Advertising card for celluloid collars and cuffs. "Because of celluloid's high price vis-a-vis linen collars and cuffs, promoters had to appeal to customers on the basis of the product's special attributes. The difficulty of doing this was compounded by the failure of celluloid to achieve any measure of fashionableness." [From *Pioneer Plastic*; courtesy of the Warshaw Collection of Business Americana, National Museum of American History]

of technology and lovers of trivia, but up until now little additional has been established. Robert Friedel remedies this in this brief volume in which he discusses celluloid's nature, career, and, most important in Friedel's scheme of things, its implications for the greater arena of material culture.

What celluloid was is simple enough: a solid solution of moderately nitrated cellulose (pyroxylin) in camphor, molded under heat and pressure. Hyatt and his brother Isaac had the formulations and necessary machinery for production developed and in place by 1872 as they recognized the invention to be a new and potentially useful substance. What neither they nor any of their contemporaries perceived was anything revolutionary about celluloid. It was one of a number of new materials—hard rubber, vulcanized rubber, gutta-percha, aluminum, magnesium—that became established during the period. Like the promoters of these other products, the Hyatts, their associates, and their successors in the Celluloid Company saw their task as a search for markets.

This search was complicated by the nature of celluloid. Unlike rubber, which it most closely resembled, celluloid did not have assertive properties. Rubber was dark; inexpensive jewelry and combs could be made from it but the items had to be black. Celluloid was white and could easily be colored to any desired shade. As a result, the hallmark of celluloid over the next 20 years became imitation, beginning with its first important use, for dental plates, where though more expensive it could readily be given the correct color. Over the next quarter-century it achieved substantial, but never dominant, shares in several markets including combs, brush handles, and costume jewelry. In each it was used because it could take the appearance of more expensive or traditional materials such as ivory, horn, tortoise shell, and ebony, as the cheaper available materials could not do. Even when marketed for a use where its innate properties gave it advantage, detachable collars and cuffs, celluloid achieved its successes by at least mimicking the appearance of something it was not, linen. The properties of celluloid did not suggest novel products to its promoters. Imitation became its signature and most important function.

Eventually, with the marketing of the first successful photographic roll films by George Eastman in 1889, celluloid found a use for which it was uniquely suited by its innate properties and for which it could and did become the dominant product. Celluloid possessed the nearly ideal combination of transparency, flexibility, toughness, and uniformity, although it did have the drawbacks of flammability and softening at temperatures over 100°C.

Celluloid was the only commercial plastic of the 19th century. Thus, its career established in the minds of both the public and subsequent inventors what a plastic was and should accomplish. Imitation of more expensive substances became one such criterion, applicability to high technology the other. When Leo Baekeland developed the next plastic, Bakelite, in 1907, he knew what he had and how to exploit it. Celluloid had traveled down unknown paths and left behind road maps for those that would follow. This was, Friedel convincingly argues, its great achievement and its legacy.

This generally admirable study is not without weaknesses. It is lacking in depth at many points; for example, there are few hard data on market shares and sales volumes. Friedel argues that in many cases this is because the needed information just was not to be found, despite his having used many novel sources. Also, one thing that has always struck me about celluloid is that it was an American invention whose commercial development took place in the American context during the era before this country became dominant in science and technology. More discussion of the way this context shaped its career would have been valuable. Still, these lacks should not detract overly from the value of this pioneering work.

SHELDON HOCHHEISER
*Rohm and Haas Company,
Philadelphia, Pennsylvania 19105*

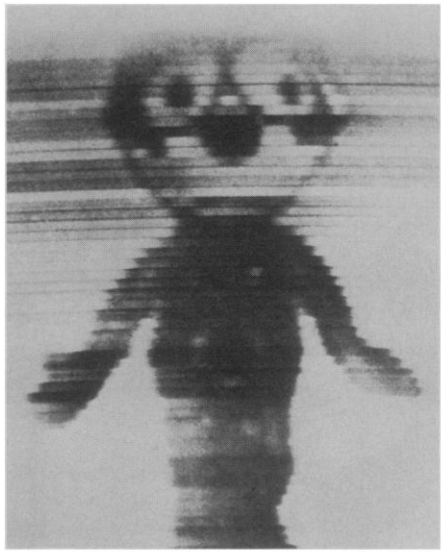
The Establishing of Television

The Great Television Race. A History of the American Television Industry, 1925–1941. JOSEPH H. UDELSON. University of Alabama Press, University, 1982. xiv, 198 pp., illus. $18.95.

