. And he did determine kinds of glass that were best for X-ray tubes, and he did discover, at least he and his team did discover, a new fluorescent material that fluoresced more than barium platinum cyanide and that was calcium tungstate, and we still use calcium tungstate. His chemist, before he determined that calcium tungstate was the best they could do, tested, it is said, about 8,500 different chemical compounds. His glass blower, incidentally, this is not a happy part of the picture, was a fellow by the name of Clarence Dally, who died from cancer about eight years after this particular episode. And apparently he’s really the first recorded martyr to X-ray. At least that’s what I’m told.

From the clinical point of view, the X-rays again were promptly used. The first X-ray laboratory seems to have been a laboratory started by a Dr. Schmidt in Chicago, who got so busy that he handed it over to an electrical engineer by the name of Fuchs, Wolfrom Fuchs, and in about 10 months, that is the months left after February, this laboratory did 1,400 x-ray examinations, which is not bad, particularly, I don’t have the picture, when you look at the equipment they had to work with. We’ll come back to that in a moment.

Incidentally, in 1919, the Mayo Clinic was doing more than 50,000 examinations, and I guess last year in this country, I think it’s about 180 million examinations were done, using up about half a billion square feet of X-ray film. That’s one of the reasons we want to get rid of this business. It’s gotten much too big.

OK—these are some of the early stories of what happened in those exciting few months.

Now, the problems, though, in really achieving modern radiology were somewhat staggering. The exposures required were of the order of, even for thin parts, an hour. It’s hard to believe but this apparently is so. The tubes that they were using were some modification or other of the Crookes tube. These did not produce X-rays very efficiently. But more than that, they were very cranky. To understand that you’ve got to understand that the cathode rays, the electron beam which is decelerated promptly in the anode, and this deceleration produces a certain number of X-rays, actually doesn’t work unless there are some positive ions in it. There’s actually a double current going on in the Crookes tube.

It requires a certain amount of gas, positive ions, to bombard the cathode to liberate the electrons to produce the X-rays. And they had no way of controlling just how much gas was in this tube, because it changed all the time. Gas got absorbed into the glass, and the tube heated up, some of the gas came out, then some of the gas apparently went back, and these tubes were extremely cranky. They had no way of determining what the amperage or the voltage was except by spark gap. They had a curious little formula, that for every inch of a spark gap, in air, it was 10,000 volts and then after that you added another 10,000. They judged the amperage by the fatness of the spark. They judged the penetration of the X-ray beam by what a fluorescent screen looked like, the brightness and the tint of the fluorescent screen, and many of them held their hand up in front of the screen testing whether the tube was ready to make a decent exposure, and as a result got their skin burns. They also apparently had their patients do this, hold a hand up in an X-ray beam in front of a fluorescent screen, to prove to the patient that it was a harmless procedure!

Well, this really tricky way of getting X-ray exposures went on for a long period of time. This goes by the name of the Gas Tube Era, and I guess really the last of the gas tube radiologists just recently died, Dr. Case, who lived, I think, to the age of 88 and was still vigorous. This era has all kinds of stories connected with it, because the pioneers of X-ray were producing X-rays in this fashion, and competing with each other in terms of quantity and quality and original observations.

The modern era, therefore, required a change in the X-ray tube, at least, and this is where William David Coolidge comes in. We're skipping an awful lot, but the name of Coolidge, in terms of X-ray, is extremely important, because the Coolidge tube is essentially what we use now.

Coolidge apparently was an extremely perceptive individual. I think he's died, although he was alive not too many years ago. He graduated from MIT in 1896, when X-rays were discovered, and apparently very promptly did similar experiments to those of the other professors of physics, although he had just graduated. In fact, in a later statement he says that he had an X-ray burn in 1896 and he was the second patient treated by another famous pioneer radiologist, Francis Williams, in Boston, for an X-ray burn, and that I guess is a true story.

