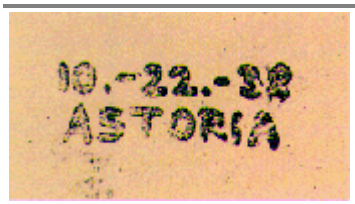
XEROX

The Story of Xerography

Our Heritage, Our Commitment



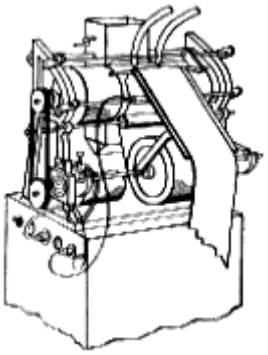
"10-22-38 ASTORIA"

This humble legend marks the time and place of an auspicious event. It is the text of the first xerographic image ever fashioned. It was created in a makeshift laboratory in Queens, NY. by a patent attorney named Chester Carlson, who believed that the world was ready for an easier and less costly way to make copies.

Carlson was proved right only after a discouraging ten-year search for a company that would develop his invention into a useful product. It was the Haloid Company, a small photo-paper maker in Rochester, N.Y, which took on the challenge and the promise of xerography and thus became, in a breathtakingly short time, the giant multinational company now known to the world as Xerox Corporation.

This report contains several stories about xerography: the man who invented it, the company that made it work, and the products it yielded for the benefit of mankind.

These stories chronicle a classic American success story: How men of courage and vision grew a highly profitable business from little more than the seed of an idea.



Certainly, Xerox has changed greatly in size and scope since the historic 914 copier was introduced in 1959. But we also believe that the basic personality of Xerox has never changed. We are convinced that the essential attributes that brought the young Xerox such spectacular rewards in office copying are the same attributes we need to assure continued success for the mature Xerox as it develops total office information capability.

Under the leadership of Joseph C. Wilson, the Haloid people demonstrated extraordinary vision when they searched far afield of their bread-and-butter business to acquire the patents of an untried invention. They saw enormous potential where others saw only the hazards.

And at Xerox today, research scientists are exploring the outer reaches of office information technology, looking in unconventional places for solutions to problems facing the offices of the world ten or twenty years from now.

We know that if we are to assume and maintain leadership in this vast new area of office information systems, we must continue to seek out new and better and cheaper ways of handling information.

The Haloid leaders also took great risks in opting to develop xerography. They put up much of the company's modest earnings, and millions of dollars more in outside investment, to develop the first xerographic products.

Because of that initial gamble, Xerox today possesses a wealth of financial and human resources to take some prudent risks on unproven technologies and untried strategies which show great promise.

Risk-taking is in our blood. And we think that, in the long run, it will enhance our balance sheet as well.

We are well aware of our heritage at Xerox, of the traditions of growth, courage and excellence. We are determined to be worthy of that heritage.

Xerography: Chester Carlson's Impossible Dream

Carlson memorabilia, including a photograph of the inventor as a high school senior and a page from his scrapbook containing a xerographic self-portrait with his annotation.

Part I

Xerography, the technology which started the office copying revolution, was born unheralded on October 22, 1938, the inspiration of a single man working in his spare time.

When he died in 1968 at the age of 62, Chester Carlson was a wealthy and honored man, Xerox annual revenues were approaching the billion dollar mark, and the whole world was making copies at the push of a button.

The astounding success of xerography is all the more remarkable because it was given little hope of surviving its infancy. For years, it seemed to be an invention nobody wanted. To know why it eventually prevailed is to understand the mind of Chester Carlson. For xerography, and the man who invented it, were both the products of hardship and travail.

An early brochure produced by Haloid (later Xerox) explaining the process of xerography to the public.