The technical development of television coincided with and well illustrates the general transition from electromechanical to electronic control. Late-19th-century innovators saw the possibility of transmitting pictures over a wire, and later by radio; means rapidly to encode and decode presented the first problems. The early solution was mechanical: a rapidly spinning disk perforated with holes arranged in a shallow spiral scanned successive lines across the image in sequence with each rotation of the disk. In Paul Nipkow's 1884 patent the image was scanned onto a selenium cell that generated the analog electrical signal. The transmitted disk modulated light through a synchronized disk at the receiving apparatus, reconstructing the picture. The frequency of the disk determined how quickly images could be replaced, the number of holes in the disk determined resolution. By the late 1920's several versions of this electromechanical method—in particular the "flying spot" system, in which the object is illuminated through the spinning disk and the transmitted signal derived by photocells from the scattered light—were presented as commercially viable to the American public.

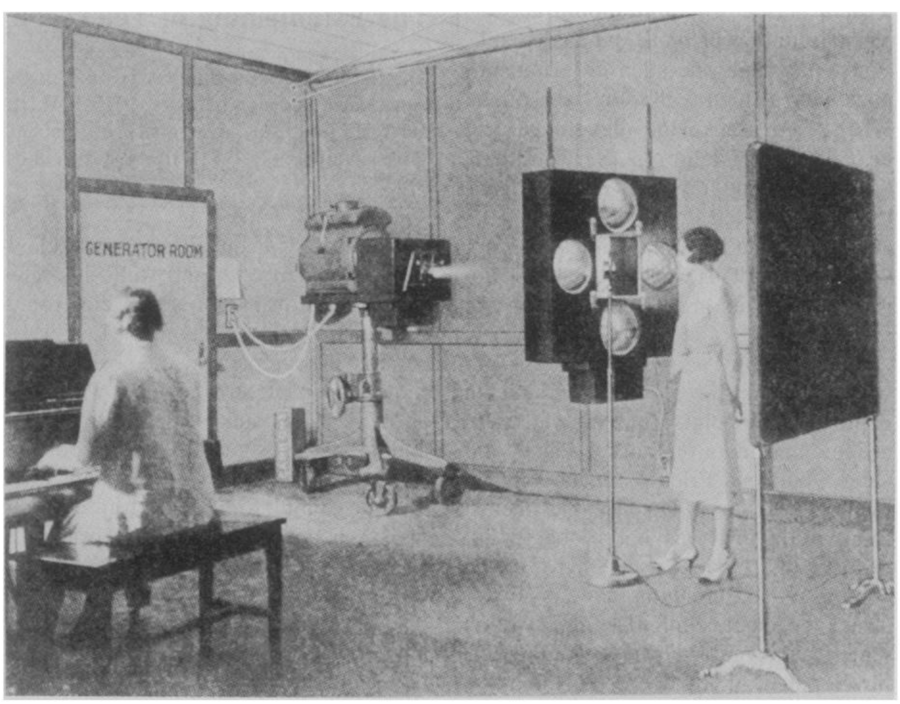
Udelson's book begins at this juncture to tell the story of how television in its first incarnation foundered because of the Depression, poor resolution (in competition with the movies), and bare tolerance by the then-new Federal Radio Commission. Acceptance by Commission and consumer came in 1941 after abandonment of the mechanical scanner in favor of an all-electronic, higher-resolution system based on Ferdinand Braun's cathode-ray tube. The Goliath in this transformation to all-electronic television was the Electronics Research Laboratory at RCA under the leadership of Russian émigré Vladimir Zworykin, Ph.D.; David was an inspired and largely self-educated Utah farm boy with the unlikely name of Philo T. Farnsworth.

Udelson's book is a welcome antidote to previous hagiographic accounts by those with vested interests: Everson's paean for Farnsworth; De Forest's self-aggrandizement; RCA's public-relations defenses. Sketchy and even misleading



Felix the Cat as he looked in the 60-line pictures that appeared on the screens of mechanically scanned television receivers during a 1928 telecast by RCA-NBC. [Courtesy of RCA; reproduced in *The Great Television Race*]

in simplified accounts of important technical points (electrons "bounce" at electrodes, residual gas mysteriously focuses an electron beam), Udelson's book is nonetheless the best account for the general reader of the evolution of this potent technology. The discussion is equally divided between the three most influential factors: technique, the creation of a broadcast industry, and government regulation by board and patent.