He then went to Leipzig for a Ph.D. and he got it, summa cum laude. That doesn't prove he was very smart, maybe he just worked hard, but that's apparently true. Then he went to work for General Electric in 1905, and they put him on a job of working with tungsten. History doesn't seem to record why they selected him to work on this, although he had some experience in both physics and chemistry. But he developed in the next few years a ductile tungsten, primarily designed for the filaments of incandescent bulbs, because the carbon filaments were not very rugged, and General Electric wanted to go into the business of making a better bulb, and he did it for them.

But then he had to look around, it seems, for some other uses for tungsten, and again history doesn't record why he returned to X-ray but perhaps it's not so hard to see. The anode in a Crookes tube originally was platinum; although a variety of metals through these early years were tested, it obviously required certain special properties. In order to produce X-rays in any quantity, they promptly discovered that it had to be of high specific gravity, high density. It also presumably required a high melting point because the heat generated, and this was 99 percent of the total energy put in, in the anode melted targets. It also had to have a low vapor pressure not to contaminate the tube. And tungsten fitted this and other bills, according to Coolidge, and he developed his ductile tungsten then as an anode of an X-ray tube.

But he went further than that, because he was well aware that this wasn't enough, that this didn't take care of the crankiness of an X-ray tube. His next step therefore was, again, reasoning it seems pretty cleanly and clearly, let's get rid of the gas and see what happens. But he repeated what other people had found, that as you get rid of the gas, the amount of X-rays produced got smaller and smaller.

Parenthetically, one of the reasons why he was able to investigate higher vacuums in these enclosures was the fact that Irving Langmuir was at General Electric at that time, and this is really a name who through the years has made many contributions and reappears in the X-ray story 25 years later with image intensification. Irving Langmuir at that time developed the mercury vapor pump, so he was able to get vacuums that by a factor of about 1,000 were better than previous partially evacuated Crookes tubes.

But he needed now some way of creating electrons in an X-ray tube. Curiously enough, in 1912, that's what we're talking about now, a gentleman by the name of Lilienfeld, down in Austria, had applied for a patent on an X-ray tube where he was utilizing—now Edison comes back into the story—the Edison effect. Edison, in working with the filaments in evacuating closures and developing the bulb, had demonstrated that a hot filament in this kind of enclosure liberated electrons—a hot filament. And I guess he had a patent on it, actually.

It was thought, however, that this Edison effect also required a certain amount of gas and positive ions, in the partially evacuated enclosure. It was Lilienfeld who said this wasn't so, and he actually applied for a patent on an X-ray tube using a hot filament, except that he apparently brought his wires up to the same kind of cathode that had always been used.

Langmuir confirmed Lilienfeld's demonstration, that it did not require gas in a tube for a hot filament to emit electrons, and told Coolidge this, and Coolidge quite promptly then incorporated a hot filament and made it the cathode of an X-ray tube.

So now he had an evacuated tube, with no gas to disturb or make the action of the tube erratic. He had a tungsten target, and he had a hot filament or source of electrons, and this was amazing. He burnt the back of his hand apparently in 10 seconds—I don't know how close he kept to it—but then he stopped using his own hand and got a leg from a physician friend of his to try out the tube.

One of the interesting stories, in the introduction of this tube in 1913, was the fact that a radiologist in New York City, Lewis Gregory Cole, a really outstanding fellow, and I guess books have been written about him, introduced this tube, because Dr. Cole was an artist, with the old gas tubes. The story was that he kept a dozen of them around, and he was able to go to a shelf and pick out exactly the right one that he needed for the right kind of examination. But Dr. Cole was also very smart, and he realized that this Coolidge tube was going to revolutionize radiology, and he invited a lot of people to a dinner at the Hotel St. Denis, which I don't think it exists any more, to introduce the Coolidge tube. And it's true, it created a sensation, because it was promptly realized that here there was a method of manufacturing X-rays in larger quantities so that the exposures could be taken in a relatively short period of time, and to know what you were doing.

