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Chester F. Carlson

Inventor of Xerography

"The Society of Photographic Scientists and Engineers has guarded its Honorary Membership jealously so that its value would not become diminished by large numbers. Honorary Membership should not become a matter of course every year. Thus, at the 1961 Conference as well as in some previous years no Honorary Membership award was made. This year we are very happy to be able to bestow again an Honorary Membership. The Honors Committee unanimously voted for a nominee whose name had been submitted by several Chapters and individual members independently—for the inventor of electrophotography—

Chester F. Carlson

... for his creation of a completely new and fruitful area in photography and his contributions to the efforts to turn his invention into a highly successful new branch of the photographic industry."

——Excerpts from the Citation by Karl Leistner, Chairman, Honors Committee, SPSE

• A Biography

ALFRED DINSDALE, *Xerox Corporation, Rochester, N.Y.*

Since the term "inventor" is used in the title of this biography, it might be helpful to begin by inquiring into the basic nature of invention and inventors. Lawrence Lessing,[1] writing about radio inventor Edwin H. Armstrong, has this to say:

"The great *Oxford English Dictionary*, based on historical principles, is admirably to the point. An inventor is 'the first finder-out.' But this common-sense view has been so obscured by the multiplicity of modern developments and the confusion of conflicting interests that many spurious ideas are afloat as to how inventions are made and who brings them about.

"One such notion, favored by pedants of pure science, is that true invention is no longer possible, for everything new is traceable back through previous discoveries to the ancient Greeks who, in one way or another, thought of nearly everything.

"Another notion, favored by corporations, is that invention has grown so diffuse that something new can rarely be credited to a single man but rather to the organizing genius of modern corporations."

In a different context, Lessing defines the inventor as "the man who first joins the disparate discoveries of the past into something entirely new."

How does an inventor work? Usually, he faces a concrete problem and worries away at it until he gets an inspiration which leads to a solution. In this respect inventors are curiously alike. For example:

Lessing describes how Armstrong was faced with the problem of trying to find a way to receive and amplify very weak shortwave signals. "No conventional means of reception with the tubes available —neither feedback nor straight heterodyne nor simple tuned circuit nor series arrangement—could hope to catch these signals. 'Suddenly,' said Armstrong later, 'all links of the chain joined up and I saw the way these signals could be handled.' "

1. Lawrence Lessing, *Man of High Fidelity, Edwin Howard Armstrong*, Lippincott, Philadelphia, 1956.

Thus, in a sudden flash of genius, the superheterodyne was borne, in 1918. After 44 years it is still the basic receiver circuit in use today for almost all purposes.

Similarly, Chester F. Carlson describes the reasoning that led to the solution of a problem in his invention of xerography. Then, he says: "With the problem so sharply defined, the solution came almost as an intuitive flash."

There are, of course, two kinds of inventors; the individual inventor and the highly organized corporate researcher whose every variation from the known normal is patented by his company. The corporate school of thought argues that the individual inventor is dying out, that he has no place in the modern industrial picture. The opposing school of thought argues that the independent inventor is still very much alive, and will continue to live and contribute the great new ideas which lead to the forming of new industries.

Philo T. Farnsworth, the inventor of our modern system of television, is quoted[2] as saying: "We must not lose track of the fact that inventions as such, important inventions, are made by individuals and almost invariably by individuals with very limited means."

By way of contrast, A. Hunter[3] says: "The days when one individual's inventiveness and enterprise could transform an industry are in the past. In this context the big firm again shows to advantage . . . These are . . . well-known facts of economic life . . ."

Apparently, these "well-known facts" were not known to Joseph C. Wilson, President of The Haloid Company, when in 1946 he initiated negotiations which resulted a year later in a deal with Battelle Memorial Institute for certain rights to Chester F. Carlson's patents in xerography. In 1946 The Haloid Company sold $6,750,000 worth of photographic and photocopy paper and machines for a net profit of $101,000. By 1961, despite the "well-known facts of economic life," Carlson's inventions had transformed The Haloid Company into the Xerox Corporation, with total sales of $59,533,000 and profits of $5,323,000. And the rate of growth is indicated by the figures for the first half of 1962: total sales, $47,116,089; net profit, $5,658,165.

So much for the economic facts of life. Who is this man Carlson? The fact sheet says he has been granted 34 United States patents, of which 28 relate to xerography, but what of the man himself?

Chester F. Carlson was born February 8, 1906, in Seattle, Washington. His grandparents on both sides came from Sweden about 100 years ago and homesteaded in Minnesota. Freedom of worship was one reason for coming to the United States.

