Is It Real? Edison's "Tone Tests" • The Secret New York Subway

AMERICAN HERITAGE OF
Invention & Technology
WINTER 1997 $4.00 • VOLUME 12/NUMBER 3

THE COLOR WAR

CBS vs. RCA in the battle for modern television technology

THE COL

BY DAVID E. FISHER AND MARSHALL JON FISHER

IN AUGUST 1940, AS AN INDUSTRY COMmittee wrestled with transmission standards for television, a young, accented voice momentarily disrupted the rush toward commercial broadcasting. The voice belonged to Peter Goldmark, CBS's Hungarian-born *Wunderkind*, who had emigrated to the United States only seven years before. As a panel chairman on the National Television System Committee (NTSC), he had squirmed in his seat for weeks listening to debates over the merits of the various black-and-white systems available at the time. Finally he stood and addressed his older colleagues.

You're beating a dead horse, he said. I've already perfected color television.

At the 1951 inauguration of CBS color, left to right: Frank Stanton, president; the entertainer Arthur Godfrey; William Paley, chairman; and Newton Minow, an industry lawyer who a decade later, as head of the FCC, called television a "vast wasteland."

BY 1940 ENGINEERS HAD SPENT more than half a century groping toward the electrical transmission of black-and-white (monochrome) images. The main elements of the problem shaped up as follows: (1) breaking an image into tiny dots of varying brightness and encoding those dots into an electrical signal, (2) transmitting the signal, (3) changing the signal back into dots of light at the other end, and (4) repeating the process dozens of times per second. Step 1 requires a substance that converts light into electrical impulses. The first such substance to be discovered was selenium, in the 1870s, and while it didn't work out for television, others eventually came along that did. Step 2 follows directly from radio voice transmission. Step 3 can be achieved in various ways; phosphorescent materials, like the ones that coat today's picture tubes, were eventually found to work best. All these problems were solved fairly reliably by the 1920s, and if it weren't for step 4—scanning the image many times per second—we could have had viable commercial television when radio was still in its infancy.

As different television systems competed for supremacy, fast scanning turned out to be the key technological battleground. There were two main ways to do it. The first one, invented in 1883 by Paul Nipkow of Germany, was to focus a small image near the edge of a much larger disk with a spiral pattern of holes punched in it. (See illustration on page 10.) As the disk rotated, each hole in succession swept over one horizontal slice of the image, letting through varying amounts of light. By the time the disk made one complete turn, it had covered the entire image. The light passing through the holes was converted into electricity, and the image was reassembled at the receiving end with the help of a similar disk spinning at a synchronized rate.

The other method of scanning was to project the image onto a photosensitive background and sweep a beam of electrons across it. The electron beam would elicit a varying flow of electricity according to the brightness of what it was shining on. With an electric or magnetic field around the beam, you could move it back and forth across the image, and with suitable circuitry the resulting electric impulses could be converted back into a picture.

The spinning-disk method was simpler, so it was used in the earliest versions of television, which were demonstrated in the 1920s in the United States and Europe. Other schemes used rotating lenses or mirrors, but they all were prone to the problems found in any mechanical system. Be-

CORBIS-BETTMANN

OR WAR

WHEN CBS AND RCA battled to establish the standard for color TV technology, they used all the weapons at their disposal: propaganda, lawsuits, Washington lobbying, and, above all, furious struggle in their engineering labs

David Sarnoff, chairman of RCA, demonstrates a videotape device in 1953, a few weeks before the FCC adopted RCA's color-television system.

cause of interference with the edges of the holes, there were limits on how many "lines," or horizontal bands, a picture could be broken into. In addition, the disk had to spin fairly slowly to get decent brightness and resolution, but that led to unrealistic, herky-jerky motion on the receiving screen. A good mechanical system might achieve sixty lines at eighteen frames per second—not enough to look natural. The electronic method was trickier, but it gave much better results since it had no moving parts and could work on a much finer scale. By the mid-1930s electronic methods, with hundreds of lines at thirty frames per second, had completely displaced mechanical systems for black-and-white transmission.

In theory color television should not have been much harder. All you had to do was scan each frame three times, once for each primary color. Even before the twentieth century physicists knew how to separate an image into blue, red, and green components by using colored filters. In 1889 a Russian scientist named Polumordvinov applied for a patent on a color-television system that used spinning Nipkow disks and concentric cylinders with slits covered by red, green, and blue filters. He had none of the technology necessary to make such a scheme work, however; even a simple monochrome system was decades away. Over the years a ghostly army of inventors with names like Adamian, von Jaworski, and even Frankenstein applied for patents on color systems that would never work. None of these inventors could possibly have built an apparatus that could synchronize the three signals and mix and focus them accurately enough to produce a clear picture.

Then, on July 3, 1928, word came out of London that color television had actually been demonstrated. John Logie Baird, a Scotsman who had been working on television for five years, had taken a spinning disk, cut three spirals in it, and covered each one with a different colored filter. As the disk spun, it scanned the image with alternating lines of red, green, and blue. At the receiver a similar disk received the three tinted images, one at a time, and flashed them on the screen. Screen colors were provided by special gas-filled cells: neon for red, helium for blue, and mercury for green. Although one impressed observer said the color images of faces and flowers were "vivid," Baird, believing that color was little more than a distraction, resumed his efforts to sell the BBC on his monochrome device. He would devote only sporadic attention to color afterward.

On June 27, 1929, Bell Labs gave the first American demonstration of color television. It also used a spinning disk, like Baird, but employed a bank of photocells with colored filters to pick up the signals. (Baird, in essence, had transmitted separate red, green, and blue signals in rapid succession, while Bell Labs transmitted a single signal with all three colors mixed together.) At the receiver three lights with filters reproduced the colored signals, and a system of mirrors mixed them on the screen. Although Bell Labs called its picture "quite striking in appearance" and *The New York Times* agreed that "the colors reproduced perfectly,"

LEFT: CORBIS-BETTMANN; TOP RIGHT: SMITHSONIAN INSTITUTION

the screen was only the size of a postage stamp and had to be viewed through a peephole in a dark room. In addition, it shared the deficiencies of all mechanical television systems: too few lines and too few frames per second.

For most of the 1930s color television was put aside in the race toward commercial black-and-white. Then, out of nowhere, Peter Goldmark appeared. He was only thirty-three years old when he rose to address his colleagues on the NTSC. "I couldn't have created a greater explosion if I had lit a stick of dynamite," he said later. An RCA delegate immediately told the committee that his company was well aware of CBS's experiments and was convinced that they would never lead to a commercial-quality system. A debate ensued. CBS finally agreed to let the delegates see a demonstration for themselves.

