Appendix A (Thesis)

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# Appendix A - Technology timelines

Timeline of display technology (Hanna *et al.*, 2015; Anon, n.d.; Anon, n.d.; Anon, n.d.; Anon, 2015; Anon, n.d.)

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| Year | Event | Major event |
| 1855 | German, Heinrich Geissler invents the Geissler tube. Created using his mercury pump this was the first practical evacuated (of air) vacuum tube, which was later modified by Sir William Crookes. | YES |
| 1859 | German mathematician and physicist, Julius Plucker first identifies and experiments with cathode rays. | YES |
| 1872 | Joseph May discovers that selenium’s conductivity is enhanced by light. | YES |
| 1878 | Englishmen, Sir William Crookes was the first person to confirm the existence of cathode rays by displaying them, with his invention of the Crookes tube, a crude prototype for all future cathode ray tubes. | YES |
| 1878 | Mr. Senleq proposes FAX transmission using a selenium scanner and telegraphy. |  |
| 1880 | First articles appear in Scientific American about the possibility of television. | YES |
| 1884 | The first electromechanical television (i.e. television scanning disk) was proposed and patented by Paul Julius Gottlieb Nipkow. Nipkow never built a working model of the electromechanical television. | YES |
| 1888 | Liquid Crystals were accidentally discovered by Friedrich Reinitzer. Liquid crystals were a scientific curiosity for about 80 years before they were used to build liquid crystal displays (LCD). | YES |
| 1890s | Victorian Trade Card predicts a device that can transmit picture and sound. |  |
| 1897 | The Birth of CRT: Karl Ferdinand Braun, a Nobel-prize winning German physicist and inventor, builds the first CRT (Cathode-Ray Tube) oscilloscope, which consists of a vacuum tube that can produce images via electron beams hitting a phosphorescent surface. The technology will later be used to display images on early televisions and computer monitors. The Braun Tube was also the forerunner of radar tubes. | YES |
| 1900 | First known use of the word “television” at 1900 Paris Exhibition |  |
| 1907 | Discovery of Electroluminescence: British radio researcher Henry Joseph Round discovers electroluminescence, a natural phenomena that serves as the foundation upon which LED technology will later be built. | YES |
| 1907 | Russian scientist Boris Rosing (who worked with Vladimir Kosma Zworykin) uses a CRT in the receiver of a television system that at the camera end made use of mirror-drum scanning. Rosing is the first to transmit crude geometrical patterns onto a television screen using CRT. | YES |
| 1908 | Campbell Swinton proposes CRT for both scanning and receiving. | YES |
| 1911 | Rosing and college student Vladimir Kosma Zworykin (as assistant), achieve first transmission of images. | YES |
| 1911 | Swinton describes CRT system in detail. | YES |
| 1919 | RCA becomes subsidiary of GE.  A 28 year old David Sarnoff is named manager. |  |
| 1921 | Philo T. Farnsworth, at age 14, has a vision of electronic TV scanning whilst plowing hay. |  |
| 1922 | C. Francis Jenkins transmits still pictures by wireless with a mechanical system. | YES |
| 1922 | Farnsworth explains his electronic TV system to his high school teacher. |  |
| 1923 | As a Westinghouse employee, Zworykin files a patent application for an all-electronic television system.  He is not able to build or demonstrate it at this time. | YES |
| 1923 | Ernst Alexanderson starts television work at GE. |  |
| 1924 | Kenjiro Takayanagi starts his television work in Japan. |  |
| 1925-1928 | Glimpses of TV’s Capabilities: John Logie Baird, a Scottish engineer, demonstrates some of the capabilities of television including transmitting recognisable human faces (1925), moving objects (1926) and colour (1928). | YES |
| 1925 | Baird demonstrates his mechanical system at Selfridge’s Store in London | YES |
| 1925 | Jenkins transmits “moving objects” – (a windmill) in Washington, D.C. | YES |
| 1925 | Zworykin demonstrates a working system to his bosses at Westinghouse. | YES |
| 1925 | Baird builds the world’s first working television system. The world’s first working television system was electromechanical. | YES |
| 1926 | Baird gets his first license to transmit television in London. | YES |
| 1926 | Farnsworth receives a $6000 advance from George Everson in Salt Lake City. |  |
| 1926 | Philo Farnsworth marries Elma Gardner, and moves to San Francisco. |  |
| 1926 | Alexanderson is proclaimed the “Inventor of Television” by the press in St. Louis. |  |
| 1927 | January - Alexanderson demonstrates mechanical TV to Radio Engineers. | YES |
| 1927 | September - Farnsworth transmits a straight line via his electronic CRT system. | YES |
| 1928 | Baird transmits from London to New York, using his mechanical system. | YES |
| 1928 | Takayanagi gives a demonstration of his CRT system in Japan. |  |
| 1928 | Farnsworth demonstrates his CRT system to the press in San Francisco. | YES |
| 1928 | Station WLEX, Lexington, Massachusetts, (about 15 miles NW of Boston) begins broadcasting via mechanical system. |  |
| 1928 | The world’s first successful colour transmission by John Logie Baird. The colour transmission was made using an electromechanical television system. | YES |
| 1928 | The first working electronic television (all-electronic) is built by Farnsworth. The all-electronic television system did not use or have the motor-generator that was used in the electromechanical television systems. | YES |
| 1929 | Zworykin begins development of the kinescope, his CRT receiver. |  |
| 1929 | April 1929 –  W1WX (which would eventually become W1XAV), the Shortwave and Television mechanical station, goes on the air. | YES |
| 1930 | January - David Sarnoff becomes President of RCA at age 38. |  |
| 1931 | Allen B. Du Mont made the first commercially practical and durable CRT for television. | YES |
| 1935 | Patent interference between Zworykin and Farnsworth ruled in favor of Farnsworth.  Prevents RCA from gaining total patent control of television. |  |
| 1935 | Sarnoff evicts Armstrong from the Empire State building and announces million dollar research and testing plans for television. |  |
| 1935 | March - Germany begins what they call the “first television broadcasting service in the world”.  This is low resolution and has few receivers. | YES |
| 1936 | April - First RCA demonstration in 4 years of all-electronic system, 343 lines, 30 frames per second. | YES |
| 1936 | Farnsworth also broadcasting 343-30 at Wyndmoor, Pennsylvania station. |  |
| 1936 | Summer – Berlin Olympics televised by Telefunken and Fernseh, using RCA and Farnsworth equipment, respectively. | YES |
| 1936 | Autumn – Farnsworths travel to England to help Baird in his competition with EMI. | YES |
| 1936 | November 2 – BBC begins two-year Baird-EMI competition, broadcasting analog TV from Alexandra Palace.  It is hailed as the “world’s first, public, regular, high-definition TV station”. | YES |
| 1936 | November 30 – Fire destroys Baird labs at Crystal Palace |  |
| 1937 | February – BBC declares EMI the victor in the competition. | YES |
| 1937 | The coronation of King George VI and the Wimbledon tennis tournament are televised in England.  Nine thousand sets are sold in London. | YES |
| 1937 | France orders the world’s most powerful transmitter to be constructed in the Eiffel Tower. |  |
| 1937 | 18 Experimental Television Stations are operating in the United States. |  |
| 1938 | June – RCA announces the Image Iconoscope, a camera tube that is almost ten times more sensitive to light than the earlier Iconoscope. | YES |
| 1938 | October – Sarnoff announces that RCA will begin regular broadcasting at the World’s Fair |  |
| 1939 | The first electronic CRT television set (DuMont model 180) was introduced to the US market, available at a cost of approximately 125 dollars (Saperecom 2015) | YES |
| 1939 | March 31 – Farnsworth begins operations at Fort Wayne, Indiana |  |
| 1939 | April 20 – Sarnoff announces from the New York World’s Fair that “Now we have added sight to sound”.  Ten days later, at the opening ceremonies, FDR is the first president to be televised,  TV sets go on sale the following day. |  |
| 1939 | Approximately twenty-thousand electronic sets operating in England. |  |
| 1939 | 1 September 1939 –  UK-television transmissions switched off due to imminent outbreak of war. | YES |
| 1939 | October 2 –  Farnsworth signs patent-licensing agreement with RCA. This is the first time that RCA ever agrees to pay royalties to another company since it was founded in 1919. |  |
| 1940 | FCC announced September 1st start date for commercial television, but canceled that decision when RCA began advertising early. |  |
| 1940 | FCC formed a special committee, called the NTSC (National Television Standards Committee), to decide on industry standards.  There were 23 experimental television broadcasting stations operating in the United States. |  |
| 1940 | JUNE:  Both RCA and Philco televised the Republican convention, held in Philadelphia |  |
| 1940 | AUGUST:  A young (33) Peter Goldmark announced to the NTSC that CBS had marketable colour television. | YES |
| 1941 | MARCH:  The NTSC announced the recommended USA standard of 525 lines and 30 fps (frames per second).  FCC announced that commercial broadcasting could begin July 1st. | YES |
| 1941 | JULY 1st:  NBC was the first broadcaster with commercially sponsored broadcasts – CBS, DuMont and others followed in the Autumn | YES |
| 1941 | DECEMBER 7th:  Pearl Harbor | YES |
| 1942-1945 | All commercial production of television equipment is banned in the U.S. for the rest of the war.  NBC’s commercial TV schedule is cancelled.  Limited broadcasting does continue, however, throughout the war years, in a few cities, for a few hours per week. | YES |
| 1946 | CBS gave the FCC a demonstration of their mechanical colour system.  Viewers were impressed. | YES |
| 1946 | John Logie Baird, Scottish television pioneer, dies. |  |
| 1946 | Post war production of American TV sets begins | YES |
| 1946 | 1946 7“ Viewtone - the first post war American television (utilising a pre-war design), marketed as a 1946 model, but sold in very small quantities starting in August 1945.  The selling price was $100.  The president of Viewtone, Mr. Irving Kane, wanted to tap into the post war television market as quickly as possible, and also wanted to offer a set that people could afford.  Eventually four different models were sold, all using Du Mont picture tubes.  The company went out of business in August 1947. & 1946 & 1946 7” RCA 621TS - RCA  announced both the 621TS (and the 630TS) to the American public on October 7th 1946.  RCA then had a five city (newspaper) advertising campaign for both sets, with sales beginning in November 1946. |  |
| 1946 | The cabinet of the 621TS (offered in mahogany, walnut and blonde wood) was designed in the pre-war period by John Vassos, however the chassis was a post-war design.  Initial price was $226.4.  The 621 was on the market very briefly and was quickly outsold by the 630TS with a 10“ screen. Production was 17000 units - not many have survived until today - the set is popular among collectors. & 1946 & 1946 10” RCA Model 630TS - Initial selling price was $352.0.  It weighed 95 lbs., and was on the market from 1946 until 1949.  Many other manufacturers bought the 630 chassis, and had their own cabinets made.  Even in 1950, the set was offered in kit form and a hobbyist could build a do-it-yourself TV set. Approximately 43000 were sold the first year and hundreds-of-thousands continued to be sold in later years. Collectors call this the Model-T of television, and it is the first set completely designed and marketed post war. | YES |
| 1947 | RCA flooded the market with black & white sets to slow the potential launch of CBS colour.  An adapter (about $100) would have to be installed to all non-CBS colour sets.  The FCC ruled CBS colour is ’premature’. | YES |
| 1947-1950s | In 1947, the Soviet Union releases the film Bwana Devil and bills it as “the first feature length motion picture in 3-dimension natural vision.” In total, between 1952 and 1955, there are 46 3D movies released, including the famous House of Wax. Poor visual quality was off-putting to viewers, and the 3D craze did not catch on until decades later. |  |
| 1948 | Pye Television, a UK firm, set up a demonstration at the Australian “Royal Easter Show”, held in Sydney, six years ahead of the first Australian public broadcasts. This was the first time TV was demonstrated in Australia. |  |
| 1949 | Facing the colour challenge head-on, Sarnoff ordered stepped-up development of an all-electronic RCA colour system. Perfected system is ready by December 1950. |  |
| 1949 | Farnsworth Radio and Television is sold to ITT.  Philo Farnsworth, at age 43, suffering from alcoholism, is no longer a part of the television industry. |  |
| Early 1950s | Colour Television: Television begins to incorporate colour, encoding both luminance and chrominance for the first time. Since TVs, which at this time in the U.S. encode programs using the NTSC (National Television System Committee) System, vary from model to model, colour changes based on viewers’ equipment. This leads to the nickname “Never The Same Color” to describe the NTSC technology. | YES |
| 1950 | CBS presents colour television system using a spinning mechanical colour wheel. In October, the FCC approves CBS colour for commercial broadcasting.  Sarnoff orders his “holy crusade” at RCA to perfect electronic colour television. | YES |
| 1951 | The share of US households with a TV passes the 20% threshold |  |
| 1951 | June 25th: CBS broadcasts a one-hour Ed Sullivan show, but only two dozen CBS sets can receive the colour broadcast.  By the end of June, RCA demonstrates its electronic colour system, and the industry takes notice. | YES |
| 1951 | October: All colour TV production is suspended for the duration of the Korean conflict. | YES |
| 1951 | December 6th:  Code of Practices for Television Broadcasters is adopted in the USA.  Also known as the “Seal of Good Practice”. |  |
| 1952 | Debut of Curved TV Screen: The Cinerama is unveiled as the first curved television screen in a handful of movie theaters. The technology is based on the science behind human vision, and it becomes a tourist attraction that people travel miles to see. The trend of curved screens will not hit the consumer TV market for more than half a century. | YES |
| 1953 | March 25th:  CBS gives victory to RCA in U.S. colour TV war. | YES |
| 1953 | December 17th: FCC approves electronic RCA colour system, reversing its prior decision to accept CBS mechanical system.  It calls this new RCA colour system “NTSC” colour. | YES |
| 1954 | RCA places its first all-electronic colour set on the market early in the year, the CTC-100, with a 12-1/2“ screen, for $1000. Sales were predicted to be 75000 units – however, only a reported 5000 were sold.  The real number is thought to be closer to 1000 sets sold to the public. Many sets were donated to schools and also sold at a discount to employees. & 1956 & Time magazine calls colour TV ”the most resounding industrial flop of 1956“ & YES 1961-1962 & Invention of LED: In 1961, Robert Biard and Gary Pittman patent an infrared LED (light-emitting diode) – the first LED – for Texas Instruments. It is, however, invisible to the human eye. The next year, Nick Holonyack invents the first light LED that’s visible to the human eye and becomes known as ”the father of the LED.“ & YES 1962 & Discovery of the Williams Domain in LC material, Sarnoff Labs & YES 1964 & The first working liquid crystal display (LCD) was built by George H. Heilmeier. The original LCD displays were based on what is called dynamic scattering mode (DSM). LCD technology makes flat-screen television possible, and later LCD research by James Fergason, an American inventor, leads to the first modern LCD watch in 1972. & YES 1964 & The first flat plasma display panel (PDP) was invented by Donald Bitzer, Gene Slottow and Robert Willson. Plasma TVs, however, do not become widely successful (or possible) until the advent of digital technologies years later. & YES 1964 & The Japan Broadcasting Corporation (NHK) begins experimenting with high-definition television after the 1964 Tokyo Olympics. & YES 1965 & Touchscreen Technology: E.A. Johnson develops what some consider to be the world’s first ”touch screen“ technology. At first, it’s used for air traffic control, but after sometime, around 1995, it becomes the predecessor to the screens used in today’s ATMs and ticketing kiosks. & YES 1967 & Birth of IMAX: The inception of IMAX occurs when Canadian filmmakers band together in Montreal to produce a multi-screen film installation – the first truly large-screen film experience – by syncing together nine film projectors. & YES 1971 & Invention of the twisted-nematic mode of LCDs & YES 1972 & Synthesis of cyanobiphenyl LC material at Hull University & YES 1972 & The first active-matrix liquid crystal display (LCD) panel was produced by Westinghouse. & YES 1974 & Panasonic designs a TV prototype that can display 1125 lines of pixels (about 2.5 times that of standard definition). & YES 1977 & The first true all LED flat panel television TV screen was developed by J. P. Mitchell. & YES 1980s and 1990s & Rise of Large-Scale TVs: Consumer televisions continue to get larger and larger. Rear projection televisions are the standard – though they take up a great deal of space – until about 2005, when they are replaced by lighter and slimmer technologies like Digital Light Processing (DLP), Liquid Crystal on Silicon (LCoS), and improved Plasma and LCD. & 1980s and 1990s & Touchscreen Invades: IBM, Microsoft, Apple, HP and Atari are among just a few of the tech companies bringing touchscreen into the mainstream in this era. In 1992, IBM’s Simon is the first phone with a touchscreen. FingerWorks, a gesture recognition company that is later acquired by Apple, produces a line of multi-touch products in 1998. & 1982 & Seiko introduces the world’s first LCD TV watch. & 1982 & The first mass-produced pocket television was the Sony Watchman FD-210. The Sony Watchman was also the first flat CRT television in production. & 1984 & First Macintosh Computer: The first Mac becomes available to the consumer market, with a 9-inch, monochrome 512×342 pixel display. Mac’s as of 2015 with Retina 5K have a 5120x2880 pixel display – this represents an increase of about 8400% – that supports millions of colours. & YES 1987 & OLED: Researchers at Eastman Kodak invent OLED (organic light-emitting diode) technology; chemists Ching W. Tang and Steven Van Slyke are the primary inventors. & YES 1988 & The Sharp Corporation develops the world’s first 14-inch colour TFT LCD TV. The LCD TV model was called the Crystaltron. & YES 1990s & Full Colour Plasma Display: Plasma displays continue to improve in resolution with technology brands debuting new and improved models throughout the ’80s and ’90s. Plasma technologies continue to evolve into the 2000s, particularly for large-sized screens (40 inches and above), until they are eventually surpassed by LCD. & 1995 & Larger Than Life LED: The Fremont Street Experience, the world’s largest LED display at the time, is put on display in Las Vegas. It measures over 1500 feet long and 90 feet high. & 1996 & The first public digital high-definition television (HDTV or HD) broadcast in the United States. The official US public launch of the HDTV digital broadcasting system is technically considered to be 1998. \*HD ready refers to the abilities of television receivers to display high-definition pictures. & YES 1998 & Launch of HDTV in the U.S: The official public launch of HDTV digital broadcasting system in the United States takes place. Though high-definition technology has been in the works (primarily in Japan and other countries) for years, it does not become mainstream in America until the late 1990s. & YES c. 2007 & Sometime around 2007, LCD televisions surpass Plasma in popularity due to their large size and lower cost. LED technologies also continue to improve, and LED-backlit LCD televisions become commonplace. OLED technologies also continue to improve, and can function without backlight. & YES 2007 & Touchscreen is the Status Quo: The 2007 iPhone is the first commercially successful smartphone that is exclusively touchscreen, though there is debate about which tech company lays claim to the ”first“ touchscreen smartphone. Touchscreen becomes the industry standard for mobile devices from this point forward. & YES 2008 & The world’s largest Plasma TV is a 150 inch Plasma TV made by Panasonic, standing 6 ft high and 11 ft wide. & 2009 & The world’s largest LED high-definition video display screen in the world is the Mitsubishi Diamond Vision display at the Dallas Cowboys Stadium. The LED HD display measures 160 ft wide and 72 ft high and is nicknamed the “JerryTron” after Cowboys owner Jerry Jones. & 2010 & The world’s largest Plasma 3D TV is a 152 inch Plasma TV made by Panasonic & 2010s & Electronic Paper: Though e-paper technology was actually pioneered in the 1970s, it became popularity in e-readers and other devices in the 2010s. E-paper is portable, reusable and can be ”erased“ – or re-written on – thousands of times. & YES 2010 & The world’s first 3D LED HDTV released by Samsung (Samsung 3D LED 7000). Announced in February, 2010. LG announced the release of their first 3D LED HDTV, the LG LX9500 in March, 2010. & YES 2013 & Quantum-Dot Technology: Quantum-dot technology arrived on the scene in 2013 with debuts by LG, but the display tech is quickly picking up speed. QD is an advanced version of an LED-backlit LCD TV, providing exceptional image quality and vivid hues. & YES 2014 & Apple begins to market its products – for the first time in 2014 – with ”Retina Display“ and later ”Retina HD" Display. The selling point is that the resolution of the screen has reached the point that the human eye is incapable of determining any pixelation at all. Retina Display is a term used exclusively with iPads, iPhones, iPods, Macs and MacBooks. & 2015 & AMOLED: AMOLED, or active-matrix organic light-emitting diode, increases screen resolution and quality of OLED screens. Today, versions of AMOLED include Super AMOLED, HD Super AMOLED, Super AMOLED Advanced and more – the labeling generally varies based on tech companies’ marketing terms. & YES 2015 & Mainstream Resurgence of 3D: 3D becomes popular in the movie theaters and at home, due to improved technologies such as alternate-frame sequencing (battery-powered glasses for 3D viewing at home) and autostereoscopic technologies (3D that does not require glasses). & YES 2015 & High resolutions continue to improve – not only on televisions, but on mobile devices and wearable technologies. Along with higher resolutions come larger televisions. In 2004, the average TV was a CRT of just 27 inches, and today’s screens often measure 60 inches or more. & 2015 & Televisions are getting thinner and more flexible – e.g. a Sony 4K TV that is 4mm thick at its thinnest point, which debuted at CES 2015. In addition, flexible OLED and AMOLED screens are in the midst of penetrating the market, and companies are competing for the first fully bendable smartphone screen. & 2015 & While curved screens on televisions are becoming increasingly popular, CES 2015 saw curved screens on more than just TVs, including the Samsung ATIV One 7 Curved, an all-in-one computer with a curved monitor. & 2015 & While 4K was a main theme of CES 2014, 5K was debuted at CES 2015. 4K, also referred to as 4K2K, means that a device has a horizontal resolution of at least 4000 pixels. & 2015 & Improved 3D and Virtual Reality: Displays are allowing for increasing user interactivity, such as the HP Zvr Virtual Reality Display, a monitor that debuted at CES 2015 that allows users to manipulate 3D images on the screen. & |  |