"About a year after I was born," says Carlson, "my father was brought down with a severe case of tuberculosis. As if that were not enough, he also developed arthritis of the spine, the two together rapidly reducing him to a bent, emaciated wreck of a man who was to spend the greater part of each day for the next 26 years lying flat on his back, wracked by coughing spells and defeated by the world. This, plus the resulting poverty and isolation, was to have a profound effect on my development.

"Work outside of school hours was a necessity at an early age, and with such time as I had I turned toward interests of my own devising, making things, experimenting, and planning for the future. I had read of Edison and other successful inventors, and the idea of making an invention appealed to me as one of the few available means to accomplish a change in one's economic status, while at the same time bringing to focus my interest in technical things and making it possible to make a contribution to society as well."

Soon after Chet was born, the family moved from Seattle and stayed briefly at several places in California, Arizona, Mexico, and finally settled in San Bernadino, California, where the young inventor-to-be went through grammar school and high school. Then he went to Riverside Junior College for three years, taking a co-operative course —one of those courses where the student works half time and goes to school half time. Then he transferred to Advanced Standing at California Institute of Technology and got his B.S. degree in Physics there in 1930.

After graduation Carlson accepted a job offer as a Research Engineer at the Bell Telephone Laboratories in New York. This turned out to be a rather dull routine job, so Chet asked for a transfer to the patent department because he thought he would have a chance to get in touch with a lot of new developments that were going on and find it more interesting. Thus, he became assistant to a patent attorney for two years, until he was laid off in 1933, during the Great Depression.

Says Carlson: "So then I walked the streets for a while, with thousands of other men, and finally landed a job in a patent attorney's office down near Wall Street, working on patent applications. I served my apprenticeship, ended up my clerkship there, thus enabling me to be registered as a patent attorney. I still didn't have any law training." (At that time it was possible to become a patent attorney without formal legal training.)

After working for the patent attorney for about a year, Chet accepted a better-paying job in a small patent department of the P. R. Mallory Co., which had an executive office in New York. He remained with Mallory until the end of 1945, by which time he was head of the patent department and had three or four men under him.

In patent work both technical and legal knowledge are essential, so it is quite common for men to enter the patent field through research or engineering and then study law while working. For this reason Carlson began in 1936 to study law at night at New York Law School and received his Ll.B. degree three years later.

The search that led to the invention of xerography

2. John Jewkes, David Sawers, and Richard Stillman, *The Sources of Invention*, Macmillan, London, 1958.
3. A. Hunter, "The Control of Monopoly," *Lloyds Bank Review*, London, October 1956.

began in earnest in 1935. When asked by this writer what caused him to look into this particular field to try to find something, Chet replied: "Well, I had had a fascination with the graphic arts from childhood. One of the first things I wanted was a typewriter—even when I was in grammar school. Then, when I was in high school I liked chemistry and I got the idea of publishing a little magazine for amateur chemists. I also worked for a printer in my spare time and he sold me an old printing press which he had discarded. I paid for it by working for him. Then I started out to set my own type and print this little paper. I don't think I printed more than two issues, 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.

"There was a gap of some years, but by 1935 I was more or less settled. I had my job, but I didn't think I was getting ahead very fast. I was just living from hand to mouth, you might say, and I had just got married. It was kind of a hard 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."

During the course of his patent work, Carlson noted that there never seemed to be enough carbon copies of patent specifications. There were only two ways to get additional copies—have expensive photocopies made or have a typist type more copies which then had to be proof-read for typographical errors, a laborious process. It soon occurred to him that it would be highly desirable to have a small copying machine in the office into which one could feed the original document and obtain a finished copy in a few seconds.

Consideration of this concept soon led to the conclusion that such a machine would have to be capable of copying all types of subject matter, regardless of chemical characteristics. In other words the basic operating principle would have to depend upon light-reflecting properties, i.e., a photographic process.

Carlson was well aware of the fact that silver halide photography and other processes based upon the use of light to initiate a chemical change had been under development for many years and were currently being exhaustively studied by the research laboratories of large corporations in the field. He decided, therefore, to steer clear of the field of chemical photography and search for any other effects he could find which depended upon the influence of light on a receiving substance.

For many months he spent hours of his spare time reviewing literature in the New York Public Library. As Chet puts it: "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."

It was not long before he was considering photoelectric effects, and through study of these he came upon the special branch known as photoconductivity. He learned that when light strikes a layer of photoconductive material the electrical conductivity of the material is increased while the light is on and, in some cases, for a period after the light is removed.