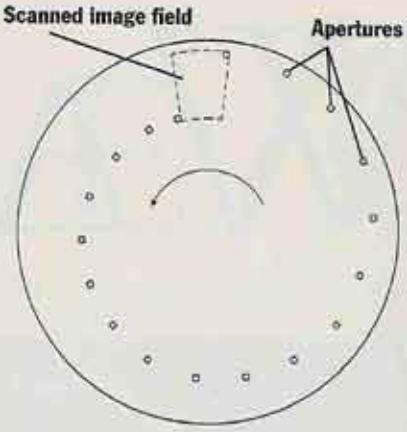
SO ON AUGUST 28 AND SEPTEMber 4, 1940, selected members of the NTSC and the Federal Communications Commission (FCC) met at the CBS labs in New York City. On screens seven inches wide, models could be seen parading in colorful dresses, and bouquets of flowers moved across the screen, their colors registering quite well. Everyone came away impressed, none more so than J. Lawrence Fly, the FCC chairman, who declared, "If we can start television off as a color proposition, instead of a black and white show, it will have a greater acceptance with the public."

Goldmark had gotten his first exposure to television in 1926, while in graduate school in Vienna. He ordered a do-it-yourself television kit from John Logie Baird, complete with Nipkow disk and 1-by-½-inch screen. Late at night, when the BBC allowed Baird to use its radio transmitter for experimental television broadcasts, Goldmark received the signal from London: a tiny dancer flitting across the tiny screen.

Before long he had devised a system of mirrors to enlarge the Baird picture. His device earned him the first Austrian patent for television. After he finished his Ph.D. work, in 1931, he wrote Baird in hopes of getting a job in the new field. Baird replied with an invitation to meet him for lunch in London. The meeting was less than a success: "Writing and drawing sketches on the white tablecloth, he criticized my system through the remainder of lunch, down to the tarts. . . . I nodded to all of Baird's ideas and then, figuring there was nothing to lose, hopefully asked him for a job. He turned me down flat."

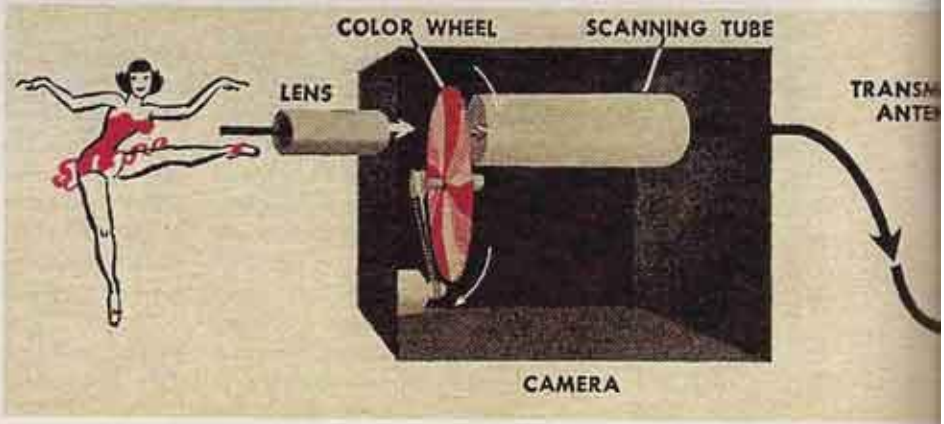
Goldmark was hired by a British firm, but a year and a half later it got out of television research. After briefly returning to Vienna, he sailed for America in September 1933. In New York he found a job as chief engineer for a radio manufacturing company but kept his eyes open for television opportunities, working on designs at home in the evenings. One of these designs was published in a British journal, and in late 1935 he received a call from an executive at the CBS radio network, which was interested in getting into television. On New Year's Day 1936 Goldmark began his career as a television engineer for CBS, heading a staff of four.

At first his laboratory focused on black-and-white television, and Goldmark set out to improve means for transmitting motion-picture films. Soon CBS hired another engineer, making a total of five including Goldmark. He then oversaw construction, at a cost of nearly a million dollars, of a transmitter on top of the Chrysler Building to compete with RCA's Empire State



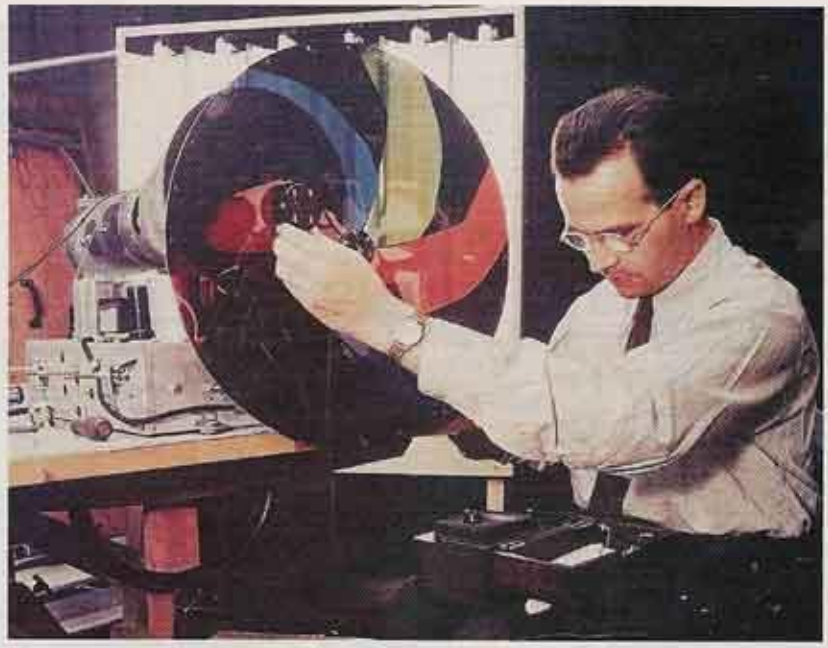
SARNOFF declared that Goldmark's apparatus was mechanical, like the old 1920s television systems that had fallen by the wayside.

Top: A Nipkow disk. By the time it makes a complete revolution, the whole image has been scanned. Below: A schematic of the CBS color system. The image is focused on the scanning tube through a spinning filter wheel, and the three resulting color components are broadcast in alternation. In the receiver a similar wheel re-creates the color image.



TOP: Encyclopaedia Britannica; BOTTOM: COURTESY OF CBS

Building transmitter. As Goldmark said, "the urge to beat RCA and its ruler, David Sarnoff, was such an overriding force at CBS that it actually began to shape the direction of my own career." Nor did Goldmark forget that RCA had declined to hire him in his early New York days.