Timeline of electric vehicles (Anon, n.d.; Anon, n.d.; Anon, n.d.; Anon, 2017)

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| Year | Event | Major event |
| 1821 | Michael Faraday creates the first weak experimental electromagnet |  |
| 1828 | Hungarian inventor Ányos Jedlik, who had invented an early electric motor, builds a small, model car powered by this motor. | YES |
| 1831 | Joseph Henry, a math professor in Albany NY, builds the first electric motor in his quest to understand electro-magnetism. It is modeled along the lines of the “walking beam” used on early steam engines and resembles an electric teeter-totter. |  |
| 1832-1839 | Scottish inventor Robert Anderson invents the first crude electric carriage powered by non-rechargeable primary cells. | YES |
| 1834 | Inspired by reading of Joseph Henry’s efforts blacksmith Thomas Davenport and his wife Emily develop the first rotary direct current electric motor and build a miniature electric railcar running in a circle on a tabletop; it is not strong enough to carry the weight of its own battery. The Davenports use silk from Emily’s wedding dress as wiring. His invention failed to interest investors. This might have been due to a lack of imagination among his audience, but practical minded people would point out the dependency on relatively expensive single use batteries, as neither practical rechargeable batteries, nor distributed electric power are available. He creates a proof of concept, which is generally ignored until after the Civil War. | YES |
| 1835 | In the Netherlands, Professor Sibrandus Stratingh of Groningen and his assistant, Christopher Becker, build a small electric car powered by primary cells (nonrechargeable batteries). |  |
| 1837 | Thomas & Emily Davenport, and colleague Orange Smalley, receive the first American patent for an electric machine/motor. | YES |
| 1837 & 1841 | Large-scale “electric cars” are finally built by chemist Robert Davidson of Aberdeen. Powered by galvanic cells, the larger one, built in 1841, can pull 6 tons at 4 miles per hour for about 1½ miles. It weighs 7 tons. Sadly, it is soon destroyed by railway workers who see it as a potential threat to their livelihood (even though electric cars were still far from economical, with the cost of using zinc in a battery being about 40 times higher than the cost of burning coal in a firebox). | YES |
| 1851 | The US Senate funds a prototype electric locomotive, which made a test run from Washington DC to Baltimore MD, a distance of about 40 miles (64 km). Charles Grafton Page, a US patent examiner, designs it and uses his Washington connections to get funding. The motor was like an electric steam engine with a solenoid and iron mass rather than a cylinder and piston. The effort fails when the clay separators in the primary battery cells crack and the solenoid coils overheat and short out as the insulation fails. Steam remains more practical for large-scale power at this point. |  |
| 1854 | Wilhelm J. Sinsteden invents the rechargeable, lead, sulfuric acid, and lead-oxide battery |  |
| 1859 | French physicist Gaston Planté improves the lead acid cell to the point of commercial viability with telegraph system use in mind and invents the rechargeable lead-acid storage battery. The original Planté design had smooth, untreated lead plates separated by parchment paper and felt. They had to be cycled (recharged) many times before building up a sufficient peroxide coating on the positive plate to develop full useful capacity. Lead-acid batteries are still used in some electric cars as of 2015, and are used in gas-powered cars to help start the engines. However, most modern electric cars use lithium-ion batteries. The lead-acid batteries used to start cars are still very similar to what Gaston created. |  |
| 1869 | Zenobe-Theophile Gramme patents the first practical dynamo in Paris. |  |
| 1876 | Nikolaus August Otto patents a practical four-stroke engine, designed for stationary use, in Germany. The engine is made to run with help from his engineer Gottlieb Daimler. | YES |
| 1880 – January 17th | Thomas Alva Edison is awarded a carbon-filament vacuum tube light bulb patent. This incandescent light becomes popular over the next three decades as the lamps become more affordable. The commercial generation and distribution of electricity for lighting, and light rail, built the necessary infrastructure for electric cars. Edison had to fight for clear patent rights, and eventually the strongest plaintiffs merged to become General Electric. | YES |
| 1881 | Camille Alphonse Faure, in France, and Charles F. Brush, in the US, independently come up with the idea of using a lead oxide paste to increase the capacity of the original 1859 Planté battery by a threefold capacity, greatly increasing the potential for battery traction vehicles, if the paste would stay on the plates. This leads to industrial-scale production of lead-acid batteries. |  |
| 1881 | An electric tricycle built by Gaston Planté is displayed at the International Exhibition of Electricity in Paris. | YES |
| 1881 | Parisian engineer and carriage builder Charles Jeantaud, with the help of Camille Alphonse Faure, builds a battery electric vehicle using a Tilbury-style buggy, a Gramme motor, and the Fulmen battery. Over the next twelve years, he continued to modify this platform, installing a British motor in 1887, and a Swiss motor with a tubular plate battery built by Tonate Thommasi in 1893. |  |
| 1881 | Englishmen William Ayrton & John Perry build an electric tricycle, the first vehicle to use electric lights. It uses lead acid cells, has a range of 10 to 25 miles, and has a maximum speed of 9 mph. |  |
| 1883 | The Brighton Electric Railway, engineered by Magnus Volk, opens in England. The route is only a quarter of a mile long at first. This is the first commercial electric tram. |  |
| 1884 | English inventor Thomas Parker builds first practical production electric car in London. He uses “high-capacity” rechargeable batteries that he designed. (Parker also electrified the London Underground, was responsible for overhead tramways in Liverpool and Birmingham, and has other such accomplishments to his name) |  |
| 1884 | College dropout Andrew Riker, while living in his parents’ basement, develops an electric trike using lead-sulfuric acid batteries that has 25 miles of range. | YES |
| 1886 | N. S. Possons has an electric tricycle built for the Brush Electric Co of Cleveland Ohio. It has a Swan incandescent electric headlight and features the Brush Company’s rechargeable battery powering a Brush motor. |  |
| 1886 | Frank Sprague invents a high torque DC traction motor. It is capable of consistent speed under varying loads and does not create sparks. |  |
| 1887 | Sprague uses his DC motor in the first commercial electric tram systems in North America, beginning with Richmond Virginia. |  |
| 1888 | German engineer Andreas Flocken builds the first four-wheeled electric car. |  |
| 1888 | Andrew Riker forms the Riker Electric Vehicle Company, which is based in Elizabeth Port, New Jersey. |  |
| 1888 | Philip Pratt demonstrates an electric tricycle built for him by Fred M. Kimball of Fred M. Kimball Company. Despite Riker’s (lesser known) electric trike being built a few years earlier, many say that Pratt’s electric trike is the first in the US, and Pratt is often given the title, “father of the American electric automobile.” |  |
| 1888 | Elwell-Parker Company and rivals merge in England to form the Electric Construction Corporation. The Electric Construction Corporation thus gains a monopoly on the production of electric cars in the coming decade. |  |
| 1890-1891 | The first American electric car is built by William Morrison of Des Moines, Iowa. The 6-passenger wagon can travel up to 23 km/h (14 mph). The car may also be the first land vehicle steered with a wheel. Morrison, a chemist, moved to Iowa from Scotland in 1880. | YES |
| 1893 | The World’s Columbian Exposition is held in Chicago IL, ushering in the electrical age for most Americans. There are several motor vehicles on stationary display including an electric taxicab designed by Walter Bersey and a few German petrol vehicles. The Morrison car, now owned by the American Battery Co, is the only one moving about. It becomes well known as it is used to drive important visitors - including many future automobile manufacturers - around the grounds. |  |
| 1894 | Louis Antoine Krieger begins building electric “horseless carriages” in Paris. They use regenerative braking, with the captured energy stored in a battery and later used to help power the motor. |  |
| 1894 | Mechanical engineer Henry G. Morris and chemist Pedro G. Salom build the first “successful” electric car. With backgrounds in the dwindling battery tram market, Morris and Salom design and commission a heavy four-wheel electric wagon, the “Electrobat”, like a small battery tram. It has a top speed of 15 mph and uses a lead acid battery. It goes into production the following year, 1895. | YES |
| 1895 | Morris & Salom come up with an elegant new design, which they call the Electrobat II. It is lighter weight and has front wheel drive with coil spring suspension at the rear wheels. Along with the Morrison electric it is entered in America’s first automobile race, which is held in Chicago. Neither car has the battery capacity to go the distance in the freezing weather, and the race is won by the Duryea brothers, followed by some German Benz based cars. |  |
| 1896 | The same Electrobat II, and a new electric built by Andrew Riker, soundly defeat five next generation Duryeas in a series of five mile sprints on a dirt horse-track in fair weather. The short range allows for a light, hot battery. Because of the high initial cost and vicissitudes of lead battery management Morris and Salom felt the vehicles are more appropriate for fleet service than individual ownership, and design an electric version of the popular horse drawn Hansom cabs for the streets of major American cities. | YES |
| 1896 | The first car dealer is set up in the US. It only sells electric vehicles. |  |
| 1896 | Morris and Salom build a 2-seat “Electric Road Wagon” and form the “Electric Carriage and Wagon Company,” apparently the first electric car company in the US. Developed as coupes and hansoms for New York City taxis, the Electric Road Wagons each have rear-wheel steering, two 1/2 hp motors, 44 lead-acid cells, and a range of 30 miles. |  |
| 1896 | To overcome range limitations and lack of charging infrastructure, a battery exchange (aka battery swap) service is proposed. Implemented by Hartford Electric Light Company, the service is initially available for electric trucks. |  |
| 1897 | Major commercial implementation: Samuel’s Electric Carriage and Wagon Company cabs in New York, based on the Electrobat II, are the first in commercial operation. The event is announced in January - with only two cabs ready - but due to licensing delays operation actually begins in March. They soon had a small fleet of 12 Hansom cabs and one Brougham (Coupé). Venture capital for the Electrobat projects came from owners of the Electric Storage Battery Company of Philadelphia under the leadership of Isaac L. Rice. ESB is founded to provide battery sets for streetcars where a trolley line is not practical, to extend service past the reach of electrical lines, and where overhead wires are restricted by ordinance. They are also used for power station backup, railway lighting, and such. On the 13th of May a Columbia Mark III, the first electric car for sale to the general public, is demonstrated to the press and public. Made by a subsidiary of Albert A. Pope’s bicycle empire and company has a significant advantage over the Morris & Salom New York cab startup as they had a factory for manufacturing the chassis and running gear, the bodies are farmed out to the New Haven Carriage Co. As such The Pope Manufacturing Company of Connecticut becomes the first large-scale American electric automobile manufacturer. Although a Bersey cab prototype has been around since 1893 it takes several years to find the capital and change laws to put them on the streets of London. On August 19th, 1897 Walter Bersey’s cab is finally put into service in London. The Bersey cabs use a 3 ½ HP Lundell motor, ran at 9 miles per hour for about 20-30 miles on a charge, and feature quick-change battery boxes. The enterprise failed in August of 1899. Painted yellow and black they were popularly called “hummingbirds” due to the bright colour and whir of the straight cut gears. | YES |
| 1897 | September: Isaac Rice takes over the New York cab company as the Electric Vehicle Company. |  |
| 1897 | The first car with power steering to be built is an electric car. |  |
| 1898 | Dr. Ferdinand Porsche, 23 years old, builds his first car, the Lohner Electric Chaise. It has a hub motor at each driving wheel and is reportedly the first front-wheel-drive car in the world. |  |
| 1898 | Count Gaston de Chasseloup-Laubat of Paris sets the first known speed record in a car, going faster than any human before at 39.24 mph (62.8 km/h) in his electric Jeantaud. This earns him the nickname “Electric Count.” Incidentally, the world record lasts for just a few days before being beaten by another electric vehicle. |  |
| 1899 | Walter C. Baker founded the Baker Motor Vehicle Company. Thomas Alva Edison, who does not drive, buys the second one made. |  |
| 1899 | Believing that electricity will run autos in the future, Thomas Alva Edison begins his mission to create a long-lasting, powerful battery for commercial automobiles. Though his research yields some improvements to the alkaline battery, he ultimately abandons his quest a decade later. |  |
| 1899 | Camille Jenatzy and Count Gaston de Chasseloup-Laubat trade speed records several times throughout the year, ending in Camille Jenatzy breaking the 100 km/h (62 mph) speed barrier in an electric vehicle. He reaches a top speed of 105.88 km/h (65.79 mph). Jenatzy’s vehicle is named La Jamais Contente (“The Never Satisfied”). |  |
| 1899 | MIT electrical & mechanical engineering graduate Clinton Edgar Woods incorporates Woods Motor Vehicle Company, 3 years after forming American Electric Vehicle Company, which then became Waverly Company. |  |
| 1899 | The Baker Electric, the first production electric car, is born. It is produced by Baker Motor Vehicle Company. | YES |
| 1899-1905 | Ferdinand Porsche designs electric and Hybrid cars for Austrian coachbuilder Jacob Lohner & Co. The vehicles from 1900 on use hub motors. |  |
| 1900 | Because of the brief lead cab bubble, many US automobiles are powered by electricity. By 1915 electric cars dropped to 5% of marketshare. Electric automobiles were most popular in Chicago, Cleveland and Buffalo. |  |
| 1900 | The Electric Vehicle Company has a lot of flash equity, mostly as stock shares, to spread around in support of anticipated growth. The Electric Carriage and Wagon, Columbia Motor-Carriage, New Haven Carriage, Riker Electric Vehicle, and Siemens-Halske (North America) companies, are folded into the Electric Vehicle Company, now controlled by a New York/Philadelphia transit holding company known as the “lead cab trust”. EVC provides vehicles for the New York City and other taxi companies; the closely tied Electric Storage Battery Company (later ESB Exide) supplied the batteries. In many cases these buyouts are stock swaps where a majority owner of the original company became a minority owner of the briefly inflated conglomerate. The game of the holding company is industry sector monopolies based on patent consolidation and exclusive franchises. |  |
| 1900 | The electric automobile is in its heyday. Of the 4192 cars produced in the United States 28% are powered by electricity (making this the top-selling vehicle type), and electric vehicles represent 38% of US automobiles (33842 cars in total). The remaining market is split between steam (40%), and gasoline (22%) powered vehicles. | YES |
| 1901 | Thomas Edison patents the nickel-iron battery. |  |
| 1902 | Things are already falling apart for the lead cabs. The men running the holding and operating companies are far more successful at selling the companies than their products, and sold more equity stakes than the wildest success might have justified. Although the New York cab company and vehicle manufacturing companies are profitable, and of more value operating than liquidated, the taxi enterprise failed in most other cities. After 1899 the Electrical Vehicle Company does not pay their preferred stock dividend obligations, much less return a dividend on common stock. Several of the original partners, such as Pope, Rice, and Riker, sold out early - were pushed out to a degree - and left the later investors holding a somewhat empty bag. This apparently fraudulent scheme gives quite a blow to the whole concept of electric vehicles in the minds of investors and customers. | YES |
| 1902 | The Baker Motor Vehicle Co. produces a fully streamlined electric racing car called the Torpedo, with a top speed said to be 120 mph. When it crashed and killed two spectators during its first speed trial at Statten Island Speedway, press toward both speed contests and electric vehicles took a negative turn. | YES |
| 1902 | Dr. Ferdinand Porsche builds second car, a hybrid with an electric range of 40 miles. |  |
| 1903 | For Walter C. Baker it is not about top speed, it is about efficiency. In 1903 he builds the Baker Torpedo Kid; it is a one-person vehicle, smaller and far lighter than the 12 HP tandem-seat Torpedo. Most racecar designers increase the power and speed of their cars with each new iteration. Baker has different priorities. The motor in the Kid has a nominal rating of 1½ HP. The Torpedo has no recorded time registered at over 80 MPH; The Kid is clocked on Ormond Beach at 103. This record stands for 64 years. It is also the first vehicle to utilize a safety belt. Later, he reportedly reaches 127 mph (204 km/h) but without officially being recorded. |  |
| 1905 | Rauch & Lang, a well-established maker of luxury coaches in Cleveland, sees the success of nearby Baker and the fading of the horse. They decide to make their coaches electric. |  |
| 1905 | All makers combined produce approximately 1200 electric motorcars in America. |  |
| 1907 | Bank panic and recession of 1907: Several of the individuals and their business practices in the lead cab holding Company were involved in causing major bank panic with the collapse of many large banks and a freeze of liquidity, ending many businesses. Although the Electric Vehicle Company had earnings of  $200000 a year from an explosion of car makers paying a royalty on the Seldon patent, and decent earnings from vehicle sales, they were not able to refinance $2500000 in mortgage backed securities, and went into receivership. At its peak there were 616 cabs and buses in the New York fleet. Gasoline cabs were introduced around 1908 and by 1910 the electric cabs were out of service. This recession was a factor in Henry Ford’s decision to make only one model at a low price. | YES |
| 1907 | Detroit Electric, an electric car produced by the Anderson Electric Car Company, is born. 13000 Detroit Electrics are produced between 1907 and 1939. |  |
| 1908 | A few months before he sold the first model T, Henry Ford bought Clara her first Detroit Electric (since she preferred electric cars). It had a special child seat for Edsel. The Ford family bought a new Detroit Electric every other year through to 1914. |  |
| 1908 | Henry Ford introduces the mass-produced and gasoline-powered Model T, which will have a profound effect on the U.S. and global automobile market. | YES |
| 1908 | Thomas Edison improves the design of his nickel-iron battery. |  |
| 1909 | William Taft becomes the first U.S. President to purchase an automobile, a Baker Electric. |  |
| 1910 | Shaft drive electric cars are made the standard by Baker. |  |
| 1911 | The first gasoline-electric hybrid car is released by Woods Motor Vehicle Company, which is based out of Chicago. |  |