Here, then, was a start towards the solution of the problem. There followed many months of experiments in the kitchen of his apartment in Jackson Heights, New York, before the basic principles of electrophotography (xerography) were established. Carlson refined and developed the idea as much as possible and filed a preliminary patent application on October 18, 1937, only a few months after he had evolved the basic concept.

It still remained to prove his theory experimentally. To quote Chet: "I was charting a new trail and there was no paved highway to the right practical combination. Still, I knew that there was little chance of interesting anyone in a mere paper idea, no matter how much faith the inventor himself might have in it."

In this case our inventor had only just got out of the red financially and was maintaining a home and paying law school tuition on a comparatively low salary, so it was not possible to spend much on equipment or pay for outside help. Furthermore, his heavy law school assignments consumed most of his time evenings and weekends. Then near-disaster struck.

"At about this time," says Carlson, "possibly due to the heavy schedule I was carrying, and the consequent physical strain, I developed severe arthritis of the spine. The constant pain and the specter of total disability contributed to making this period one of the most frustrating and discouraging in my life. In some ways, though, this situation also served as an added inducement to produce a marketable invention."

Nevertheless, a little time was stolen from weekend law assignments, and experimental work proceeded at home. At one point he tried placing a few crystals of sulphur on a brass plate and melting them over the kitchen gas range. The sulphur melted easily enough, but when an attempt was made to spread it over the surface of the plate, the sulphur caught fire and filled the house with fumes. In a classic understatement Chet says: "My experiments became very unpopular around the house."

In the fall of 1938, Carlson decided to dip into his meager resources and get some help. He hired Otto Kornei, a refugee physicist recently arrived from Germany, and rented a back room on the second floor of a house in Astoria, Long Island. The room had once been the kitchen of an apartment, so it had running water and gas connections. The first floor of the building was occupied by a bar and grill and the front of the second floor by a beauty parlor. In these surroundings Kornei went to work.

A break-through was not long in coming. In Carlson's own words: "October 22, 1938, was an

historic occasion. I went to the lab that day and Otto had a freshly-prepared sulphur 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.'

"We pulled down the shade to make the room as dark as possible, then he rubbed the sulphur 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 sulphur 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."

Just ten years later to the day, on October 22, 1948, the Haloid Company made the first public announcement of xerography. The intervening years, however, were filled with a vast amount of work and many disappointments.

Otto Kornei remained with Carlson for six months after the initial success, and many improvements were effected. Then Chet set about designing a working model with which to demonstrate his invention and try to interest some company enough to take it up. After many troubles with model makers and delays due to the disruptions of World War II, he decided to do what he could with a crude demonstration kit which Otto Kornei had built. His first basic patent was issued in November, 1940, and he knew that as the 17 years of basic patent protection began to run the value of the patent position would start to be whittled away.

There followed nearly four years of contacts of one sort or another with over 20 different companies, as well as the National Inventors Council and the Army Signal Corps. Finally, on October 6, 1944, an agreement was signed between Carlson and Battelle Development Corporation, a subsidiary formed by Battelle Memorial Institute for the specific purpose of sponsoring new inventions. This was the turning point. From there on, organized applied research went to work.

In 1946 The Haloid Company (now Xerox Corporation) got in touch with Carlson indirectly, through a New York intermediary. This led to an agreement whereby Haloid obtained a patent license and began sponsoring research work at Battelle in January, 1947. As already noted, on October 22, 1948, the first formal public announcement of xerography was made by Haloid and Battelle jointly in New York. Two years later, in 1950, the first sale was made of commercial xerographic equipment, in the form of Haloid's Xerox Copier.

When asked if, as he looked back on events, he felt satisfied with what had developed, and his part in it, Carlson replied: "I am extremely satisfied with the way everything has turned out. There were times when I felt impatient. You see, 15 years elapsed from the time I started working on xerography and the time the first piece of commercial equipment went on the market. And for exactly ten of those years I was working on my own, on my own limited resources. But I am very lucky, really, to have had the good fortune to make a tie-up with two such high-grade organizations as Battelle and Haloid."

To repeat Philo T. Farnsworth's statement: "We must not lose track of the fact that inventions as such, important inventions, are made by individuals and almost invariably by individuals with very limited means."

However, as the experiences of Chester F. Carlson and many other great inventors prove, it is a long, rough road—costing much time and money—from "important invention" to market place, and the organized research of great corporations becomes a great and indispensable necessity.