Television (TV), the electronic delivery of moving images and sound from a source to a receiver. By extending the senses of vision and hearing beyond the limits of physical distance, television has had a considerable influence on society. Conceived in the early 20th century as a possible medium for education and interpersonal communication, it became by mid-century a vibrant broadcast medium, using the model of broadcast radio to bring news and entertainment to people all over the world. Television is now delivered in a variety of ways: "over the air" by terrestrial radio waves (traditional broadcast TV); along coaxial cables (cable TV); reflected off of satellites held in geostationary Earth orbit (direct broadcast satellite, or DBS, TV); streamed through the Internet; and recorded optically on digital video discs (DVDs) and Blu-ray discs.

The technical standards for modern television, both monochrome (black-and-white) and colour, were first established in the middle of the 20th century. Improvements have been made continuously since that time, and television technology changed considerably in the early 21st century. Much attention was focused on increasing the picture resolution (high-definition television [HDTV]) and on changing the dimensions of the television receiver to show wide-screen pictures. In addition, the transmission of digitally encoded television signals was instituted to provide interactive service and to broadcast multiple programs in the channel space previously occupied by one program.

Despite this continuous technical evolution, modern television is best understood first by learning the history and principles of monochrome television and then by extending that learning to colour. The emphasis of this article, therefore, is on first principles and major developments—basic knowledge that is needed to understand and appreciate future technological developments and enhancements.

The development of television systems

Mechanical systems

The dream of seeing distant places is as old as the human imagination. Priests in ancient Greece studied the entrails of birds, trying to see in them what the birds had seen when they flew over the horizon. They believed that their gods, sitting in comfort on Mount Olympus, were gifted with the ability to watch human activity all over the world. And the opening scene of William Shakespeare's play Henry IV, Part 1 introduces the character Rumour, upon whom the other characters rely for news of what is happening in the far corners of England.

For ages it remained a dream, and then television came along, beginning with an accidental discovery. In 1872, while investigating materials for use in the transatlantic cable, English telegraph worker Joseph May realized that a selenium wire was varying in its electrical conductivity. Further investigation showed that the change occurred when a beam of sunlight fell on the wire, which by chance had been placed on a table near the window. Although its importance was not realized at the time, this happenstance provided the basis for changing light into an electric signal.

In 1880 a French engineer, Maurice LeBlanc, published an article in the journal La Lumière électrique that formed the basis of all subsequent television. LeBlanc proposed a scanning mechanism that would take advantage of the retina’s temporary but finite retainment of a visual image. He envisaged a photoelectric cell that would look upon only one portion at a time of the picture to be transmitted. Starting at the upper left corner of the picture, the cell would proceed to the right-hand side and then jump back to the left-hand side, only one line lower. It would continue in this way, transmitting information on how much light was seen at each portion, until the entire picture was scanned, in a manner similar to the eye reading a page of text. A receiver would be synchronized with the transmitter, reconstructing the original image line by line.

The concept of scanning, which established the possibility of using only a single wire or channel for transmission of an entire image, became and remains to this day the basis of all television. LeBlanc, however, was never able to construct a working machine. Nor was the man who took television to the next stage: Paul Nipkow, a German engineer who invented the scanning disk. Nipkow’s 1884 patent for an Elektrisches Telescop was based on a simple rotating disk perforated with an inward-spiraling sequence of holes. It would be placed so that it blocked reflected light from the subject. As the disk rotated, the outermost hole would move across the scene, letting through light from the first “line” of the picture. The next hole would do the same thing slightly lower, and so on. One complete revolution of the disk would provide a complete picture, or “scan,” of the subject.

This concept was eventually used by John Logie Baird in Britain (see the photograph) and Charles Francis Jenkins in the United States to build the world’s first successful televisions. The question of priority depends on one’s definition of television. In 1922 Jenkins sent a still picture by radio waves, but the first true television success, the transmission of a live human face, was achieved by Baird in 1925. (The word television itself had been coined by a Frenchman, Constantin Perskyi, at the 1900 Paris Exhibition.)

