RECHERCHE ET DEVELOPPEMENT

X-Rays, MRI and Philips Research c. 1920 - c. 2020

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Abstract

Philips encountered X-rays during the First World War, when the deliveries of X-ray tubes from Germany to the Netherlands came to a standstill. Medical doctors turned to the Philips company headquarters in Eindhoven, asking whether their broken tubes could be repaired. Philips had considerable experience with glass and vacuum technology, and a great deal of knowledge about materials. From 1918 onwards, Philips added the production of X-ray tubes to that of lamps – albeit on a small scale. Philips researcher Albert Bouwers was responsible for many interesting innovations in the X-ray tube, which secured a firm position in the market for Philips. This marked the beginning of an expanding range of increasingly diversified and advanced medical products. Philips has now become a global leader of health technology, including imaging technologies such as Computer Tomography (CT) and Magnetic Resonance Imaging (MRI).
Keywords: X-rays, Metalix, MRI, Philips, Healthcare

Résumé

Philips : Rayons-X, IRM et Recherche, des années 1920 aux années 2020

Philips s'intéressa aux rayons X pendant la Première Guerre mondiale, lorsque les livraisons de tubes à rayons X de l'Allemagne vers les Pays-Bas ont été interrompues. Les médecins s'adressèrent à Eindhoven, berceau de la compagnie, pour demander si leurs tubes cassés pouvaient être réparés. Philips possédait une grande expérience du verre et de la technologie du vide, ainsi qu'une grande connaissance des matériaux. À partir de 1918, Philips produisit autre chose que des lampes, des tubes à rayons X, mais à petite échelle. Albert Bouwers, chercheur chez Philips, fut notamment à l'origine de nombreuses innovations intéressantes dans le domaine des tubes à rayons X, ce qui assura à Philips une position solide sur le marché. Ce fut la naissance d'une gamme de produits médicaux de plus en plus diversifiés et avancés. Aujourd'hui, Philips est devenu un leader mondial des technologies de la santé, y compris des technologies d'imagerie telles que la tomographie assistée par ordinateur (CT) et l'imagerie par résonance magnétique (IRM).
Mots-clés : *Rayons-X, Metalix, IRM, Philips, soin*

The Philips company started in the 1890s with the production of carbon filament lamps. In 1914, Philips established a physics laboratory in Eindhoven to reveal the remaining secrets of the incandescent lamp. Research involved electric discharge in gases and fluorescence, which led to new products like neon tubes and FT (fluorescent tube) lamps. Philips' expertise in these fields enabled them to produce their own X-ray tubes in 1918, at the end of World War One. Philips has been involved in medical technology ever since, resulting in the production of iron lungs, hearing aids, electric razors and toothbrushes. After the introduction of MRI-scanners in the 1980s, Philips made major changes to its business activities. Production of lighting, consumer electronics, domestic appliances and personal healthcare ceased. In the 21st century, Philips has transformed from an electronics company to a health tech company.

The beginning of Philips Research: the NatLab

Philips was established in 1891 by Gerard Philips.[1] A remarkable characteristic of the young company was its focus on a single product: the incandescent light bulb, a carbon filament lamp. After a few years, Anton Philips (fifteen years younger than his brother Gerard) joined the company. As a result, Philips began to make a profit. While Anton preferred to devote his efforts to sales, Gerard combined the tasks of a manufacturer/entrepreneur with those of manager and builder. The combination of Anton's capacity for hard negotiations with Gerard's solid organization, sound financial management and open attitude towards technological innovation formed the foundation for an exceptionally strong competitive position for Philips.

To improve production quality, Philips Research was founded in 1914.[2] Until then, Philips had been able to fend off the competition by appropriating and adapting innovations that had been developed elsewhere. Their strategy had not involved launching original new ideas. This placed the company in a technologically vulnerable position that could only be maintained for as long as the absence of patent law in the Netherlands enabled Philips to copy the inventions of others without penalty. When this legislation was (re-)introduced in the Netherlands, Philips opened its own research laboratory, as General Electric in the United States had done before them.[3] Under the directorship of Gilles Holst, the main task of Philips Research was to build up a patent portfolio based on ground-breaking research and consequent new inventions.

