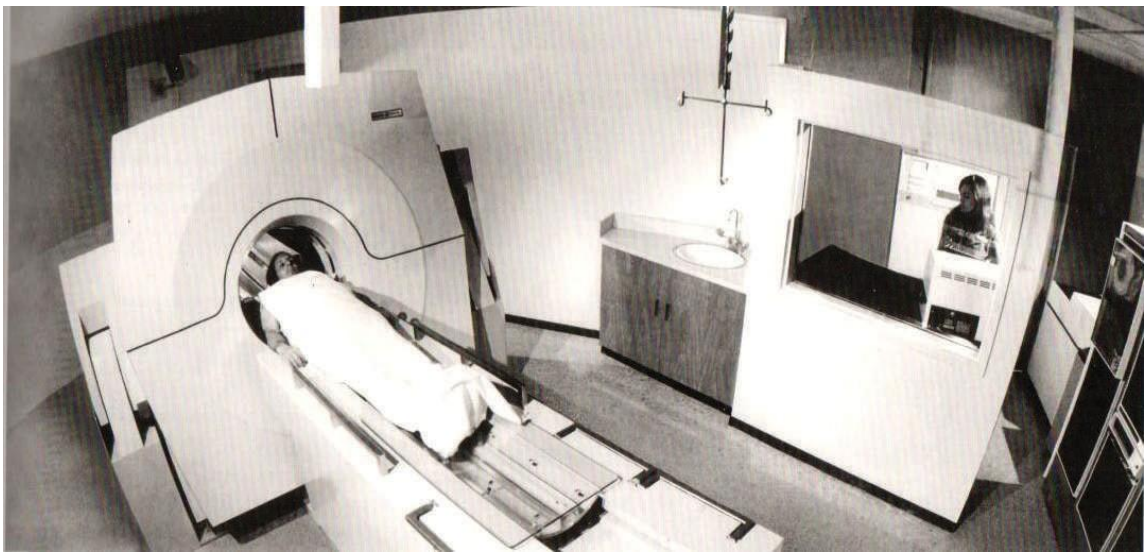


CT Scanner Protoype at UCSF Medical Center 1976

X-Ray Machines, CT Scanners, MRIs: The Pivotal Role of the GE Research and Development Center

by Walter L. Robb

Early Years

In 1895, Professor Wilhelm Conrad Röntgen in Germany announced to the world that he had invented a method for generating x-ray beams. To demonstrate the use of these beams to produce human structure, he showed the x-ray image of his wife's hand.

Laboratories all over the world duplicated his experiment, including Edison's lab in Menlo Park, New Jersey. For 15 years there were incremental improvements in Roentgen's device, sufficient to obtain images of broken bones in any part of the body.

In the summer of 1896, a young MIT graduate named William Coolidge also produced x-rays using an electrostatic voltage generator, and he reportedly sold it to a local doctor. A few years later in 1900, he was one of the first scientists hired by Dr. Willis Whitney, as he began staffing the newly-formed GE Research Laboratory in Schenectady.

For the next seven years, it is not known if Coolidge ever thought about x-rays, but what he accomplished was to learn how to produce a tough ductile tungsten thread that was perfect for replacing the carbon fiber in Edison's light bulbs. With that invention going into production, Dr. Coolidge turned his attention to x-ray tubes, which were still similar to what Röntgen had invented: filled with inert gas, unstable, and limited in the energy of x-rays they could produce.

Coolidge soon had his ductile tungsten forming the key components in a vacuum x-ray tube, and by 1910, the world had a greatly improved imaging device. GE dedicated

Coolidge's patents to the public, while still manufacturing tubes for the numerous small companies making x- ray imaging systems. With this tube, tissue as well as bones could now be imaged. Dr. Coolidge went on to become the Director of the GE Research Laboratory in 1932.

In 1926, GE decided to invest in one of the many x-ray equipment start-ups and, in 1946, the company bought control of Victor X-Ray Company in Chicago. The business was moved to Milwaukee, WI in 1946, where it would it eventually become GE Medical Systems. General Electric, in addition to Picker Corporation in Cleveland, shared the bulk of the U.S. x-ray imaging market. Siemens, Phillips and Toshiba served the rest of the world.

The Birth of CT

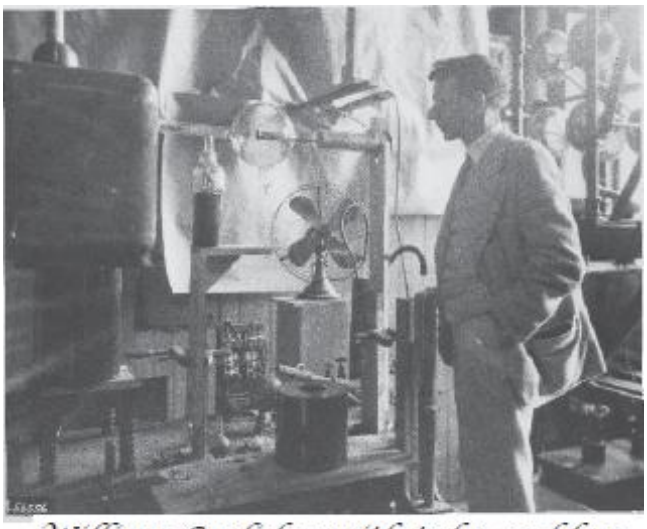
For 50 years, thanks to the Coolidge x-ray tube, GE was considered the technical leader in imaging. But in 1963, unbeknownst to the x-ray industry, Godfrey Hounsfield, a smart British computer scientist working for EMI (manufacturer of radar equipment), was allowed to pursue an idea that, unbeknownst to him, had been a curiosity in academia. It was called COMPUTER- ASSISTED TOMOGRAPHY (CAT), and the goal was to better differentiate various tumor entities in the human body, for example, to see tumors in the human brain.