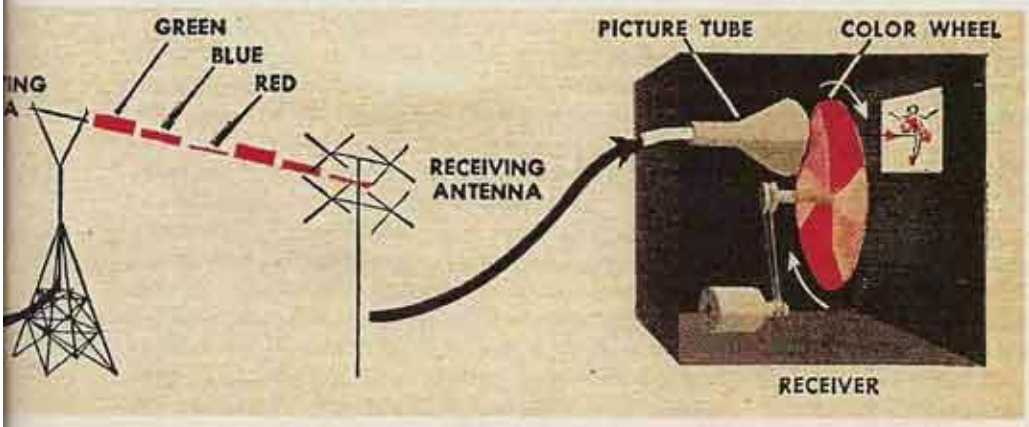
Peter Goldmark of CBS and his color wheel, with its sets of red, blue, and green filters.

HOW WAS HE TO BEAT THEM at television technology, though? Even CBS's wonderful new studio was using RCA monochrome cameras. The answer came to him in March 1940 in Montreal, on a postponed honeymoon with his wife. While killing time waiting for their train back to New York, they decided to see the previous year's blockbuster movie *Gone With the Wind*. "It was the first color movie I had seen, and the color was magnificent," Goldmark wrote. "I could hardly think of going back to the phosphor images of regular black-and-white television. All through the long, four-hour movie I was obsessed with the thought of applying color to television.

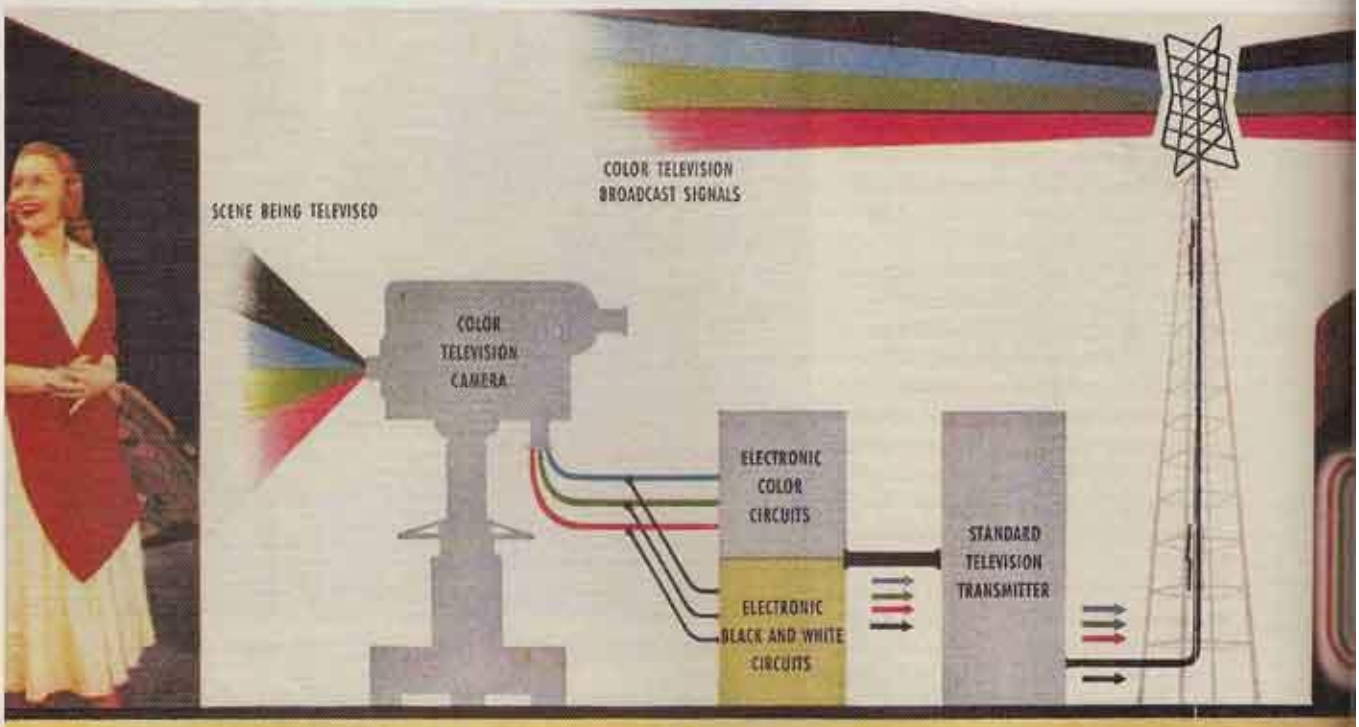
"During the intermission I slipped into a corner of the lobby, whisked out my notebook, and started to calculate what would be required for color in television. In the hotel and on the sleeper back to New York I continued to fill the pages with equations. It was perhaps fortunate that I had seen the movie at the end of my honeymoon trip."

As soon as he returned to the CBS labs, Goldmark got the okay to work on color, and for the next six months he and his staff were "consumed night and day" with making Goldmark's notebook sketches into practical reality. What they came up with was a hybrid electronic-mechanical system. Behind the lens in the camera tube Goldmark put a spinning wheel (not a Nipkow disk) with three sets of filters—red, blue, and green. He then synchronized the wheel with an electron beam, which scanned the red, blue, and green portions of the image separately and combined them into one signal. A similar filtered wheel in the receiving tube separated the signal back into its components. The Goldmark system took advantage of the electron beam's sharpness and resolution but was still handicapped by the mechanical limitations of the wheel.

By June 1940 Goldmark had his apparatus working well enough to demonstrate it to CBS management. Before the vice-president and research director, he presented a transmission from still color slides, "including a lovely Spanish dancer—dressed in a strong red-and-white costume." It was a success, and Goldmark got the go-ahead to begin transmitting experimental broadcasts of color movies. By August he was convinced he could take over the fledgling industry with his color system, and he made his bold announcement at the NTSC meetings. His demonstrations for FCC and NTSC members followed, and for a moment it looked as if he might be right.