It was essential for Holst to be surrounded by excellent scientists. He therefore ensured that the academic climate of his physics laboratory (Dutch abbreviation: NatLab) made people feel that they were working in a high-level scientific environment. Holst encouraged publication in scientific

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1 For a history of the Philips company see: Heerding A. *The origin of the Dutch incandescent lamp industry. The history of N.V. Philips gloeilampenfabriek.* Vol. 1. Cambridge: Cambridge University Press 1986; Heerding A. *A company of many parts*. Vol. 2. Cambridge: Cambridge University Press 1988; Blanken IJ. *The development of N.V. Philips' Gloeilampenfabrieken into a major electrical group. The history of Philips Electronics N.V.* Vol.3. Zaltbommel: European Library 1999; Blanken, IJ. *Under German rule. The history of Philips Electronics N.V.* Vol. 4, Zaltbommel: European Library 1999.

2 Boersma K. *Inventing structures for industrial research: a history of the Philips NatLab 1914-1946.* Amsterdam: Aksant academic publishers 2002; De Vries Mark J. *80 years of research at the Philips Natuurkundig Laboratorium 1914-1994*. Amsterdam: Pallas publications 2005; Maas A, Van Delft Dirk. *Philips Research. 100 Years of Inventions that Matter*. Zwolle: W-books, 2014.

3 Whitney Willis R. *General Electric and the Origins of Industrial Research*. New York: Columbia University Press 1985.

journals, which reflected well on Philips, the NatLab and the individual researcher. He also organized colloquia with renowned physicists, who informed the staff members of the NatLab about new developments on the scientific front. Paul Ehrenfest, a Leiden professor of theoretical physics, made dozens of appearances in Eindhoven, and was accompanied by speakers from his own colloquia in Leiden, including Albert Einstein. It considerably enhanced the NatLab's ability to attract academic talent. Some NatLab employees eventually returned to the academic world.

The encounter of Philips and X-Rays

Albert Bouwers and the X-ray programme

Philips' first experience of X-rays occurred during the First World War (1914-1918), when the deliveries of X-ray tubes from Germany to the Netherlands came to a standstill. Medical doctors turned to the laboratory in Eindhoven, asking whether their broken tubes could be repaired. Philips had considerable experience with glass and vacuum technology, and a great deal of knowledge about materials.

From 1918 onwards, Philips started to produce its own X-ray tubes. At the NatLab, researcher Albert Bouwers was the creative brain behind the X-ray programme. He created his own independent position within the NatLab, where he had started as a young researcher who had yet to complete his doctorate. Bouwers had a private secretary, and one of his employees referred to him as a 'grand-seigneur'. His obstinacy led him to consider commercial matters to be less important than technological novelty. Before the production of new X-ray equipment had started in earnest, he had already developed the following innovation.

The Metalix tube

In 1925 Bouwer invented the Metalix tube. Physicians soon discovered that X-ray radiation could pose a health hazard. Doctors working with X-ray equipment on a regular basis needed to be protected from radiation. In the Metalix tube, a large portion of the wall is made of metal, instead of glass. It is surrounded by a layer of lead that blocks any radiation that is not emitted in the desired direction within the tube. The radiation can only leave the tube through a small window. This powerful, concentrated radiation allowed the first images of the heart, lungs and stomach.

Another advantage offered by the Metalix was that it was more compact than conventional tubes. From the moment it was put on sale, the Metalix tube was enthusiastically received and used by doctors and the medical industry. In 1928, Philips started producing portable X-ray appliances such as the Metalix Junior, which made it possible for doctors to make diagnoses at the bedside (Fig. 1.).

In 1927, Bouwers develops a new invention that combines the design of the Metalix tube with the application of a rotating anode – the positively charged electrode that receives the electron radiation transmitted by the cathode. Although the rotating anode was first described in 1898, previous attempts to use it in practice had been unsuccessful. The rotation enabled the parts of the anode that were exposed to the intense electron bundle to continuously alternate, making them less likely to overheat. This made it possible to use a higher radiation intensity, which produced sharper images.

Remarkably, radiologists were not particularly impressed with this mobile X-ray appliance. They feared competition from doctors who were not competent to make judgements.