| 1912 | Charles Kettering invents the first practical electric automobile starter. Ironically, Kettering’s invention makes gasoline-powered autos more alluring to consumers by eliminating the unwieldy hand crank starter and ultimately helps pave the way for the electric car’s demise. | YES |
| 1912 | Global EV stock reaches historical peak, with 38843 electric vehicles on the roads in the United States | YES |
| 1913 | Mass production of the Ford Model T on the first modern assembly line deals a strong blow to early-era electric cars, as it brings down the cost of gasoline cars considerably (making electric cars two or even three times more expensive in the coming years). Electric car sales would slowly taper off over the coming years. Main factors leading to the demise of electric cars in the following years and into the 1920s were: cheap Texas oil leading to the ready availability of gasoline; a more developed road network and the ability/desire to travel long distances (electric cars typically had driving ranges of 30 to 40 miles and limited charging infrastructure); the electric starter making petrol-powered vehicles easier and more attractive; the lack of horsepower and slower speeds in electric vehicles (about 20 mph or 32 km/h); tough economic times during World War I; and the stigma that electric cars are for women. | YES |
| 1915 | The Baker Motor Vehicle Company merges with Rauch & Lang. Only two versions of the Baker Electric are sold through the following year and the Baker brand is only used for industrial trucks through the rest of the Twentieth Century. |  |
| 1915 | The Milburn Wagon Company is the last important maker of electric pleasure cars to enter the market. |  |
| 1916 | Venerable Chicago electric vehicle maker Woods introduces a hybrid car called the Woods Dual Power in an attempt to revive the company. This is the most serious attempt at a true hybrid automobile for the general public. |  |
| 1919 | Only Detroit Electric, Milburn, and Baker, Rauch & Lang survive World War I, the Influenza pandemic, and the postwar recession. Production slowed to a trickle. Electric starting and lighting systems, combined with much more reliable gasoline engines, and better sliding gear transmissions, made the advantages of electric cars less significant. | YES |
| 1919 | A few serious attempts were made to revive the electric car, notably by Charles Proteus Steinmetz, but none had any market impact. |  |
| 1920 | During the 1920s the electric car ceases to be a viable commercial product. | YES |
| 1923 | Milburn, one of few remaining electric vehicle companies, sells out to main body client General Motors. |  |
| 1929 | W. C. Anderson, 75 years old and in poor health, sells his Detroit Electric company. The last entirely new Detroit Electric was likely sold in 1926. |  |
| 1930s | By 1935, EVs become all-but-extinct due to the predominance of internal combustion engine (ICE) vehicles and availability of cheap petrol. |  |
| 1947 | Oil rationing in Japan leads carmaker Tama to release a 4.5hp electric car with a 40V lead acid battery. |  |
| 1957 | Sputnik is launched and the US space program engages in advanced battery research & development. | YES |
| 1959-1961 | The Henney Kilowatt, a small electric car, is produced by Henney Coachworks and the National Union Electric Company. It achieves a top speed of 60 mph (97 km/h) and a range of 60 miles (97 kilometers), but its high price keeps away potential buyers. |  |
| 1966 | Congress introduces the earliest bills recommending use of electric vehicles as a means of reducing air pollution. A Gallup poll indicates that 33 million Americans are interested in electric vehicles. | YES |
| 1967 | The Electric Auto Association is founded by Walter Laski. |  |
| 1967-1969 | American Motors Corporation (AMC) & Gulton Industries team up to produce a few electric cars using a lithium-based battery and a nickel-cadmium battery, such as the Amitron (1967, lithium batteries) and and all-electric Rambler American (1969, nickel-cadmium batteries). The Amitron introduces regenerative braking. |  |
| 1971 | The first manned vehicle to drive on the moon, the Lunar Rover, is an electric car. | YES |
| 1972 | Victor Wouk, the “Godfather of the Hybrid,” builds the first full-powered, full-size hybrid vehicle out of a 1972 Buick Skylark provided by General Motors (G.M.) for the 1970 Federal Clean Car Incentive Program. The Environmental Protection Association later kills the program in 1976. |  |
| 1972 | The Electric Auto Association holds its first annual electric vehicle rally. |  |
| 1973 | The OPEC oil embargo causes high oil prices, long lines at petrol filling stations, and renewed interested in EVs. | YES |
| 1973-1977 | The Enfield 8000 is built by Enfield Automotive in the UK. Using lead-acid batteries, the car has a top speed of 48 mph (77 km/h) and a top range of about 40 miles (64 kilometers). |  |
| 1974 | Vanguard-Sebring’s CitiCar makes its debut at the Electric Vehicle Symposium in Washington, D.C. The CitiCar has a top speed of over 30 mph and a reliable warm-weather range of 40 miles. By 1975 the company is the sixth largest automaker in the U.S. but is dissolved only a few years later. |  |
| 1975 | The U.S. Postal Service purchases 350 electric delivery jeeps from AM General, a division of AMC, to be used in a test program. |  |
| 1976 | Congress passes the Electric and Hybrid Vehicle Research, Development, and Demonstration Act. The law is intended to spur the development of new technologies including improved batteries, motors, and other hybrid-electric components. | YES |
| 1976 | France’s government launches the “PREDIT” programme accelerating EV RD&D. | YES |
| 1977 | AMC & Gulton Industries again team up to produce the AMC Electron, a 3-passenger, electric, commuter, city car. |  |
| 1982 | The first modern hybrid car is made at GE Research Lab. It is computer controlled and is the ancestor of current commercial hybrid cars. | YES |
| 1983 | A fleet of electric vehicles drive from San Jose to San Francisco and back (100 miles / 161 kilometers) without recharging. |  |
| 1985 | Saied Motai drives an electric vehicle 230 miles (370 kilometers) on a single charge. |  |
| 1988 | Roger Smith, CEO of G.M. , agrees to fund research efforts to build a practical consumer electric car. G.M. teams up with California’s AeroVironment to design what would become the EV1, which one employee called “the world’s most efficient production vehicle.” Some electric vehicle enthusiasts have speculated that the EV1 was never undertaken as a serious commercial venture by the large automaker. | YES |
| 1989 | Audi creates a hybrid called the “Duo” with NiCad batteries and a 5 cylinder gas engine. The vehicle never sees mainstream production |  |
| 1990 | General Motors (GM) introduces the GM Impact, an electric concept car, at the Los Angeles Auto Show. GM President Roger Smith also announces that GM will produce electric cars for the consumer market (which finally happens in 1997, but the car is only available to lease). | YES |
| 1990 | The California Air Resources Board (CARB), the government of California’s “clean air agency,” pushes for automakers to produce more-fuel-efficient, low-emissions vehicles and eventually transition to zero emissions vehicles (e.g., electric vehicles). The main law is the Zero Emission Vehicle (ZEV) Mandate, which requires 2% of California’s vehicles to have 0 tailpipe emissions by 1998, and 10% by 2003. As a result, automakers develop several electric vehicle models in the coming years. However, the automakers do not really get behind the idea, and do not market their electric vehicles well (if at all), and eventually sue CARB, resulting in the repeated weakening and eventual dropping of the ZEV Mandate. | YES |
| 1991 | The Kewet, a 100% electric microcar produced in Norway, is introduced. |  |
| 1992 | The Škoda Favorit ELTRA 151L & 151 Pick-Up is released, selling for under $20000 without subsidy. It has a top speed of 50 mph (80 km/h) and a top range of 50 miles (80 kilometers). |  |
| 1992 | California passes a $1000 tax credit for electric vehicles. | YES |
| 1994 | 12 other US states adopt California’s ZEV Mandate. |  |
| 1994 | The GM Impact EV (later named the EV1) drives 187 mph (301 km/h), breaking the electric vehicle speed record. GM also began PrEView, a program whereby 50 handbuilt Impact electric cars would be lent to drivers for periods of 1–2 weeks. This program existed for about 2 years. | YES |
| 1994 | The REVA Electric Car Company is formed in India, a joint venture between the Maini Group India and AEV of California. |  |
| 1995 | Toyota debuted a hybrid concept car at the Tokyo Motor Show |  |
| 1996 | The first 660 EV1s produced are built with GM lead-acid batteries with an advertised range of 70–100 miles (but closer to 60). (Later, they were upgraded to Panasonic lead-acid batteries and had a realistic driving range of 90 miles. Starting in 1999, 457 Gen2 EV1s had NiMh batteries, with a top range of 160 miles.) The EV1 is produced until 2003, but is only available for lease. And GM reclaims and destroys the electric cars, not allowing owners in love with the vehicle to buy them off of GM. EV1s that were donated to engineering schools and museums are not reclaimed but are deactivated, except for the one donated to the Smithsonian. (Honda, Nissan, and Toyota similarly offered their vehicles under closed-ended leases and repossessed/crushed them at the end of the lease periods.) | YES |
| 1997 | Audi creates the Duo III and it makes it to series production |  |
| 1997 | Toyota unveils the Prius – the world’s first commercially mass-produced and marketed hybrid car – in Japan. Nearly 18000 units are sold during the first production year (1999). | YES |
| 1997 | GM releases the Chevrolet S10 EV, an electric pickup truck. It has a top speed of 73 mph (118 km/h) and a top range of 90 miles (144 kilometers). It is produced until 1998. |  |
| 1997 | Honda releases the EV Plus, which has a top speed of over 80 mph (130 km/h) and a top range of 80 to 110 miles (130 to 180 kilometers). It is produced until 1999. |  |
| 1997 | Toyota releases the RAV4 EV, which has a top speed of 78 mph (125 km/h) and a top range of 87 miles (140 kilometers). It is produced until 2002. |  |
| 1998 | Nissan produces 200 of the Altra EV from 1998-2002 |  |
| 1998 | Ford releases the Ranger EV, which has a range of 74 miles (119 kilometers). It is produced until 2002. |  |
| 1999 | The Honda Insight and Toyota Prius, hybrid electric cars, go on sale. These are the first hybrid vehicles on the market since the 1917 Woods hybrid. The Insight comes to the US, while the Prius comes to Japan. (The Prius was introduced in the US 2 years later, in 2001.) |  |
| 2001 | REVA Electric Car Company releases the REVAi (aka “G-Wiz” in the UK), an electric microcar powered by lead-acid batteries. |  |
| 2002 | GM and DaimlerChrysler finally sue CARB over the ZEV Mandate, and are joined in the suit by the Bush Administration. They win the lawsuit and the California ZEV Mandate is changed to allow ZEV credits instead of ZEVs. | YES |
| 2003 | G.M. announces that it will not renew leases on its EV1 cars saying it can no longer supply parts to repair the vehicles and that it plans to reclaim the cars by the end of 2004. | YES |
| 2003 | Tesla Motors is founded in California. | YES |
| 2004 | Tesla Motors begins work on the Tesla Roadster, a 100% electric sports car based on the design of the popular and stylish Lotus Elise. | YES |
| 2004 | The last of the EV1s are taken back from leaseholders and destroyed or donated. All EV1s donated to museums and schools are deactivated, except one. Serial number 660, donated to the Smithsonian, is not disabled. |  |
| 2005 | On February 16, electric vehicle enthusiasts begin a “Don’t Crush” vigil to stop G.M. from demolishing 78 impounded EV1s in Burbank, California. The vigil ends twenty-eight days later when G.M. removes the cars from the facility. In the film “Who Killed the Electric Car” G.M. spokesman Dave Barthmuss states that the EV1s are to be recycled, not just crushed. |  |
| 2005 | Who Killed The Electric Car? is released in cinemas. |  |
| 2005 | Plug In America is launched in the US. |  |
| 2006 | Tesla Motors publicly unveils the ultra-sporty Tesla Roadster at the San Francisco International Auto Show in November. The first production Roadsters will be sold in 2008 with a base price listing of $98950. The car changes the image of electric cars for many, and also spurs some major automakers to genuinely jump into the electric car market. | YES |
| 2007 | The Kewet gets rebranded as “Buddy.” |  |
| 2008 | The Th!nk City electric city car goes into production in Norway. |  |
| 2008 | The Tesla Roadster becomes the first production electric vehicle to use lithium-ion battery cells as well as the first production electric vehicle to have a range of over 200 miles on a single charge. | YES |
| 2008 - January | The Israeli government announces its support for a sweeping project to promote the use of electric cars in Israel. The effort will be a joint venture between Better Place, a Palo Alto start-up founded by software maven Shai Agassi, and French automaker Renault-Nissan. Agassi’s plan is to create an extensive network of charging spots and to sell EV drivers mileage in their cars like minutes on a cell phone plan. The first Renault electric cars are scheduled to hit the streets of Tel Aviv and other cities in 2011. Better Place announces a host of partnerships to support electric vehicle projects in Denmark, Canada, Japan, Australia and the U.S. |  |
| 2008 - July | Oil prices reach more than USD 145 per barrel and car sales drop to their lowest levels in a decade. American automakers begin to shift their production lines away from SUVs and other large vehicles toward smaller, more fuel-efficient cars. | YES |
| 2008 - August | On the campaign trail, presidential candidate Barack Obama says he will push to have one million plug-in hybrid and electric vehicles on America’s roads by 2015. |  |
| 2008 - November | Struggling to remain profitable during the economic downturn, executives from the Big Three American automakers go to Washington to make the case for a $25 billion Federal bailout of the U.S. automotive industry. |  |
| 2008 - December | BYD, a Chinese battery manufacturer turned automaker, releases the F3DM, the world’s first mass produced plug-in hybrid compact sedan. Though they pack less energy than more conventional lithium ion batteries, BYD opts to power the F3DM with a more stable lithium iron phosphate battery. BYD plans to release the F3DM in the U.S. in 2011, but some industry insiders have doubts about whether the car is ready for the U.S. market. Though sales of the car remain sluggish, Warren Buffett’s Berkshire Hathaway purchases a 10% stake in the company. | YES |
| 2008 - December | The National Bureau of Economic Research states officially that the U.S. has been in a recession since December 2007. The economic downturn is global in scope and will continue to exert financial pressures on the already battered U.S. auto industry. | YES |
| 2009 | Ford Fusion hybrid is released |  |
| 2009 | REVA Electric Car Company releases the REVA L-ion, an updated version of its electric microcar this time powered by lithium-ion batteries. |  |
| 2009 | Tesla unveils the Model S electric sedan, which quickly gets top ratings from leading auto journalists and consumer technology review company Consumer Reports. By many, it is considered the best mass-production car of any type in the world. | YES |
| 2009 | The Mitsubishi i-MiEV goes on sale in Japan. It hits the European, Chinese, and Australian markets in 2010; and then the US and other markets in 2011. |  |
| 2009 - February | The American Recovery and Reinvestment Act of 2009 allocates $2 billion for development of electric vehicle batteries and related technologies. The Department of Energy adds another $400 million to fund building the infrastructure necessary to support plug-in electric vehicles. | YES |
| 2009 - April | Prime Minister Gordon Brown announces that the British government will promote the use of electric vehicles in the U.K. by offering a £2000 subsidy to purchasers. A high-ranking government official estimates that 40% of all cars in Britain will need to be electric or hybrid for the country to reach it’s goal of cutting 80% of its CO2 emissions by 2050. |  |
| 2009 - April | Chrysler files for Chapter 11 bankruptcy. As part of its restructuring, Chrysler forms a partnership with the Italian car maker Fiat. |  |
| 2009 - May | President Obama announces a new gas-mileage policy that will require automakers to meet a minimum fuel-efficiency standard of 35.5 miles a gallon by 2016. |  |
| 2009 - June | General Motors, the leading producer of automobiles for most of the 20th Century, files for bankruptcy protection. While strong GM brands such as Chevrolet, Cadillac and GMC are slated to continue, smaller names like Saturn, Hummer and Pontiac will be sold or closed. The federal government will hold a 61 percent stake in the reborn General Motors. |  |
| 2009 - June | The Department of Energy awards $8 billion in loans to Ford, Nissan, and Tesla Motors to support the development of fuel-efficient vehicles. The automaker loans are the first distributions from a larger $25 billion fund created under the Energy Independence and Security Act of 2007. | YES |
| 2009 - August | Nissan unveils its new electric car, called the LEAF (“Leading, Environmentally Friendly, Affordable, Family Car”). The LEAF is capable of a maximum speed of more than 90 mph, can travel 100 miles on a full charge, and has a battery that can be recharged to 80% of its capacity in 30 minutes. Similar to the Better Place initiative in Israel, Nissan plans to work with the Japanese government and private companies to set up charging station networks across several countries. The first production LEAFs are scheduled to go on sale in Japan, Europe, and the U.S. in the fall of 2010. |  |
| 2010 | Mercedes-Benz collaborates with Tesla Motor Company to produce the A-Class E-Cell |  |
| 2010 | Mass production of the 100% electric Nissan Leaf begins in Japan, and the car is sold in Japan and the US. It has a max speed of over 90 mph (145 km/h), has a top range of 100 miles (161 kilometers), and can be recharged to 80% of battery capacity in 30 minutes. | YES |
| 2010 | Production of the BYD e6 begins in China, initially just for fleet customers. |  |
| 2010 | Mass production of the Chevy Volt, an extended-range electric vehicle (also referred to as a plug-in hybrid electric vehicle), begins in the US. The instigation of this car and possibly all other modern plug-in cars was the Tesla Roadster. Bob Lutz, who was vice chairman of GM at the time, said in 2009: “All the geniuses here at General Motors kept saying lithium-ion technology is 10 years away, and Toyota agreed with us – and boom, along comes Tesla. So I said, ‘How come some tiny little California startup, run by guys who know nothing about the car business, can do this, and we can’t?’ That was the crowbar that helped break up the log jam.” | YES |
| 2010 | Tesla Motors goes public with an IPO on NASDAQ. |  |
| 2010 | 25000 electric cars are on the roads globally (fewer than were on US roads in 1912, but many more than just a few years prior). | YES |
| 2011 | The world’s largest electric car sharing service, Autolib, is launched in Paris with a targeted stock of 3000 EVs. |  |
| 2011 | French government fleet consortium commits to purchase 50000 EVs over four years. |  |
| 2011 | Nissan LEAF wins European Car of the Year award. |  |
| 2011 | The Bolloré Bluecar is released in France, initially just used in Paris’ Autolib’ carsharing program. |  |
| 2011 | The Mitsubishi i-MiEV becomes the first electric car to see more than 10000 sales (including under various other badges — Citroën C-Zero and Peugeot iOn). |  |
| 2011 | 80000 electric cars are on the roads globally (new historical peak), more than three times the number from the year before. | YES |
| 2012 | The PHEV Chevrolet Volt outsells half the car models on the U.S. market. |  |
| 2012 | Tesla unveils the Model X, an electric SUV/crossover with similar performance to the Model S. | YES |
| 2012 | Tesla begins building a North American Supercharger network, which Tesla owners can use for free. | YES |
| 2012 | 200000 electric cars are on the roads globally, 2.5 times more than the year before. | YES |
| 2013 | The Nissan Leaf becomes the first electric car to see over 50000 sales. | YES |
| 2013 | The Nissan Leaf gets a $6000 price cut in the US thanks to the start of production in the US (Tennessee). |  |
| 2013 | For certain months, the Nissan Leaf and the Tesla Model S each become the top-selling car of any type in Norway. | YES |
| 2013 | The Renault–Nissan Alliance passes 100000 plug-in electric vehicle sales globally, the first company to do so. |  |
| 2013 | 405000 electric cars are on the roads globally, more than twice the number from the year before. | YES |
| 2014 | Numerous 100% electric and plug-in hybrid electric vehicles are now on the market, such as: BMW i3, BMW i8, Bolloré Bluecar, BYD e6, BYD Qin, Cadillac ELR, Chevy Spark EV, Chevy Volt, Citröen Berlingo Électrique, Citröen C-Zero, Fiat 500e, Ford C-Max Energi, Ford Fusion Energi, Ford Focus Electric, Honda Accord Plug-in, Honda Fit EV, Kia Soul EV, Mercedes-Benz B-Class Electric, Mia Electric, Mitsubishi i-MiEV, Mitsubishi Outlander Plug-in, Nissan e-NV200, Nissan Leaf, Opel Ampera, Peugeot iOn, Peugeot Partner EV, Porsche Panamera S-E Hybrid, Renault Kangoo ZE, Renault Twizy, Renault Zoe, Smart Electric Drive, Tesla Model S, Tesla Model X, Toyota Prius Plug-in, Toyota RAV4 EV, Via Motors VTRUX SUV/Truck/Van, Volvo C30 Electric, Volvo V60 Plug-in, Volkswagen e-Golf, Volkswagen e-Up!, Volkswagen XL1, Wheego LiFE, Wheego Whip. |  |
| 2014 | Tesla announces plans to build a battery “gigafactory” in order to ensure it has enough batteries for its current and upcoming vehicles. | YES |
| 2014 | Tesla opens up its patents to anyone wanting to use them “in good faith.” | YES |