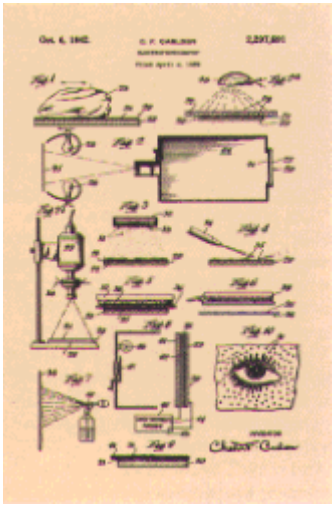
Chester Carlson was born in Seattle on February 8, 1906, the only child of an itinerant barber. The family settled in San Bernardino, Calif., and at the age of fourteen, Carlson was working after school and on weekends as the chief support of his family. His father was crippled with arthritis and his mother died of tuberculosis when he was seventeen.

Even as a boy, Carlson had the curious mind that always asked the how and why of things. He was fascinated with the graphic arts and with chemistry -- two disciplines he would eventually explore with remarkable result.

As a teenager he got a job working for a local printer, from whom he acquired, in return for his labor, a small printing press about to be discarded. He used the press to publish a little magazine for amateur chemists.

"I don't think I printed two issues,"Carlson later recalled, "and they weren't much. However, this experience did impress me with the difficulty of getting words into hard copy, and this, in turn, started me thinking about duplicating processes. I started a little inventor's notebook, and I would jot down ideas from time to time."

Upon graduating from high school, Carlson worked his way through a nearby junior college where he majored in chemistry. He then entered California Institute of Technology, and was graduated in two years with a degree in physics.



The front page of Chester Carlson's original patent describing his invention of electrophotography, later called xerography, which would eventually revolutionize office copying. This historic patent was filed April 4, 1939, several months after Carlson made the first xerographic image. It was issued Oct. 6, 1942 as number 2,297,691.

More problems faced Carlson as he entered a job market shattered by the developing Depression. He applied to eighty-two firms, and received only two replies before landing a $35-a-week job as a research engineer at Bell Telephone Laboratories in New York City.

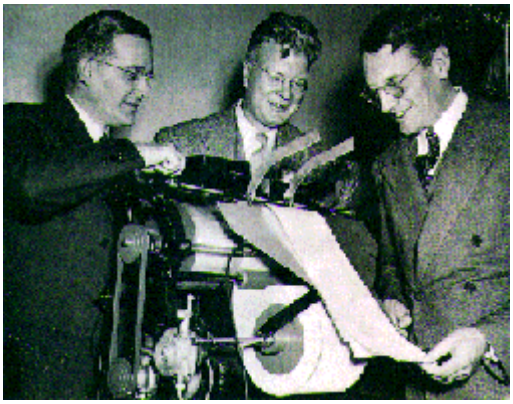
As the Depression deepened, he was laid off at Bell, worked briefly for a patent attorney, and then secured a position with the electronics firm of PR. Mallory & Co. While there, he studied law at night, earning a law degree from New York Law School. Carlson was eventually promoted to manager of Mallory's patent department.

"I had my job," he recalled, "but I didn't think I was getting ahead very fast. I was just living from hand to mouth, and I had just gotten married. It was kind of a struggle, so I thought the possibility of making an invention might kill two birds with one stone: It would be a chance to do the world some good and also a chance to do myself some good."

As he worked at his job, Carlson noted that there never seemed to be enough carbon copies of patent specifications, and there seemed to be no quick or practical way of getting more. The choices were limited to sending for expensive photo copies, or having the documents retyped and then reread for errors.

A thought occurred to him: Offices might benefit from a device that would accept a document and make copies of it in seconds. For many months Carlson spent his evenings at the New York Public Library reading all he could about imaging processes. He decided immediately not to research in the area of conventional photography, where light is an agent for chemical change, because that phenomenon was already being exhaustively explored in research labs of large corporations.

Xerography: Chester Carlson's Impossible Dream



The Xeroprinter demonstrated in the late 1940s by John H. Dessauer, Haloid's research head; Chester Carlson; and Haloid President Joseph C. Wilson. This early xerographic device, which printed on rolled paper, commanded public attention, but was never marketed as a product.

Part II

Obeying the inventor's instinct to travel the uncharted course, Carlson turned to the little-known field of photoconductivity, specifically the findings of Hungarian physicist Paul Selenyi, who was experimenting with electrostatic images. He learned that when light strikes a photoconductive material, the electrical conductivity of that material is increased.