The Philips mobile Metalix, 1930. The Metalix Junior made it possible for doctors to make diagnoses at the bedside ©Philips Company Archives

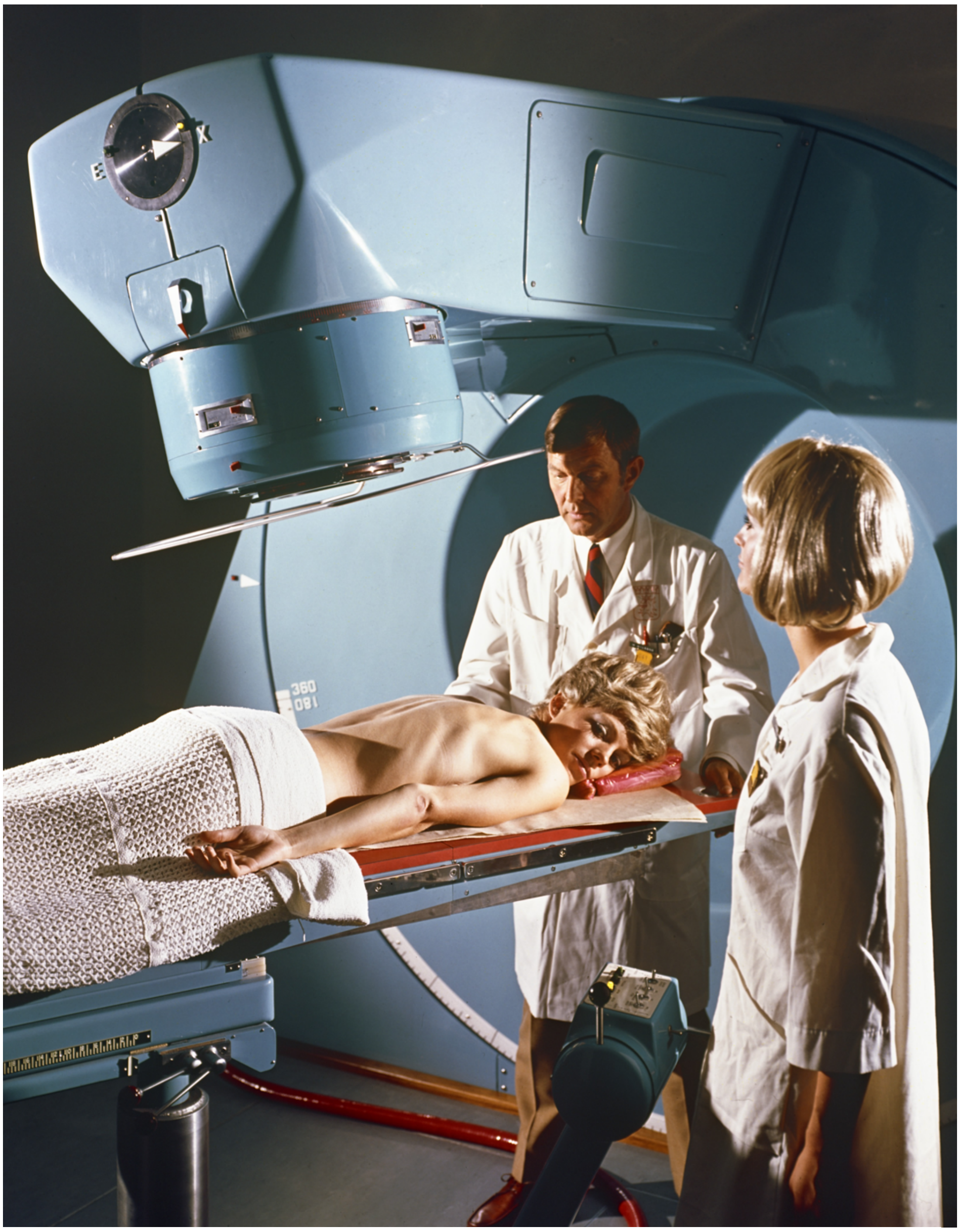
X-Ray, business and health

The sale of X-ray tubes to a small group of demanding customers was quite different from marketing mass products (e.g. light bulbs). Because Philips itself did not possess the necessary expertise, it bought the C.H.F. Müller[4] firm in Hamburg (which had previously been a major competitor) in 1927. The Müller company had been highly astute in its X-ray tube sales management, and its profits would provide the basis for the research laboratory that Philips established in Hamburg in 1957.

