Innovations that Changes the World
An Introduction to The David Sarnoff Collection at TCNJ

I. Introduction – Sarnoff and RCA

America is a nation of inventors. From the colonial period to the present, the country has taken pride in its technological achievements. Beginning in the early 20th century, corporations organized laboratories to harness this creative impulse and systematize the invention of new technologies.

These research centers traced their ancestry to Thomas Edison's New Jersey workshops, and the state remained an important site for industrial innovation throughout much of the 20th century. Long before the rise of Silicon Valley, New Jersey scientists and engineers formed the core of the nation's electronics industry.

David Sarnoff was, in his own way, as central to New Jersey's emergence as a center for innovation as Edison. He was not a scientist or inventor, but as chairman of the Radio Corporation of America (RCA), Sarnoff oversaw the development of the communication technologies that came to define the Information Age. Under his leadership, RCA organized the first radio broadcasting network, perfected both black-and-white and color television, and established a research center in Princeton that made important contributions to the growth of digital computing, integrated circuitry, and flat-panel displays.

This exhibition explores the evolution of these technologies and David Sarnoff's involvement in their production and promotion. The stories of Sarnoff and RCA highlight the challenges associated with managing complex technical projects, the effects of social, economic, and political trends on industrial research and development, and the extent to which one person's vision can transform an industry.

David, Leah, Lew, and Morris Sarnoff in Borisov, Belarus (c. 1896)

David Sarnoff spent his early years in Uzlian, a shtetl (Jewish village) located in modern-day Belarus. His father Abraham worked as a house painter, but like many in Eastern Europe during the late 19th century believed he could find a better life in the United States.

In 1896, Abraham traveled to America and after four years accumulated enough money to buy passage for his wife (Leah) and three sons (David, Lew, and Morris). In July 1900, the reunited Sarnoff family moved into a fourth-floor tenement in New York City's Lower East Side and started looking for ways to make ends meet.

David Sarnoff at the Marconi Wireless Company Station at John Wanamaker's New York Store (c. 1912)

Two months after arriving in America, Sarnoff enrolled in English classes, and when he was not in school, he found part-time jobs selling Yiddish-language newspapers and singing in a synagogue choir.

When his father fell ill in 1906, Sarnoff found full-time work delivering telegrams for the Commercial Cable Company. Although he was fired for requesting time off for the Jewish High Holy Days, his newfound interest in electrical communication soon earned him an operator position at the Marconi Wireless Telegraph Company.

Wireless Telegraph Key Operated by David Sarnoff (c. 1912)

Sarnoff proved a skilled telegraph operator, and in 1912, he was assigned to manage the Marconi station at the Wanamaker department store in New York City. This promotion led to Sarnoff's participation in a pivotal moment in the history of radio.

On the evening of April 14th, 1912, the ocean liner Titanic struck an iceberg and started taking on water. Almost immediately, the ship began transmitting distress signals. Sarnoff stayed at his Wanamaker post for three days, using this telegraph key to contact rescue ships and compile the names of survivors. He later referred to the incident as a turning point in his career, noting that "the Titanic disaster brought radio to the front, and incidentally me."

Commercial 1st Grade Radio Operator License (May 7, 1913)

While the sinking of the Titanic showcased radio's potential to save lives, it also raised questions about the need to control its use. The lack of lack of clear guidelines concerning shipboard wireless equipment and interference from amateur operators had hindered rescue efforts and cost lives.

Congress, which had previously hesitated to regulate the airwaves, seized upon the disaster to pass the Radio Act of 1912. This law mandated that all American operators, even experienced ones like David Sarnoff, had to be licensed. To accommodate the demand for trained wireless experts, the Marconi Company recruited Sarnoff to act as an instructor at a newly organized technical institute.

David Sarnoff in Military Uniform (c. 1945)

Another way for immigrants to demonstrate their patriotism was through military service. Sarnoff registered for the draft during World War I, but the Navy rejected him, arguing that his job as Marconi's commercial manager was more important. In 1924, with assistance from RCA president and military hero James Harbord, Sarnoff received a commission as a lieutenant colonel in the U.S. Army Signal Corps. Sarnoff took his responsibilities as a reserve officer seriously, setting aside his work at RCA for two weeks each year for active duty at Fort Monmouth, NJ. By the time, the United States entered World War II, Sarnoff had become a full colonel.

U.S. Army General's Garrison Cap (c. 1942)
Military Awards and Decorations (c. 1945)

As soon as Sarnoff received word of the Japanese attack on Pearl Harbor, he sent a telegram to the White House:

"All our facilities are ready and at your instant service. We await your commands."

For the remainder of the war, RCA scientists and engineers made vital contributions to military radar and sonar, as well as mobile broadcasting equipment. Dwight Eisenhower also recruited Sarnoff to coordinate all radio traffic associated with the D-Day invasion.

In recognition of his contributions to the liberation of Europe, Sarnoff received a French Legion of Merit medal and many other military honors. Most important of all, in December 1944, he received a promotion to brigadier general, as indicated by the sterling silver star on his garrison cap. From then on, Sarnoff expected to be referred to by his new rank, both inside and outside of RCA. Until his death in 1971, he would be known as "General Sarnoff" or "The General."

David Sarnoff and Otto Schairer at RCA Laboratories Breaking Ground (1941)

Sarnoff began his career in radio as a wireless operator and retained an interest in the technical aspects of telecommunications for the rest of his life. During the Great Depression, he demonstrated his commitment to research by using the royalties from RCA's electronics patents to support its laboratories. He also authorized the construction of a new central research laboratory in Princeton, halfway between RCA's factories in Camden and Harrison, NJ. Company executives, including Sarnoff and RCA vice-president Otto Schairer, participated in the groundbreaking ceremony in August 1941.

David Sarnoff's Identification Badge (1966)

Compared to other executives, Sarnoff maintained unusually close ties with RCA's scientists and engineers. In the late 1930s, he regularly traveled from New York to Camden to discuss the development of black-and-white television with Vladimir Zworykin. Once the company initiated its campaign to create an all-electronic color television system, Sarnoff's visits to Princeton grew so frequent that an office and bedroom were set up for him at RCA Laboratories. Like other members of RCA's technical staff, he also received an identification badge, which he wore even after 1951, when the facility was renamed in his honor.

David Sarnoff on the Cover of Time Magazine (July 23, 1951)
Emmy Award (1962)

“Who would dare to predict the future?” The caption to David Sarnoff’s 1951 image on the cover of Time reflects his estimation of himself as a technological visionary. By the time this magazine was published, he had demonstrated his foresight by anticipating the emergence of radio broadcasting and both black-and-white and color television.