But Goldmark had underestimated the determination of the companies that had devoted themselves for so long to perfecting monochrome television. Most of all, he had underestimated David Sarnoff. At an RCA staff meeting around the time of Goldmark's demonstrations, Sarnoff declared that Goldmark's apparatus was mechanical,



PICKUP AND TRANSMISSION OF RCA COLOR

like the old 1920s television systems that had fallen by the wayside. If the NTSC accepted CBS's color system, it "would set back the cause of our technology by a generation. . . . The RCA will never allow this counterfeit scheme to be foisted on the American people," he vowed.

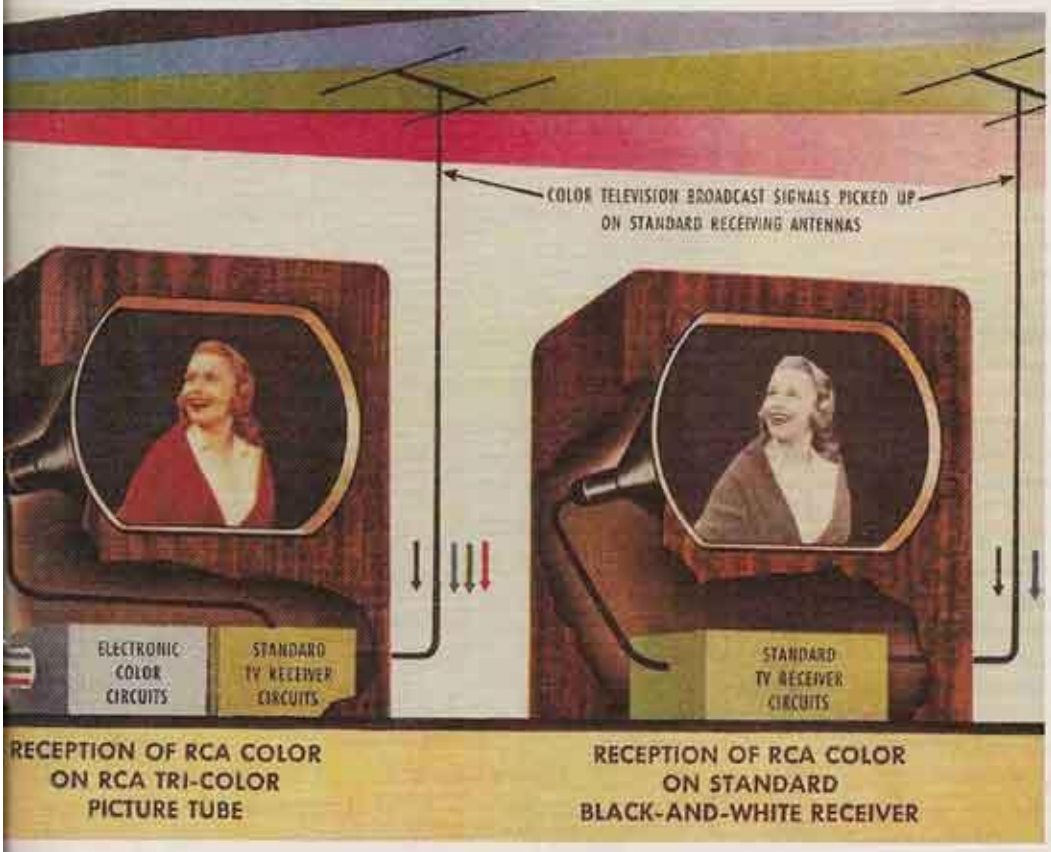
Goldmark took offense at the characterization of his system as mechanical. "CBS's field-sequential system is electronic," he wrote later. ". . . The only mechanical part is really the device that inserts the color at the transmitter, and the only reason we used a revolving color filter at the receiver was that no color tubes capable of performing this function were available at the time." Of course, the electronic portion of the system was not Goldmark's invention at all; it was just an ordinary Image Dissector tube, invented by Philo Farnsworth in 1927. The only major part original with Goldmark was the mechanical revolving filter.

But Sarnoff had unwittingly put his own company in a defensive position months earlier. The RCA labs in Camden, New Jersey, had been working for some time on an all-electronic color system, and although it was far from perfect, Sarnoff had decided to demonstrate an early, partly mechanical version to the FCC in February 1940. The colors were inaccurate and the image was distorted, but that didn't seem to bother Sarnoff. "The pictures were terrible, but the principles for electronic transmission were sound," he said years later. "My scientists could make mechanical color as well as anyone. It didn't require any basic discoveries. It was the quick and easy way, but it was wrong from the beginning, and I knew it." Still, RCA's primitive demonstration served only to underscore the high quality of Goldmark's system seven months later.

The debate went on for the next year. Had the FCC been inclined toward color, CBS would certainly have been the committee's choice, but the agency was reluctant to bypass monochrome television before giving it a chance in the marketplace. Meanwhile, Goldmark stayed hard at work. At the September 1940 demonstration he had been unable to transmit live subjects in color. He cleared this hurdle in December by switching from the Image Dissector tube to a modified RCA Orthicon. The following June the FCC gave CBS permission to broadcast in color on an experimental basis, and regular broadcasts began.

Even RCA seemed unsure that CBS color would fade away. Its own network, NBC, gave a demonstration on May 1, 1941, of a color system almost identical to Goldmark's. RCA was careful, though, to make clear that the future belonged to all-electronic color—when it was finally perfected.

On July 1, 1941, however, commercial monochrome television began (to an audience of a few thousand sets), and color was all but forgotten. Sarnoff and his allies had succeeded in keeping the spotlight on black-and-white TV. Goldmark kept working on his system, but his push for public



A 1950 test of the two systems was no contest. The *Variety* headline read RCA LAYS COLORED EGG, and the FCC approved CBS color.

The RCA system uses mirrors to split an image into three color components. Each one is scanned electronically, and the signals are combined and broadcast together. Color receivers untangle the chromatic information; black-and-white receivers ignore it.

support had slowed. Then, on December 7, the war came to America, and color and black-and-white both went on the back shelf.

IN LATE 1944 DAVID SARNOFF RETURNED FROM EUROPE, where he had taken part in the Allied invasion as Eisenhower's top communications expert, eventually attaining the rank of brigadier general. On arriving, he called his top executives together to discuss his next battle strategy. "Gentlemen," he declared, "the RCA has one priority: television. Whatever resources are needed will be provided. . . . There's a vast market out there, and we're going to capture it before anyone else."

Sarnoff formed an unofficial committee that included the chief of NBC, the chief of manufacturing, and various service representatives. Once a month they met in Washington. "Everything came out just like each person promised," said one of his colleagues. "Because Sarnoff pounded on people, he made it impossible for them to say, 'We didn't do this.'"