At the initiative of Dr. G.C.E. Burger, the director of Corporate Health Services, and with permission from Anton Philips, the Philips company began using X-rays to examine its employees for signs of pulmonary tuberculosis in the 1920s. The testing programme was gradually extended to include the relatives of Philips employees and the pupils of the Philips schools. Other companies followed suit, and the testing eventually resulted in national campaigns that would reach millions of people in the Netherlands after the Second World War. This was certainly not bad for business.

For a long time, the Philips X-ray department was not profitable. The relatively small group of professional customers, each of whom had specific demands for the tubes, hampered Philips' access to mass production. For Anton Philips, the importance of the X-ray tube lay primarily in the prestige that this service provided to high-level professionals. Being able to contribute to the wellbeing of people made him feel good.

4 C.H.F. are the initials of business man Carl Heinrich Florenz Müller.



Philips X-ray device, 1970 ©Philips Company Archives

The development of the MRI scanner

After the Second World War, the television set defined the image of Philips for decades (both literally and figuratively). The rise of consumer electronics (cassette recorder, compact disc, etc.) led the company to change its name from Philips Gloeilampenfabrieken (lightbulb factories) to Philips Electronics. Nevertheless, medical products continued to be part of the portfolio, albeit on a small scale. While the products changed, there was a startling continuity in the underlying technology. For this reason, the introduction of CT-scans (Computed Tomography) in the 1970s and MRI-scans (magnetic resonance imaging) in the 1980s allowed Philips Research to add its own innovations to these new medical devices. At the turn of the century, the Philips company had made a complete transformation from consumer electronics to health-tech.

Philips, a pioneer in Computed Tomography imaging

While the two-dimensional images generated by conventional X-ray imaging are extremely useful, there are occasions when doctors require 3-dimensional images of a patient's internal organs. In 1992, Philips used its C-arm X-ray machine technology to perform Rotational Angiography (RA), in which a series of images is captured as the C-arm rotates around the patient. Viewed in a loop, these images create the impression of a 3D view.

With computing power came Computed Tomography, a technique that uses a narrow X-ray beam to capture multiple images from different angles. These images can then can be processed by a computer to build up incredibly detailed cross-sectional images, i.e. showing slices of a patient's internal anatomy. Philips quickly became a pioneer in CT imaging with several world firsts, notably in the development of innovative solid-state X-ray detector technologies that progressively improved image quality while at the same time reducing X-ray dose. The company also pioneered Spectral CT, a technique that delivers high diagnostic quality with a low contrast agent dose, thus making CT's diagnostic capabilities available to vulnerable patients such as those with reduced renal function.

One of Philips' most recent innovations in this field is the Spectral Photon-Counting CT detector (SPCCT). This detector allows CT scanners to perform imaging on a molecular level. By linking specific chemical elements to different colors, black and white CT-images are upgraded to color images, leading to further improvements in precision diagnosis.

Philips and the challenge of MRI

MRI stands for Magnetic Resonance Imaging: powerful magnetic fields make the various tissues in the body visible, and reveal their condition, healthy or otherwise. The first researcher to make a MRI scan of a live human body was the American physician Raymond Damadian, in his Brooklyn laboratory in 1977.[5] Three years previously, a mouse was the first subject to undergo MTI. In those days scans took hours and provided low spatial resolution.