This was not the only basic change in X-ray equipment that was required. The date of this, you recall, was 1913. In the same year, Dr. Bucky of Germany published a paper about the Bucky diaphragm. We take the Bucky diaphragm for granted. I think most of you may know what the Bucky diaphragm is, a bunch of lead strips with cardboard or something else in between, to cut off what we called secondary scattered radiation. But this was essential for the progress of radiology, because the films that people were getting without this Bucky diaphragm or grid were gray films. They had no contrast. They might have had enough density if you had left a long enough exposure, but they had no contrast, particularly if you tried to get a radiograph of a thick part.

Incidentally, this was the reason why for the first 20 odd years of radiology, fluoroscopy was in most people's hands more important than radiography. They could look at a fluoroscopic screen, if they darkened it themselves, and see things promptly and see them better than they could on most radiographs.

What Bucky showed, and really to look at his original grid, it looks kind of silly to us these days because it looks like an egg crate or the kind of thing you see on fluorescent lamps to cut out glare. The spaces in between his lead strips were apparently on the order of a half or three-quarters of an inch. It's not clear why this worked so well, but he knew what he was doing. Originally, apparently he started with two, one on top of the patient, one below the patient, and he got radiographs of much better quality by using his grid.

This made something else possible. This goes back to some of the chest problems, Al. Because of the problem of scattered radiation before the use of the grid, the films were small, glass plates actually until 1925 or so. If you tried a thick part you got nothing but grayness on the film. So they really didn't use 14 by 17 [inch] films. They had no way of getting a decent radiograph of a large area. And in the chest, people were breathing. The chest fortunately has a lot of air in it so that they could do better than the abdomen, but the abdomen is really extraordinary that they were able to pick up calculi with the films that they had to deal with. So the Bucky grid was essential.

Now, it really did not catch on, because if you look at the reproductions of his photographs, you see this egg crate over it, and that's the first thing you see, it's hard to see the radiograph behind the egg crate. So something else had to be done, and Bucky really knew what he had to do. He had to get rid of the picture of his diaphragm, and he started to investigate moving it, and he tried to get patents on various methods of moving it. But anyway, he moved it, but because he had a criss-cross arrangement, you still saw some lines.

Actually, it seems he didn't really solve this problem, despite the fact that he worked on it for a few years. But it was solved by a Chicago radiology by the name of Hollis Potter. I like to talk about Potter, because I guess something like ten years ago at the meeting of one of the American Roentgen Ray Society, I happened to be at a table with a very nice, pleasant, intelligent gentleman who was introduced to me as Dr. Potter. And I didn't know Dr. Potter from a hole in the wall, I only learned later that this was the same Potter who in 1915-16-17 learned how to move a grid and not have a picture of the grid on your radiograph. Because he cut out the cross hatch—simple idea but somebody's got to get it—he just used large _______ strips of lead and moved it crosswise to the strips. So we have the Potter-Bucky grid or the Bucky-Potter grid, and there was a lot of business about what to call this kind of thing, and apparently Dr. Bucky got angry at a large number of people for calling some of these Potter grids or Potter-Bucky grids.

The story of Dr. Bucky also is, incidentally, an interesting story, because he did come to this country in 1923, and was appointed at Joint Diseases, at Beth Israel, the record shows, and Seaview Hospital, I think. But he returned in 1930 to Berlin to become a director of radiotherapy. But with Hitler coming on the scene, he came back three years later. The story seems to go that his friends who welcomed him in 1923 did not welcome him on his return subsequently because he had left, and actually he was in private practice in this city for many years without any substantial appointments. There's a story about his son, too, that I won't go into.

Now we have the Potter-Bucky grid, we had the Coolidge tube—what was required, and time doesn't permit to go into details—approximately the same time, 1920 or so, or before or a little after, intensifying screens became practical. They'd been thought of in 1896 actually and people had tried them. It's really fantastic, all of the things that were accomplished later, somebody thought of in 1896 in a matter of months. But the grain was such that they were not useful intensifying screens.