| 2014 | Tesla announces that its 3rd-generation, much more affordable vehicle will be called Tesla Model III. It is supposed to have a range of about 200 miles (320 kilometers), be about 20% smaller than the Model S, have a base price of about $30000, and go into production in 2017. | YES |
| 2014 | Tesla starts working on production of the Model X. |  |
| 2014 | The Nissan Leaf becomes the first electric car to see over 100000 sales. | YES |

Timeline of fibre optics (Hecht, 2004; Cattani, 2006; Cattani, 2005; Warf, 2006; Carter, 2009; Anon, n.d.)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| Circa 2500 BC | Earliest known glass. | YES |
| Roman Times | Glass is drawn into fibers. | YES |
| 1713 | Réné de Réaumur makes spun glass fibers. | YES |
| 1790s | Claude Chappe invents ‘‘optical telegraph’’ in France. | YES |
| 1841 | Daniel Colladon demonstrates light guiding in jet of water in Geneva; it also is demonstrated in London and Paris. | YES |
| 1842 | Daniel Colladon publishes report on light guiding in Comptes Rendus; Jacques Babinet also reports light guiding in water jets and bent glass rods. | YES |
| 1853 | Paris Opera uses Colladon’s water jet in the opera Faust. |  |
| 1854 | John Tyndall demonstrates light guiding in water jets at the suggestion of Michael Faraday, duplicating but not acknowledging Colladon. |  |
| 1873 | Jules de Brunfaut makes glass fibers that can be woven into cloth. | YES |
| 1880 | Alexander Graham Bell invents Photophone. | YES |
| 1880 | William Wheeler invents system of light pipes to illuminate homes from an electric arc lamp in basement, Concord, Mass. | YES |
| 1884 | International Health Exhibition in South Kensington district of London has first fountains with illuminated water jets, designed by Sir Francis Bolton. Colladon republishes his 1842 paper to show the idea was his. |  |
| 1887 | Charles Vernon Boys draws quartz fibers for mechanical measurements. | YES |
| 1887 | Royal Jubilee Exhibition in Manchester has illuminated ‘‘Fairy Fountains’’ designed by W. and J. Galloway and Sons. |  |
| 1888 | Dr. Roth and Prof. Reuss of Vienna use bent glass rods to illuminate body cavities for dentistry and surgery. | YES |
| 1889 | Universal Exhibition in Paris shows refined illuminated fountains designed by G. Bechmann. |  |
| 1892 | Herman Hammesfahr shows glass dress at Chicago World’s Fair. |  |
| 1895 | Henry C. Saint-René designs a system of bent glass rods for guiding light in an early television scheme (Crezancy, France). | YES |
| 1898 | David D. Smith of Indianapolis applies for patent on bent glass rod as a surgical lamp. | YES |
| 1920s | Bent glass rods common for microscope illumination. | YES |
| June 2, 1926 | C. Francis Jenkins applies for US patent on a mechanical television receiver in which light passes along quartz rods in a rotating drum to form an image. | YES |
| October 15, 1926 | John Logie Baird applies for British patent on an array of parallel glass rods or hollow tubes to carry image in a mechanical television. He later built an array of hollow tubes. | YES |
| December 30, 1926 | Clarence W. Hansell proposes a fiber-optic imaging bundle in his notebook at the RCA Rocky Point Laboratory on Long Island. He later receives American and British patents. | YES |
| 1930 | Heinrich Lamm, a medical student, assembles first bundle of transparent fibers to carry an image (of an electric lamp filament) in Munich. His effort to file a patent is denied because of Hansell’s British patent. | YES |
| December 1931 | Owens-Illinois mass-produces glass fibers for Fiberglas. | YES |
| August 20, 1932 | Norman French of Bell Labs applies for patent on an ‘‘optical telephone system’’ using quartz rods. | YES |
| Mid-1930s | Frank Hyde develops flame hydrolysis to make fused silica at Corning Glass Works. | YES |
| 1939 | Curvlite Sales offers illuminated tongue depressor and dental illuminators made of Lucite, a transparent plastic invented by DuPont. |  |
| October 31, 1945 | Ray D. Kell and George Sziklai apply for patent on transmitting signals through quartz or glass rods, issued May 9, 1950. | YES |
| Circa 1949 | Holger Møller Hansen in Denmark and Abraham C. S. van Heel at the Technical University of Delft begin investigating image transmission through bundles of parallel glass fibers. | YES |
| April 11, 1951 | Holger Møller Hansen applies for a Danish patent on fiber-optic imaging in which he proposes cladding glass or plastic fibers with a transparent low-index material. Patent claim is denied because of Hansell patent. | YES |
| October 1951 | Brian O’Brien (University of Rochester) suggests to van Heel that applying a transparent cladding would improve transmission of fibers in his imaging bundle. |  |
| July 1952 | Harold Horace Hopkins applies for a grant from the Royal Society to develop bundles of glass fibers for use as an endoscope at Imperial College of Science and Technology. Hires Narinder S. Kapany as an assistant after he receives grant. | YES |
| Early 1953 | O’Brien joins American Optical as vice president and research director. His top priority is developing a wide-screen movie system for promoter Mike Todd; fiber optics is sidetracked. |  |
| Spring 1953 | Hopkins tells Fritz Zernicke his idea of fiber bundles; Zernicke tells van Heel, who decides to publish quickly. |  |
| May 21, 1953 | Nature receives brief paper by van Heel on simple bundles of clad fibers. |  |
| June 12, 1953 | Dutch-language weekly De Ingeneur publishes van Heel’s first report of clad fiber. |  |
| November 22, 1953 | Nature receives paper on bundles of unclad fibers for imaging written by Hopkins and Kapany. |  |
| January 2, 1954 | Nature publishes papers by Hopkins and Kapany and by van Heel. The long delay of the van Heel paper has never been explained. | YES |
| 1954 | Basil Hirschowitz visits Hopkins and Kapany in London from the University of Michigan. |  |
| September 1954 | American Optical hires Will Hicks to develop fiber-optic image scramblers, proposed by O’Brien to the Central Intelligence Agency. |  |
| Summer 1955 | Kapany completes doctoral thesis on fiber optics under Hopkins, moves to University of Rochester. |  |
| Summer 1955 | Hirschowitz and C. Wilbur Peters hire undergraduate student Larry Curtiss to work on their fiber-optic endoscope project. |  |
| 1956 | First transatlantic telephone cable, TAT-1, goes into operation. It uses coaxial cable to carry 36 voice circuits. | YES |
| Summer 1956 | Curtiss suggests making glass-clad fibers by melting a tube onto a rod of higher-index glass. Peters and other Michigan physicists push plastic-clad fibers, which Curtiss makes instead. |  |
| October 1956 | Frederick H. Norton starts consulting with American Optical on fiber development. Later he suggests ways to make glass cladding. |  |
| October 1956 | Curtiss and Peters describe plastic-clad fibers at Optical Society of America meeting in Lake Placid, New York. Kapany also presents a paper. Hicks attends but does not give a talk. | YES |
| December 8, 1956 | Curtiss makes first glass-clad fibers by rod-in-tube method; they are much clearer than plastic-clad fibers. |  |
| February 18, 1957 | Hirschowitz tests first fiber-optic endoscope in a patient. | YES |
| Early 1957 | Hicks experiments with glass-clad fibers and fusing many fibers into a rigid bundle, an idea suggested by Norton. |  |
| May 1957 | Hirschowitz demonstrates fiber endoscope to American Gastroscopic Society. | YES |
| Mid-1957 | Kapany leaves Rochester to head group at Illinois Institute of Technology Research Institute in Chicago. |  |
| Mid-1957 | Image scrambler project ends after Hicks tells CIA the code is easy to break. American Optical shifts to developing faceplates, adding more people as Todd-AO wide-screen movie project fades. |  |
| 1957 | Hirschowitz, Peters, and Curtiss license gastroscope technology to American Cystoscope Manufacturers Inc. |  |
| Late 1957–Early 1958 | Charles Townes and Arthur Schawlow outline principles of laser operation. Gordon Gould starts work on his own laser proposal. | YES |
| Early 1958 | Hicks develops practical fiber-optic faceplates for military imaging systems. |  |
| 1958 | Hicks, Paul Kiritsy, and Chet Thompson leave American Optical to form Mosaic Fabrications in Southbridge, Mass., the first fiber-optics company. |  |
| 1958 | Alec Reeves begins investigating optical communications at Standard Telecommunication Laboratories. |  |
| 1959 | Working with Hicks, American Optical draws fibers so fine they transmit only a single mode of light. Elias Snitzer recognises the fibers as single-mode waveguides and applies for a patent (with Hicks) in 1960. | YES |
| May 16, 1960 | Theodore Maiman demonstrates the first laser at Hughes Research Laboratories in Malibu. | YES |
| December 12, 1960 | Ali Javan makes first helium-neon laser at Bell Labs, the first laser to emit a steady beam. | YES |
| Circa 1960 | George Goubau at Army Electronics Command Laboratory, Stew Miller of Bell Telephone Laboratories, and Murray Ramsay of Standard Telecommunication Laboratories begin investigating confocal optical waveguides with regularly spaced lenses. |  |
| January 1961 | Charles C. Eaglesfield of STL proposes hollow optical pipeline made of reflective pipes. |  |
| May 1961 | Eli Snitzer of American Optical publishes theoretical description of single-mode fibers. | YES |
| 1961 | Narinder Kapany founds Optics Technology Inc. |  |
| 1962 | Experiments at STL show high loss in Eaglesfield’s hollow optical pipeline. |  |
| 1962 | AT&T starts converting to digital telephone transmission. |  |
| September-October 1962 | Four groups nearly simultaneously make first semiconductor diode lasers, which emit pulses at liquid-nitrogen temperature. Robert N. Hall’s group at General Electric is first. | YES |
| 1962 | Dwight Berreman of Bell Labs proposes gas lens waveguide. |  |
| 1962–1963 | STL abandons millimeter waveguide development. Alec Reeves pushes optical waveguides but sees problems with confocal lens waveguides. |  |
| 1962–1963 | Experiments show high loss when sending laser beams through atmosphere. |  |
| 1963 | Heterostructures proposed for semiconductor lasers. |  |
| 1963–1964 | Antoni E. Karbowiak of STL realizes that unclad transparent optical waveguides would have to be impractically thin. He considers clad optical fibers, but thinks a flexible thin-film waveguide would have lower loss. |  |
| October 1964 | Charles Koester and Eli Snitzer describe first optical amplifier, using neodymium-doped glass. | YES |
| December 1964 | Charles K. Kao takes over STL optical communication program when Karbowiak leaves to become chair of electrical engineering at the University of New South Wales. Kao and George Hockham soon abandon thin-film waveguide in favor of single-mode clad optical fiber. |  |
| February 1965 | Stewart Miller of Bell Labs applies for patent on graded-index waveguides for light and millimeter waves. |  |
| Autumn 1965 | Kao concludes that the fundamental limit on glass transparency is below 20 decibels per kilometer, which would be practical for communications. Hockham calculates that clad fibers should not radiate much light. They prepare a paper proposing fiber-optic communications. | YES |
| January 1966 | Kao tells Institution of Electrical Engineers in London that glass fibers could be made with loss below 20 decibels per kilometer for communications. | YES |
| Early 1966 | F. F. Roberts starts fiber-optic communications research at British Post Office Research Laboratories. |  |
| July 1966 | Kao and Hockham publish paper outlining their proposal in Proceedings of the Institution of Electrical Engineers. | YES |
| July 1966 | John Galt at Bell Labs asks Mort Panish and Izuo Hayashi to figure out why diode lasers have high thresholds at room temperature. |  |
| September 1966 | Alain Werts, a young engineer at CSF in France, publishes proposal similar to Kao’s in French-language journal L’Onde Electronique, but CSF does nothing further for lack of funding. |  |
| 1966 | Roberts tells William Shaver, a visitor from the Corning Glass Works, about interest in fiber communications. This leads Robert Maurer to start a small research project on fused-silica fibers. |  |
| 1966 | Kao travels to America early in year but fails to interest Bell Labs. He later finds more interest in Japan. |  |
| Early 1967 | British Post Office allocates an extra £12 million to research; some goes to fiber optics. | YES |
| Early 1967 | Shojiro Kawakami of Tohoku University in Japan proposes graded-index optical fibers. |  |
| Summer 1967 | Corning summer intern Cliff Fonstad makes fibers with Frank Zimar. Loss is high, but Maurer decides to continue the research using titania-doped cores and pure-silica cladding. |  |
| October 1967 | Clarence Hansell dies at 68. |  |
| Late 1967 | Robert Maurer recruits Peter Schultz from Corning’s glass chemistry department to help make pure glasses. |  |
| January 1968 | Donald Keck starts work for Maurer as the first full-time fiber developer at Corning. |  |
| August 1968 | Dick Dyott of British Post Office picks up suggestion for pulling clad optical fibers from molten glass in a double crucible. |  |
| 1968 | Kao and M. W. Jones measure intrinsic loss of bulk fused silica at 4 decibels per kilometer, the first evidence of ultratransparent glass, prompting Bell Labs to seriously consider fiber optics. | YES |
| 1969 | Martin Chown of Standard Telecommunication Labs (STL) demonstrates fiber-optic repeater at Physical Society exhibition. | YES |
| April 1970 | STL demonstrates fiber-optic transmission at Physics Exhibition in London. | YES |
| Spring 1970 | First continuous-wave room-temperature semiconductor lasers made in early May by Zhores Alferov’s group at the Ioffe Physical Institute in Leningrad (now St. Petersburg) and on June 1 by Mort Panish and Izuo Hayashi at Bell Labs. | YES |
| June 30, 1970 | AT&T introduces Picturephone in Pittsburgh. The telephone monopoly plans to install millimeter waveguides to provide the needed extra capacity. |  |
| Summer 1970 | Maurer, Donald Keck, and Peter Schultz at Corning make a single-mode fiber with loss of 16 decibels per kilometer at 633 nanometers by doping titanium into fiber core. | YES |
| September 30, 1970 | Maurer announces Corning’s fiber results at London conference devoted mainly to progress in millimeter waveguides. |  |
| November 1970 | Measurements at British Post Office and STL confirm Corning results. | YES |
| Late Autumn 1970 | Charles Kao leaves STL to teach at Chinese University of Hong Kong; Murray Ramsay heads STL fiber group. |  |
| 1970–1971 | Dick Dyott at British Post Office and Felix Kapron of Corning separately find pulse spreading is lowest at 1.2 to 1.3 micrometers. | YES |
| May 1971 | Murray Ramsay of STL demonstrates digital video transmission over fiber to Queen Elizabeth at the Centenary of the Institution of Electrical Engineers. | YES |
| October 13, 1971 | Alec Reeves dies in London. |  |
| 1971–1972 | Unable to duplicate Corning’s low loss, Bell Labs, the University of Southampton, and CSIRO in Australia experiment with liquid-core fibers. |  |
| 1971–1972 | Focus shifts to graded-index fibers because single-mode offers few advantages and many problems at 850 nanometers. |  |
| June 1972 | Maurer, Keck, and Schultz make multimode germania-doped fiber with 4 decibel per kilometer loss and much greater strength than titania-doped fiber. | YES |
| Late 1972 | STL modulates diode laser at 1 billion bits per second. Bell Labs stops work on hollow light pipes. |  |
| December 1972 | John Fulenwider proposes a fiber-optic communication network to carry video signals to homes at International Wire and Cable Symposium. | YES |
| 1973 | John MacChesney develops modified chemical vapor deposition process for making fiber at Bell Labs. |  |
| Mid-1973 | Diode laser lifetime reaches 1000 hours at Bell Labs. | YES |
| Spring 1974 | Bell Labs settles on graded-index fibers with 50 to 100 micrometer cores. |  |
| December 7, 1974 | Heinrich Lamm dies at 66. |  |
| January 1975 | First technical meeting, Topical Conference on Optical Fiber Transmission, Williamsburg, Virginia. |  |
| February 1975 | Bell completes installation of 14 kilometers of millimeter waveguide in New Jersey. After tests, Bell declares victory and abandons the technology. | YES |
| June 1975 | First commercial continuous-wave semiconductor laser operating at room temperature offered by Laser Diode Labs. | YES |
| September 1975 | First nonexperimental fiber-optic link installed by Dorset (UK) police after lightning knocks out their communication system. | YES |
| October 1975 | British Post Office begins tests of millimeter waveguide; like Bell it declares the tests successful, but never installs any. |  |
| 1975 | Dave Payne and Alex Gambling at University of Southampton calculate pulse spreading should be zero at 1.27 micrometers. | YES |
| January 13, 1976 | Bell Labs starts tests of graded-index fiber-optic system transmitting 45 million bits per second at its plant in Norcross, Georgia. Laser lifetime is main problem. |  |
| Early 1976 | Valtec launches Communications Fiberoptics division. |  |
| Early 1976 | Masaharu Horiguchi (Nippon Telegraph Telephone Ibaraki Lab) and Hiroshi Osanai (Fujikura Cable) make first fibers with low loss—0.47 decibel per kilometer—at long wavelengths (1.2 micrometers). | YES |
| March 1976 | Japan’s Ministry for International Trade and Industry announces plans for Hi-OVIS fiber-optic ‘‘wired city’’ experiment involving 150 homes. | YES |
| Spring 1976 | Lifetime of best laboratory lasers at Bell Labs reaches 100000 hours (10 years) at room temperature. | YES |
| Summer 1976 | Horiguchi and Osanai discover third fiber-optic transmission window at 1.55 micrometers. | YES |
| July 1976 | Corning sues ITT alleging infringement of American patents on communication fibers. |  |
| Late 1976 | J. Jim Hsieh makes indium-gallium arsenidephosphide (InGaAsP) lasers emitting continuously at 1.25 micrometers. |  |
| Spring 1977 | F. F. Roberts reaches mandatory retirement age of 60; John Midwinter becomes head of fiber-optic group at British Post Office. |  |
| April 1, 1977 | AT&T sends first test signals through field test system in Chicago’s Loop district. | YES |
| April 22, 1977 | General Telephone and Electronics sends first live telephone traffic through fiber optics (6 million bits per second) in Long Beach, Calif. | YES |
| May 1977 | Bell System starts sending live telephone traffic through fibers at 45 million bits per second fiber link in downtown Chicago. | YES |
| June 1977 | British Post Office begins sending live telephone traffic through fibers in underground ducts near Martlesham Heath. |  |
| June 29, 1977 | Bell Labs announces one million hour (100 year) extrapolated lifetime for diode lasers. | YES |
| Summer 1977 | F. F. Roberts dies of heart attack. |  |
| October 1977 | Valtec ‘‘acquires’’ Comm/Scope, but Comm/Scope owners soon gain control of Valtec. |  |
| Late 1977 | AT&T and other telephone companies settle on 850-nanometer gallium arsenide light sources and graded-index fibers for commercial systems operating at 45 million bits per second. | YES |
| 1977–1978 | Low loss at long wavelengths renews research interest in single-mode fiber. | YES |
| May 22–23, 1978 | Fiber Optic Con, first fiber-optic trade show. |  |
| July 1978 | Optical fibers begin carrying signals to homes in Japan’s Hi-OVIS project. | YES |
| August 1978 | Nippon Telegraph and Telephone transmits 32 million bits per second through a record 53 kilometers of graded-index fiber at 1.3 micrometers. |  |
| September 1978 | Richard Epworth reports modal noise problems in graded-index fibers. | YES |
| September 1978 | France Telecom announces plans for fiber to the home demonstration in Biarritz, connecting 1500 homes in early 1983. |  |
| 1978 | AT&T, British Post Office, and Standard Telephones and Cables commit to developing a single-mode transatlantic fiber cable, using the new 1.3-micrometer window, to be operational by 1988. By the end of the year, Bell Labs abandons development of new coaxial cables for submarine systems. | YES |
| Late 1978 | NTT Ibaraki lab makes single-mode fiber with record 0.2 decibel per kilometer loss at 1.55 micrometers. | YES |
| January 1980 | AT&T asks Federal Communications Commission to approve Northeast Corridor system from Boston to Washington, designed to carry three different wavelengths through graded-index fiber at 45 million bits per second. |  |
| February 1980 | STL and British Post Office lay 9.5-kilometer submarine cable in Loch Fyne, Scotland, including single-mode and graded-idex fibers. | YES |
| Winter 1980 | Graded-index fiber system carries video signals for 1980 Winter Olympics in Lake Placid, New York, at 850 nanometers. |  |
| September 1980 | With fiber optics hot on the stock market, M/A Com buys Valtec for $224 million in stock. |  |
| 1980 | Bell Labs publicly commits to single-mode 1.3-micrometer technology for the first transatlantic fiber-optic cable, TAT-8. | YES |
| July 27, 1981 | ITT signs consent agreement to pay Corning and license Corning communication fiber patents. |  |
| 1981 | Commercial second-generation systems emerge, operating at 1.3 micrometers through graded-index fibers. | YES |
| 1981 | British Telecom transmits 140 million bits per second through 49 kilometers of single-mode fiber at 1.3 micrometers, starts shifting to single-mode. |  |
| Late 1981 | Canada begins trial of fiber optics to homes in Elie, Manitoba. |  |
| 1982 | British Telecom performs field trial of single-mode fiber, abandons graded-index in favor of singlemode. | YES |
| December 1982 | MCI leases right of way to install single-mode fiber from New York to Washington. The system will operate at 400 million bits per second at 1.3 micrometers. This starts the shift to single-mode fiber in America. |  |
| Late 1983 | Stew Miller retires as head of Bell Labs fiber development group. |  |
| January 1, 1984 | AT&T undergoes first divestiture, splitting off its seven regional operating companies but keeping long-distance transmission and equipment manufacture. |  |