Reflecting on these early discoveries, Carlson later said, "Things don't come to mind readily, all of a sudden, like pulling things out of the air. You have to get your inspiration from somewhere, and usually you get it from reading something else."

Soon, though, he began some rudimentary experiments, beginning first -- to his wife's aggravation -- in the kitchen of his apartment in Jackson Heights, Queens. It was here that Carlson unearthed the fundamental principles of what he called electrophotography --later to be named xerography -- and defined them in a patent application filed in October of 1937. "I knew," he said, "that I had a very big idea by the tail, but could I tame it?" So he set out to reduce his theory to practice.

Frustrated by a lack of time, and suffering from painful attacks of arthritis, Carlson decided to dip into his meager resources to pursue his research. He set up a small lab in nearby Astoria and hired an unemployed young physicist, a German refugee named Otto Kornei, to help with the lab work.

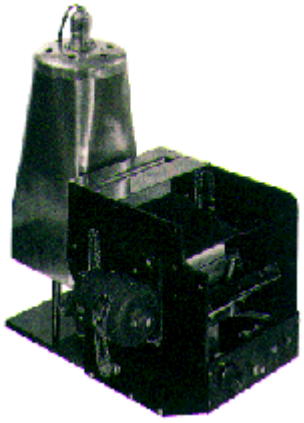
It was here, in a rented second-floor room above a bar, where xerography was invented. This is Carlson's account of that moment: "I went to the lab that day and Otto had a freshly-prepared sulfur coating on a zinc plate. We tried to see what we could do toward making a visible image. Otto took a glass microscope slide and printed on it in India ink the notation '10-22-38 ASTORIA.'

The Inventor of the Year Award given to Carlson in 1964. It was one of many such honors he received during his years of fame.

"We pulled down the shade to make the room as dark as possible, then he rubbed the sulfur surface vigorously with a handkerchief to apply an electrostatic charge, laid the slide on the surface and placed the combination under a bright incandescent lamp for a few seconds. The slide was then removed and lycopodium powder was sprinkled on the sulfur surface. By gently blowing on the surface, all the loose powder was removed and there was left on the surface a near-perfect duplicate in powder of the notation which had been printed on the glass slide.

"Both of us repeated the experiment several times to convince ourselves that it was true, then we made some permanent copies by transferring the

powder images to wax paper and heating the sheets to melt the wax. Then we went out to lunch and to celebrate."



Carlson's first xerographic apparatus. It never worked well, but researchers at Battelle Memorial Institute and Haloid Company later applied the resources needed to turn the basic discovery into functional, and ultimately profitable, machines.

Fearful that others might be blazing the same trail as he -- which is not an uncommon occurrence in the history of scientific discovery -- Carlson carefully patented his ideas as he learned more about this new technology.

His fear was unfounded. Carlson was quite alone in his work, and in his belief that xerography was of practical value to anyone. He pounded the pavement for years in a fruitless search for a company that would develop his invention into a useful product. From 1939 to 1944, he was turned down by more than twenty companies. Even the National Inventors Council dismissed his work.

"Some were indifferent," he recalled, "several expressed mild interest, and one or two were antagonistic. How difficult it was to convince anyone that my tiny plates and rough image held the key to a tremendous new industry.

"The years went by without a serious nibble.. .I became discouraged and several times decided to drop the idea completely. But each time I returned to try again. I was thoroughly convinced that the invention was too promising to be dormant."

Finally, in 1944, Battelle Memorial Institute, a non-profit research organization, became interested, signed a royalty-sharing contract with Carlson, and began to develop the process.

And in 1947, Battelle entered into an agreement with a small photo-paper company called Haloid (later to be known as Xerox), giving Haloid the right to develop a xerographic machine.

Xerography: Chester Carlson's Impossible Dream

Part III

It was not until 1959, twenty-one years after Carlson invented xerography, that the first convenient office copier using xerography was unveiled. The 914 copier could make copies quickly at the touch of a button on plain paper. It was a phenomenal success. Today, xerography is a foundation stone of a gigantic worldwide copying industry, including Xerox and other corporations which make and market copiers and duplicators producing billions and billions of copies a year.