Sarnoff’s prediction that RCA’s all-electronic color system would become the national standard, though widely debated in 1951, came true a decade later. In 1962 the Academy of Television Arts and Sciences awarded Sarnoff an Emmy for his many contributions to the television industry.

Inscribed Photos

Winston S. Churchill Inscribed to David Sarnoff (1951)
Franklin D. Roosevelt Inscribed to David Sarnoff (1940)
Harry S. Truman Inscribed to David Sarnoff (1945)
Dwight D. Eisenhower Inscribed to David Sarnoff (1956)
John F. Kennedy Inscribed to David Sarnoff (1961-1963)

Letters to Sarnoff

Franklin D. Roosevelt Autographed Typed Letter to David Sarnoff (September 17, 1956)
Dwight D. Eisenhower Autographed Typed Letter to David Sarnoff (September 17, 1956)
John F. Kennedy Autographed Typed Letter to David Sarnoff (June 22, 1962)
Winston Churchill Autographed Typed Letter to David Sarnoff (1956)
Harry Truman Typed Letter to David Sarnoff

David Sarnoff Letters and Photographs
Bust of David Sarnoff by Jo Davidson (Mid-20thCentury)

In 1967, David Sarnoff stepped down as chief executive officer of RCA, leaving the company's daily affairs in the hands of his son and successor, Robert. Instead, he devoted his time to constructing a library, mirroring those built to honor the U.S. presidents he had advised over the years. The facility, built in a wing of RCA's Princeton laboratories, housed artifacts and documents related to his career, including correspondence and photographs of world leaders, as well as awards, honorary degrees, and personal correspondence. Visitors entering the library were greeted by a bust of the General created by sculptor Jo Davidson, whose other portrait busts included Franklin Delano Roosevelt, Albert Einstein, and John D. Rockefeller. The Sarnoff Library remained open to the public for more than forty years, offering students of all ages an opportunity to learn more about the life of one of the 20th-century's greatest innovators.

II. Vacuum Tubes & Radio

In its earliest form, radio technology was a medium for long-distance, point-to-point communication, using a telegraph key to send Morse code signals to destinations beyond the reach of wires. The invention of the vacuum tube, a device similar to a light bulb that could both detect and amplify radio waves, provided the first practical means of transmitting the human voice.

In 1915, David Sarnoff proposed an alternative to the point-to-point use of radio. Vacuum tubes, he realized, enabled music or other programming to be broadcast from centrally located radio stations to all surrounding households.

Sarnoff's supervisors at American Marconi ignored his suggestions, even after General Electric's 1919 purchase of the company and its subsequent reinvention as the Radio Corporation of America. Only in 1920, after the government started issuing broadcasting licenses, did RCA establish its first experimental station.

Entertainment radio swiftly became RCA's largest business, and the firm secured a leading position in the new industry through the strategic licensing of its patents and the 1926 formation of the National Broadcasting Company—America's first radio network.

Crystal Radio Set (c. 1915)
Radio Periodicals (c. 1920)

In October 1899, Italian inventor Guglielmo Marconi demonstrated his new “wireless telegraph” by providing live bulletins during the America’s Cup yacht race. Although Marconi saw commercial telegraph and telephone companies as the target audience for his invention, the resulting American press coverage also inspired a growing group of amateurs fascinated by the idea of instant communication without wires.

No technology facilitated the democratization of radio as much as the crystal set. This low-cost receiver took its name from its reliance upon a small piece of galena (lead sulfide) to rectify radio waves, converting their oscillations into a unidirectional current that was then fed into headphones or speakers.

Early Edison Light Bulb (c. 1900)

Crystal sets were cheap and easy to build but possessed several shortcomings. Users often had to reposition a thin wire known as the “cat’s whisker” along the surface of the galena to ensure the best possible reception. More importantly, crystal sets had no means of signal amplification.

Thomas Edison had stumbled across the beginnings of a solution to both problems in 1883 while experimenting with incandescent lamps. Edison inserted an additional metal plate into one of his light bulbs and determined that current could flow from the filament to the plate, but only if the plate had a positive charge. This phenomenon became known as the “Edison effect,” but it received little attention until a Marconi employee used it to develop a new radio wave detector.

Collection of Vacuum Tubes (1915-1944)
Repairman’s Case (c. 1960)

John Ambrose Fleming had worked for the Edison Company in London before becoming a scientific adviser for Marconi. In 1904, Fleming replicated Edison’s earlier experiment and soon realized that when he applied alternating current to the filament of the modified bulb, direct current emerged from the plate. Fleming's "oscillation valve" served a similar rectifying function to the galena in crystal sets.

In 1906, inventor Lee DeForest added a third piece to Fleming's tube: a wire grid regulating the current flow through the valve. The resulting device, referred to as the triode or "audion" tube could both receive and amplify radio signals and would eventually enable the transmission and reception of the human voice.

Until the 1960s, vacuum tubes served as the technological foundation of the consumer electronics industry, and RCA repairmen often carried kits like this one filled with replacement vacuum tubes to fix broken radio or television sets.

Aeriola Sr. Receiver Radio, Type RF (c. 1922)
Pair of Radio Headsets (c. 1915)

World War I reinforced the military significance of radio and prompted American officials to consolidate the nation's wireless manufacturing industry. In 1919, the government authorized General Electric to purchase the U.S. subsidiary of the British-owned Marconi Company, which was renamed the Radio Corporation of America.

The new firm—RCA—would be jointly owned by G.E., Westinghouse, AT&T, and the United Fruit Company, each of which owned important radio-related patents. It would have no manufacturing facilities and would act primarily as a merchandising agent for equipment produced by its parent companies, such as Westinghouse's Aeriola Senior, the first radio model built for the general public. RCA sold the Aeriola for $75, but that did not include the cost of the tube, antenna, or batteries.

Victor Model 86K7 (1936)

Four years before the creation of RCA, David Sarnoff, then a manager at American Marconi, wrote a memorandum in which he described "a plan of development which would make radio a 'household utility.'" Sarnoff envisioned homes equipped with a "Radio Music Box" tuning into signals emanating from centrally located transmitters. Sarnoff brought up the idea again after

Marconi's consolidation into RCA, but the company considered it a long-term prospect until 1920, when Westinghouse started broadcasting programs from its Pittsburgh factory.

By 1922, the Department of Commerce was issuing dozens of broadcasting licenses each month and entertainment radio had become RCA's largest business. Initially RCA focused on meeting the demand for household radios, but in 1926, it purchased all of AT&T's broadcast stations and formed the National Broadcasting Company (NBC)—the first-ever radio network.