| 1984 | British Telecom lays first submarine fiber cable to carry regular traffic, to the Isle of Wight. | YES |
| 1985 | Single-mode fiber spreads across America to carry long-distance telephone signals at 400 million bits per second and up. |  |
| Summer 1986 | All 1500 Biarritz homes connected to fiber to the home system. |  |
| October 30, 1986 | First fiber-optic cable across the English Channel begins service. | YES |
| 1986 | AT&T sends 1.7 billion bits per second through single-mode fibers. | YES |
| Early 1987 | David Payne reports making the first erbium-doped optical fiber amplifier at the University of Southampton. | YES |
| November 1987 | Emmanuel Desurvire develops model to predict behavior of erbium optical amplifier at Bell Labs. |  |
| January 1988 | Eli Snitzer reports that erbium amplifiers can be pumped at 1.48 micrometers. |  |
| 1988 | Linn Mollenauer of Bell Labs demonstrates soliton transmission through 4000 kilometers of single-mode fiber. |  |
| December 1988 | TAT-8, first transatlantic fiber-optic cable, begins service using 1.3-micrometer lasers and single-mode fiber. | YES |
| Early 1989 | Emmanuel Desurvire measures very low crosstalk when signals are transmitted through an erbium amplifier at two separate wavelengths, pointing toward wavelength division multiplexing. |  |
| November 1989 | NTT reports gain of 46.5 decibels in erbium amplifier excited by 1.48 micrometer laser. |  |
| January 1990 | KDD transmits 2.4 billion bit per second signals at 4 wavelengths through 6 erbium amplifiers and 459 kilometers of fiber. |  |
| February 1991 | Neal Bergano of Bell Labs transmits five billion bits per second through 9000 kilometers of fiber. That design later selected for TAT-12 cable. | YES |
| February 1991 | Masataka Nakazawa of NTT sends soliton signals through a million kilometers of fiber. |  |
| February 1991 | Mollenauer transmits solitons at two wavelengths through 9000 kilometers of fiber. |  |
| February 1993 | Mollenauer transmits 10 billion bits per second through 20000 kilometers of fibers with a simple soliton system. |  |
| 1994 | World Wide Web grows from 500 to 10000 servers. | YES |
| February 1995 | NTT transmits 10 billion bits per second on each of 16 wavelengths through 1000 kilometers of fiber using dispersion compensation. |  |
| 1995–1996 | Internet traffic hits peak growth, doubling in 3–4 months. |  |
| February 1996 | Fujitsu, NTT Labs, and Bell Labs all report sending one trillion bits per second through single fibers in separate experiments. | YES |
| 1996 | Commercial wavelength-division multiplexing systems introduced. |  |
| 1996 | TAT-12 transatlantic cable put in service, the first with optical amplifiers. | YES |
| October 1996 | Lucent Technologies splits from AT&T, taking most of Bell Labs. |  |
| May 15, 1997 | Amazon.com has initial public offering of stock early in Internet boom. |  |
| February 1998 | NTT transmits 1 trillion bits per second through a series of optical amplifiers and 600 kilometers of fiber; Bell Labs does similar experiment through 400 kilometers of fiber. |  |
| 1998 | First long-distance submarine cables with wavelength-division multiplexing. Commercial systems transmit dozens of wavelengths at 2.5 billion bits per second. Developers promise systems transmitting 10 billion bits per second on dozens of channels. | YES |
| February 1999 | NTT reaches three trillion bits per second through 40 kilometers of fiber. |  |
| 1999 | NASDAQ average nearly doubles as the bubble takes off. |  |
| March 7–10, 2000 | NASDAQ hits record high of 5132.52. Optical Fiber Communication Conference attracts record crowd of 16934 to Baltimore. |  |
| July 2000 | Peak of telecom bubble. JDS Uniphase announces plans to merge with SDL Inc. in stock deal valued at $41 billion. | YES |
| March 19–22, 2001 | Optical Fiber Communication Conference attracts record crowd of 38015 to Anaheim, with 970 companies exhibiting. |  |
| March 22, 2001 | NEC Corp. reports transmitting 10.92 trillion bits per second through 117 kilometers of fiber. |  |
| Spring and Summer 2001 | Telecom bubble deflates and stocks tumble. Layoffs begin. | YES |
| December 2001 | TAT-8 submarine cable fails. It is later retired because repairs would be too expensive and other transatlantic cables have extra capacity. | YES |
| July 21, 2002 | WorldCom files for bankruptcy, the largest bankruptcy in U.S. corporate history. | YES |
| January 2003 | Total transatlantic transmission capacity in use is 2700 billion bits per second, about 5000 times that of TAT-8. Total potential capacity is 12300 billion bits per second. |  |
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Timeline of geothermal electricity (Tester *et al.*, 2012; Anon, n.d.; Anon, n.d.; Anon, n.d.)

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| Year | Event | Major event |
| 1807 | As European settlers moved westward across the continent, they gravitated toward warm springs. In 1807, the first European to visit the Yellowstone area, John Colter, probably encountered hot springs, leading to the designation “Colter’s Hell.” Also in 1807, settlers founded the city of Hot Springs, Arkansas, where, in 1830, Asa Thompson charged one dollar each for the use of three spring-fed baths in a wooden tub, making this the first known commercial use of geothermal energy. | YES |
| 1847 | William Bell Elliot, a member of John C. Fremont’s survey party, stumbles upon a steaming valley just north of what is now San Francisco, California. Elliot calls the area The Geysers—a misnomer—and thinks he has found the gates of Hell. |  |
| 1852 | The Geysers is developed into a spa called The Geysers Resort Hotel. Guests include J. Pierpont Morgan, Ulysses S. Grant, Theodore Roosevelt, and Mark Twain. |  |
| 1862 | At springs located southeast of The Geysers, businessman Sam Brannan pours an estimated half million dollars into an extravagant development dubbed “Calistoga,” replete with hotel, bathhouses, skating pavilion, and racetrack. Brannan’s was one of many spas reminiscent of those of Europe. |  |
| 1864 | Homes and dwellings have been built near springs through the millennia to take advantage of the natural heat of these geothermal springs, but the construction of the Hot Lake Hotel near La Grande, Oregon, marks the first time that the energy from hot springs is used on a large scale. | YES |
| 1892 | Residents in Boise, Idaho, receive the world’s first district heating system as water is piped from hot springs to town buildings. Within a few years, the system is serving 200 homes and 40 downtown businesses. Today, there are four district heating systems in Boise that provide heat to over 5 million square feet of residential, business, and governmental space. Although no one imitated this system for some 70 years, as of 2013 there are 17 district heating systems in the United States and dozens more around the world. | YES |
| 1900 | Hot springs water is piped to homes in Klamath Falls, Oregon. | YES |
| 1904 | The first dry steam geothermal power plant was built in Larderello in Tuscany, Italy, by Prince Piero Ginori Conti. The Larderello plant today provides power to about 1 million households. | YES |
| 1921 | John D. Grant drills a well at The Geysers with the intention of generating electricity. This effort is unsuccessful, but one year later Grant meets with success across the valley at another site, and the United States’ first geothermal power plant goes into operation. Grant uses steam from the first well to build a second well, and, several wells later, the operation is producing 250 kilowatts, enough electricity to light the buildings and streets at the resort. The plant, however, is not competitive with other sources of power, and it soon falls into disuse. |  |
| 1921 | Hot Springs National Park in Arkansas is created. |  |
| 1927 | Pioneer Development Company drills the first exploratory wells at Imperial Valley, California. |  |
| 1930 | The first commercial greenhouse use of geothermal energy is undertaken in Boise, Idaho. The operation uses a 1000-foot well drilled in 1926. In Klamath Falls, Charlie Lieb develops the first downhole heat exchanger (DHE) to heat his house. As of 2013, more than 500 DHEs are in use around the US. | YES |
| 1940 | The first residential space heating in Nevada begins in the Moana area in Reno. |  |
| 1948 | Geothermal technology moves east when Professor Carl Nielsen of Ohio State University develops the first ground-source heat pump, for use at his residence. J.D. Krocker, an engineer in Portland, Oregon, pioneers the first commercial building use of a groundwater heat pump. | YES |
| 1958 | New Zealand builds the first new Geothermal electricity powerplant since Larderello | YES |
| 1960 | The United States’ first large-scale geothermal electricity-generating plant begins operation. Pacific Gas and Electric operates the plant, located at The Geysers. The first turbine produces 11 megawatts (MW) of net power and operates successfully for more than 30 years. By 2013, 69 generating facilities are in operation at 18 resource sites around the US. | YES |
| 1970 | Re-injection of spent geothermal water back into the production reservoir was introduced as a way to dispose of waste water and to extend reservoir life. |  |
| 1970 | The Geothermal Resources Council is formed to encourage development of geothermal resources worldwide. | YES |
| 1970 | The Geothermal Steam Act is enacted, which provides the US Secretary of the Interior with the authority to lease public lands and other federal lands for geothermal exploration and development in an environmentally sound manner. | YES |
| 1972 | Deep well drilling technology improvements led to deeper reservoir drilling and to access to more resources. |  |
| 1972 | The Geothermal Energy Association is formed. The association includes U.S. companies that develop geothermal resources worldwide for electrical power generation and direct-heat uses. | YES |
| 1973 | The Arab Oil Embargo occurred, in which several Arab nations in the Organization of Petroleum Exporting Countries (OPEC) embargoed oil to the United States and Holland to protest their support of Israel in the Arab-Israeli “Yom Kippur” War. Arab OPEC production was cut by 25%, which caused some temporary shortages and helped oil prices to triple. This contributed to an increased interest in alternatives to petroleum, including geothermal power. | YES |
| 1973 | The National Science Foundation becomes the lead agency for federal geothermal programs. |  |
| 1974 | Scientists began to develop the first hot dry rock (HDR) reservoir at Fenton Hill, New Mexico. An HDR power facility was tested at the site in 1978 and started to generate electricity two years later. |  |
| 1974 | The U.S. government enacts the Geothermal Energy Research, Development and Demonstration (RD&D) Act, instituting the Geothermal Loan Guaranty Program, which provides investment security to public and private sectors using developing technologies to exploit geothermal resources. | YES |
| 1975 | The Energy Research and Development Administration (ERDA) is formed. The Division of Geothermal Energy takes over the RD&D program. The Geo-Heat Center is formed. The center, located at the Oregon Institute of Technology, disseminates information to potential users and conducts applied research on using low- to moderate-temperature geothermal resources. The U.S. Geological Survey releases the first national geothermal resource estimate and inventory. | YES |
| 1977 | The U.S. Department of Energy (DOE) is formed. | YES |
| 1978 | U.S. Department of Energy (DOE) funding for geothermal research and development was increased substantially. | YES |
| 1978 | The Public Utility Regulatory Policies Act (PURPA) is enacted. PURPA encourages the development of independent, nonutility cogeneration and small power projects by requiring electric utilities to interconnect with them. The act results in the development of several water-dominated resources. |  |
| 1978 | Geothermal Food Processors, Inc., opens the first geothermal food-processing (crop-drying) plant in Brady Hot Springs, Nevada. The Loan Guaranty Program provides $3.5 million for the facility. |  |
| 1978 | A hot dry rock geothermal facility is created and tested in Fenton Hill, New Mexico, with financial assistance from DOE. The facility generates electricity two years later, in 1980. | YES |
| 1979 | The first electrical development of a water-dominated geothermal resource occurs, at the East Mesa field in the Imperial Valley in California. The plant is named for B.C. McCabe, the geothermal pioneer who, with his Magma Power Company, did field development work at several sites, including The Geysers. |  |
| 1979 | DOE institutes funding of direct-use demonstration projects. Among the beneficiaries of this effort are several office buildings, district heating systems, and agribusinesses. |  |
| 1980s | California’s Standard Offer Contract system for PURPA-qualifying facilities provided renewable electric energy systems a relatively firm, stable market for output, allowing the financing of capital-intensive technologies like geothermal energy facilities. | YES |
| 1980 | The first commercial-scale binary plant in the United States began operation in Southern California’s Imperial Valley. | YES |
| 1980 | TAD’s Enterprises of Nevada pioneers the use of geothermal energy for the cooking, distilling, and drying processes associated with alcohol fuels production. UNOCAL builds the country’s first flash plant, generating 10 MW at Brawley, California. |  |
| 1981 | With a supporting loan from DOE, Ormat successfully demonstrates binary technology in the Imperial Valley of California. This project establishes the technical feasibility of larger-scale commercial binary power plants. The project is so successful that Ormat repays the loan within a year. | YES |
| 1981 | The first electricity is generated from geothermal resources in Hawaii. The Department of Energy demonstrates the production of electricity from moderate temperature geothermal resources using binary technology at Raft River, Idaho. |  |
| 1982 | Geothermal (hydrothermal) electric generating capacity, reached a new high of 1000 megawatts. | YES |
| 1982 | Economical electrical generation begins at California’s Salton Sea geothermal field through the use of crystallizer-clarifier technology. The technology resulted from a government/industry effort to manage the high-salinity brines at the site. |  |
| 1984 | A 20-MW plant begins commercially generating power at Utah’s Roosevelt Hot Springs. Nevada’s first geothermal electricity is generated when a 1.3-MW binary power plant begins operation. |  |
| 1984 | The Heber dual-flash power plant goes online in the Imperial Valley of California with 50 MW. |  |
| 1986 - 2000 | Decline, on the average, of fossil energy prices in constant dollars saps motivation for vigorous pursuit of the more expensive categories of alternatives. This is then reinvigorated by post-2000 oil price escalation | YES |
| 1987 | Geothermal fluids are used in the first geothermal-enhanced heap leaching project for gold recovery, near Round Mountain, Nevada. |  |
| 1989 | The world’s first hybrid (organic Rankine/gas engine) geopressure-geothermal power plant (1 MW) begins operation at Pleasant Bayou, Texas, using both the heat and the methane of a geopressured resource. | YES |
| 1990 | DOE funding for geothermal energy research and development declined throughout the 1980s and reached a low of $15 million. | YES |
| 1991 | The world’s first magma exploratory well was drilled in the Sierra Nevada Mountains to a depth of 7588 feet. |  |
| 1991 | The Bonneville Power Administration selects three sites in the Pacific Northwest for geothermal demonstration projects. |  |
| 1992 | Electrical generation begins at the 25-MW geothermal plant in the Puna field of Hawaii. |  |
| 1993 | A 23-MW binary power plant is completed at Steamboat Springs, Nevada. |  |
| 1994 | California Energy became the world’s largest geothermal company through its acquisition of Magma Power. |  |
| 1994 | DOE creates two industry/government collaborative efforts to promote the use of geothermal energy to reduce greenhouse gas emissions. One effort is directed toward the accelerated development of geothermal resources for electric power generation; the other is aimed toward the accelerated use of geothermal heat pumps. | YES |
| 1995 | Worldwide geothermal capacity reached 6000 megawatts. | YES |
| 1995 | Integrated Ingredients dedicates a food-dehydration facility that processes 15 million pounds of dried onions and garlic per year at Empire, Nevada. A DOE low-temperature resource assessment of 10 western states identifies nearly 9000 thermal wells and springs and 271 communities collocated with a geothermal resource greater than 50ºC. |  |
| 1999 | California’s geothermal power plants provided 54.9% of the State’s electricity. | YES |
| 2000 | DOE initiates its GeoPowering the West program to encourage development of geothermal resources in the western U. S. An initial group of 21 partnerships with industry is funded to develop new technologies. |  |
| 2001 | GeoPowering the West brings together representatives from industry and agencies such as the U.S. Bureau of Land Management and U.S. Forest Service to identify major barriers to geothermal development in the west. The report of the proceedings listed specific action items and recommendations. Several of the recommendations pertained to leasing, permitting, and access to federal lands. |  |
| 2001 | US Secretary of the Interior Gail Norton convened a renewable energy summit with officials from DOI, DOE, and other agencies to identify actions required to support renewable energy development. Recommendations specific to geothermal emerged from the meeting, including a mandate to BLM to accelerate issuing leases and permits on federal lands. |  |
| 2002 | Organized by GeoPowering the West, geothermal development working groups are active in five states — Nevada, Idaho, New Mexico, Oregon, and Washington. Group members represent all stakeholder organizations. The working groups are identifying barriers to geothermal development in their state, and bringing together all interested parties to arrive at mutually beneficial solutions. |  |
| 2003 | The Utah Geothermal Working Group is formed. |  |
| 2004 | Geothermal energy costs dropped from $.10 - .16 per kilowatt hour to $.5 - .8 per kilowatt hour. | YES |
| 2005 | The Energy Policy Act of 2005 was signed into law. It changed U.S. energy policy by providing tax incentives and loan guarantees for various types of energy production. It included provisions aimed at making geothermal energy more competitive with fossil fuels in generating electricity. The Act amended the Geothermal Steam Act of 1970 to modify how royalties are calculated, how land is leased, and how federal income from geothermal development is distributed. | YES |
| 2005 | According to the U.S. Department of Interior’s Bureau of Land Management, geothermal energy generated over 14800 GWh of electricity in 2005, enough power to supply the annual needs of 1.3 million homes. |  |
| 2006 | The U.S. geothermal industry became a $1.5 billion a year business that involved electricity generation and thermal energy in direct use such as indoor heating, greenhouses, food drying, aquaculture. |  |
| 2006 | Alaska installed a 200 kilowatt power plant that used low-temperature (74ºC) geothermal water along with cooling water (4ºC). |  |
| 2007 | The Energy Independence and Security Act of 2007 which includes the Advanced Geothermal Research and Development Act of 2007 provided authorization and direction for DOE’s geothermal research activities. |  |
| 2008 | Idaho’s first commercial geothermal power plant began operating. |  |
| 2009 | Through the American Recovery and Reinvestment Act (ARRA) of 2009, the Geothermal Technologies Office awarded $368.2 million to 149 geothermal projects in 38 states and the District of Columbia. | YES |
| 2010 | In FY 2010, the DOE Geothermal Technologies Office contributed $786000 to the Small Business Innovation Research (SBIR) Program and $94000 to the Small Business Technology Transfer (STTR) program for geothermal projects. |  |
| 2011/2012 | According to the Geothermal Energy Association (GEA) Annual U.S. Geothermal Power Production and Development Report, the U.S. geothermal industry continued to grow steadily in 2011 and through the first quarter of 2012. Geothermal companies increased installed capacity from 3102 MW to 3187 MW over this time frame. |  |
| 2012 | The Enhanced Geothermal Systems (EGS) field demonstration project achieves a steam production equivalent of five megawatts at an abandoned part of The Geysers field in Northern California, encouraging expectations that this vast energy source (100+ GW) can be further developed and scaled up for nationwide deployment in the long-term. |  |
| 2013 | In 2013, the Desert Peak project completes an 8-month, multi-stage stimulation of an existing but underperforming well, successfully validating fluid injection and stimulation increases to levels within the magnitude of a commercial well, and dramatically increasing flow rate. This project is the first EGS project in America to generate commercial electricity by providing an additional 1.7 MW at the existing well-field. |  |
| 2013 | In April, a DOE investment deploys a project that takes advantage of close-looped geothermal power generation—as a thermal byproduct of gold mining—to generate essentially emission-free electricity for less than 6 cents/kWh. This patented plug-and-play technology is the first in the US to employ cost-free geothermal brine at a mine operation and the technology is thought to have the potential for broader applications in many parts of the US and globally, including oil and gas operations, establishing a commercially deployable clean energy enterprise. |  |
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Timeline of hydro electricity (Smil, 2004; Anon, n.d.)