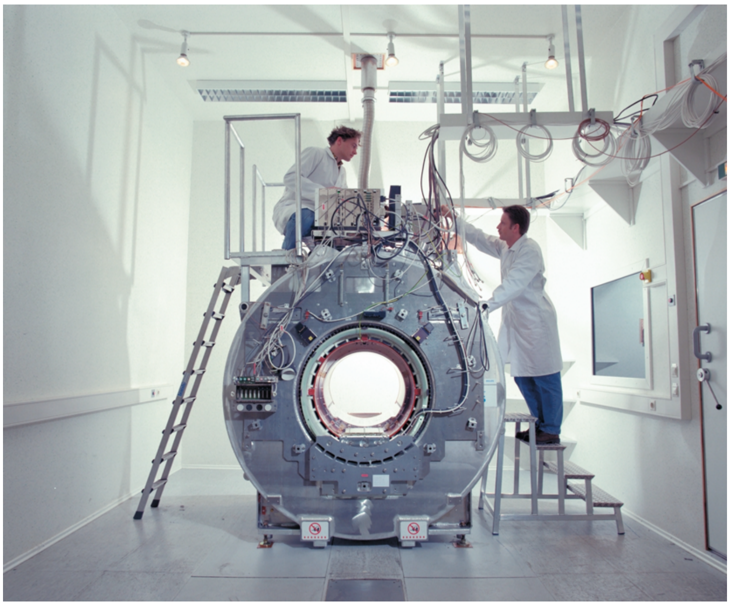
Philips Research began work on MRI in 1984. The world of MRI brings together diverse technologies: magnets, high current electrical engineering, signaling, electromagnetic waves and signal processing – all at extreme levels of precision. In the development of past products (for example magnetic materials for loudspeakers), Philips Research had built up ample experience of these types of technologies. In its laboratory in Hamburg, under the leadership of Johan Overweg, Philips Research had to face problems like dealing with stray fields (the strength of the magnetic field outside the MRI opening for the patient's body), or with the growing world shortage of helium.

Designing an MRI scanner involves major optimization issues.[6] How powerful should the magnetic field be? What is the ideal field volume to attain sufficient quality for the creation of images? How large should the MRI opening be (in other words how big can the patient be)? By far the most expensive component is the magnet. In practice, a MRI scanner is made up of a number of coil systems. The outer coil generates a powerful magnetic field. The large magnet makes use of superconductivity that in turn calls for a cryogenic system based on liquid helium –we owe both of these scientific feats to the Leiden low-temperature physicist Heike Kamerlingh Onnes (1853-1926).

5 Damadian RV. Goldsmith M., and Minkoff L. NMR in cancer: XVI. FONAR image of the live human body. *Physiol. Chem. Phys.* 1977, 9,1: 97-100.

6 Wehrli Felix W. The Origins and Future of Nuclear Magnetic Resonance Imaging. *Physics Today*, 1992, 45, 6: 34-42.

In order to reduce the magnetic field outside the scanner, shield coils are installed in which the current flows in reverse. An additional gradient coil enables the strength of the field in the patient to be adjusted locally, so that the location of the signal can be precisely determined. Detectors capture this signal and the computer converts all these elements into an image. These are complicated machines that combine a range of different technologies: high-power electrical engineering, high-frequency electromagnetic waves, magnet technology, signaling technology and signal processing. Philips currently build their MRI scanners in Schenectady, in the state of New York.



Philips currently builds its MRI scanners in Scenectady, New York ©Philips Company Archives

The integration of MRI scanners into radiotherapy treatment is a recent development, allowing the use of radiation to fight tumors from outside the body. Because the brain can be viewed throughout the process, the radiologist can directly see the impact that the treatment is having. Philips has developed this type of combined system with Utrecht University Medical Centre.

Conclusion

At Philips, the customer now takes center stage: the company aims to respond to customer needs, together with the challenges faced by society as a whole. In the 21st century, Philips aims to respond to trends in modern healthcare. The world population continues to increase and is also ageing. People with chronic diseases now live longer and medical costs are spiraling out of control. Care at home will increasingly replace hospital care. At the same time, people are becoming more aware of the influence of lifestyle on health. In healthcare, the ageing population is an enormous problem that calls for sustainable solutions to prevent costs from becoming uncontrollable.

Bringing an end to the increase in cardiovascular diseases, and making safe and comfortable cities a reality: these are the kind of areas that Philips is increasingly claiming as its own. The result is innovative imaging technologies using low-dose X-ray or ultrasound, or software that enables pacemaker replacement by combining monitoring (using an MRI scanner) with medical intervention.

In the immediate future, the Philips Innovation Center in Eindhoven will focus on so-called breakthrough innovations: major technological discoveries that could potentially earn the company a billion euros or more.[7] These discoveries will result in products that hopefully will not suffer from costly recalls, as seen recently for millions of ventilators and other respiratory devices.

7 *Bits & Chips*, January 30, 2023.