"Studio of Boston's visual station W1XAV and sound station W1XAU. Note the photocells suspended from the ceiling in this flying-spot scanning arrangement." [Reproduced in *The Great Television Race* from "The Romance of Short Waves and Television," 1931]

Farnsworth and Zworykin both realized that the transmitter pickup, not the cathode-ray tube receiver, constituted the main problem for electronic TV. Moved from Westinghouse when its radio staff was subsumed into the new RCA in 1928, Zworykin incorporated principles of electrostatic deflection in his "iconoscope" pickup tube. The optical image is projected on a mosaic of amalgam photocells, creating a charge pattern of the image by photoemission in proportion to illumination. As a scanning electron beam traverses the mosaic, it produces an amplified electrical signal proportional to the charge retained at each point. Special signal impulses, impressed at the end of each line and each frame, kept the receiver and transmitter synchronized. But Zworykin's iconoscope suffered from instabilities created by secondary electrons emitted after irradiation by the powerful scanning electron beam.

Farnsworth, working with private funds in San Francisco, created a focused electron beam copy of the optical image that was in its entirety deflected horizontally and vertically past a stationary anode receiver, generating the linear transmitted signal. This "image dissector" principle was protected by patent; RCA policy opposed cross-patent agreements, and Farnsworth refused to sell rights to RCA. In turn, Farnsworth's approach suffered in intensity what it gained in stability, for signals were very weak. Eventually he introduced a primitive form of electron multiplier in the anode to amplify the output. RCA found itself in straits on the eve of commercial application of its $10 million investment, and set its own precedent by entering into a nonexclusive cross-licensing agreement with the Farnsworth company. Successful TV emerged from the best of both systems.

Technical means thus prepared, RCA met an unexpected struggle from the independent radio manufacturers who now entered the field, even before the (renamed) Federal Communications Commission approved standards. Philco led the opposition, proposing different frequency bands and higher resolution than those wished by RCA, and the FCC repeatedly refused sanction for commercial broadcasting until it saw the unanimity that would protect the consumer. The matter was further complicated by competition for the high-frequency bands from Edwin Armstrong's recently perfected frequency modulation system of radio. FCC action against RCA, which had overstepped approval for limited commercial broadcasting, led to Senate hearings in 1940. Finally a "National Television Standards Committee," faced with new proposals from CBS for an incompatible color broadcast system, resolved enough of the differences that license was granted in 1941 for commercial TV. The exigencies of war drastically slowed implementation; but the television that achieved growing application in the postwar period, and that has brought less enlightenment than intellectual torpor to our culture, was essentially the same as that approved in 1941.

BRUCE R. WHEATON
Office for History of Science and Technology, University of California, Berkeley 94720

Chronicle of a Program

Fusion. Science, Politics, and the Invention of a New Energy Source. JOAN LISA BROMBERG. MIT Press, Cambridge, Mass., 1982. xxviii, 344 pp., illus. $30.

In reading Joan Lisa Bromberg's *Fusion: Science, Politics, and the Invention of a New Energy Source* one can be both pleased and disappointed. The book, commissioned by the Office of Magnetic Fusion Energy of the U.S. Department of Energy, is a scholarly history of the magnetic fusion program from 1951 to September 1978. In five chapters following an introduction it recounts, with extremely good documentation, the development of the program up to the second Atoms for Peace conference held in Geneva in 1958. The remaining seven chapters are devoted to the subsequent period, after the declassification of the fusion program.