Above, Chester Carlson uses his original lab equipment to recreate his 1938 experiment which established the process of xerography.

And to Carlson, who had endured and struggled for so long, came fame, wealth and honor, all of which he accepted with a grace and modesty much in keeping with his shy and quiet personality.

Even during the hectic and heady 1960s, when the 914 and successor products were spelling glory for Xerox, Carlson remained in the background, and he gave his opinion only when asked. "I prefer anonymity," he once said during a tour of a manufacturing plant.

Had he held onto it all, Carlson would have earned well over $150 million from his remarkable invention. But before he died he had given away some $100 million to various foundations and charities.

One of the first versions of the XeroX Copier. Introduced in 1949 as the first xerographic product to be marketed, it was only a modest success, but it paved the way for much bigger things.

During Carlson's last years he was given dozens of honors for his pioneering work, including the Inventor of the Year in 1964 and the Horatio Alger Award in 1966.

In 1965, at the commemoration of the 175th anniversary of the U.S. patent system, he gave some of his original equipment, as well as that first xerographic print, to the Smithsonian Institution, where it is on display.

But Carlson's gift to Xerox was even greater than his historic invention. Joseph C. Wilson, the man who led the tiny company to greatness by gambling on xerography, said this about Chester Carlson's contribution:

"From this life, we of Xerox have learned much, and from it we have adopted policies that affect everything we do. "First, we will never forget that in the individual is the origin of the great creative act…"

"Second, we learned that great rewards come to those who see needs that have not been clearly identified by others, and who have the innovating capacity to devise products and services which fill these needs."

Haloid: The Little Company that Went for Broke

An historical montage: An 813 drum, nameplates from various models, pellets of the photoconductor selenium, an early sales brochure, XeroX copiers, the first 914 off the line, and Xerox President Wilson with Sales Vice President McColough in 1960. McColough went on to become chairman of Xerox.

Part I

The Haloid Company after World War II was headed for trouble.

While revenues of the small Rochester, N.Y firm were increasing, its earnings were shrinking, and the prognosis for improvement was poor.

Since its founding in 1906 as a tiny company, Haloid had grown in a modest but consistent fashion by making and selling photographic paper. Even during the horrible Depression years, when companies all over the nation were closing down, Haloid kept several hundred people fully employed, managed to turn a profit and even acquired a firm which made photo-copying equipment. But after the booming war years, the Haloid market share began to shrink, and worse, there was nothing in the works to avert the inexorable decline.

Joseph C. Wilson, who was about to assume Haloid's leadership from his retiring father, decided that the answer lay in acquiring a promising new technology. Young Wilson knew well the basic logic of the free enterprise system: Success depends on profit, profit depends on growth, and growth depends on new ideas.

As fate would have it, there was at that time a new idea looking for a company. The two were introduced in the July, 1944 issue of *Radio News*, a technical periodical brought to the attention of John H. Dessauer, Haloid's research head. In the magazine was an article on electrophotography. Dessauer showed it to Wilson, and they agreed this process warranted a closer look.

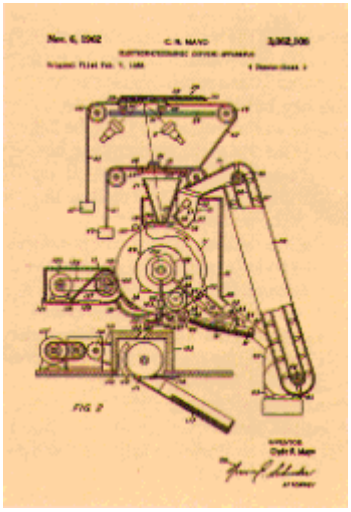
In 1953, Chester Carlson was awarded the prestigious Longstreth Medal from the Franklin Institute, earlier than most to recognize the significance of the inventor's discovery.