The efforts of Jenkins and Baird were generally greeted with ridicule or apathy. As far back as 1880 an article in the British journal Nature had speculated that television was possible but not worthwhile: the cost of building a system would not be repaid, for there was no way to make money out of it. A later article in Scientific American thought there might be some uses for television, but entertainment was not one of them. Most people thought the concept was lunacy.

Nevertheless, the work went on and began to produce results and competitors. In 1927 the American Telephone and Telegraph Company (AT&T) gave a public demonstration of the new technology, and by 1928 the General Electric Company (GE) had begun regular television broadcasts. GE used a system designed by Ernst F.W. Alexanderson that offered "the amateur, provided with such receivers as he may design or acquire, an opportunity to pick up the signals," which were generally of smoke rising from a chimney or other such interesting subjects. That same year Jenkins began to sell television kits by mail and established his own television station, showing cartoon pantomime programs. In 1929 Baird convinced the British Broadcasting Corporation (BBC) to allow him to produce half-hour shows at midnight three times a week. The following years saw the first "television boom," with thousands of viewers buying or constructing primitive sets to watch primitive programs.

Not everyone was entranced. C.P. Scott, editor of the Manchester Guardian, warned: "Television? The word is half Greek and half Latin. No good will come of it." More important, the lure of a new technology soon paled. The pictures, formed of only 30 lines repeating approximately 12 times per second, flickered badly on dim receiver screens only a few inches high. Programs were simple, repetitive, and ultimately boring. Nevertheless, even while the boom collapsed a competing development was taking place in the realm of the electron.

Electronic systems

The final, insurmountable problems with any form of mechanical scanning were the limited number of scans per second, which produced a flickering image, and the relatively large size of each hole in the disk, which resulted in poor resolution. In 1908 a Scottish electrical engineer, A.A. Campbell Swinton, wrote that the problems "can probably be solved by the employment of two beams of kathode rays" instead of spinning disks. Cathode rays are beams of electrons generated in a vacuum tube. Steered by magnetic fields or electric fields, Swinton argued, they could "paint" a fleeting picture on the glass screen of a tube coated on the inside with a phosphorescent material. Because the rays move at nearly the speed of light, they would avoid the flicker problem, and their tiny size would allow excellent resolution. Swinton never built a set (for, as he said, the possible financial reward would not be enough to make it worthwhile), but unknown to him such work had already begun in Russia. In 1907 Boris Rosing, a lecturer at the St. Petersburg Institute of Technology, put together equipment consisting of a mechanical scanner and a cathode-ray-tube receiver. There is no record of Rosing actually demonstrating a working television, but he had an interested student named Vladimir Zworykin, who soon emigrated to America.

In 1923, while working for the Westinghouse Electric Company in Pittsburgh, Pennsylvania, Zworykin filed a patent application for an all-electronic television system, although he was as yet unable to build and demonstrate it. In 1929 he convinced David Sarnoff, vice president and general manager of Westinghouse's parent company, the Radio Corporation of America (RCA), to support his research by predicting that in two years, with $100,000 of funding, he could produce a workable electronic television system. Meanwhile, the first demonstration of a primitive electronic system had been made in San Francisco in 1927 by Philo Farnsworth, a young man with only a high-school education. Farnsworth had garnered research funds by convincing his investors that he could market an economically viable television system in six months for an investment of only $5,000. In the event, it took the efforts of both men and more than $50 million before anyone made a profit.

With his first hundred thousand dollars of RCA research money, Zworykin developed a workable cathode-ray receiver that he called the Kinescope. At the same time, Farnsworth was perfecting his Image Dissector camera tube. In 1930 Zworykin visited Farnsworth's laboratory and was given a demonstration of the Image Dissector. At that point a healthy cooperation might have arisen between the two pioneers, but competition, spurred by the vision of corporate profits, kept them apart. Sarnoff offered Farnsworth $100,000 for his patents but was summarily turned down. Farnsworth instead accepted an offer to join RCA's rival Philco, but he soon left to set up his own firm.