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| --- | --- | --- |
| Year | Event | Major event |
| B.C. | Hydropower was used by the Greeks to turn water wheels for grinding grains more than 2000 years ago. |  |
| 1753 | French hydraulic and military engineer Bernard Forest de Belidor wrote Architecture Hydraulique, a four-volume work describing vertical- and horizontal-axis machines. |  |
| 1832 | Reaction water turbine developed by Benoit Fourneyron | YES |
| 1847 | Inward-flow water turbine developed by James B. Francis | YES |
| 1880–95 | Hydropower was beginning to be used for electricity. The first hydroelectric plants were direct current (DC) stations used to power nearby arc and incandescent lighting. |  |
| 1880 | Michigan’s Grand Rapids Electric Light and Power Company generated DC electricity, using hydropower at the Wolverine Chair Factory. A dynamo belted to a water turbine at the factory generated electricity to light 16 brush-arc lamps in the store front. | YES |
| 1881 | Street lamps in the city of Niagara Falls were powered by hydropower (direct current). | YES |
| 1882 | The world’s first central DC hydroelectric station provided power for a paper mill in Appleton, Wisconsin. | YES |
| 1886 | Between 40 to 50 hydroelectric plants were operating in the United States and in Canada. |  |
| 1888 | About 200 electric companies relied on hydropower for at least part of their generation. |  |
| 1889 | Pelton machines (jet-driven turbines) introduced | YES |
| 1889 | The first AC hydroelectric plant in the US, Williamette Falls Station, began operation in Oregon City, Oregon. | YES |
| 1893 | The Austin Dam, near Austin, Texas, was completed. It was the first dam specifically designed for generating hydropower. | YES |
| 1895–96 | The Niagara Falls hydropower station opened. It originally provided electricity to the local area. One year later, when a new AC powerline was opened, electric power from Niagara Falls was sent to customers over 20 miles away in Buffalo, New York. | YES |
| 1901 | The first Federal Water Power Act required special permission for a hydroelectric plant to be built and operated on any stream large enough for boat traffic. |  |
| 1902 | The Reclamation Act of 1902 created the United States Reclamation Service, later renamed the U.S. Bureau of Reclamation. The Reclamation Service was formed to manage water resources and was given the authority to build hydropower plants at dams. |  |
| 1905 | The Reclamation Service installed a hydropower plant at the Arizona construction site of the Theodore Roosevelt Dam. The power plant was originally built to provide electricity for constructing the dam, but sales of extra electricity helped pay for the project and improved life in the local community. |  |
| 1920 | Federal Power Act established the Federal Power Commission (later replaced by the Federal Energy Regulatory Commission) to issue licenses for hydropower development on public lands in the U.S. |  |
| 1933 | The Tennessee Valley Authority (TVA) was established to take charge of the hydroelectric potential of the Mississippi River in the Tennessee Valley. |  |
| 1933 | Construction of the Grand Coulee Dam began on the Columbia River. Originally built to meet irrigation needs, it had more electric generating capacity than any other dam in North America. |  |
| 1935 | Federal Power Commission authority was extended to all hydroelectric projects built by utilities engaged in interstate commerce. |  |
| 1936 | Boulder Dam (later renamed the Hoover Dam) began operating on the Colorado River. The hydropower plant produced up to 130000 kilowatts of electricity. | YES |
| 1937 | The U.S. Army Corp of Engineers finished the Bonneville Dam, on the Columbia River in Oregon and Washington. |  |
| 1937 | The Bonneville Power Administration (BPA) was established. |  |
| 1941 | Grand Coulee, the United States’ largest hydroelectric dam, began operation. |  |
| 1949 | Almost one-third of the United States’ electricity came from hydropower. |  |
| 1961 | The Columbia River Treaty was signed between the United States and Canada. Under the treaty, Canada built two dams for storage and one dam for generation. This resulted in greater power and flood control, which benefited U.S. facilities downstream. |  |
| 1977 | The Federal Power Commission was disbanded by Congress. A new agency was created, the Federal Energy Regulatory Commission (FERC), to regulate energy production and transmission. |  |
| 1978 | Congress passed the Public Utility Regulatory Policies Act (PURPA) of 1978. The Act required utilities to purchase electricity from qualified independent power producers. Portions of the Act stimulated growth of small-scale hydro plants to help meet the United States’ energy needs. | YES |
| 1980 | Conventional hydropower plant capacity nearly tripled in United States since 1940. |  |
| 1980 | Poor salmon runs in the Columbia River system prompted Congress to pass the Pacific Northwest Power Planning and Conservation Act of 1980. This Act established the Northwest Power Planning Council, responsible for the protection and recovery of salmon runs in the Columbia River system. These laws resulted in a more complex, expensive process to obtain a license for a hydroelectric facility. | YES |
| 1986 | Congress amended the Federal Power Act to increase the environmental review of hydropower projects. |  |
| 1988 | The Northwest Power Planning Council designated 44000 miles of Pacific Northwest streams as protected areas because of their importance as critical fish and wildlife habitats. |  |
| 1994 | Court ruled that the 1993 Biological Opinion, which guided coordinated use of the Columbia River System, failed to meet legal standards associated wtih the Endangered Species Act. |  |
| 2006 | The United States ranked among the Top 4 countries in the world for hydroelectric generation, along with China, Canada, and Brazil. These countries generated 44% of the world’s electricity from hydropower. |  |
| 2009 | Between 6% and 10% of U.S. electricity comes from hydropower, depending on water supply and annual rainfall. In total, the United States has about 80000 megawatts of conventional capacity and 18000 megawatts of pumped storage capacity. |  |

Timeline of the internet (Zakon, 1997)

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| --- | --- | --- |
| Year | Event | Major event |
| 1957 | USSR launches Sputnik, first artificial earth satellite. In response, US forms the Advanced Research Projects Agency (ARPA), the following year, within the Department of Defense (DoD) to establish US lead in science and technology applicable to the military | YES |
| 1961 | Leonard Kleinrock, MIT: “Information Flow in Large Communication Nets” (May 31): First paper on packet-switching (PS) theory | YES |
| 1962 | J.C.R. Licklider & W. Clark, MIT: “On-Line Man Computer Communication” (August): Galactic Network concept encompassing distributed social interactions | YES |
| 1964 | Paul Baran, RAND: “On Distributed Communications Networks”: Packet-switching networks; no single outage point | YES |
| 1965 | ARPA sponsors study on “cooperative network of time-sharing computers”: TX-2 at MIT Lincoln Lab and AN/FSQ-32 at System Development Corporation (Santa Monica, CA) are directly linked (without packet switches) via a dedicated 1200bps phone line; Digital Equipment Corporation (DEC) computer at ARPA later added to form “The Experimental Network” | YES |
| 1966 | Lawrence G. Roberts, MIT: “Towards a Cooperative Network of Time-Shared Computers” (October): First ARPANET plan | YES |
| 1967 | ARPANET design discussions held by Larry Roberts at ARPA IPTO PI meeting in Ann Arbor, Michigan (April) | YES |
| 1967 | ACM Symposium on Operating Systems Principles in Gatlinburg, Tennessee (October): First design paper on ARPANET published by Larry Roberts: “Multiple Computer Networks and Intercomputer Communication”, first meeting of the three independent packet network teams (RAND, NPL, ARPA) | YES |
| 1967 | National Physical Laboratory (NPL) in Middlesex, England develops NPL Data Network under Donald Watts Davies who coins the term packet. The NPL network, an experiment in packet-switching, used 768kbps lines | YES |
| 1968 | PS-network presented to the Advanced Research Projects Agency (ARPA) |  |
| 1968 | Request for quotation for ARPANET (29 Jul) sent out in August; responses received in September |  |
| 1968 | University of California Los Angeles (UCLA) awarded Network Measurement Center contract in October |  |
| 1968 | Network Working Group (NWG), headed by Steve Crocker, loosely organized to develop host level protocols for communication over the ARPANET. |  |
| 1968 | Tymnet built as part of Tymshare service |  |
| 1969 | Bolt Beranek and Newman, Inc. (BBN) awarded Packet Switch contract to build Interface Message Processors (IMPs) in January |  |
| 1969 | US Senator Edward Kennedy sends a congratulatory telegram to BBN for its million-dollar ARPA contract to build the “Interfaith” Message Processor, and thanking them for their ecumenical efforts |  |
| 1969 | ARPANET commissioned by DoD for research into networking | YES |
| 1969 | First Request for Comment (RFC): “Host Software” by Steve Crocker (7 April) |  |
| 1969 | First packets sent by Charley Kline at UCLA as he tried logging into SRI. The first attempt resulted in the system crashing as the letter G of LOGIN was entered. (October 29) | YES |
| 1969 | Univ of Michigan, Michigan State and Wayne State Univ establish X.25-based Merit network for students, faculty, alumni |  |
| 1970 | First publication of the original ARPANET Host-Host protocol: C.S. Carr, S. Crocker, V.G. Cerf, “HOST-HOST Communication Protocol in the ARPA Network,” in AFIPS Proceedings of SJCC | YES |
| 1970 | First report on ARPANET at AFIPS: “Computer Network Development to Achieve Resource Sharing” (March) | YES |
| 1970 | ALOHAnet, the first packet radio network, developed by Norman Abramson, Univ of Hawaii, becomes operational (July): connected to the ARPANET in 1972 | YES |
| 1970 | ARPANET hosts start using Network Control Protocol (NCP), first host-to-host protocol | YES |
| 1970 | First cross-country link installed by AT&T between UCLA and BBN at 56kbps. This line is later replaced by another between BBN and RAND. A second line is added between MIT and Utah |  |
| 1971 | 15 nodes (23 hosts): UCLA, SRI, UCSB, Univ of Utah, BBN, MIT, RAND, SDC, Harvard, Lincoln Lab, Stanford, UIU(C), CWRU, CMU, NASA/Ames |  |
| 1971 | BBN starts building IMPs using the cheaper Honeywell 316. IMPs however are limited to 4 host connections, and so BBN develops a terminal IMP (TIP) that supports up to 64 terminals (September) |  |
| 1971 | Ray Tomlinson of BBN invents email program to send messages across a distributed network. The original program was derived from two others: an intra-machine email program (SENDMSG) and an experimental file transfer program (CPYNET) | YES |
| 1971 | Project Gutenberg is started by Michael Hart with the purpose of making copyright-free works, including books, electronically available. The first text is the US Declaration of Independence |  |
| 1972 | Ray Tomlinson (BBN) modifies email program for ARPANET where it becomes a quick hit. The @ sign was chosen from the punctuation keys on Tomlinson’s Model 33 Teletype for its “at” meaning (March) | YES |
| 1972 | Larry Roberts writes first email management program (RD) to list, selectively read, file, forward, and respond to messages (July) | YES |
| 1972 | International Conference on Computer Communications (ICCC) at the Washington D.C. Hilton with demonstration of ARPANET between 40 machines and the Terminal Interface Processor (TIP) organized by Bob Kahn. (October) | YES |
| 1972 | First computer-to-computer chat takes place at UCLA, and is repeated during ICCC, as psychotic PARRY (at Stanford) discusses its problems with the Doctor (at BBN). | YES |
| 1972 | International Network Working Group (INWG) formed in October as a result of a meeting at ICCC identifying the need for a combined effort in advancing networking technologies. Vint Cerf appointed first Chair. By 1974, INWG became IFIP WG 6.1 |  |
| 1972 | Louis Pouzin leads the French effort to build its own ARPANET - CYCLADES | YES |
| 1973 | First international connections to the ARPANET: University College of London (England) via NORSAR (Norway) | YES |
| 1973 | Bob Metcalfe’s Harvard PhD Thesis outlines idea for Ethernet. The concept was tested on Xerox PARC’s Alto computers, and the first Ethernet network called the Alto Aloha System (May) | YES |
| 1973 | Bob Kahn poses Internet problem, starts Internetting research program at ARPA. Vinton Cerf sketches gateway architecture in March on back of envelope in a San Francisco hotel lobby | YES |
| 1973 | Cerf and Kahn present basic Internet ideas at INWG in September at Univ of Sussex, Brighton, UK | YES |
| 1973 | Network Voice Protocol (NVP) specification (RFC 741) and implementation enabling conference calls over ARPAnet. |  |
| 1973 | SRI (NIC) begins publishing ARPANET News in March; number of ARPANET users estimated at 2000 |  |
| 1973 | ARPA study shows email composing 75% of all ARPANET traffic |  |
| 1973 | Christmas Day Lockup - Harvard IMP hardware problem leads it to broadcast zero-length hops to any ARPANET destination, causing all other IMPs to send their traffic to Harvard (25 December) |  |
| 1974 | Vint Cerf and Bob Kahn publish “A Protocol for Packet Network Intercommunication” which specified in detail the design of a Transmission Control Program (TCP). [IEEE Trans Comm] | YES |
| 1974 | BBN opens Telenet, the first public packet data service (a commercial version of ARPANET) | YES |
| 1975 | Operational management of Internet transferred to DCA (now DISA) |  |
| 1975 | First ARPANET mailing list, MsgGroup, is created by Steve Walker. Einar Stefferud soon took over as moderator as the list was not automated at first. A science fiction list, SF-Lovers, was to become the most popular unofficial list in the early days |  |
| 1975 | John Vittal develops MSG, the first all-inclusive email program providing replying, forwarding, and filing capabilities. | YES |
| 1975 | Satellite links cross two oceans (to Hawaii and UK) as the first TCP tests are run over them by Stanford, BBN, and UCL | YES |
| 1976 | Elizabeth II, Queen of the United Kingdom sends out an email on 26 March from the Royal Signals and Radar Establishment (RSRE) in Malvern |  |
| 1976 | UUCP (Unix-to-Unix CoPy) developed at AT&T Bell Labs and distributed with UNIX one year later. |  |
| 1976 | Multiprocessing Pluribus IMPs are deployed |  |
| 1977 | THEORYNET created by Larry Landweber at Univ of Wisconsin providing electronic mail to over 100 researchers in computer science (using a locally developed email system over TELENET) |  |
| 1977 | Tymshare spins out Tymnet under pressure from TELENET. Both go on to develop X.25 protocol standard for virtual circuit style packet switching |  |
| 1977 | First demonstration of ARPANET/SF Bay Packet Radio Net/Atlantic SATNET operation of Internet protocols with BBN-supplied gateways in July |  |
| 1978 | TCP split into TCP and IP (March) | YES |
| 1978 | Possibly the first commercial spam message is sent on 1 May by a DEC marketer advertising an upcoming presentation of its new DECSYSTEM-20 computers | YES |
| 1979 | Meeting between Univ of Wisconsin, DARPA, National Science Foundation (NSF), and computer scientists from many universities to establish a Computer Science Department research computer network (organized by Larry Landweber). | YES |
| 1979 | USENET established using UUCP between Duke and UNC by Tom Truscott, Jim Ellis, and Steve Bellovin. All original groups were under NET.\* hierarchy. |  |
| 1979 | ARPA establishes the Internet Configuration Control Board (ICCB) | YES |
| 1979 | Packet Radio Network (PRNET) experiment starts with DARPA funding. Most communications take place between mobile vans. ARPANET connection via SRI. | YES |
| 1979 | On April 12, Kevin MacKenzie emails the MsgGroup a suggestion of adding some emotion back into the dry text medium of email, such as -) for indicating a sentence was tongue-in-cheek. Though flamed by many at the time, emoticons became widely used after Scott Fahlman suggested the use of :-) and :-( in a CMU BBS on 19 September 1982 |  |
| 1980 | ARPANET grinds to a complete halt on 27 October because of an accidentally-propagated status-message virus | YES |
| 1981 | BITNET, the “Because It’s Time NETwork”: Started as a cooperative network at the City University of New York, with the first connection to Yale; original acronym stood for ’There’ instead of ’Time’ in reference to the free NJE protocols provided with the IBM systems; provides electronic mail and listserv servers to distribute information, as well as file transfers | YES |
| 1981 | CSNET (Computer Science NETwork) built by a collaboration of computer scientists and Univ of Delaware, Purdue Univ, Univ of Wisconsin, RAND Corporation and BBN through seed money granted by NSF to provide networking services (especially email) to university scientists with no access to ARPANET. CSNET later becomes known as the Computer and Science Network. | YES |
| 1981 | Minitel (Teletel) is deployed across France by France Telecom. |  |
| 1982 | Norway leaves network to become an Internet connection via TCP/IP over SATNET; UCL does the same |  |
| 1982 | DCA and ARPA establish the Transmission Control Protocol (TCP) and Internet Protocol (IP), as the protocol suite, commonly known as TCP/IP, for ARPANET: this leads to one of the first definitions of an “internet” as a connected set of networks, specifically those using TCP/IP, and “Internet” as connected TCP/IP internets. DoD declares TCP/IP suite to be standard for DoD. | YES |
| 1982 | EUnet (European UNIX Network) is created by EUUG to provide email and USENET services (original connections between the Netherlands, Denmark, Sweden, and UK) | YES |
| 1982 | Exterior Gateway Protocol (RFC 827) specification. EGP is used for gateways between networks. | YES |
| 1983 | Name server developed at Univ of Wisconsin, no longer requiring users to know the exact path to other systems | YES |
| 1983 | Cutover from NCP to TCP/IP (1 January) | YES |
| 1983 | Stuttgart and Korea get connected |  |
| 1983 | Movement Information Net (MINET) started early in the year in Europe, connected to Internet in Sept |  |
| 1983 | CSNET / ARPANET gateway put in place | YES |
| 1983 | ARPANET split into ARPANET and MILNET; the latter became integrated with the Defense Data Network created the previous year. 68 of the 113 existing nodes went to MILNET | YES |
| 1983 | Desktop workstations come into being, many with Berkeley UNIX (4.2 BSD) which includes IP networking software |  |
| 1983 | Networking needs switch from having a single, large time sharing computer connected to the Internet at each site, to instead connecting entire local networks |  |
| 1983 | Internet Activities Board (IAB) established, replacing ICCB | YES |
| 1983 | EARN (European Academic and Research Network) established. Very similar to the way BITNET works with a gateway funded by IBM-Europe | YES |
| 1984 | Domain Name System (DNS) introduced | YES |
| 1984 | Number of hosts breaks 1000 | YES |
| 1984 | JUNET (Japan Unix Network) established using UUCP |  |
| 1984 | JANET (Joint Academic Network) established in the UK using the Coloured Book protocols; previously SERCnet | YES |
| 1984 | Moderated newsgroups introduced on USENET (mod.\*) |  |
| 1984 | Canada begins a one-year effort to network its universities. The NetNorth Network is connected to BITNET in Ithaca from Toronto |  |