Battelle Memorial Institute, a non-profit research organization in Columbus, Ohio, was developing the process. Battelle had acquired the rights from an unknown inventor named Chester Carlson, who had created an electrostatic image on a photoconductive surface, then transferred the image to a piece of paper. Carlson had tried in vain to interest large companies in developing his findings, but no one was interested.

While working as a patent attorney for an electronics firm in New

York, Carlson had some business dealings with Battelle physicist Russell Dayton. As they were chatting, he handed Dayton one of his patents, and asked if Battelle migh be interested. It was. Carlson demonstrated his process in Columbus, and when he finished, Dayton told his colleagues:

"However crude this may seem, this is the first time any of you has seen a reproduction made without any chemical reaction and by a dry process."



Above, part of a Haloid patent describing the "electrophotographic copying apparatus" destined to become the famous 914 copier. The inventor was development engineer Clyde Mayo, a Xerox research executive.

A deal was struck, with Battelle agreeing to do the development work for 60 percent of any royalties. Still, Battelle people were unsure of just what good use would come of this new process. Their ideas included a catalogue printer and a child's toy, as well as an office copier.

Their development work was crucial. In selenium, Battelle researchers found an ideal photoconductor for a xerographic device. Known for years as one of the Earth's commonest chemical elements, selenium proved to be much more effective than the sulfur Carlson had been using. Battelle also devised the developer -- a mixture of dry ink particles (toner) and "carrier" beads that remains the basic formula today.

But Battelle, like Carlson, encountered difficulties finding a buyer. There was little interest until that day Wilson and Dessauer arrived from Rochester to have a closer look. A contract was signed, effective January 1, 1947, which gave Haloid a license to develop a xerographic machine.

It was a gamble for Battelle. Haloid's earnings in 1946 were only $101,000 on $6.75 million in sales. Wilson later wondered aloud why Battelle picked Haloid:

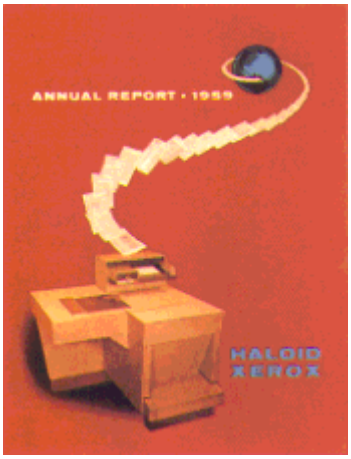
"Financially we were very limited. We had a limited marketing organization and a limited research group. I guess what sold them was that we were going to make or break with it… And they were afraid that bigger companies would have it as a side issue, on the back burner."

The parties also agreed that "electrophotography," the word Carlson coined, was too cumbersome. So Battelle went to an Ohio State classical language professor, who coined "xerography," from the Greek words for "dry" and "writing."

Haloid demonstrated its new process at a Detroit meeting of the American Optical Society on October 22, 1948, ten years to the day after Carlson created the first xerographic image. Society members were interested, but couldn't see how this crude process offered any particular advantage.

Through subsequent contracts with Battelle, Haloid acquired more and more of the development burden. Marshalling its meager resources, it introduced in 1949 its first xerographic machine-the XeroX (with a capital "X") Copier. It was slow, dirty and required a number of carefully executed manual operations to produce a decent copy. But fortunately, it stumbled into a ready-made market. Slow as it was as a document copier, the XeroX Copier proved to be a quick master maker for a type of small office printing press requiring paper masters which ordinarily had to be typed by hand.

Haloid: The Little Company that Went for Broke



In 1953, the cover of the 1959 Annual Report graphically and boldy predicted the future of the company's first officer copier, the revolutionary 914.

Part II

In 1954. Haloid hired C. Peter McColough, 31, to head the reprographic service centers. A vice president of sales with Lehigh Navigation Coal Sales Company, McColough was looking for a company with growth potential.

