**Radio**

RADIO transmission or reception of electromagnetic radiation in the radio frequency range. The term is commonly applied also to the equipment used, especially to the radio receiver.

**Uses of Radio Waves**

The prime purpose of radio is to convey information from one place to another through the intervening media (i.e., air, space, nonconducting materials) without wires. Besides being used for transmitting sound and television signals, radio is used for the transmission of data in coded form. In the form of radar it is used also for sending out signals and picking up their reflections from objects in their path. Long-range radio signals enable astronauts to communicate with the earth from the moon and carry information from space probes as they travel to distant planets (see space exploration ). For navigation of ships and aircraft the radio range , radio compass (or direction finder), and radio time signals are widely used. Radio signals sent from global positioning satellites can also be used by special receivers for a precise indication of position (see navigation satellite ). Digital radio , both satellite and terrestrial, provides improved audio clarity and volume. Various remote-control devices, including rocket and artificial satellite operations systems and automatic valves in pipelines, are activated by radio signals. The development of the transistor and other microelectronic devices (see microelectronics ) led to the development of portable transmitters and receivers. Cellular and cordless telephones are actually radio transceivers. Many telephone calls routinely are relayed by radio rather than by wires; some are sent via radio to relay satellites. Some celestial bodies and interstellar gases emit relatively strong radio waves that are observed with radio telescopes composed of very sensitive receivers and large directional antennas (see radio astronomy ).

**Transmission and Reception of Radio Waves**

For the propagation and interception of radio waves, a transmitter and receiver are employed. A radio wave acts as a carrier of information-bearing signals; the information may be encoded directly on the wave by periodically interrupting its transmission (as in dot-and-dash telegraphy) or impressed on it by a process called modulation . The actual information in a modulated signal is contained in its sidebands , or frequencies added to the carrier wave, rather than in the carrier wave itself. The two most common types of modulation used in radio are amplitude modulation (AM) and frequency modulation (FM). Frequency modulation minimizes noise and provides greater fidelity than amplitude modulation, which is the older method of broadcasting . Both AM and FM are analog transmission systems, that is, they process sounds into continuously varying patterns of electrical signals which resemble sound waves. Digital radio uses a transmission system in which the signals propagate as discrete voltage pulses, that is, as patterns of numbers; before transmission, an analog audio signal is converted into a digital signal, which may be transmitted in the AM or FM frequency range. A digital radio broadcast offers compact-disc-quality reception and reproduction on the FM band and FM-quality reception and reproduction on the AM band.

In its most common form, radio is used for the transmission of sounds (voice and music) and pictures (television). The sounds and images are converted into electrical signals by a microphone (sounds) or video camera (images), amplified, and used to modulate a carrier wave that has been generated by an oscillator circuit in a transmitter. The modulated carrier is also amplified, then applied to an antenna that converts the electrical signals to electromagnetic waves for radiation into space. Such waves radiate at the speed of light and are transmitted not only by line of sight but also by deflection from the ionosphere .

Receiving antennas intercept part of this radiation, change it back to the form of electrical signals, and feed it to a receiver. The most efficient and most common circuit for radio-frequency selection and amplification used in radio receivers is the superheterodyne. In that system, incoming signals are mixed with a signal from a local oscillator to produce intermediate frequencies (IF) that are equal to the arithmetical sum and difference of the incoming and local frequencies. One of those frequencies is applied to an amplifier. Because the IF amplifier operates at a single frequency, namely the intermediate frequency, it can be built for optimum selectivity and gain. The tuning control on a radio receiver adjusts the local oscillator frequency. If the incoming signals are above the threshold of sensitivity of the receiver and if the receiver is tuned to the frequency of the signal, it will amplify the signal and feed it to circuits that demodulate it, i.e., separate the signal wave itself from the carrier wave.

There are certain differences between AM and FM receivers. In an AM transmission the carrier wave is constant in frequency and varies in amplitude (strength) according to the sounds present at the microphone; in FM the carrier is constant in amplitude and varies in frequency. Because the noise that affects radio signals is partly, but not completely, manifested in amplitude variations, wideband FM receivers are inherently less sensitive to noise. In an FM receiver, the limiter and discriminator stages are circuits that respond solely to changes in frequency. The other stages of the FM receiver are similar to those of the AM receiver but require more care in design and assembly to make full use of FM's advantages. FM is also used in television sound systems. In both radio and television receivers, once the basic signals have been separated from the carrier wave they are fed to a loudspeaker or a display device (usually a cathode-ray tube), where they are converted into sound and visual images, respectively.

**Development of Radio Technology**

Radio is based on the studies of James Clerk Maxwell, who developed the mathematical theory of electromagnetic waves, and Heinrich Hertz, who devised an apparatus for generating and detecting them. Guglielmo Marconi, recognizing the possibility of using these waves for a wireless communication system, gave a demonstration (1895) of the wireless telegraph, using Hertz's spark coil as a transmitter and Edouard Branly's coherer (a radio detector in which the conductance between two conductors is improved by the passage of a high-frequency current) as the first radio receiver. The effective operating distance of this system increased as the equipment was improved, and in 1901, Marconi succeeded in sending the letter S across the Atlantic Ocean using Morse code . In 1904, Sir John A. Fleming developed the first vacuum electron tube , which was able to detect radio waves electronically. Two years later, Lee de Forest invented the audion, a type of triode, or three-element tube, which not only detected radio waves but also amplified them.

Radio telephony—the transmission of music and speech—also began in 1906 with the work of Reginald Fessiden and Ernst F. W. Alexanderson, but it was not until Edwin H. Armstrong patented (1913) the circuit for the regenerative receiver that long-range radio reception became practicable. The major developments in radio initially were for ship-to-shore communications. Following the establishment (1920) of station KDKA at Pittsburgh, Pa., the first commercial broadcasting station in the United States, technical improvements in the industry increased, as did radio's popularity. In 1926 the first broadcasting network was formed, ushering in the golden age of radio. Generally credited with creating the first modern broadband FM system, Armstrong built and operated the first FM radio station, KE2XCC, in 1938 at Alpine, N.J. The least expensive form of entertainment during the Great Depression, the radio receiver became a standard household fixture, particularly in the United States. Subsequent research gave rise to countless technical improvements and to such applications as radio facsimile , radar, and television. The latter changed radio programming drastically, and the 1940s and 50s witnessed the migration of the most popular comedy and drama shows from radio to television. Radio programming became mostly music and news and, to a lesser extent, talk shows. The turn of the century saw a potential rebirth for radio as mobile digital radio entered the market with a satellite-based subscription service in Europe (1998) and in the United States (2000). Two years later, a land-based digital radio subscription service was inaugurated in the United States.

Radios that combine transmitters and receivers are now widely used for communications. Police and military forces and various businesses commonly use such radios to maintain contact with dispersed individuals or groups. Citizens band (CB) radios, two-way radios operating at frequencies near 27 megahertz, most typically used in vehicles for communication while traveling, became popular in the 1970s. Cellular telephones , despite the name, are another popular form of radio used for communication.