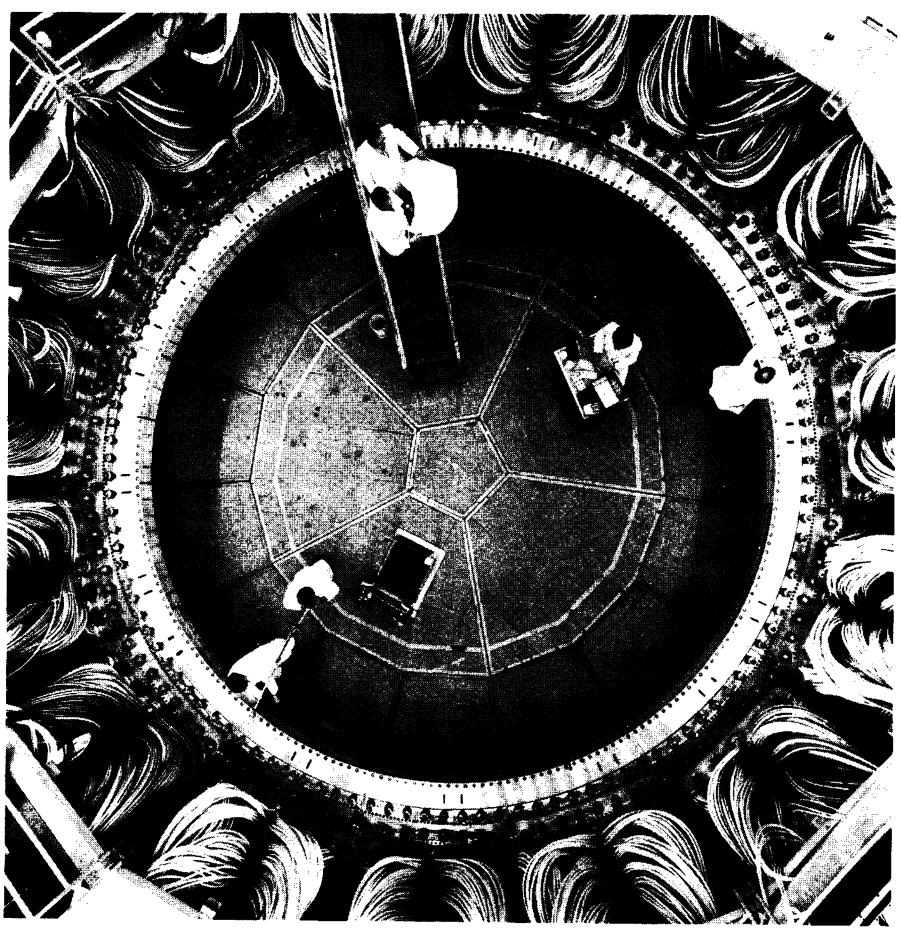
The reader who has been following fusion research as it has developed may well wonder that almost half of this history is devoted to the so-called classified era, especially in light of the large number of approaches that were attempted and the abandonment, at that time, of most of them. This exciting period of fusion research was in fact the beginning of essentially all of the current approaches to plasma confinement. Without Bromberg's serious review of the Atomic Energy Commission files and interviews with key personalities of the time this seemingly remote part of the history would be lost.

One of the particularly interesting bits of history provided by the book is the account of the frantic scrambling that was undertaken by United States politicians and researchers in order to be able to make an impressive showing at the 1958 Geneva conference. The impact on these efforts of the Soviet launch of Sputnik in 1957 is an interesting reflection on the politics of science. A second interesting part of the story has to do with the task of understanding the source of the neutrons that were produced by the Zero Energy Thermonuclear Assembly (ZETA) put into operation by the British in 1957. Runaway electrons, Bohm diffusion, Ioffe stabilization, Soviet tokamak successes, and the difficulty of making experiments work were sources of many frustrations, which the book captures well.

After the early to mid-'60's, during which the program was in a depressed state with progress stalemated and funding inadequate, there came a period, following reports of promising tokamak results obtained in the Soviet Union, of numerous and increasingly expensive experiments. For this period the book falls short because there are too many strong advocates with too many experiments in too many places to be adequately covered in the space allocated to them. A table in the appendix helps the reader follow the experiments at the principal locations, but many are left out since the table stops at 1975. Unfortunately, this useful table is not referred to in the text.

The fusion program has been blessed with many strong, brilliant, and dedicated individuals. Histories will be better able to assess their contributions as the story continues to unfold. In this first attempt, the author was able to capture the strength of key individuals in too few instances. She clearly has identified some, but the balance is uneven. Further, she has not captured the strong camaraderie developed among many of the international players in the world fusion community.

Every reader with a fusion background will see a slightly different twist to the story in each instance where he or she has personal experience. This reviewer, for example, would have liked to see more attention given to the General Atomic program with funding by the Texas Atomic Energy Research Foundation, and perhaps to how the university role in the fusion program was initiated and developed. Even with the painstaking research and many interviews, it has



Los Alamos Scientific Laboratory's Scyllac, 1974. The last of the line of devices that since the late 1950's had been the principal focus of Los Alamos's controlled fusion program, Scyllac was a toroidal machine first proposed in 1966. Its operation was terminated in 1977. [From *Fusion: Science, Politics, and the Invention of a New Energy Source*]