Radiola No. 26 (c. 1925)
Radiola Speaker, Model 100 (1925)

While working for Marconi, Sarnoff made the acquaintance of a talented engineer named Edwin Armstrong. As an undergraduate at Columbia, Armstrong had analyzed the behavior of Lee De Forest's audion tube and determined that by feeding an incoming radio signal back to its grid, it could serve as a powerful amplifier. As a member of the Signal Corps during World War I, Armstrong built upon this invention and created the superheterodyne circuit, a high-frequency signal amplifier, which remains used today in radio and television tuners. After the war, Sarnoff purchased the rights to manufacture superheterodyne radios, like the Radiola 26.

Victor Portable Radio Model BP-10 Superheterodyne (c. 1940)

The sale of the superheterodyne circuit made Armstrong RCA's largest private shareholder, but his strong working relationship with Sarnoff would not last. In 1933, Armstrong devised a method to transmit signals through frequency modulation (FM), which would eliminate the static associated with conventional amplitude modulation (AM) signals. Sarnoff refused to support this new technology, since RCA had already invested heavily in AM equipment.

Armstrong split from RCA in 1935to build up the FM system on his own. The emotional strain and legal battles associated with his conflicts with Sarnoff over bandwidth and patent rights likely contributed to his 1954 suicide. Meanwhile, RCA continued to capitalize on the superheterodyne, which enabled the creation of this pocket-sized radio.

III. PHONOGRAPH

The arrival of radio broadcasting captivated consumers but inspired fear among phonograph manufacturers, who worried that radios might supplant record players in America's living rooms. Radio stations could transmit music into people's homes for free, removing any incentive to purchase new recordings for one's personal collection. Moreover, the electronic amplification of music, made possible through the use of vacuum tubes, offered an increased volume that acoustic phonographs could not match.

While most viewed the radio and phonograph as competitors, David Sarnoff recognized that the two technologies served a common function: sound reproduction. Microphones and loudspeakers developed for radio applications, he argued, might also benefit the recording industry. With these objectives in mind, in 1929, Sarnoff negotiated the purchase of the Victor Talking Machine Company.

The purchase of Victor enabled RCA to enter a new sector of the home entertainment market, and it granted the firm a greater degree of independence. Before 1929, RCA did not possess any manufacturing facilities of its own; it sold radios produced by General Electric and Westinghouse. By acquiring Victor, RCA gained access to that company's research organization, a globally recognized trademark—Nipper, the dog—and most importantly, its factory in Camden, New Jersey.

The Graphophone, Model Q, Columbia Phonograph Co. (c. 1899)

Thomas Edison opened his Menlo Park laboratories in 1876, the same year that Alexander Graham Bell demonstrated how to electrically transmit the human voice. Edison recognized the advantages Bell's telephone system had over the telegraph, but telegraphs offered one major advantage—it was possible to record Morse code messages on to strips of paper using specially modified hole punches. There was no way to capture a telephone message.

In 1877, Edison invented the first phonograph, which converted sound vibrations into etchings on the surface of a foil-wrapped cylinder. These early cylinders could only be replayed a few times before the message was lost, prompting a search for an improved recording medium.

Ultimately, it was not Edison, but Bell who first lined a recording cylinder with wax, creating an improved talking machine called the graphophone. Others, including Edison and Edward Easton of the newly established Columbia Phonograph Company, quickly followed suit.

Nipper Sculpture (c. 1940)

Loaned by the Johnson Victrola Museum, State of Delaware Division of Historical and Cultural Affairs

Most early sound recordings were preserved on wax cylinders, but in 1888 Emile Berliner, a German-born telephone expert, replaced Edison's cylinders with a flat metal disk, which he used to stamp out duplicate recordings. Berliner approached Eldridge Johnson, a machine shop owner in Camden, N.J., to produce equipment for the newly formed Berliner Gramophone Company. Johnson later purchased Berliner's patents and in 1901 and established the Victor Talking Machine Company.

Despite competition from Edison and Columbia, between 1901 and 1910, Victor produced over 600,000 phonographs, and sales boomed thanks to an advertising campaign featuring Nipper, an alert fox terrier, who is unable distinguish "His Master's Voice" from a recording.

Victor Electrola-Radiola RE75 (1929)

The proliferation of radio represented a significant threat to the phonograph industry. Phonograph manufacturers responded by slashing prices and preventing artists signed to recording contracts from appearing on the radio.

Realizing that the two technologies shared a common function—sound reproduction—David Sarnoff proposed an alliance between RCA and the Victor Talking Machine Company. Though Victor's leadership initially deferred, Sarnoff persisted and, in 1929, oversaw RCA's acquisition of Victor. The purchase granted RCA access to Victor's manufacturing facilities and sales operations, while Victor benefitted from the technical expertise of RCA's staff and the use of radio to advertise its records and players. Soon the Camden factories were producing home entertainment consoles combining radios and phonographs into a single unit.

78 RPM records (c. 1930)

During a 1902 trip to Milan, a Victor employee persuaded the famous tenor Enrico Caruso to record ten arias for $400. The recordings generated so much interest in the United States that Caruso received an invitation to appear at the Metropolitan Opera and Victor received a flood of inquiries from other prestigious musicians. Victor's Red Seal label became synonymous with high quality musical performances and imbued the record player, which had previously been viewed as a novelty, with a newfound respectability. Over time, the RCA Victor catalog expanded to include other well-known classical, country, jazz, and rock artists including Marian Anderson, Roy Rogers, Duke Ellington, and Elvis Presley.

Victor 45 RPM Record Player (c. 1950)

Before World War II, records were made of shellac-based mixture, which were capable of withstanding the pressure of a steel phonograph needle while spinning at 78 revolutions per minute (rpm) but generated a lot of background noise during playback. The introduction of vinyl resins offered a way to eliminate this audio interference. These tough materials could also hold more grooves than conventional records, allowing more audio information to be held on a smaller disc.

RCA Victor engineer Benjamin Carson took advantage of vinyl's improved properties to develop the 45 rpm system. Released to the public in 1949, RCA's new records held only 5 minutes of music per side, but the company also sold phonographs with a built-in changing mechanism, allowing a stack of 45s to be played consecutively with only a minimal delay between discs.

Sarnoff Demonstrating Propaganda Phonograph at a meeting of the Oversees Press Club (1955)
Prototype Propaganda Phonograph (c.1965)

During the Cold War, even seemingly peaceful technologies like the record player were conscripted to counter the threat of Communism. In November 1955, David Sarnoff presented a new weapon in the propaganda war against the Soviet Union: a hand-powered plastic phonograph intended to be air-dropped along with records made of cardboard into areas without electric power. Not only would this device cost less to manufacture than a radio, but the accompanying pro-democracy messages would be impossible for enemies to jam. Sarnoff contacted President Eisenhower directly about this invention, but although the U.S. Information Agency expressed an interest in the idea, it was never produced in significant numbers.