So in late 1946, while most of the industry was still preparing its postwar campaigns, RCA's 630-TS television set, the Model T of television, began rolling off the production line. By the end of the year the set, with its ten-inch screen, had sold 10,000 units at $385 each. The next year 250,000 television sets were sold, four-fifths of them by RCA. Broadcasting stations were popping up around the country, and advertisers were paying a total of three million dollars to NBC for prime-time slots.

For his part, Goldmark had spent much of the war commuting between New York and Cambridge, Massachusetts, where he worked on radar-jamming technology. He also spent time overseas. Back at CBS after the war, Goldmark returned to color television, with an added dimension. In his work on radar countermeasures he had become infatuated with ultrahigh frequency (UHF.) Using UHF, he could give the public forty channels, as opposed to the twelve available on very high frequency (VHF) at the time, and the greater bandwidth would allow better picture quality. It was easy enough to persuade Bill Paley, CBS's young millionaire president, to fund the work; he needed something big to stand up to Sarnoff's takeover of the new television industry. By late 1945 Goldmark was demonstrating his newest apparatus at the CBS labs for special guests, including advertisers and prominent visitors from business and government.

In early 1946 CBS decided it was time for a formal demonstration of Goldmark's UHF color to the FCC. So on January 31 Charles Denny (the new chairman of the FCC) and other guests filed into the Tappan Zee Inn in Nyack, New York. After many days of strained nerves and assiduous care, Goldmark's team had finished setting up several laboratory models of their color receiver, each with a twelve-inch screen. Goldmark recalled, "I gave the necessary intro-

duction to the assemblage, threw the switch, silently prayed a bit in Hungarian, and waited.

"In an instant starlet Patty Painter, our nineteen-year-old heroine from Beckley, West Virginia, filled the tube. Her skin glowed a natural flesh pink, her long auburn blonde hair glistened, and the piquant smile and dancing blue eyes drew appreciative smiles from all of us."

Denny seemed as pleased with the picture as Goldmark, and they weren't the only ones. *The New York Times* called CBS color "superior to the Technicolor seen in the movies. . . . A few looks at [CBS] color television and black and white seems drab indeed." The New York *World-Telegram* called it "beautiful beyond description," while *The Wall Street Journal* had "little doubt that color television has reached the perfection of black and white."

ALL THROUGH 1946, WHILE THE FCC deliberated the commercialization of color, Sarnoff waged a public war against CBS, making *incompatible* a byword for those following the new technology. Because Goldmark's color transmitter sent out three separate pulses, one for each primary color, ordinary receivers could not pick up the picture. If CBS color was authorized by the FCC, said Sarnoff, all the black-and-white sets already out there would show nothing but static. In fact, Goldmark had developed a converter to let black-and-white sets receive his color signal, a device he called "relatively small, simple, and neat, one that I felt would add little cost to the set owner." Sarnoff brushed it off as "inefficient, ugly, and expensive."

RCA color, on the other hand, would be, when it was perfected, completely compatible with existing black-and-white sets. If the FCC could only wait the five years or so necessary to complete development, the public would be rewarded with five good years of black-and-white television, followed by color that would be of much higher quality than CBS's and could still be viewed on old black-and-white sets.

Knowing that each black-and-white set sold was a blow against its color system, CBS began a public relations campaign urging Americans to wait for color before buying a set and calling on the FCC to approve color quickly. It stressed that it had a working system ready to go, instead of RCA's vague promises for the distant future. As a show of confidence CBS declined to apply for licenses to operate VHF black-and-white stations in four major cities, retaining only its New York City license. Instead it prepared to apply solely for UHF licenses.

Then, without warning, the tide turned against CBS. On March 18, 1947, the FCC declared that the CBS color system was premature and needed further testing before it could be approved. The commission reaffirmed its monochrome standards, RCA happily flooded the market with receivers, and CBS rushed to buy the four VHF licenses it had abandoned, paying a new price that had risen by millions.

Six months later Denny accepted a post as vice-president of NBC. Everyone at CBS felt sure that David Sarnoff had once again seduced government and gotten his own way. But Goldmark couldn't accept that his dream was over. He found an outlet for his passion in 1948, when a pharmaceutical firm approached him about using television to teach surgery. Within a year he and his lab had rigged their color system into a closed-circuit television specially adapted for medical use. On May 31, 1949, the first live operation in front of color television cameras took place at the University of Pennsylvania. The following week Goldmark took his system to the American Medical Association's annual meeting in Atlantic City, New Jersey, and televised operations to 15,000 viewers in the convention hall. Reception was so good, said Goldmark, that "we began to measure the impact of our television shows by the number of faintings we could count."

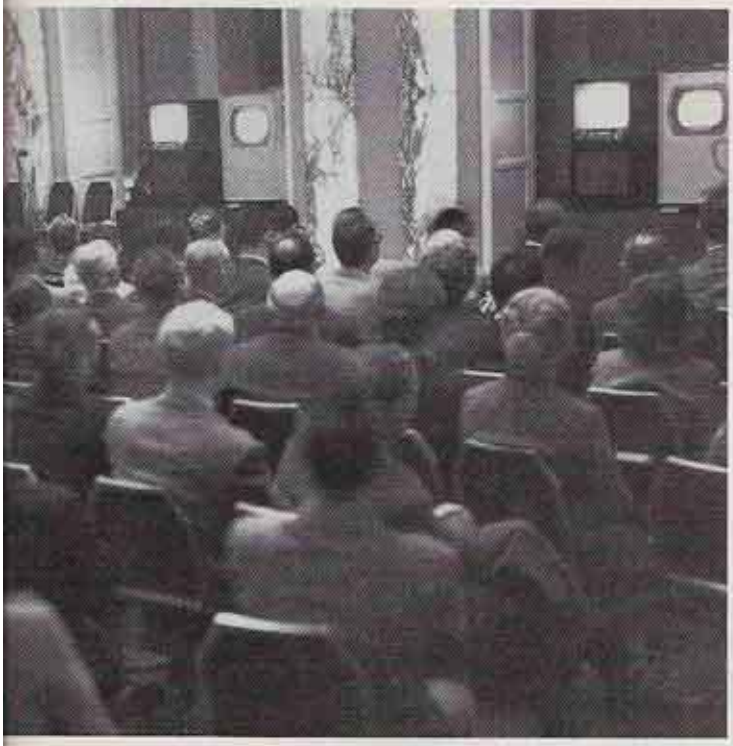
The response from audiences and the press was enormous, but Paley was fast losing confidence. When Goldmark returned from Atlantic City, he received word from management: "The chairman has decided he has no further use for the [television] lab. He'll give you just thirty days to shut down —and lay off the personnel." Goldmark responded with outrage and managed to get a ninety-day delay.