However, there's one famous historical picture – can we have the lights off again - taken by Dr. Michael Pupin at Columbia in this city, with an intensifying screen. This happens to be Edison looking through his hand-held fluoroscope. It's not highly recommended. It's a picture of his fluoroscope. He coined the term fluoroscope, by the way. This is Dr. Pupin's picture taken, it seems, in 1896, too. He describes the circumstances under which this was taken in his autobiography, written about 25 years afterwards. And historians have discovered that his account of what happened here was entirely false, because they went back to the *Daily Tribune.* It seems, for some reason, he reported the fact that this patient with buckshot in his hand had come to him, I think it was February 12th or something and returned two days later because he wasn't prepared to take it, and that this exposure required an hour. Now, the interesting thing about this was, it had occurred to Dr. Pupin, as it did to several people throughout the world, that if you combined the photographic film with an intensifying screen, a fluorescent screen, you could convert the x-ray to the light and the light would have a more potent effect on the film. This, of course, what we do all the time now. But this picture, it's curious, it is reproduced in many places. It's an extraordinarily good film. Of the thousands of hands that must have been taken in 1896, I have no doubt that this was probably the best. I have seen some others and they are really extraordinarily poor. Nobody seems to have commented on the quality of this radiograph and nobody therefore knows how he was able to achieve it. At any rate, there it is, and it's extraordinarily good even by modern standards. OK, can we have the lights again?

Well, actually, I haven't covered too much about the role of doctors in radiology. But you can take almost any field of radiology and go through a long list of people and discoveries that contributed to what Al has referred to as a vital part of modern medicine. One of the most interesting stories to us at Sinai is, of course, Dr. Moses Swick.

I might go back to Wessler a bit, by the way, [Harry] Wessler and Jaches. [Leopold] Jaches was the first chief of department here, on a full-time basis at any rate. He published a book on the lungs in 1923 that was really extraordinary and revolutionary. Wessler was not being immodest in what he said to you Al. He did NOT get all the credit that he deserved for his really great contribution to pulmonary radiology and medicine. I spoke to Kelly [Coleman] Rabin a couple of days ago, and he assures me, for example, that it was Wessler who discovered the infraclavicular infiltrations of secondary tuberculosis prior to Assmann's description of it pathologically, and Kelly seemed to indicate that Assmann got it from Wessler. At any rate, Wessler was an extraordinarily bright and perceptive man, and it is still worthwhile reading their book. The radiographs presented in there are really not bad.

The story of Dr. Swick is kind of a controversial story, and I don't intend to take any sides. But, Dr. Swick was sent by [Emanuel] Libman, at least on a Libman Fellowship, over to a suburb of Hamburg, Altona, to work with a Dr. [Leopold] Lichtwitz. And Dr. Lichtwitz was interested in trying to visualize kidneys by some— Hm?

Lyons: Was that Lichtman [unclear]?

Wolf: No, I don't think so. Dr. Lichtwitz had available certain compounds created by a chemist, Dr. Binz, Selectan Neutral, which had been developed some years before by the chemist, Dr. Binz as a method of treating syphilis or other infections. Apparently it was Dr. Swick that gave this to an animal, because they knew that it was excreted in the urine, and also the bile. It did not demonstrate the gallbladder, but did demonstrate the kidney in the animal and decided with Dr. Lichtwitz to investigate this material as, what we would call, an intravenous urographic material. It wasn't very good. Previous to that, in 1923, sodium iodine had been tried at the Mayo Clinic, and it wasn't very good either. But Selectan Neutral wasn't very good.

But it seems then, and this is where the story gets kind of confused, that either Mo suggested the change from a methyl to a sodium acetate radical, or Dr. Lichtwitz did, or Dr. Binz did. But, at any rate, they used another, pyridine compound that Dr. Binz insists he had synthesized a couple of years before, which was more soluble for one thing, even though it had less iodine in it. And this material, which was named by Lichtwitz as Uroselectan, it was Dr. Swick's demonstration on a patient in Berlin under [Alexander] von Lichtenberg, on his service where more patients were, Dr. Swick demonstrated that this was clinically useful.