IV. Black-and-White Television

As early as 1923, David Sarnoff predicted that just as radio had evolved from point-to-point communication to broadcasting, the electronic transmission of sound would eventually give way to a means of sending and receiving images. He recognized, however, that development of television would have to wait until RCA acquired its own research and manufacturing capabilities. The merger with Victor fulfilled these objectives, and when Sarnoff became RCA's president in 1930, television became the company's top priority.

Almost immediately, technical staff in Camden faced a choice between two competing approaches to television development. Previous investigations at GE and AT&T utilized spinning, perforated disks to scan and reproduce an image, while others, including independent inventor Philo Farnsworth and Westinghouse researcher Vladimir Zworykin embraced an all-electronic approach with no moving parts. Sarnoff supported the latter option and recruited Zworykin to oversee RCA's television research.

Despite the Great Depression, RCA invested more than $10 million in television research. Sarnoff unveiled the completed system at the 1939 World's Fair, although it would take several years before the Federal Communications Commission (FCC) accepted RCA's approach as the basis for a national broadcasting standard.

Early Kinescope CRT Prototype (c. 1934)

RCA engineer Vladimir Zworykin was eager to demonstrate that electronic television systems could match the performance of earlier mechanical approaches, and he initially focused his attention on creating a display system based upon the cathode ray tube (CRT).

A CRT consisted of an evacuated glass tube containing a piece of metal that emitted a stream of electrons when heated. Zworykin's first display, the kinescope, used a series of electrically charged plates to accelerate this beam and guide it across a phosphor-coated screen to create an image.

Iconoscope II (1930)

Zworykin submitted a patent for an electronic video camera in 1923 while he was working at Westinghouse, but it would take a decade before he reduced the idea to practice. The resulting device, the iconoscope, projected light onto a target known as the "mosaic," which created an electronic version of the image. When the mosaic was scanned with an electron beam, this image was discharged, producing a video signal. Early iconoscopes were two-sided, with light shining in on one side and the electron beam scanning the other. Eventually, Zworykin and his team were able to produce a single-sided iconoscope like the one seen here.

First Image Orthicon Tube (c. 1944)
Miniature Image Orthicon Tube (MIMO) (Late 1940s)

During World War II, engineers at the David Sarnoff Research Center received a military contract to explore the possibility of a television-guided bomb for use in the Pacific theater. These investigations culminated in the construction of the image orthicon, a camera hundreds of times more sensitive than the iconoscope. A miniaturized version of this device, known as the MIMO (miniature image orthicon) was mounted in the nosecone of an experimental missile system but was never used in combat.

After the war, the image orthicon's low-light sensitivity helped it become the standard camera used in the television industry, and its nickname—the "immy" —served as the namesake for the Emmy Awards presented each year by the Academy of Television Arts & Sciences.

TV Image of David Sarnoff at the NY World's Fair (1939)
Sarnoff and NBC TV Crew at NY World's Fair (1939)

By the end of the 1930s, RCA scientists had overcome the technological hurdles to commercial television, but the FCC refused to endorse any formal broadcasting standards. Frustrated with this lack of action, Sarnoff decided to move forward on his own.

At the opening of the 1939 New York World's Fair, Sarnoff announced that NBC would begin regular television broadcasts from its studios at Rockefeller Center. "Today we are on the eve of launching a new industry based on imagination, on scientific research, and accomplishment," he declared. "And now we add radio sight to sound." For the next eighteen months, visitors to the World's Fair could stroll through RCA's exhibits and watch live television images of people behind them in line.

TV Console Model 641 (c. 1947)

The government banned commercial television production until after the war, but RCA took advantage of this hiatus to improve its assembly lines and lower receiver costs. Before Pearl Harbor, a television sold for between $500 and $1000. When RCA introduced its first mass-market black-and-white set, the RCA 630-TS, in 1946, it sold for $375. The following year, it released a console version of the same set, the RCA-641, combining AM, FM, and shortwave radios, a phonograph, and a television into a single unit. A precursor of today's home entertainment system, RCA sold 8,000 of these "Five-in-One" consoles at a market price of $795.

RCA 8TS-30 Black and White TV (1948)

After the war, not only did RCA expand its own television production capacity, it also shared the new technology with its many patent licensees. Sarnoff and his second-in-command Frank Folsom argued that the entire industry would profit from expanding access to reliable television equipment. The 8TS-30 model, featuring a 10-inch screen and a mahogany cabinet, proved particularly popular.

Although RCA sold only 325,000 televisions by the end of 1948, the large number of available models based on the 8TS-30 led the firm to describe it as its first "million proof" set, implying that it could be found in a million American homes.

Indian Head Test Card (c. 1939)

Early television researchers utilized a variety of test images to evaluate their equipment. Philo Farnsworth transmitted pictures of shapes, including a triangle and a dollar sign, while British inventor John Logie Baird first aimed his cameras at a ventriloquist dummy named “Stooky Bill.” RCA’s first experimental television station, W2XBS, broadcast images of a Felix the Cat figurine, but by the 1940s, the image of this Indian Head card created at RCA’s television factory in Harrison, NJ, had become a familiar sight to television owners. Broadcast at regular intervals during the day as well as after stations went off the air, the lines and circles on this test pattern allowed technicians to diagnose and resolve reception problems on home sets.

V. Color Television

The high cost of early television receivers and the relative lack of programming delayed the technology’s proliferation until after World War II. As black-and-white sets rolled off of RCA’s assembly lines, scientists at the company’s new research center in Princeton started to develop televisions capable of displaying full-color images. A key objective was the manufacture of televisions compatible with the company’s monochrome receivers, so that color broadcasts could be viewed in black-and-white on older sets.

Before RCA perfected such a device, however, the Columbia Broadcasting System announced the invention of its own color television system. While RCA focused its attention upon electronic televisions with no moving parts, CBS embraced a mechanical approach that relied upon motorized colored filters. In response to the CBS threat, Sarnoff initiated a crash program to perfect color television on his own terms. At the same time, he launched an aggressive lobbying campaign in Washington to promote “compatible color” technology and discredit his opponents.

Initially, RCA had trouble matching the picture quality of CBS’s sets, but between 1950 and 1953, engineers in Princeton overcame these difficulties and persuaded the FCC to adopt the compatible color broadcasting standard that remained in place until 2009. Although Sarnoff hailed the FCC's decision as a major victory, it still took nearly a decade before RCA's investment in color television generated any profits.

Jar of Willemite & Bottles of Other Phosphors (c. 1936)

The inner face of a television picture tube is lined with phosphors, chemicals that emit light when they are struck by an electron beam. Early television pioneers like Philo Farnsworth coated their screens with willemite, a zinc compound that glowed green when hit with electrons. Willemite screens produced recognizable, if somewhat dim, images.