Desperate and distracted, with staff members jumping ship, Goldmark settled on a new course. If UHF was out, why not go back to VHF and simply mold his newest color system to the old transmission standards? After a month of "weight-losing, intensive concentration, and frenetic activ-

SHIFTS AT RCA's research lab went to eighteen hours, including weekends. All work unrelated to color was put aside; no expense was spared.

Having given up the fight for its spinning-wheel broadcast system earlier in the year, CBS demonstrates its new color picture tube in October 1953. Observers were not impressed.

CORBIS-UPI/BETTMANN



ity," he developed a new method of transmitting his color on the low frequencies, as well as a new process that he called "crispening," which sharpened the picture considerably. At the same time, word of the Atlantic City success was spreading—Congress even thanked CBS for "an important contribution to mankind"—and people began to wonder why Bill Paley was withholding his wonderful color system. The order to liquidate the lab was quickly forgotten.

The FCC's new chairman, Wayne Coy, showed a definite friendliness toward CBS, and he invited its scientists (as well as those from RCA) to Washington to give more demonstrations. CBS took out full-page ads announcing the color shows and on January 12, 1950, presented the first public broadcast of its "new" color system. Influential voices such as Edwin Johnson, chairman of the Senate Commerce Committee, demanded that the FCC "clear the way for color" before too many black-and-white sets were sold.

Amid the charges and countercharges RCA's development of an all-electronic color system had been progressing steadily since 1946. It had moved along particularly well since late 1949, when an intense effort began to develop a color picture tube. At the same time, Sarnoff continued the public relations battle. In 1949 he appointed a new RCA president who would be his aide-de-camp in this effort: Frank Folsom, a merchandising expert who had directed naval procurement in Washington during the war. Folsom had come to RCA in 1944 to handle marketing for the postwar television drive and quickly created the nationwide RCA Service Company to fix the problems any customer might have with an RCA set. The company was the first of its kind and a major factor in pushing RCA to the top of the sales charts.

SARNOFF HAD ALSO RETAINED THE SERVICES OF ONE of the country's top public relations firms, Carl Byoir and Associates, to champion the cause of RCA electronic color, and now Folsom summoned the Byoir staff to his office. As one RCA manager wrote, "Folsom briefed the five Byoir men seated in front of his desk on the history and dimensions of the color conflict. It was, he assured them, the most fateful industrial conflict in American history. The future of electronics technology hung in the balance. If the forces of mechanical color triumphed, the march of science would be subverted by the horse and buggy. America's leadership of free world technology would be weakened. Stalin would love it. To one of the impressionable young Byoir staffers, a mental picture formed of dark and deserted scientific laboratories dotting the nation, grass growing in their streets."

Folsom told them that the public had formed an image of RCA as a wealthy, corpulent emperor of communications and of CBS as the underdog, riding on the invention of the brilliant scientist Goldmark. They had to stem CBS's momentum and buy time until electronic color could take over.

FCC hearings got under way again in February, and throughout 1950 the color war raged in the papers, on radio, and before the commission. Both sides also participated in heavy lobbying and secret meetings with congressional leaders. The slurs flew back and forth. RCA derided the "slave sets" with their bulky converters that CBS was promising, the "Rube Goldberg contraptions" or "mechanical harnesses" to be attached to pure electronic television. Frank Stanton, president of CBS, fought back, saying, "These criticisms are not true. Present sets can be adapted at reasonable cost; compatibility can be built into all future sets at a lower cost." By the end of the year, Sarnoff and FCC chairman Coy would publicly accuse each other of lying.

Coy, by now clearly a supporter of CBS, called for immediate tests between the two color systems. The September competition was no contest at all. A *Variety* headline read RCA LAYS COLORED EGG. Sarnoff later recalled, "The monkeys were green, the bananas were blue, and everybody had a good laugh." Goldmark's color picture, in contrast, looked brilliant. On October 10, 1950, the FCC approved CBS's color television system and declared that it could be marketed at once.

Sarnoff struck back by ordering escalated manufacturing and marketing of black-and-white sets. "Every set we get out there makes it that much tougher on CBS," he said. And while Paley had responded to his own earlier FCC setback by cutting back on television research, Sarnoff now called for an even greater intensification of lab research, a holy crusade of science to bring the color tube to perfection and obliterate the spinning disk from the television landscape.

Shifts expanded to eighteen hours, including weekends. All work unrelated to color was put aside, and no expense

was spared. Sarnoff offered rewards of thousands of dollars for key developments. And like a motivational football coach taping clippings to the locker-room wall, he circulated excerpts of Goldmark's FCC testimony. "I don't think the field tests will improve the [RCA] system," Goldmark had said. Asked if RCA should "drop the system now," he had replied, "I certainly do." Below these quotes Sarnoff added his own comment: "The above is the most unprofessional and ruthless statement I have ever seen made by anyone publicly about a competitor. I have every confidence that the scientists and engineers of the RCA will answer this baseless charge by the improvements which I have already seen since the first demonstration and which will be made during the coming months." Months, not years.

In the meantime Sarnoff filed suit in the U.S. district court in Chicago to nullify the FCC ruling. The court granted a temporary injunction but then upheld the FCC's decision on December 22, 1950. Sarnoff and RCA appealed to the U.S. Supreme Court, which rejected the appeal in May.

THIS WAS A MONUMENTAL VICTORY FOR CBS. "We had taken on the great Sarnoff, the king of Radio City, and won," declared Goldmark. "David had beaten the Goliath of industry. We trumpeted our victory from the pages of every important newspaper in the country." The victory was clear; less so were its consequences. CBS was authorized to begin commercial color broadcasting—but who would see it? There were no CBS color sets on the market, and CBS had no manufacturing capability at the time. The rest of the industry, with a large inventory of monochrome sets, was not eager to cooperate.

And so the official premiere of CBS color broadcasting—a one-hour show on June 25, 1951, featuring Ed Sullivan and other CBS stars—was largely invisible. No one aside from special studio parties could pick up the celebration. There were twelve million television sets in America, but only a few dozen could receive CBS color. To remedy the situation, CBS purchased the Hytron Radio and Electronics Corporation. Its subsidiary Air King, one of the top fifteen television-set makers, prepared to put out spinning-wheel color receivers. But it would be years before Air King could turn out color sets economically and profitably. Meanwhile, RCA's color technology would be gaining on CBS.

In fact, it had already caught up. In the six months since Sarnoff had begun legal proceedings, RCA's laboratory blitzkrieg had been marching forward without cease. Elmer Engstrom, head of RCA's research laboratory in Princeton, New Jersey, remembered it as "the most intense, and exhilarating, experience" in his professional life. The labs worked twenty-four hours a day, manned by specialists in camera tubes, receiving tubes, set design, fluorescent materials, electron guns, and radio transmission. Buoying them all with constant support, criticism, and domineering leadership was Sarnoff.