And I don't think there's any question that in demonstrating that this particular material was satisfactory for intravenous urography, that this was really a major breakthrough in terms of the contribution of radiology, not only to the GU field but as you know, subsequent to that a variety of water soluble opaques have appeared which have made possible angiography of all kinds. And this was the first very useful water soluble opaque material that could be injected. That's a very interesting story that one of these days perhaps you can have Dr. Moe Swick tell you.

One of the other pioneers in another field of application of radiology was actually Dr. I. C. Rubin [a Mount Sinai Gynecologist] who, as far back 1914, injected collago [?], a silver protein material, into the uterus, to outline the uterus and the tubes. This was not however a very safe material, and was replaced in 1922 by lipiodol and there's a whole story about lipiodol as well.

One minute after 6, Al, I'm afraid we're going to have to stop the story at this point.

Lyons: Thank you very much. [applause] Are there any questions or observations? Whatever the story with Uroselectan and the intravenous pyelogram, the excretory urogram, to be more accurate, it was not done in this country at all until Dr. Swick came back, and it was after he came back that this country began to use the intravenous, the excretory urography.

Kaunitz: I'd like to make a correction here—

Lyons: Just one minute—this is Dr. Kaunitz who was one of the very early users of the X-ray in this country.

Kaunitz: I might say I was one of the first ones to do radiotherapy here—only one case. I was called in by one of the dermatologists to apply X-rays to a man who had a carcinomatosis, and at that time, we knew nothing at all about amperage or voltage. We had a tube that looked like a Coolidge tube, on some sort of a frame like a music stand, and it turned out some X-rays—you turned on the X-ray and you waited a few minutes, then you turned it off. You didn't know how long to give it. You didn't know what you were giving. That was in back of Ward K, one of the little rooms there, they had this room.

Then, as to the pioneers, in X-ray, really, Dr. Walter Brickner, I don't know if you ever knew him, and Seth Hirsch - does that name ring a bell, Seth Hirsch? - and Walter Brickner. They had a room just about one quarter the size of this room here, and they had also a tube on a sort of a stand, and they used to take—they took pictures. That was about 1906. That was before Dr. Wessler's time, see. But the mistake there is this, that they did use X-rays, but on bones. Not on chests. It was during Wessler's period they began using in on the chest. Everything was very primitive.

I'd like to ask you something about the type of X-ray, the type of electricity they used. I have a recollection that the earliest was a static electricity. They had great big glass wheels, one in cooptation to the other causing friction and that way obtaining the static electricity. Am I right about that?

Wolf: They had both. They had induction coils, _______ curls and static machines.

Kaunitz: Why do you think they—

Wolf: —induction coils—

Kaunitz: —[unclear] because I saw this X-ray apparatus here, very primitive.

Lyons: Thank you very much. Did you have a question?

Wolf: I wasn't attempting to go through the Sinai history, and you're perfectly right. Apparently Dr. Brickner was—I'm not sure, the first one to take a radiograph in this hospital. I think Dr. Crohn gave me the name of somebody else, but at any rate, he was the first one who did it with any serious intentions. If any of you are interested, there's not much to see, but one of the really great names in Mount Sinai is Dr. Eli Moschcowitz and he gave me this reprint of the second Mittel?—the second contribution of Roentgen in, I think, January, 1896. Curiously, the thing about Roentgen, one of the things I can't figure out, Al, and maybe Saul Jarcho could do it, sometimes Conrad, he spells it with K, sometimes with a C. You apparently can identify which is first and which second by whether it's a C or a K.

Incidentally, if any of you are interested in some reprints or early issues of the *American Journal of Roentgenology* going back to 1914. The first article in April, 1914, is the Roentgen diagnosis of gastric ulcer. Curiously enough, Dr. [R. D.] Carman of the Mayo Clinic—there's a whole story there—has some stereoscopic views of specimens. If you can cross your eyes, they really are stereoscopic views. Okay.

Lyons: Thank you very much. Next month, the history of human genetics.