Starting in 1964, Hounsfield developed a head scanner that had a single detector for x-rays and an x-ray tube emitting a pencil beam of x-rays on the other side of the head. Once every second, the tube and detector would scan the head, rotating its position one degree for each passage as the tube/detector frame circled the head. The data defined a single slice, one-centimeter thick, which was imputed to a fast computer that could calculate an image of the slice.

In 1971, Dr. Hounsfield published his results. The industry was excited about his invention, but assumed it would be limited in use to neuro-radiologists and not have a large market. Its price was twice the cost of the most expensive conventional x-ray system. It took 4 ½ minutes to make a scan and the resolution was poor. But, unlike conventional x-rays, the scanner could detect the density difference of a tumor, a tumor that was evident in the computed image.

In 1973, EMI produced 12 units that they sold at a fraction of their real cost to the top 12 medical schools in the world. These systems did require clamping the head of the patient against motion during the 4 ½ minutes to image one slice of the brain. A typical procedure would usually consist of 4 - 6 slices, which meant that the patient's head was held in place for more than ½ hour. It did seem worth the time and effort to find a brain tumor.

The response of the radiology community exceeded expectations and by early 1974, EMI had over 100 orders at $375,000 apiece. That got the attention of not only the existing x-ray companies, but also of entrepreneurial scientists, who saw the need for computer processing as equally important as the generation of an x-ray beam. Except for one or two start-ups, all of these companies settled on their main improvement being to reduce the scan time per slice to two minutes. The engineering team at GE Medical Systems also concluded that it was time to develop a two-minute-per-slice scanner as quickly as possible and estimated completion in 18 months. The total test time was reduced, but the patient's head still had to be held immobile.



William Coolidge with tube and fan.

Fortunately, the Medical Systems business in Milwaukee asked the GE research scientists in Schenectady if they had any suggestions for this development. Much to the surprise of the Milwaukee engineers and management, Laddy Stahl and Russell "Red" Reddington described an entirely different design involving a fan-beam of x-ray detectors, containing hundreds of x-ray detectors in a frame that would rotate around the patient's head and not back and forth as was the case with the Hounsfield apparatus. That device had been far too complicated for the system that Hounsfield had conceived in the 1960s.

But it had the advantage of permitting an image to be created in five seconds. The potential was huge, since even images in the abdomen could be gotten with a five-second scanner. And the resolution was expected to be significantly improved. The Milwaukee team was excited with the idea, but it was seen as an early research concept, with the prototype not anticipated to be available for five years. The business could not wait to get started on the much-simpler two-minute prototype and estimated the development time to be 18 months.

As the General Manager of GE Medical Systems, I was determined not to be the 14th

company making a two- minute scanner. I called my friend Art Bueche, VP and Director of the GE R&D Center, regarding the dilemma. Would it be conceivable to build a fan-beam scanner in 18 months? The team in Schenectady not only said yes, but set check points at six-month intervals that would hopefully give us confidence that they were on track. I terminated all work on our two-minute scanner and cast the success of the business on the Research Center's efforts.

Thanks to meeting the first 6-month objective to have a new x-ray detector invented which would make the fan- beam of over 300 detectors possible, Milwaukee got a boost in confidence that the Center might actually achieve their schedule. In another six months, when a small five- inch diameter prototype was actually working, the enthusiasm regarding this being a huge breakthrough in imaging exploded. In an unprecedented move, Milwaukee sent engineering and manufacturing personnel to Schenectady, assuming the whole-body scanner would work. With 6 months still to go, Milwaukee started investing in a plant to produce the 5-second scanner.

The goal for the first body image was December 31, 1975. To the day, the prototype worked, champagne was poured, and the Milwaukee team already had a building to move into. Without question, this 18-month accomplishment is acknowledged as the fastest development of a breakthrough product that General Electric had ever seen. In February, 1976, we announced this achievement and invited 100 radiologists to see the scanner working in the GE R&D Center laboratory. Within months, half of these radiologists gave GE orders with a down payment of $100,000 on the half million dollar system.

In a spring Dinner of Appreciation at the Mohawk Golf Club, 82 laboratory employees were recognized as having been key to this project. Art Bueche and his team had a timetable that no one had believed could be accomplished. The team leaders included Red Reddington, Art Chen, Walt Berninger and Lonnie Edelheit, who would move on to become manager for the CT Laboratory being formed in Milwaukee.

The initial laboratory prototype was actually shipped in April, 1976 to the Radiology Department at the University of California in San Francisco Hospital. While it did not perform perfectly and GE had the scare of having it possibly returned, these issues got resolved between the Milwaukee and Schenectady labs. Thirteen scanners were actually sold in 1976, 35 in 1977, and well over 100 in 1978. By then GE had over 50% of the U.S. scanner market, even though multiple imaging companies had by then announced their own fan-beam scanners.

With this success in America, GE Medical formed a joint venture in Japan and established marketing branches in the rest of the world. By 1980, GE was getting over 50% of the world orders and other imaging companies were licensing the patents that GE possessed on the CT fan-beam, 5-second scanner.

Forty years after the introduction of this scanner, it still represents the gold standard in CT imaging. Gradual improvements have reduced the scan time to a fraction of a second and improved resolution by a factor of 10. The success of the GE CT endeavor gave Milwaukee confidence to count on a breakthrough from Schenectady when magnetic resonance imaging (MRI) was invented by two SUNY professors. Once again, the GE R&D Center produced the gold standard in MRI technology.

Thanks to the R&D Center, chances are that if you go for a CT scan you will be using a GE CT scanner. Looking back, it is likely that if GE had only produced another 2-minute scanner, it would probably not be in the medical imaging business today.

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