The apparatus that came out of Princeton was ingenious. The major principles it made use of had existed for decades, but the intricate precision necessary to make it work had come only from the twenty-four-hour furnace of perspiration and inspiration fired by Sarnoff. "It's all done with mirrors," they say about certain acts of legerdemain, and indeed the RCA color camera did start with mirrors—dichroic mirrors, to be precise. A blue dichroic mirror reflected the blue component of the original image off to one side, where it was focused onto a regular monochrome camera tube. The rest of the light—the red and green components—passed through to a red dichroic mirror. This reflected red light to the other side, where it was focused onto another monochrome camera tube. The remaining light, which by now was pure green, continued on a straight path and was focused onto a third monochrome picture tube. So the color camera contained three black-and-white cameras and emitted three signals, corresponding to the red, green, and blue components of the image.

The RCA tricolor receiving tube contained three electron guns—one responding to the red signal, one to the green, and one to the blue. The screen held a matrix of hundreds of thousands of tiny triangles, each composed of three discrete dots. Each dot was made of a different chemical, called a phosphor, that glowed a particular color when excited by an electron beam. The blue signal activated the blue dots, the red signal activated the red dots, and the green signal activated the green dots. The scanning process was repeated sixty times per second.

The final ingenious aspect to RCA's color system was its compatibility. By complex electronic methods the RCA researchers managed to convert the three signals into two: the total brightness, or luminance, which was called the Y signal, and a second signal containing the color information. At the receiver, color sets would convert the Y and color signals back into red, green, and blue components, while black-and-white sets would use luminance alone and ignore the other signal.

At the end of June 1951, just a few days after CBS's invisible premiere, Sarnoff and RCA proudly unveiled their new achievement in a demonstration at NBC's Washington studios. The following week they presented a larger demonstration at the RCA Exhibition Hall in New York City, a twenty-minute program for more than two hundred invited guests from the industry and the media. It was a

Workers make final adjustments on color televisions at RCA's plant in Bloomington, Indiana, in 1954. Seven years would pass before RCA made a profit on color sets.

IT TOOK YEARS for RCA to make its sets profitable, but somewhere along the line "V-C Day" had passed; the color war was won.

triumph. Nanette Fabray and Yma Sumac danced and sang show tunes; performing lovebirds fluttered their wings; Buster Crabbe and a troupe of swimmers and divers showed off at a nearby swimming pool. Jack Gould of *The New York Times* reported that the demonstration "changes the whole outlook on the dispute over video in natural hues." The demonstration, he said, "put the FCC on a spot which is certain to become controversial and embarrassing. Technically, it ultimately may be proved that the FCC committed a classic 'boner.'"

Sarnoff himself was less jubilant. Although his hour of triumph was apparently at hand, he insisted that the system was still two to five years away from commercial viability. Just as he had resisted a premature launching of television in the 1930s, for fear of infringing on the radio market, now he was reluctant to throw anything in the way of RCA's monochrome gold mine.

ONCE AGAIN WAR—NOW IN KOREA—PLAYED ITS part in the drama of unfolding technology. The materials needed for production of color sets were deemed crucial to the war effort, and when the government ordered a suspension of their manufacture (and of color broadcasts) in October 1951, both CBS and RCA were secretly pleased. The edict took CBS off the hook, saving it the embarrassment of being unable to take advantage of its FCC victory. Yet Sarnoff couldn't have scripted it any better. As long as the war went on, RCA would continue to mass-produce black-and-white televisions, pulling in a fortune as the market leader and inundating the country with sets that couldn't receive CBS color. By the end of the war there would be six million more strikes against CBS. At the same time, RCA engineers could continue to improve their color system.

When the wartime ban was modified in June 1952, CBS's color system was still the only one approved by the FCC, but there was little doubt that RCA color was the way of the future. The millions of black-and-white set owners were unlikely to shell out another hundred dollars for a CBS adapter. CBS was making little effort to push such adapters, and there were virtually no CBS color sets on the market. The NTSC, consisting of two hundred engineers from ninety-one manufacturing companies, settled on what was virtually the RCA system under another name. According to his biographer Kenneth Bilby, Sarnoff "was willing to play along since he recognized the political advantages of an industry system—a 'face-saving' device for the FCC, he privately called it."

On March 25, 1953, only two and a half years after CBS's huge FCC victory, CBS's president, Frank Stanton, put up the white flag at a House committee hearing. With twenty-three million black-and-white sets in consumers' homes, he admitted, "it becomes quixotic and economically foolish for us single-handedly at this time to resume a large-scale broadcasting and manufacturing program." On December 17, 1953, the FCC officially reversed its 1950 decision and voted to accept the RCA system for commercial broadcasting. It would officially be known as the NTSC color system, but Sarnoff didn't mind. RCA owned almost all of the hundreds of patents controlling it.

In late December Sarnoff ran full-page ads in the leading newspapers proclaiming RCA's "great victory." "We added sight to sound at the World's Fair of '39," the ads read. "Now we add color to sight. . . . The opportunity to enrich the lives of people everywhere is a privilege of leadership." Industry rivals were incensed, and Philco, a long-time enemy of RCA, put out its own full-page ads declaring that the new color standards were the result of an industrywide effort, "not the work of any one company." This campaign was futile; Sarnoff made sure the public knew that the standards set by the NTSC were based on the system that had been invented and brought to commercial quality by RCA.

A year later, however, RCA color had lost all momentum. CBS may have surrendered, but the marketplace beach-

front was far from won, and General Sarnoff was back on the warpath. He later called it "the toughest battle of my life." In early 1954 the first RCA color TV set had gone on sale. It had a 12½-inch screen and cost $1,000—a quarter of the average annual salary—as compared with the $300, 21-inch top-of-the-line black-and-white set. The idea, as with most new technological products, was first to attract wealthy buyers and then to gradually bring the price down. Sarnoff announced bold sales predictions, rising from 75,000 units in 1954 to 5 million in 1958.

At the end of the year warehouses were bulging with unsold sets. Only 5,000 had been sold, not 75,000. Performing in a controlled demonstration was one thing, but mass-producing a set that could stand up in the hands of the average consumer was quite another. The RCA Service Company was receiving twice as many calls from the few owners of color sets as from the millions of owners of monochrome sets.

SARNOFF'S ENEMIES JUMPED AT THIS OPENING. ZENITH announced in early 1955 that it would produce no more color sets until the technology had improved. General Electric, Philco, and Westinghouse (which had actually beaten RCA to the punch by putting out the first commercial model) halted production as well. GE's revered chief, Ralph Cordiner, complained that "if you have a color set, you've almost got to have an engineer living in the house." The general opinion, from Wall Street to corporate offices (even those of RCA), was that Sarnoff had jumped the gun. *Time* called color television "the most resounding industrial flop of 1956."