In the 1930s, RCA chemists under the leadership of Humboldt Leverenz tested over 6,000 different materials before synthesizing white phosphors that were bright enough to be viewed under normal lighting, which could be used in the company's first monochrome televisions. During the 1950s, Leverenz and his colleagues sprang into action once again, synthesizing red, green, and blue phosphors, which permitted the display of full-color television pictures.

RCA Scientists Examine Five Different Color Picture Tubes (1951)

David Sarnoff always envisioned a transition from monochrome to color television but did not anticipate that another company might beat RCA to the punch. Consequently, in 1940, when CBS demonstrated a television set using a spinning three-color filter, Sarnoff pressured his scientists to develop their own color system. RCA's experiments focused on an electronic approach that, unlike CBS's, possessed no moving parts.

Although World War II put a damper on color TV research, by the late 1940s, it was RCA's #1 priority. In October 1949, RCA Laboratories initiated a massive engineering project, culminating in the creation of five different color television tube designs. After careful consideration, research managers selected the shadow-mask CRT for commercialization.

First Shadow Mask Cathode Ray Tube (CRT) (1948)

The shadow-mask picture tube—the first color television tube—was the centerpiece of RCA's all-electronic, compatible color television system. This display drew heavily upon the ideas of two engineers at the Princeton labs. Alfred Schroeder showed that one could control three electron guns with a single set of electromagnets and created the “shadow mask,” a perforated metal plate, which ensured that only one electron beam, could strike any given phosphor as it swept back and forth.

Harold Law figured out how to deposit the thousands of red, blue, and green phosphor dots on the faceplate to ensure they lined up with the appropriate electron gun. The complexity of the shadow-mask picture tube hindered early mass production, but it eventually found a place in almost all color televisions produced in the 20th century.

First Color TV Receiver, CT-100 (c. 1954)

Between 1950 and 1954, RCA and CBS engaged a heated battle to persuade the FCC to support their respective color television systems. CBS received permission to begin commercial color broadcasts but faced resistance from manufacturing firms whose monochrome sets would be rendered obsolete, as well as material shortages due to the Korean War.

Meanwhile, RCA worked to refine its system and in December 1953, persuaded the FCC to endorse the compatible color standard. The following March, the firm released its first color television set, the CT-100, which sold for $995—five times the cost of a black-and-white set. RCA produced fewer than 5,000 of these sets, of which only 140 exist today.

Plaque Presented to David Sarnoff with Silver Certificate (1962)
Advertisement for Big Color (1955)
RCA Victor Color Television Radio Age (July 1956)

David Sarnoff predicted that 1.5 million color sets would be in operation by the end of 1956. When actual sales were closer to 75,000, Time magazine labeled color television “the most resounding industrial flop” of the year. With the exception of NBC, no broadcasters produced color programs and most Americans were content with less expensive, monochrome sets. For the remainder of the 1950s, RCA did its best to promote color broadcasting on its own.

Finally in 1962, after spending over $19 million on the technology, the company finally broke even on its investment.

Autographed Baseball Trophy (1960)

Sporting events provided an early source of content for radio and television broadcasters. The first televised major league baseball game, between the Cincinnati Reds and the Brooklyn Dodgers, aired on RCA's experimental TV station (W2XBS) in August 1939.

Coincidentally, the Reds also played in the first nighttime baseball game broadcast in color—a 1960 matchup against the New York Giants. To mark this milestone, Reds manager Gabriel Paul and several other reporters and broadcasters signed the ball on this commemorative trophy.

Autographed Model of the Ground Command Color TV Assembly (1971)

During the 1960s, RCA continued to develop smaller, lighter color TV equipment, which allowed NASA to capture images of the moon's surface during the Apollo 15 mission in 1971. Their new camera was mounted on the astronauts' lunar rover and could be operated remotely by mission control in Houston. NASA was so pleased with the resulting images that it asked RCA to provide cameras for the Apollo 16 and 17 missions. This non-operational model was presented to RCA chairman and CEO Robert Sarnoff and is signed by the Apollo 15 astronauts. The original camera remains on the moon.

VI. Electron Microscope

RCA was first and foremost a communications company, but occasionally radio and television research resulted in commercial applications that were not connected with any of the firm's existing product lines. Vladimir Zworykin's interest in electromagnetic fields' ability to alter the trajectory of charged particles led him to approach David Sarnoff in 1938 to authorize the development of a new form of microscope. This device would utilize electron beams to scan samples at a much higher resolution than traditional optical instruments.

Other firms, including Kodak and General Electric, had already built electron microscopes by the time RCA initiated its project, but their prototypes were not intended for consumers. Zworykin's goal, however, was a user-friendly electron microscope that could be sold to a growing community of biologists seeking to study life processes at the molecular level.

In February 1940, Zworykin recruited James Hillier, a physics graduate student from the University of Toronto, to oversee the new instrument's construction. Five months later, Hillier and engineer Art Vance successfully demonstrated the Model B, the world's first commercially available electron microscope. Electron microscopy transformed how scientists engaged with otherwise invisible specimens and bolstered RCA's reputation for technical achievement.

Model EMB-4 Electron Microscope (1944)
Advertisement for the Electron Microscope (c. 1940)

After persuading David Sarnoff to sponsor the development of an electron microscope, Vladimir Zworykin recruited Belgian chemist Ladislaus Marton to join the staff of the company's Camden laboratories in autumn 1938. Marton produced a prototype referred to as the "Model A," which while functional, was large, heavy, difficult to use, and expensive. When Marton refused to alter his microscope's design to make it more marketable, Zworykin hired James Hillier, a physics graduate student at the University of Toronto who was building an electron microscope for his doctoral thesis. Working with engineer Art Vance, in July 1940 Hillier demonstrated a more compact and user-friendly device referred to as the "Model B," the first commercially available electron microscope in the United States.

Electron Microscope: Vladimir Zworykin and James Hillier sitting with EMB-3 (c. 1941-1945)
Electron Microscope Images from "Into Unseen Worlds" (1941)

From the outset, RCA intended to sell electron microscopes to biologists, who were increasingly using physical science techniques to study life processes on a molecular level. Zworykin invited prominent researchers from nearby universities to visit RCA and view bacteria, viruses, and various plant and animal tissues under the microscope. Each of these specimens had to be carefully prepared to withstand bombardment from the electron beam while ensuring high contrast images. Despite the difficulties associated with sample preparation, biologists embraced the electron microscope, due to its $10,000 price tag. RCA sold only fifty-eight Model B's before releasing a successor model, the RCA-EMU, in 1944.