If first impressions counted, he would have gone elsewhere. As he was interviewed by John B. Hartnett, the Haloid vice president for marketing. McColough was momentarily dismayed at what he saw: An orange crate served as Hartnett's bookcase, and on the "bookcase" was his lunch pail. "What am I doing here," McColough thought. But Hartnett's enthusiasm and Wilson's persuasiveness won him over. He took a $17,000-a-year job with a company offering nothing but promise. McColough went on to become president, and then chairman of the company.

In 1955 came Copyflo, the first completely automated xerographic machine. It produced enlarged prints on a continuous roll from microfilm originals, and spawned a line of Xerox microsystems products which are still turning significant profits. Copyflo was also the first product to use a drum, instead of a plate, as the photoconductive surface. The rotating drum, an ingenious solution to the problem of how to make copies quickly, has been used again and again in Xerox machines.

Revenues from Copyflo were healthy, and by 1956, xerographic products accounted for almost 40 percent of revenues. Inspired by its modest success, Haloid optimistically changed its name to Haloid Xerox in 1958. By that time it was well into a much larger effort: the development of a fast, cheap, convenient office copier. People didn't have one then. But they had plenty of other options:

The A. B. Dick mimeograph machine worked well, but involved the time and expense of master making. The Photostat machine gave good reproduction; but was costly and slow. The 3M Company's Thermo-Fax unit needed treated paper and produced copies which darkened in time. And Eastman Kodak's Verifax machine made damp copies that had to be dried.

It was time for a breakthrough, all right. But was xerography the method, and was Haloid the means?

Though the company was doing well, Wilson feared that revenues were simply not enough to stage the development of the hoped-for xerographic office copier, which was becoming extremely costly. He even considered offering to share the project with larger companies which had the wherewithal. But just as Carlson had been rejected, so were Wilson's probes. Haloid, forced to either quit or go for broke, took the latter course, staking all it had, and a lot it didn't have, on a product no one could say would either work or sell.

In the fall of 1959, the world saw the 914 copier (so named because it could copy sheets as large as 9 by 14 inches). In March of 1960, when the first 914 was shipped to a customer, there were predictions that maybe 5,000 units would be placed in three years. By the end of 1962, 10,000 had been shipped,

and manufacturing people were backlogged with orders.

In short, the 914 was an astounding success, one of the most successful single products ever made. It launched a major corporation and revolutionized an industry. In 1959, the company's net income was $2 million. In 1960, the first year of the 914 in the marketplace, net income was $2.6 million. In 1961, it was $5.3 million. In 1962, $13.9 million. In 1963, $22.6 million.

The 813 desktop copier was introduced in 1963 and also made a hit. In 1964, the 2400 (named for the number of copies it could make in an hour) was introduced.

And three generations of highly profitable xerographic copiers and duplicators -- some two dozen products in two decades -- grew from the 914.

In 1961, Haloid Xerox took the name of Xerox, and its stock was listed on the New York Stock Exchange. XRX was an especially hot issue even in those go-go years.

Straining under the phenomenon it had created. Xerox frantically tried to keep up with the demand for its products. Every third person in Xerox in 1963 had been hired that year. In the Town of Webster, about ten miles east of Rochester, a huge manufacturing and research complex blossomed on a thousand acres where only apple trees had bloomed a few years earlier. And an entire sales and service force was hired and trained from scratch.

It was an enormous gamble that paid off in spades. Some $12.5 million -- more than the company's total earnings in the ten years from 1950 through 1959 -- had been spent to develop the 914. The feat was accomplished by pouring profits back into research, by heavy borrowing, by convincing investors to buy more shares.

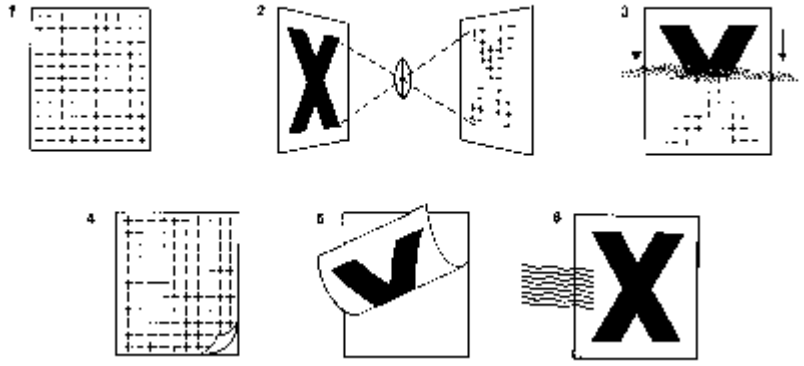
As xerography became paramount, Haloid made xerox a trademark with its own logo, then changed its name to Haloid Xerox before taking the name Xerox in 1961.