| 1984 | Kremvax message announcing USSR connectivity to USENET | YES |
| 1985 | Whole Earth ’Lectronic Link (WELL) started |  |
| 1985 | Information Sciences Institute (ISI) at USC is given responsibility for DNS root management by DCA, and SRI for DNS NIC registrations |  |
| 1985 | Symbolics.com is assigned on 15 March to become the first registered domain. Other firsts: cmu.edu, purdue.edu, rice.edu, berkeley.edu, ucla.edu, rutgers.edu, bbn.com (24 Apr); mit.edu (23 May); think.com (24 may); css.gov (June); mitre.org, .uk (July) |  |
| 1985 | 100 years to the day of the last spike being driven on the cross-Canada railroad, the last Canadian university is connected to NetNorth in a one year effort to have coast-to-coast connectivity. |  |
| 1986 | NSFNET created (backbone speed of 56Kbps). NSF establishes 5 super-computing centers to provide high-computing power for all (JVNC@Princeton, PSC@Pittsburgh, SDSC@UCSD, NCSA@UIUC, Theory Center@Cornell). This allows an explosion of connections, especially from universities. | YES |
| 1986 | Internet Engineering Task Force (IETF) and Internet Research Task Force (IRTF) comes into existence under the IAB. First IETF meeting held in January at Linkabit in San Diego |  |
| 1986 | The first Freenet (Cleveland) comes on-line 16 July under the auspices of the Society for Public Access Computing (SoPAC). Later Freenet program management assumed by the National Public Telecomputing Network (NPTN) in 1989 |  |
| 1986 | Network News Transfer Protocol (NNTP) designed to enhance Usenet news performance over TCP/IP. | YES |
| 1986 | Mail Exchanger (MX) records developed by Craig Partridge allow non-IP network hosts to have domain addresses. |  |
| 1986 | The first in a series of congestion collapses begin occurring in October. | YES |
| 1986 | The great USENET name change; moderated newsgroups changed in 1987. |  |
| 1986 | BARRNET (Bay Area Regional Research Network) established using high speed links. Operational in 1987. |  |
| 1986 | New England gets cut off from the Net as AT&T suffers a fiber optics cable break between Newark/NJ and White Plains/NY. All seven New England ARPANET trunk lines were in the one severed cable. Outage took place between 1:11 and 12:11 EST on 12 December | YES |
| 1987 | NSF signs a cooperative agreement to manage the NSFNET backbone with Merit Network, Inc. (IBM and MCI involvement was through an agreement with Merit). Merit, IBM, and MCI later founded ANS. |  |
| 1987 | UUNET is founded with Usenix funds to provide commercial UUCP and Usenet access. Originally an experiment by Rick Adams and Mike O’Dell |  |
| 1987 | First TCP/IP Interoperability Conference (March), name changed in 1988 to INTEROP |  |
| 1987 | Email link established between Germany and China using CSNET protocols, with the first message from China sent on 20 September. |  |
| 1987 | The concept and plan for a national US research and education network is proposed by Gordon Bell et al in a report to the Office of Science and Technology, written in response to a congressional request by Al Gore. (Nov) It would take four years until the establishment of this network by Congress | YES |
| 1987 | Number of hosts breaks 10000 |  |
| 1987 | Number of BITNET hosts breaks 1000 |  |
| 1988 | 2 November - Internet worm burrows through the Net, affecting  6000 of the 60000 hosts on the Internet |  |
| 1988 | CERT (Computer Emergency Response Team) formed by DARPA in response to the needs exhibited during the Morris worm incident. The worm is the only advisory issued this year. | YES |
| 1988 | DoD chooses to adopt OSI and sees use of TCP/IP as an interim. US Government OSI Profile (GOSIP) defines the set of protocols to be supported by Government purchased products |  |
| 1988 | Los Nettos network created with no federal funding, instead supported by regional members (founding: Caltech, TIS, UCLA, USC, ISI). |  |
| 1988 | NSFNET backbone upgraded to T1 (1.54Mbps) |  |
| 1988 | CERFnet (California Education and Research Federation network) founded by Susan Estrada. |  |
| 1988 | Internet Assigned Numbers Authority (IANA) established in December with Jon Postel as its Director. Postel was also the RFC Editor and US Domain registrar for many years. |  |
| 1988 | Internet Relay Chat (IRC) developed by Jarkko Oikarinen |  |
| 1988 | First Canadian regionals join NSFNET: ONet via Cornell, RISQ via Princeton, BCnet via Univ of Washington |  |
| 1988 | The first multicast tunnel is established between Stanford and BBN in the Summer of 1988. |  |
| 1988 | Countries connecting to NSFNET: Canada (CA), Denmark (DK), France (FR), Iceland (IS), Norway (NO), Sweden (SE) |  |
| 1989 | Number of hosts breaks 100000 | YES |
| 1989 | RIPE (Reseaux IP Europeens) formed (by European service providers) to ensure the necessary administrative and technical coordination to allow the operation of the pan-European IP Network. |  |
| 1989 | First relays between a commercial electronic mail carrier and the Internet: MCI Mail through the Corporation for the National Research Initiative (CNRI), and CompuServe through Ohio State Univ |  |
| 1989 | Corporation for Research and Education Networking (CREN) is formed by merging CSNET into BITNET (August) |  |
| 1989 | AARNET - Australian Academic Research Network - set up by AVCC and CSIRO; introduced into service the following year | YES |
| 1989 | First link between Australia and NSFNET via Hawaii on 23 June. Australia had been limited to USENET access since the early 1980s |  |
| 1989 | UCLA sponsors the Act One symposium to celebrate ARPANET’s 20th anniversary and its decommissioning (August) |  |
| 1989 | Countries connecting to NSFNET: Australia (AU), Germany (DE), Israel (IL), Italy (IT), Japan (JP), Mexico (MX), Netherlands (NL), New Zealand (NZ), Puerto Rico (PR), United Kingdom (UK) |  |
| 1990 | ARPANET ceases to exist | YES |
| 1990 | Electronic Frontier Foundation (EFF) is founded by Mitch Kapor |  |
| 1990 | The World comes on-line (world.std.com), becoming the first commercial provider of Internet dial-up access | YES |
| 1990 | ISO Development Environment (ISODE) developed to provide an approach for OSI migration for the DoD. ISODE software allows OSI application to operate over TCP/IP |  |
| 1990 | CA\*net formed by 10 regional networks as national Canadian backbone with direct connection to NSFNET |  |
| 1990 | The first remotely operated machine to be hooked up to the Internet, the Internet Toaster by John Romkey, (controlled via SNMP) makes its debut at Interop. | YES |
| 1990 | Countries connecting to NSFNET: Argentina (AR), Austria (AT), Belgium (BE), Brazil (BR), Chile (CL), Greece (GR), India (IN), Ireland (IE), Korea (KR), Spain (ES), Switzerland (CH) |  |
| 1991 | First connection takes place between Brazil, by Fapesp, and the Internet at 9600 baud. |  |
| 1991 | Commercial Internet eXchange (CIX) Association, Inc. formed by General Atomics (CERFnet), Performance Systems International, Inc. (PSInet), and UUNET Technologies, Inc. (AlterNet), as NSF lifts restrictions on the commercial use of the Net (March) |  |
| 1991 | Wide Area Information Servers (WAIS), invented by Brewster Kahle, released by Thinking Machines Corporation |  |
| 1991 | Gopher released by Paul Lindner and Mark P. McCahill from the Univ of Minnesota |  |
| 1991 | World-Wide Web (WWW) released by CERN; Tim Berners-Lee developer. First Web server is nxoc01.cern.ch, launched in Nov 1990 and later renamed info.cern.ch. | YES |
| 1991 | US High Performance Computing Act (Gore 1) establishes the National Research and Education Network (NREN) | YES |
| 1991 | NSFNET backbone upgraded to T3 (44.74Mbps) |  |
| 1991 | NSFNET traffic passes 1 trillion bytes/month and 10 billion packets/month |  |
| 1991 | Defense Data Network NIC contract awarded by DISA to Government Systems Inc. who takes over from SRI on 1 Oct |  |
| 1991 | Start of JANET IP Service (JIPS) which signaled the changeover from Coloured Book software to TCP/IP within the UK academic network. IP was initially ’tunneled’ within X.25. |  |
| 1992 | Internet Society (ISOC) is chartered under CNRI (January); incorporation took place in December |  |
| 1992 | IAB reconstituted as the Internet Architecture Board and becomes part of the Internet Society |  |
| 1992 | Number of hosts breaks 1000000 | YES |
| 1992 | First MBONE audio multicast (March) and video multicast (November) |  |
| 1992 | RIPE Network Coordination Center (NCC) created in April to provide address registration and coordination services to the European Internet community |  |
| 1992 | Veronica, a gopherspace search tool, is released by Univ of Nevada |  |
| 1992 | World Bank comes on-line |  |
| 1992 | The term “surfing the Internet” is coined by Jean Armour Polly; Brendan Kehoe uses the term “net-surfing” as early as 6 June 1991 in a USENET post |  |
| 1993 | InterNIC created by NSF to provide specific Internet services: directory and database services (AT&T); registration services (Network Solutions Inc.); information services (General Atomics/CERFnet) |  |
| 1993 | US White House email comes on-line at whitehouse.gov; web site launches in 1994 |  |
| 1993 | Worms of a new kind find their way around the Net - WWW Worms (W4), joined by Spiders, Wanderers, Crawlers, and Snakes ... |  |
| 1993 | Internet Talk Radio begins broadcasting |  |
| 1993 | United Nations (UN) comes on-line |  |
| 1993 | US National Information Infrastructure Act |  |
| 1993 | Businesses and media begin taking notice of the Internet | YES |
| 1993 | InterCon International KK (IIKK) provides Japan’s first commercial Internet connection in September. TWICS, though an IIKK leased line, begins offering dial-up accounts the following month |  |
| 1993 | Mosaic takes the Internet by storm (22 Apr); WWW proliferates at a 341634% annual growth rate of service traffic. Gopher’s growth is 997%. | YES |
| 1994 | ARPANET/Internet celebrates 25th anniversary |  |
| 1994 | Communities begin to be wired up directly to the Internet (Lexington and Cambridge, Mass., USA) |  |
| 1994 | US Senate and House provide information servers |  |
| 1994 | Shopping malls arrive on the Internet | YES |
| 1994 | First cyberstation, RT-FM, broadcasts from Interop in Las Vegas |  |
| 1994 | Arizona law firm of Canter & Siegel “spams” the Internet with email advertising green card lottery services; Net citizens flame back |  |
| 1994 | NSFNET traffic passes 10 trillion bytes/month |  |
| 1994 | WWW edges out telnet to become 2nd most popular service on the Net (behind ftp-data) based on % of packets and bytes traffic distribution on NSFNET |  |
| 1994 | First Virtual, the first cyberbank, open up for business | YES |
| 1994 | Radio stations start rockin’ (rebroadcasting) round the clock on the Net: WXYC at Univ of NC, KJHK at Univ of KS-Lawrence, KUGS at Western WA Univ | YES |
| 1994 | The first banner ads appear on hotwired.com in October. They were for Zima (a beverage) and AT&T | YES |
| 1994 | Trans-European Research and Education Network Association (TERENA) is formed by the merger of RARE and EARN, with representatives from 38 countries as well as CERN and ECMWF. TERENA’s aim is to “promote and participate in the development of a high quality international information and telecommunications infrastructure for the benefit of research and education” (October) |  |
| 1994 | The first web-based machine translation system is developed by this Timeline’s author, supporting 9 languages, and made available the following year to hundreds of thousands of users on OSIS and Intelink, both US government networks |  |
| 1994 | Countries connecting to NSFNET: Algeria (DZ), Armenia (AM), Bermuda (BM), Burkina Faso (BF), China (CN), Colombia (CO), Jamaica (JM), Jordan (JO), Lebanon (LB), Lithuania (LT), Macao (MO), Morocco (MA), New Caledonia (NC), Nicaragua (NI), Niger (NE), Panama (PA), Philippines (PH), Senegal (SN), Sri Lanka (LK), Swaziland (SZ), Uruguay (UY), Uzbekistan (UZ) |  |
| 1995 | NSFNET reverts back to a research network. Main US backbone traffic now routed through interconnected network providers | YES |
| 1995 | The new NSFNET is born as NSF establishes the very high speed Backbone Network Service (vBNS) linking super-computing centers: NCAR, NCSA, SDSC, CTC, PSC |  |
| 1995 | Hong Kong police disconnect all but one of the colony’s Internet providers for failure to obtain a license; thousands of users are left without service |  |
| 1995 | Sun launches JAVA on May 23 | YES |
| 1995 | RealAudio, an audio streaming technology, lets the Net hear in near real-time |  |
| 1995 | Radio HK, the first commercial 24 hr., Internet-only radio station starts broadcasting |  |
| 1995 | WWW surpasses ftp-data in March as the service with greatest traffic on NSFNet based on packet count, and in April based on byte count |  |
| 1995 | Traditional online dial-up systems (CompuServe, America Online, Prodigy) begin to provide Internet access |  |
| 1995 | Chris Lamprecht (aka “Minor Threat”) becomes the first person banned from accessing the Internet by a US District Court judge in Texas |  |
| 1995 | Thousands in Minneapolis-St. Paul (USA) lose Net access after transients start a bonfire under a bridge at the Univ of MN causing fiber-optic cables to melt (30 July) |  |
| 1995 | A number of Net related companies go public, with Netscape leading the pack with the 3rd largest ever NASDAQ IPO share value (9 August) |  |
| 1995 | Registration of domain names is no longer free. Beginning 14 September, a $50 annual fee has been imposed, which up until now was subsidized by NSF. NSF continues to pay for .edu registration, and on an interim basis for .gov |  |
| 1995 | The first official Internet wiretap was successful in helping the Secret Service and Drug Enforcement Agency (DEA) apprehend three individuals who were illegally manufacturing and selling cell phone cloning equipment and electronic devices |  |
| 1995 | Operation Home Front connects, for the first time, soldiers in the field with their families back home via the Internet. |  |
| 1995 | Technologies of the Year: WWW, Search engines |  |
| 1995 | Emerging Technologies: Mobile code (JAVA, JAVAscript), Virtual environments (VRML), Collaborative tools |  |
| 1996 | Internet phones catch the attention of US telecommunication companies who ask the US Congress to ban the technology (which has been around for years) |  |
| 1996 | The controversial US Communications Decency Act (CDA) becomes law in the US in order to prohibit distribution of indecent materials over the Net. A few months later a three-judge panel imposes an injunction against its enforcement. Supreme Court unanimously rules most of it unconstitutional in 1997. |  |
| 1996 | BackRub, Google’s precursor, comes online | YES |
| 1996 | Various ISPs suffer extended service outages, bringing into question whether they will be able to handle the growing number of users. AOL (19 hours), Netcom (13 hours), AT&T WorldNet (28 hours - email only) |  |
| 1996 | New York’s Public Access Networks Corp (PANIX) is shut down after repeated SYN attacks by a cracker using methods outlined in a hacker magazine (2600) |  |
| 1996 | MCI upgrades Internet backbone adding  13000 ports, bringing the effective speed from 155Mbps to 622Mbps. |  |
| 1996 | A malicious cancelbot is released on USENET wiping out more than 25000 messages |  |
| 1996 | The WWW browser war, fought primarily between Netscape and Microsoft, has rushed in a new age in software development, whereby new releases are made quarterly with the help of Internet users eager to test upcoming (beta) versions. | YES |
| 1996 | Internet2 project is kicked off by representatives from 34 universities on 1 Oct |  |
| 1996 | Restrictions on Internet use around the world: China: requires users and ISPs to register with the police; Germany: cuts off access to some newsgroups carried on CompuServe; Saudi Arabia: confines Internet access to universities and hospitals; Singapore: requires political and religious content providers to register with the state; New Zealand: classifies computer disks as “publications” that can be censored and seized (source: Human Rights Watch) |  |
| 1996 | Technologies of the Year: Search engines, JAVA, Internet Phone |  |
| 1996 | Emerging Technologies: Virtual environments (VRML), Collaborative tools, Internet appliance (Network Computer) |  |
| 1997 | 71618 mailing lists registered at Liszt, a mailing list directory |  |
| 1997 | The American Registry for Internet Numbers (ARIN) is established to handle administration and registration of IP numbers to the geographical areas currently handled by Network Solutions (InterNIC), starting March 1998. |  |
| 1997 | CA\*net II launched in June to provide Canada’s next generation Internet using ATM/SONET |  |
| 1997 | Domain name business.com sold for US$150000 |  |
| 1997 | Early in the morning of 17 July, human error at Network Solutions causes the DNS table for .com and .net domains to become corrupted, making millions of systems unreachable. |  |
| 1997 | 101803 Name Servers in whois database |  |
| 1997 | Technologies of the Year: Push, Multicasting |  |
| 1997 | Emerging Technologies: Push |  |
| 1998 | US Depart of Commerce (DoC) releases the Green Paper outlining its plan to privatize DNS on 30 January. This is followed up by a White Paper on June 5 |  |
| 1998 | Web size estimates range between 275 (Digital) and 320 (NEC) million pages for 1Q | YES |
| 1998 | Internet users get to be judges in a performance by 12 world champion ice skaters on 27 March, marking the first time a television sport show’s outcome is determined by its viewers. |  |
| 1998 | Network Solutions registers its 2 millionth domain on 4 May |  |
| 1998 | Electronic postal stamps become a reality, with the US Postal Service allowing stamps to be purchased and downloaded for printing from the Web. |  |
| 1998 | Canada kicks off CA\*net 3, the first national optical internet |  |
| 1998 | CDA II and a ban on Net taxes are signed into US law (21 October) |  |
| 1998 | US DoC enters into an agreement with the Internet Corporation for Assigned Numbers (ICANN) to establish a process for transitioning DNS from US Government management to industry (25 November) |  |
| 1998 | San Francisco sites without off-city mirrors go offline as the city blacks out on 8 December |  |
| 1998 | Chinese government puts Lin Hai on trial for “inciting the overthrow of state power” for providing 30000 email addresses to a US Internet magazine (December) [ He is later sentenced to two years in jail ] |  |
| 1998 | Open source software comes of age |  |
| 1998 | Technologies of the Year: E-Commerce, E-Auctions, Portals |  |
| 1998 | Emerging Technologies: E-Trade, XML, Intrusion Detection |  |
| 1999 | IBM becomes the first Corporate partner to be approved for Internet2 access |  |
| 1999 | European Parliament proposes banning the caching of Web pages by ISPs |  |
| 1999 | US State Court rules that domain names are property that may be garnished |  |
| 1999 | MCI/Worldcom, the vBNS provider for NSF, begins upgrading the US backbone to 2.5Gbps |  |
| 1999 | A forged Web page made to look like a Bloomberg financial news story raised shares of a small technology company by 31% on 7 April. |  |
| 1999 | SETI@Home launches on 17 May and within four weeks its distributed Internet clients provide more computing power than the most powerful supercomputer of its time | YES |
| 1999 | First large-scale Cyberwar takes place simultaneously with the war in Serbia/Kosovo | YES |
| 1999 | Abilene, the Internet2 network, reaches across the Atlantic and connects to NORDUnet and SURFnet |  |