Sarnoff responded with yet another holy crusade. He tripled advertising expenses and sent complimentary sets to influential journalists, financiers, congressional leaders, and the White House. RCA organized neighborhood parties to view special NBC "colorcasts." And Sarnoff got his old pal and wartime boss, President Eisenhower, to appear on NBC dedicating the network's new Washington studios.

Sarnoff also began cutting the price of his color sets, down to $700 in 1955 and $500 the next year. But sales remained sluggish through the 1950s. By 1959 RCA had poured more than $130 million into color development and marketing, still without recording a dollar of profit. As *Fortune* magazine later wrote, "for five years after it marketed its first set in 1954, RCA found itself the solitary tenant of the new world."

In the summer of 1960 Sarnoff took an important step by acquiring the popular Walt Disney television program from ABC, where it had been broadcast in black and white. NBC announced that it would begin showing the program in color that fall. From the moment it premiered, "Walt Disney's Wonderful World of Color" was a national hit. The NBC peacock, displaying its feathers in brilliant color, became famous.

RCA had also improved its color sets by now, with bigger screens, more stable color, and simpler controls. As the black-and-white market became saturated, the public slowly began to turn to the newest attraction. At the end of 1960 RCA announced that for the first time it had registered a profit from color sales.

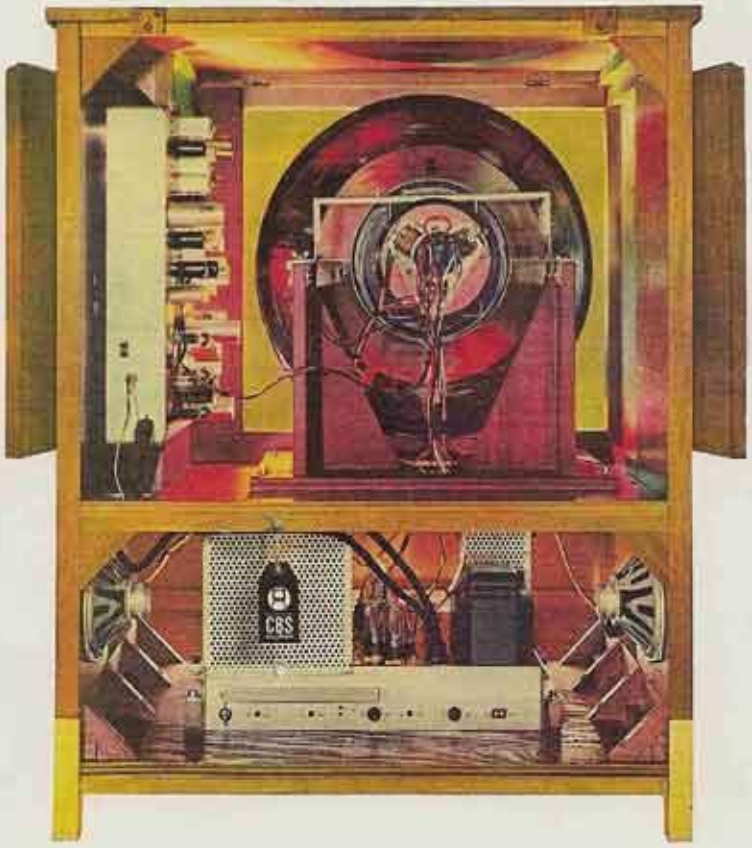
IN 1961 ZENITH FINALLY GAVE IN AND PLACED AN ORDER for 50,000 twenty-one-inch color tubes. Four years later twenty companies were manufacturing color sets using RCA tubes. Sarnoff declared 1965 "the year of fulfillment for our long struggle," and for good reason. Mainly because of color TV, RCA's net profit that year surpassed $100 million. Sarnoff ordered a $50 million expansion of RCA's manufacturing plant to meet orders from the rest of the industry. Somewhere along the line "V-C Day" had passed; the color war was won.

Back at CBS Peter Goldmark had enjoyed some later success, most prominently with the invention and marketing of the 33⅓-rpm long-playing record, which beat out RCA's 45-rpm record during the 1950s to be the industry standard for thirty years. But Paley could never forgive his chief inventor for the color debacle, and he came to consider Goldmark "a thorn in my side." "I couldn't wait until he reached sixty-five," Paley later remembered, "so I could retire him." To the bitter end Goldmark insisted that his sequential color system had been the best available at the time and that his aggressive pushes in 1940, 1946, and 1950 had served a vital purpose: spurring on color development and bringing color to the American home years, if not decades, earlier than might otherwise have happened.

He may indeed have served an important historical purpose as Sarnoff's foe, for certainly nothing motivated Sarnoff like a direct challenge, particularly a challenge to his beloved electron. With black-and-white television comfortably sweeping the country and profits pouring in, RCA might well have enjoyed the gradual saturation of the market and let the progress in its color labs proceed at a normal scientific rate. If not for Goldmark, that annoying, self-assured, persuasive thorn, Sarnoff would never have ordered around-the-clock research and $10,000 bonuses for breakthroughs; he would never have rallied his troops into a six-month crusade in late 1950 to produce electronic color at all costs.

It was certainly the high point of an unequaled career in corporate battle. Looking back in 1981, Paley marveled at the performance of his old mentor, friend, and rival: "The way he refused to accept defeat . . . the way he kept coming back to Washington and rallying his people . . . the way he drove those scientists to perfect his system. No doubt about it, Sarnoff was magnificent in color." ★

David E. Fisher is a professor of cosmochemistry at the University of Miami and the author of twenty previous books. Marshall Jon Fisher lives in Cambridge, Massachusetts. He has written for The Atlantic Monthly, The Sciences, *and other magazines. This article is adapted from their book* Tube: The Invention of Television, *just published by Counterpoint Press.*



In 1954 CBS could proudly tout the advanced electronics inside its $1,100 Model 360 Full Fidelity Color Television Receiver, pictured above. Yet a few years earlier it had ridiculed the very same technology. CBS achieved working color television as far back as 1940; ten years later its system was still far and away the best. Within months, though, a crash development program at RCA came up with a superior method, and soon CBS was licensing patents from its long-time competitor. The story of RCA's triumph appears inside in living color.

AMERICAN HERITAGE COLLECTION

AMERICAN HERITAGE OF
INVENTION & TECHNOLOGY
FORBES Inc.
60 Fifth Avenue
New York, NY 10011

Address Correction Requested

Periodical Postage
Rate Paid at
New York, N.Y.
and at additional
Mailing Offices