Scanning Electron Microscope (c. 1944)

RCA continued to produce electron microscopes until the 1960s. While many of these were transmitting microscopes, like the Model B, Hillier and his colleagues Richard Snyder and Les Flory also built one of the world's first "scanning" electron microscopes. Where previous electron microscopes fired a beam of electrons through a specimen, scanning microscopes swept an electron beam back and forth across its surface. This beam kicked off electrons, which were directed onto a cathode-ray tube. The resulting images possessed an attractive three-dimensional appearance, but the complexity of the system limited its commercialization until 1967.

VII. COMPUTING

Before the 1940s, the word "computer" referred to a person who solved equations. By the end of World War II, the term became linked with a new class of sophisticated electronic machines capable of performing thousands of complex mathematical operations in a second. RCA engineers participated in many wartime computing projects and remained fascinated with electronic data processing afterwards.

RCA's interest in computing increased in the late 1950s when federal antitrust litigation prevented it from collecting royalties on its radio and television patents. In response, the company diverted money and manpower towards computer-related research. The increased availability of military contracts for Cold War data processing projects reinforced this trend.

RCA found it difficult to compete against industry leader IBM while simultaneously maintaining its own radio and television research. After David Sarnoff stepped down as RCA's chairman in 1970, his son and successor Robert Sarnoff launched a final campaign to remake the corporation into a major player in commercial computing. Within a year, however, the financial losses associated with this strategy prompted the younger Sarnoff to reverse course. RCA sold off its electronic data processing division and terminated almost all of its computer-related research.

Project Typhoon (1950)

RCA's investigations into electronic computing dated to the late 1930s, when the U.S. Army approached engineers in Camden for help developing an anti-aircraft fire control system. The resulting device was an analog computer, which solved problems by constructing a physical model of the problem under investigation.

After WWII, RCA built a larger analog computer system for the U.S. Navy. A company press release claimed this room-sized guided-missile simulator, codenamed "Typhoon," could solve as many equations in sixty seconds as two mathematicians in six months. The Typhoon computer was moved from Princeton to the U.S. Naval Air Development Center in Johnsville, Pa. in 1952.

Jan Rajchman (1950)

RCA engineers also played an important role in the development of digital computers, which manipulated numbers symbolically rather than by changing the physical parameters of the system. Jan Rajchman, who later became head of the David Sarnoff Research Center's Computer Research Laboratory, designed memory systems for the ENIAC project at the University of Pennsylvania and John von Neumann's computer at the Institute for Advanced Study in Princeton. Rajchman's work on these projects culminated in 1950 with the fabrication of the first magnetic core memory arrays built in an industrial laboratory.

100-Bit Early Computer Memory (1950)
10,000 Core Myriabit Memory (1955)

Slow data retrieval and storage speeds limited the utility of early computers. Working independently, Jan Rajchman and a team of researchers at MIT developed a solution to this problem by creating memory arrays consisting of a wire matrix with doughnut-shaped cores made of ferrite, a magnetic ceramic, at each intersection. Applying a current to a given set of horizontal and vertical wires switched the direction of a particular core's magnetic field, corresponding to a 1 or 0 in binary code. Although cumbersome to construct—each core had to be wired by hand—core memory powered commercial computers until the end of the 1960s.

Cryoelectric Memory 262-KB Superconducting Memory (c. 1960)

As the number of military and government agencies relying upon electronic data processing grew, so too did calls for faster equipment. In 1957, the Navy initiated "Project Lightning," a five-year, $25-million program aimed at creating a computer capable of making calculations in one billionth of a second—one thousand times faster than existing commercial models.

Jan Rajchman was placed in charged of a team of engineers that developed a variety of new logic and memory devices, including this cryoelectric memory plate, which utilized superconductors cooled with liquid nitrogen to increase memory density by an order of magnitude.

RCA 501 Core Memory Block (c. 1959)

From the 1930s to the early 1950s, RCA relied upon royalties from its radio and television patents to fund its research budget. In 1958, however, the federal government filed an antitrust suit against RCA, and the resulting settlement prevented the company from generating revenue from patents on "radio-purpose electronics." RCA's management responded by funneling money into electronic data processing and announced the development of the RCA 501, the company's fully transistorized digital computer. Although the 501 was well designed, its peripheral equipment (card readers, printers, etc.) broke down frequently, and the computer was a commercial failure.

Personal Computer Model 00 (1972)

RCA remained in the commercial computing business until 1971, when Robert Sarnoff's ambitious attempt to compete against IBM backfired. The firm sold off its Computer Systems

Division and took a $490 million write-off, the largest suffered by an American business up until that time.

A few people within RCA believed the company should continue to invest in computers. Rather than selling mainframes to other businesses, Joseph Weisbecker believed RCA should target home users. To demonstrate the feasibility of his idea, in 1972 he built the Model 00 computer. Users could program this machine using cards or cassettes and play simple video games after connecting it to a TV set or oscilloscope.

Cosmac VIP (1977)

The development of microprocessors—integrated circuits that combined the logic and memory systems of a computer's central processing unit on a single chip—opened up new possibilities in computer design. After overseeing the development of a new microprocessor using low power CMOS (complementary metal oxide semiconductor) circuits, Weisbecker incorporated it into the COSMAC VIP.

The VIP was sold as a kit for $275. After hooking the system up to a television, users entered programs using a 16-button keypad. The VIP also contained audio circuitry, permitting users to add music or sounds to the programs they designed.

Studio II Game System (c. 1976)

The COSMAC also formed the core of the Studio II, a video game system that went on the market in 1977. Using the keypads, players could enjoy five built-in games, including Bowling, Freeway (a racing game), and Doodle (a drawing program). Players desiring more variety could program their own games or purchase additional cartridges featuring titles like Tennis, Blackjack, and Spacewar. Unfortunately, the Studio II's black-and-white graphics paled in comparison with the full-color games offered on the Atari 2600, which was released the same year, and by 1979, RCA discontinued its system.

VIII. Transistors and Integrated Circuitry

Although the vacuum tube's signal amplification abilities made it an essential component in early electronic equipment, it possessed many shortcomings. Vacuum tubes were fragile, required large amounts of operating power, and generated a great deal of heat. These deficiencies complicated efforts to develop smaller, more efficient consumer products.

In 1948, a team of scientists from Bell Labs in Murray Hill, NJ announced a potential solution to all these problems. Their invention, the transistor, took advantage of the unique electrical properties of semiconductors like germanium and silicon to replicate the electrical behavior of a vacuum tube. Transistors were compact and rugged, and they posed an inescapable threat to RCA, the country's largest manufacturer of vacuum tubes. At the same time, they offered a new avenue for potential expansion.

RCA was one of the first firms to commercialize the transistor, and the firm invested heavily in semiconductor research. Much of this work focused on the creation of integrated circuitry, which would combine the functions of numerous circuit elements in a single device. RCA scientists also sought solid-state replacements for the vacuum tubes utilized in television sets and video cameras.