But mostly it was done on inspiration and courage. Like few others in their time, the Haloid people were believers. Their motivation created one of the most spectacular business success stories of the century.

How Xerography Works

In 1938, Chester Carlson invented xerography out of two natural phenomena already known: materials of opposite electrical charges are attracted, and certain materials become better conductors of electricity when exposed to light. By combining these phenomena in a unique way, he was able to create a new process for making cheap, fast, good copies on plain paper.

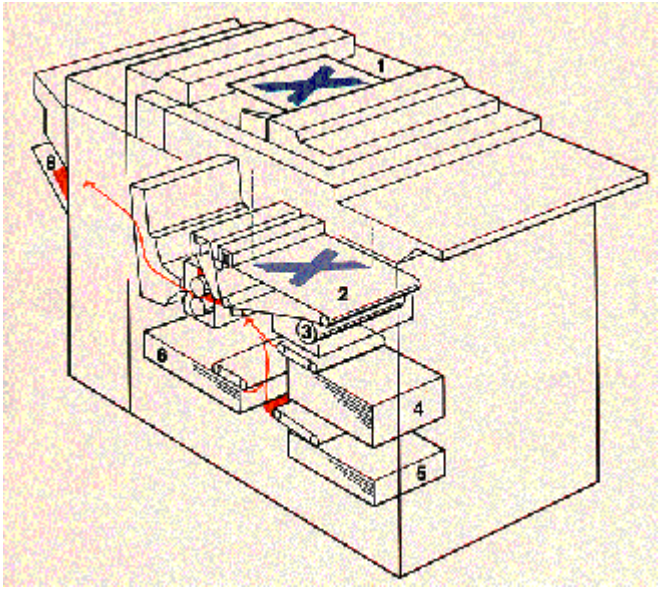
Here are two diagrams of xerography at work. The first describes the process in elemental terms, roughly the way Carlson worked with it. The second shows how Xerox inventors have applied it, along with many other technologies, to an advanced xerographic machine.



Basic Xerography
(1) a photoconductive surface is given a positive electrical charge (+).
(2) The image of a document is exposed on the surface. This causes the charge to drain away from the surface in all but the image area, which remains unexposed and charged.
(3) Negatively charged powder is cascaded over the surface. It electrostatically adheres to the positively charged image area making a visible image.
(4) A piece of plain paper is placed over the surface and given a positive charge.
(5) The negatively charged powder image on the surface is electrostatically attracted to the positively charged paper.
(6) The powder image is fused to the paper by heat.

After the photoconductive surface is cleaned, the process can be repeated.

How Xerography Works



How Xerography Works
The original document is moved automatically from the document handler (1) to the platen (under the document handler), where it is projected by a system of lamps, mirrors and lenses onto the photoreceptor belt (2). The belt carries a charge of static electricity that is discharged in those areas receiving light from the projected image. The charge remaining forms a latent, invisible image.
Magnetic rollers (3) brush the belt with dry ink that is, itself, charged with static electricity of opposite polarity. This charge makes the dry ink cling to the latent image on the photoreceptor, making the image visible.
A sheet of copy paper moves from a paper tray (4, 5, or 6) to the belt. As it approaches the belt, the paper, too, is given a charge of static electricity. This charge has the same polarity as the charge on the belt, but it is strong enough to attract the dry ink forming the image away from the belt. The copy then goes between two rollers (7) that apply heat and pressure, fusing the dry-ink image into the paper.
The completed copy emerges at an output station (8).