Then in 1931 Zworykin's RCA team, after learning much from the study of Farnsworth's Image Dissector, came up with the Iconoscope camera tube, and with it they finally had a working electronic system.

In England the Gramophone Company, Ltd., and the London branch of the Columbia Phonograph Company joined in 1931 to form Electric and Musical Industries, Ltd. (EMI). Through the Gramophone Company's ties with RCA-Victor, EMI was privy to Zworykin's research, and soon a team under Isaac Shoenberg produced a complete and practical electronic system, reproducing moving images on a cathode-ray tube at 405 lines per picture and 25 pictures per second. Baird excoriated this intrusion of a "non-English" system, but he reluctantly began research on his own system of 240-line pictures by inviting a collaboration with Farnsworth. On November 2, 1936, the BBC instituted an electronic TV competition between Baird and EMI, broadcasting the two systems from the Alexandra Palace (called for the occasion the "world's first, public, regular, high-definition television station"). Several weeks later a fire destroyed Baird's laboratories. EMI was declared the victor and went on to monopolize the BBC's interest. Baird never really recovered; he died several years later, nearly forgotten and destitute.

By 1932 the conflict between RCA and Farnsworth had moved to the courts, both sides claiming the invention of electronic television. Years later the suit was finally ruled in favour of Farnsworth, and in 1939 RCA signed a patent-licensing agreement with Farnsworth Television and Radio, Inc. This was the first time RCA ever agreed to pay royalties to another company. But RCA, with its great production capability and estimable public-relations budget, was able to take the lion's share of the credit for creating television. At the 1939 World's Fair in New York City, Sarnoff inaugurated America's first regular electronic broadcasting, and 10 days later, at the official opening ceremonies, Franklin D. Roosevelt became the first U.S. president to be televised.

Important questions had to be settled regarding basic standards before the introduction of public broadcasting services, and these questions were not everywhere fully resolved until about 1951. The United States adopted a picture repetition rate of 30 per second, while in Europe the standard became 25. All the countries of the world came to use one or the other, just as all countries eventually adopted the U.S. resolution standard of 525 lines per picture or the European standard of 625 lines. By the early 1950s technology had progressed so far, and television had become so widely established, that the time was ripe to tackle in earnest the problem of creating television images in natural colours.

Colour television

Colour television was by no means a new idea. In the late 19th century a Russian scientist by the name of A.A. Polumordvinov devised a system of spinning Nipkow disks and concentric cylinders with slits covered by red, green, and blue filters. But he was far ahead of the technology of the day; even the most basic black-and-white television was decades away. In 1928, Baird gave demonstrations in London of a colour system using a Nipkow disk with three spirals of 30 apertures, one spiral for each primary colour in sequence. The light source at the receiver was composed of two gas-discharge tubes, one of mercury vapour and helium for the green and blue colours and a neon tube for red. The quality, however, was quite poor.

In the early 20th century, many inventors designed colour systems that looked sound on paper but that required technology of the future. Their basic concept was later called the "sequential" system. They proposed to scan the picture with three successive filters coloured red, blue, and green. At the receiving end the three components would be reproduced in succession so quickly that the human eye would "see" the original multicoloured picture. Unfortunately, this method required too fast a rate of scanning for the crude television systems of the day. Also, existing black-and-white receivers would not be able to reproduce the pictures. Sequential systems therefore came to be described as "noncompatible."

An alternative approach—practically much more difficult, even daunting at first—would be a "simultaneous" system, which would transmit the three primary-colour signals together and which would also be "compatible" with existing black-and-white receivers. In 1924, Harold McCreary designed such a system using cathode-ray tubes.