Replica of First Transistor Invented at Bell Labs (December 23, 1947)

Depending upon how well they carry an electric current, most materials can be classified as conductors or insulators. Some substances, however, do not fall neatly into either category. Semiconductors, like silicon, had been used as detectors in crystal radios since 1906, but extensive research into their physical properties did not start until shortly before World War II. The successful development of semiconducting components for military radar and computing projects inspired a team of researchers at Bell Labs in Murray Hill, NJ to continue examining such substances. Their efforts culminated in the 1947 construction of the transistor—a solid-state device that could mimic the switching and amplification functions of a vacuum tube.

Lab Transistor and Point Contact Transistors (c. 1953)
Transistors, Radio Age (April 1952)

Bell Labs announced the creation of the transistor in June 1948. One month later, RCA researcher Jerome Kurshan built the company's first transistor. Both the Bell and RCA devices were "point-contact" transistors, consisting of a piece of germanium with two wires affixed to its surface. Later, both companies would set aside these devices in favor of "junction" transistors, which resembled a sandwich with two layers of one type of semiconductor surrounding a second kind. Though difficult to manufacture, junction transistors—made with germanium or silicon—were more durable, operated at lower power than point-contact devices, and were widely available by the end of the 1950s.

First Transistor Television Prototype (c. 1952)

In November 1952, RCA Laboratories hosted a symposium to show patent licensees how transistors might be incorporated into commercial products. In addition to AM and FM radio receivers and a portable phonograph, RCA also demonstrated the world's first transistorized television. Developed by George Sziklai, Robert Lohman, and Gerald Herzog, this 5-inch set contained 37 transistors, weighed 27 pounds and had only one channel. Good reception was initially limited to a radius of 5 miles from a TV transmitter, but was later increased to 15 miles.

INTEGRATED CIRCUITRY

Micromodule Display (1960s)

As transistors replaced vacuum tubes in commercial products like radios and televisions, they also drew the attention of the U.S. military, which wished to capitalize on their size, durability, and low power requirements in computer and aerospace applications. The military's call for smaller, lighter components led many companies to explore new ways to reduce the size of electronic circuitry. RCA's earliest approach to miniaturization was the micromodule: a self-contained array of uniformly shaped circuit components layered on a ceramic wafer and encased in a cube of epoxy resin. Before the project's cancellation in the early 1960s, micromodules were incorporated into inertial guidance systems, infrared sensors, and portable radios.

Microcircuit Acrylic Display (1961)

Collection of Microchips (c. 1970)

In 1957, the same year that work began on the micromodule project, RCA engineer J. Torkel Wallmark proposed a different solution to the miniaturization problem—using semiconductors to the create an "integrated device which combines in one unit the functions to be performed by a whole assembly of capacitors, resistors, amplifiers, and switches." Within a year, Wallmark developed a prototype digital logic device based on his idea, but it was not fully functional in the spring of 1959, when Texas Instruments announced the creation of the first integrated circuit. Today, integrated circuits, with thousands of transistors embedded on a single block of silicon, form the basis of all digital electronic devices.

SOLID STATE CAMERAS

First TFT Solid State Image Sensor (c. 1968)

Another method for fabricating integrated circuits came from RCA physicist Paul Weimer. Weimer oversaw the development of the Vidicon camera tube and wondered whether he could create a semiconductor device capable of performing the same function. In 1961, he evaporated several layers of cadmium selenide and metal electrodes on to a glass substrate, creating the first thin-film transistor (TFT). Weimer later obtained an Air Force contract to build a solid-state camera based on this technology. The resulting prototype delivered in 1967, contained a 180 x 180 array of TFT picture elements—the largest integrated circuit in the world at that time.

3 CCD Camera Circuit Board (1984)
Solid State CCD Video Camera (c. 1975)

Soon after Weimer demonstrated his solid-state camera prototype, scientists at Bell Labs demonstrated a new sensor that stored up electric charge in response to light exposure. Originally intended as a new form of computer memory, Bell planned to incorporate this new "charge-coupled device" (CCD) into their Picturephone system, but set CCD work aside after that project's cancellation in 1972.

RCA, meanwhile, recognized the new technology's potential and in 1984 announced the creation of the first commercial broadcast camera using CCDs. The new camera's picture quality was impressive enough to earn the company a Technical Emmy the following year.

SOLID STATE DISPLAYS

Gallium Arsenide Ingot (1950s)

One advantage that silicon transistors had over their germanium counterparts was their ability to operate over a wider temperature range. Since electrons move more slowly in silicon, however, RCA researchers started looking for another material that would enable both high-temperature and high-speed operation. One promising candidate was gallium arsenide, which became the focus of an intense research effort at the Princeton laboratories during the 1950s. Although transistors based upon this compound never became popular, it served as the basis for some of the earliest light-emitting diodes (LEDs).

First GaN blue light emitting diode (c. 1972)

By the late 1960s, RCA scientists had synthesized red and green LEDs using gallium arsenide and gallium phosphide. The director of the company's Material Research Laboratory, James Tietjen, realized that if a blue LED could be developed, it might facilitate the creation of a flat-panel television display. Tietjen assigned the task to Herbert Maruska who in 1972 worked with Jacques Pankove, to create a bright blue-violet LED using gallium nitride. While the project was canceled in 1974, LEDs prepared in a similar fashion have since found a place in light bulbs, televisions, and high-definition DVD systems.

IX. VIDEODISC

As RCA's color television earnings leveled off, personnel throughout the company wondered what technology would take its place as a focus for research and development activity. In 1964, James Hillier, the recently appointed head of the Princeton laboratories, proposed that the firm develop a home video player, which would benefit from the technical staff's familiarity with both television and recording systems.

For more than ten years, RCA's technical staff and personnel at its manufacturing divisions explored different recording systems, including magnetic tape, holographic tape, and laser-read discs, before the company's leaders finally settled on a system that stored video information in the grooves of a conductive vinyl record.

The SelectaVision VideoDisc player was released early 1981. However, by then Americans had been introduced to videocassette systems, which offered the ability to both play and record programs. Marketing experts thought that the lower price of discs compared to cassettes would make their product more competitive, but consumers demonstrated an unforeseen willingness to rent, rather than buy, movies. Citing poor sales, the company announced plans to halt production in 1984.

The VideoDisc system was RCA's last major commercial venture. Two years later, in 1986, the entire company was purchased by General Electric for $6.3 billion.

RCA SelectaVision VideoDisc Player (c. 1980)

Released in February 1981, the SFT-100 was the first commercially available VideoDisc player, the result of a $200-million dollar research program dating to the early 1970s. The most sophisticated piece of consumer hardware that RCA ever developed, this player spun a twelve-inch vinyl disc at 450 revolutions per minute and converted the information encoded in its grooves into a full-color television picture. The SFT-100 originally had a suggested retail price of $500, but competition from other home video technologies prompted RCA to reduce the cost of its players to as low as $150 by October 1984.

VideoDisc Demonstration Surface (c. 1960)

Like the phonographs RCA manufactured in the 1930s, the VideoDisc system utilized a stylus to read the surface of a vinyl disc. To contain all the audio and video information associated with an hour-long television program, the grooves on each side of a VideoDisc were nearly forty times smaller than on a conventional record.

This model shows a section of the disc surface enlarged by 10,000 times. Instead of a needle, the system relied on a tiny piece of diamond with a thin piece of titanium deposited on its edge. As this stylus rides above the groove, the player detects the amount of electric charge stored between the titanium electrode and the disc. These changing capacitance measurements are then translated into an analog video signal, which explains why the format is sometimes referred to as CED: Capacitance Electronic Disc.

Group of SelectaVision VideoDiscs (c. 1980)

Between 1981 and 1986, RCA released almost 1,700 different VideoDisc titles. The initial catalog of 100 discs included such classics as Casablanca, Rocky, and Butch Cassidy and the Sundance Kid. Each VideoDisc came enclosed in a plastic caddy to protect it from dust, humidity, or messy fingers. To watch a film, a user inserted the caddy into the player, which extracted the disc and began playback. Each side of a VideoDisc could store an hour of video footage, meaning that users had to flip the disc over halfway through a standard length movie. Films lasting longer than two hours, like The Godfather, were sold in two-disc sets.

X. Flat-Panel Displays

David Sarnoff cultivated a reputation as a technological visionary, capable of foreseeing new electronic innovations and fostering the research necessary to bring them to market. Some of Sarnoff's innovations, including radio broadcasting and television became successful during his lifetime. Others, such as flat-panels TVs, did not become a reality until after his death.

Sarnoff first introduced the possibility of a wall-mounted television in 1951. Members of RCA's technical staff latched on to the idea and over the next two decades explored a variety of technologies that might enable the construction of such a display.

The most promising approach utilized a relatively unknown group of materials known as liquid crystals. RCA physical chemist Richard Williams was the first to propose incorporating liquid crystals into flat-panel displays, and between 1965 and 1968, a team of chemists, physicists, and engineers led by electrical engineer George Heilmeier succeeded in constructing functional prototypes based upon this concept.

RCA became the first company to incorporate LCDs into commercial products. Although the firm eventually sold its liquid crystal operation in 1976, the screens used in today's laptops and flat-panel televisions can all trace their origins to RCA's Princeton labs.

Benjamin Kazan Demonstrates Light Amplifying Panel (c. 1955)

In 1951, RCA renamed its Princeton laboratories in honor of David Sarnoff. On that occasion, Sarnoff challenged his research staff to develop a “light amplifier” in time for the 1956 celebration of his 50-year career in electronics. He imagined such a device might facilitate the creation of a television that could hang on the wall like a painting.
Five years later, Benjamin Kazan and Frederic Nicoll presented Sarnoff with this panel, which used a combination of photoconductive and electroluminescent materials to reproduce any picture projected upon it with a 1000X increase in brightness. The panel’s inability to display moving images made it impractical for television applications, but RCA briefly considered selling it to hospitals to increase the brightness of X-ray screens.

Jan Rajchman, Early Flat Panel Screen Demonstration Model (c. 1955)

As Kazan and Nicoll improved their light-amplifying panels, computer expert Jan Rajchman developed a display of his own, using an addressing system based on magnetic core memories to activate each pixel. Early prototypes, like this one, utilized incandescent bulbs as picture elements, but in 1955, Rajchman demonstrated a display with 1200 electroluminescent pixels capable of showing moving images captured with a video camera. While an impressive technical accomplishment, Rajchman recognized the impracticality of hand-wiring enough cores to create a high-resolution television display and set the project aside in 1957.

Two Early Electroluminescent Display Panels (Late 1960s)

After becoming head of computer research at the David Sarnoff Research Center in 1961, Rajchman assigned engineer Bernard Lechner to reexamine the problem of assembling a flat-panel electroluminescent display. Lechner replaced the ferromagnetic cores of Rajchman's earlier prototype with switches deposited on ceramic strips, which were easier to manufacture and operated at lower power. He also dispensed with individual picture elements in favor of the faceplate seen here: a single pane of glass with an electroluminescent coating. Lechner delivered the completed display to Wright-Patterson Air Force Base in Dayton, OH in the summer of 1966, where it remains to this day.

Patent for Liquid Crystal Displays (May, 30 1967)

Liquid crystals—materials that behave like a fluid but retain the optical properties of a crystalline solid—had been studied since the 19th century, but the first person to propose incorporating them into a flat-panel display was an RCA physical chemist named Richard Williams. In 1962, Williams showed that the passage of light through a liquid crystal sample could be modulated by applying a voltage across it. In this patent, Williams described how his discovery could enable the construction of a variety of displays and hinted at the possibility of a liquid crystal television.

Photograph of George Heilmeier Demonstrating a Digital Counter at an RCA Press Conference (May 1968)

Despite recognizing the display potential of liquid crystals, Williams never built any functional displays. Instead, the task of constructing the first practical liquid crystal displays fell to a research team led by electrical engineer George Heilmeier.

In 1965, Heilmeier demonstrated an effect he referred to as "dynamic scattering," which caused a transparent liquid crystal sample to turn milky-white. Heilmeier persuaded his superiors to authorize a formal project based on this work, and in 1968, RCA held a press conference announcing that the dynamic scattering effect had facilitated the creation of the first LCDs.

Experimental Car Mirror (c. 1970)

Shortly before the 1968 press conference unveiling the first LCDs, Heilmeier contacted personnel at RCA's semiconductor facility in Somerville, NJ to begin incorporating LCDs into commercial products.

This project received only limited financial support from management. Instead, RCA engineers pursued outside funding to build three prototype devices—an animated advertising display, a gas pump readout, and a car mirror, similar in operation to the one shown here, which used dynamic scattering to reduce nighttime glare.

Optel LCD Watches (c. 1971)

Having already demonstrated a dynamic scattering clock, Heilmeier believed that an LCD watch was an obvious next step. Once again, management offered little support, and soon after a frustrated Heilmeier left Princeton to pursue a White House fellowship. Several of his colleagues had already abandoned RCA to establish their own LCD spinoff companies. One such firm, Optel, whose staff included Heilmeier's former technician Lou Zanoni, would ultimately succeed in creating the first dynamic scattering wristwatches.