| 1999 | The Web becomes the focal point of British politics as a list of MI6 agents is released on a UK Web site. Though forced to remove the list from the site, it was too late as the list had already been replicated across the Net. (15 May) |  |
| 1999 | Activists Net-wide target the world’s financial centers on 18 June, timed to coincide with the G8 Summit. Little actual impact is reported. |  |
| 1999 | DoD issues a memo requiring all US military systems to connect via NIPRNET, and not directly to the Internet by 15 Dec 1999 (22 Aug) |  |
| 1999 | ISOC approves the formation of the Internet Societal Task Force (ISTF). Vint Cerf serves as first chair |  |
| 1999 | Free computers are all the rage (as long as you sign a long term contract for Net service) |  |
| 1999 | Technologies of the Year: E-Trade, Online Banking, MP3 |  |
| 1999 | Emerging Technologies: Net-Cell Phones, Thin Computing, Embedded Computing |  |
| 2000 | The US timekeeper (USNO) and a few other time services around the world report the new year as 19100 on 1 Jan |  |
| 2000 | A massive denial of service attack is launched against major web sites, including Yahoo, Amazon, and eBay in early February | YES |
| 2000 | Web size estimates by NEC-RI and Inktomi surpass 1 billion indexable pages | YES |
| 2000 | Internet2 backbone network deploys IPv6 (16 May) |  |
| 2000 | Various domain name hijackings took place in late May and early June, including internet.com, bali.com, and web.net |  |
| 2000 | After months of legal proceedings, the French court rules Yahoo! must block French users from accessing hate memorabilia in its auction site (Nov). Given its inability to provide such a block on the Internet, Yahoo! removes those auctions entirely (Jan 2001). The case is eventually thrown out (Feb 2003). |  |
| 2000 | The European Commission contracts with a consortium of 30 national research networks for the development of Géant, Europe’s new gigabit research network meant to enhance the current capability provided by TEN-155 (6 Nov) |  |
| 2000 | Technologies of the Year: ASP, Napster |  |
| 2000 | Emerging Technologies: Wireless devices, IPv6 |  |
| 2001 | The first live distributed musical – The Technophobe & The Madman – over Internet2 networks debuts on 20 Feb |  |
| 2001 | VeriSign extends its multilingual domain testbed to encompass various European languages (26 Feb), and later the full Unicode character set (5 Apr) opening up most of the world’s languages |  |
| 2001 | Forwarding email in Australia becomes illegal with the passing of the Digital Agenda Act, as it is seen as a technical infringement of personal copyright (4 Mar) |  |
| 2001 | High schools in five states (Michigan, Missouri, Oregon, Virginia, and Washington) become the first to gain Internet2 access |  |
| 2001 | Napster keeps finding itself embroiled in litigation and is eventually forced to suspend service; it comes back later in the year as a subscription service |  |
| 2001 | European Council finalises an international cybercrime treaty on 22 June and adopts it on 9 November. This is the first treaty addressing criminal offenses committed over the Internet. |  |
| 2001 | Afghanistan’s Taliban bans Internet access country-wide, including from Government offices, in an attempt to control content (13 Jul) |  |
| 2001 | Code Red worm and Sircam virus infiltrate thousands of web servers and email accounts, respectively, causing a spike in Internet bandwidth usage and security breaches (July) |  |
| 2001 | A fire in a train tunnel running through Baltimore, Maryland seriously damages various fiber-optic cable bundles used by backbone providers, disrupting Internet traffic in the Mid-Atlantic states and creating a ripple effect across the US (18 Jul) |  |
| 2001 | GÉANT, the pan-European Gigabit Research and Education Network, becomes operational (23 Oct), replacing the TEN-155 network which was closed down (30 Nov) |  |
| 2001 | First uncompressed real-time gigabit HDTV transmission across a wide-area IP network takes place on Internet2 (12 Nov). |  |
| 2001 | Dutch SURFnet and Internet2’s Abilene connect via gigabit ethernet (15 Nov) |  |
| 2001 | Emerging Technologies: Grid Computing, P2P |  |
| 2002 | US ISP Association (USISPA) is created from the former CIX (11 Jan) |  |
| 2002 | Global Terabit Research Network (GTRN) is formed composed of two OC-48 2.4GB circuits connecting Internet2 Abiline, CANARIE CA\*net3, and GÉANT (18 Feb) |  |
| 2002 | Abilene (Internet2) backbone deploys native IPv6 (5 Aug) |  |
| 2002 | Internet2 now has 200 university, 60 corporate, and 40 affiliate members (2 Sep) |  |
| 2002 | Having your own Blog becomes hip |  |
| 2002 | A distributed denial of service (DDoS) attack struck the 13 DNS root servers knocking out all but 5 (21-23 Oct). Amidst national security concerns, VeriSign hastens a planned relocation of one of its two DNS root servers |  |
| 2002 | The FBI teams up with Terras Lycos to disseminate virtual wanted posts across the Web portal’s properties (11 Dec) |  |
| 2003 | The first official Swiss online election takes place in Anières (7 Jan) |  |
| 2003 | The SQL Slammer worm causes one of the largest and fastest spreading DDoS attacks ever. Taking roughly 10 minutes to spread worldwide, the worm took down 5 of the 13 DNS root servers along with tens of thousands of other servers, and impacted a multitude of systems ranging from (bank) ATM systems to air traffic control to emergency (911) systems (25 Jan). This is followed in August by the Sobig.F virus (19 Aug), the fastest spreading virus ever, and the Blaster (MSBlast) worm (11 Aug), another one of the most destructive worms ever |  |
| 2003 | Flash mobs, organized over the Net, start in New York and quickly form in cities worlwide |  |
| 2003 | The French Ministry of Culture bans the use of the word “e-mail” by government ministries, and adopts the use of the more French sounding “courriel” (Jul) |  |
| 2003 | Last Abilene segment upgraded to 10Gbps (5 Nov) |  |
| 2004 | For the first time, there are more instances of DNS root servers outside the US with the launch of an anycast instance of the RIPE NCC operated K-root server |  |
| 2004 | Abiline, the Internet2 backbone, upgrade from 2.5Gbps to 10Gbps is completed (4 Feb) |  |
| 2004 | Thefacebook launches (4 Feb) | YES |
| 2004 | CERNET2, the first backbone IPv6 network in China, is launched by the China Education and Research Network (CERN) connecting 25 universities in 20 cities at speeds of 1-10Gbps (27 Dec) |  |
| 2004 | Emerging Technologies: Social networking, Web mashups |  |
| 2005 | Estonia offers Internet voting nationally for local elections |  |
| 2005 | Pakistan suffers a near complete Internet outage as a submarine cable becomes defective (Jun) |  |
| 2005 | Number of Internet users reaches 1 Billion (Oct) | YES |
| 2006 | Zimbabwe looses most of its Internet access after its satellite connectivity is cut by the provider for non-payment |  |
| 2006 | ICANN lifts price controls on .biz, .info, and .org domain names, after the same was done for .net in 2005, raising fears of tiered pricing where popular domains would cost more |  |
| 2006 | First tweet is sent out by Jack Dorsey (21 Mar) – “just setting up my twttr” |  |
| 2006 | The 6bone, an IPv6 testbed, is phased out after 10 years operation (6 Jun) |  |
| 2006 | Internet2 connectivity begins switching from Abilene to its new network (Nov) |  |
| 2006 | Internet connectivity to southeast Asia is severely limited after major fiber optic lines are severely damaged by an earthquake in Taiwan and subsequent underwater mudslides (Dec) |  |
| 2006 | Emerging Technologies: Cloud computing |  |
| 2007 | Estonia offers the first online national parliamentary elections on 26-28 Feb |  |
| 2007 | Internet2 traffic in the Northeast US is disrupted on 1 May when a homeless man starts a fire under a Boston bridge causing a fiber break |  |
| 2007 | Use of #hashtag proposed by Tweeter user number 1186, Chris Messina (23 Aug) |  |
| 2007 | Internet2’s Abilene network is retired (Sep) as the last connections are switched over to the new Level 3 network |  |
| 2007 | Internet2 completes US East to West coast span of its 100GB/s network on 9 Oct |  |
| 2008 | NASA successfully tests the first deep space communications network modeled on the Internet, using the Disruption-Tolerant Networking (DTN) software to transmit images to/from a science spacecraft  20 million miles above Earth | YES |
| 2008 | Google’s crawler reaches 1 trillion pages, although only a fraction are indexed by the search engine. For comparison, Google’s original index had 26 million pages in 1998, and reached 1 billion in 2000 |  |
| 2008 | The Middle East, India, and other parts of Africa and Asia see a major degradation in Internet service, including outages, after several undersea cables carrying Internet traffic to the region are cut within 1 week (Jan-Feb) |  |
| 2008 | YouTube becomes unreacheable for a couple of hours after Pakistan Telecom starts an unauthorised announcement of YouTube’s subnet prefix (24 Feb) |  |
| 2009 | Bitcoins start being minted | YES |
| 2009 | US Department of Commerce relaxes control over ICANN, in favor of a multi-national oversight group |  |
| 2009 | Twitter is asked by the US Government to delay planned maintenance of its service on 15 June as a result of heavy use by Iranian users during unrest in that country |  |
| 2009 | Crowdfunding becomes a popular means of raising startup funds; Kickstart founded on April 28 | YES |
| 2009 | Emerging Technologies: Location awareness |  |
| 2010 | Astronaut T.J. Creamer inaugurates the new International Space Station direct link to the Internet (aka Crew Support LAN) with a tweet (22 Jan) – “Hello Twitterverse! We r now LIVE tweeting from the International Space Station – the 1st live tweet from Space! :) More soon, send your ?s” |  |
| 2010 | Google announces on 22 January that along with 20+ other US companies, it had been the target of a cyber attack originating in China, and on 22 March stops censoring its services in China |  |
| 2010 | Google+ service launches in public beta on 28 June; surpasses 10M users in Jul 2011, 100M in Feb 2012, and 400M in Sep 2012 |  |
| 2010 | Number of registered domain reach 200M (  Aug) |  |
| 2010 | A BGP experiment between RIPE NCC and Duke U results in a partial Internet outage (27 Aug) |  |
| 2010 | US Senate authorizes US Dept of Homeland Security to seize domains of sites suspected of piracy (Nov) |  |
| 2010 | Myanmar is temporarily taken offline by a denial of service attack (Nov) |  |
| 2010 | Photo-sharing sees a renewal with the launch of social-based services such as Pinterest and Instagram |  |
| 2011 | LinkedIn reaches 100M users (Mar); surpasses 200M in Jan 2013 |  |
| 2011 | Egypt shuts down its last ISP on 31 Jan and remains offline for two days |  |
| 2011 | Internet traffic in Lybia is significantly curtailed for several days in February |  |
| 2011 | World IPv6 Day is 8 June |  |
| 2011 | Number of Internet users reaches 2 Billion (Nov) | YES |
| 2012 | ICANN begins accepting applications for new generic top-level domains (gTLDs) on 12 Jan |  |
| 2012 | Facebook reaches 1 billion monthly active users (604M mobile) on 14 Sep @ 12:50pm PT, with 581M daily on average | YES |
| 2012 | Amazon becomes the largest hosting location by number of web-facing computers (118k), knocking China Telecom from first place (116k) |  |
| 2012 | World IPv6 Launch is 6 June |  |
| 2012 | Minitel shuts down at the end of June |  |
| 2012 | GoDaddy service goes down, making millions of sites inaccessible for several hours (10 Sep) |  |
| 2012 | Twitter surpasses 200M active users (Dec), and 500M tweets per day (Oct) |  |
| 2012 | NASA’s Curiosity Rover checks-in on FourSquare from Mars (3 Oct) |  |
| 2012 | Syria is disconnected from the Internet for two days (29 Nov - 1 Dec) |  |
| 2012 | “Gangnam Style” becomes the first YouTube video to reach 1 billion views (21 Dec) | YES |
| 2013 | Netflix and YouTube account for over 50% of Internet traffic measured by bytes |  |
| 2013 | US National Security Agency (NSA) is revealed to be collecting considerable more Internet data than previously thought, including encrypted information from major Internet sites |  |
| 2013 | The number of Internet hosts surpass 1 billion | YES |
| 2014 | Most of the Internet traffic in China is redirected to US-based Dynamic Internet Technology for over an hour (21 Jan) |  |
| 2014 | .py ccTLD hacked – full whois registry data leaked and domains redirected (e.g., google.com.py) (20 Feb) |  |
| 2014 | The number of Web servers surpass 1 billion |  |
| 2014 | After an EU court ruling requiring Google to honor “requests to be forgotten”, 12000 requests are submitted in the first day (30 May) |  |
| 2014 | Many networks are taken offline due to a Verizon glitch introducing thousands of new prefixes into the global routing table, causing popular but unpatched Cisco routers to reach their 512000 limit and crash (12 Aug) |  |
| 2015 | A Georgian scavenging for copper cuts off much of the Internet in neighbouring Armenia when her spade slices a buried cable (28 Mar) |  |
| 2015 | Out of 100 billion monthly Google searches, those from mobile devices surpass desktops for the first time | YES |
| 2015 | 1 billion users (1 in 7 people on Earth) access Facebook on a single day (24 Aug) | YES |
| 2015 | WordPress powers 25% of web sites as of early November |  |
| 2015 | Most of the internal Internet connectivity in Azerbaijan is lost as a result of a fire in a telecommunications facility (16 Nov) |  |
| 2016 | Internet Society celebrates 25th anniversary (1 Jan) |  |
| 2016 | United Nations Human Rights Council adopts a resolution on the promotion, protection and enjoyment of human rights on the Internet (27 Jun) |  |
| 2016 | A California District Court Judge grants a motion for what is thought to be the first permitted serving of a lawsuit via Twitter (30 Sep) |  |
| 2016 | Yahoo discloses 500 million accounts compromised in 2014 (22 Sep) and that 1 billion accounts were compromised in Aug 2013 (14 Dec) |  |
| 2016 | DDoS attacks wreak havoc across the Internet with some topping over 1Tbps in bandwidth and powered by over 150000 hacked Internet devices |  |
| 2016 | Several prominent Internet sites become unreacheable as domain infrastructure provider Dyn is knocked offline by a DDoS attack (21 Oct) |  |
| 2016 | IPv6 reaches 10% deployment globally, and becomes the dominant (>50%) Internet protocol for US mobile networks |  |
| 2016 | Coordination and management of the Internet’s unique identifiers transition to the private sector as the IANA contract between ICANN and the US Dept of Commerce’s NTIA expires (1 Oct) |  |
| 2016 | Annual global IP traffic surpasses 1 zettabyte | YES |
| 2017 | IETF enters into an agreement with the National Library of Sweden for archival of RFC series in NLS’ bunker (16 Jan) |  |
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ccc Year & Event & Major event  
Throughout history & Voice telegraphs used hundreds of years BC through the Middle Ages and in the Canary Islands today. &  
1200 BC & Homer talks about signal fires in the Illiad. &  
700 BC to 300 AD & Carrier pigeons used in Olympic games &  
1588 AD & Arrival of the Spanish Armada announced by signal fires &  
1667 & Robert Hooke creates an acoustic string telephone that conveys sounds over a taut extended wire by mechanical vibrations. &  
 1800 AD & A line of canon from Buffalo to NYC used to announce Gov. DeWitt Clinton’s inaugural trip through the Erie Canal. It took 80 minutes. &  
1791 & The Chappe brothers, in France, were in their teens and were going to schools some distance apart but visible to each other. They obtained permission to set up a signaling system so they could send messages to each other. Their semaphore system consisted of movable arms on a pole whose positions denoted letters of the alphabet. &  
1793 & The Chappe brothers established the first commercial semaphore system between two locations near Paris. Napoleon thought this was a great idea. Soon there were semaphore signaling systems covering the main cities of France. Semaphore signaling spread to Italy, Germany and Russia. Thousands of men were employed manning the stations. Speed: about 15 characters per minute. Code books came into play so that whole sentences could be represented by a few characters. Semaphores were not very successful in England because of the fog and smog caused by the Industrial Revolution. Claude Chappe headed France’s system for 30 years and then was “retired” when a new administration came into power. There were semaphore systems in the U.S., especially from Martha’s Vineyard (an island near Cape Cod) and Boston, reporting to Boston’s Custom House on the movement of sailing ships. This was also true around New York City and San Francisco. Samuel F.B. Morse, the inventor of the electric telegraph, reportedly saw the semaphore system in operation in Europe. The last operational semaphore system went out of business in 1860. It was located in Algeria. &  
1837 & Cooke and Wheatstone obtain a patent on telegraph in England. Morse publicly demonstrates his telegraph. & YES  
1838 & Morse’s Electro-Magnetic Telegraph patent approved. &  
1840 & Congress was requested to provide funding for a semaphore system running from NYC to New Orleans. Samuel Morse, it is said, advised against funding of this system because of his work on developing the electric telegraph. &  
1843 & FAX invented by the Scotch physicist Alexander Bain. &  
1844 & Morse demonstrates the electric telegraph. Samuel F.B. Morse demonstrates his telegraph by sending a message to Baltimore from the chambers of the Supreme Court in Washington, DC. The message, “What hath God wrought?,” marks the beginning of a new era in communication. & YES  
1844 & Morse’s first telegraph line between Washington and Baltimore opens in May. &  
1844 & Innocenzo Manzetti first suggests the idea of an electric “speaking telegraph”, or telephone. & YES  
1846 & First commercial telegraph line completed. The Magnetic Telegraph Company’s lines ran from New York to Washington. & YES  
1846 & House’s Printing Telegraph patent approved. &  
1847 (March 3) & Birth of Alexander Graham Bell, Edinburgh, Scotland. &  
1848 & Associated Press formed to pool telegraph traffic. &  
1849 & Antonio Meucci demonstrates a communicating device to individuals in Havana. It is disputed if this is an electromagnetic telephone, but is said to involve direct transmission of electricity into the user’s body. & YES  
1849 & Alexander Bain’s Electro-Chemical patent approved. &  
1850s & Telegraph expansion in the U.S. and into Europe: The electrical telegraph is broadly introduced in Europe during the 1850s. It is based on a number of discoveries and inventions in the use of electricity. The telegraph implies a revolutionary improvement in the transport of written messages. The telegraph is often linked to the building of railway transportation networks. & YES  
1851 & Telegraph first used to coordinate train departures. &  
1851 & There are 51 telegraph companies in operation &  
1851 & Hiram Sibley and associates incorporate ’New York and Mississippi Valley Printing Telegraph Company’. This later became Western Union. &  
1854 & Charles Bourseul publishes a description of a make-and-break telephone transmitter and receiver in L’Illustration, (Paris) but does not construct a working instrument. & YES  
1854 & Meucci demonstrates an electric voice-operated device in New York, but it is not clear what kind of device he demonstrated. & YES  
1856 & Western Union formed by six men from Rochester, N.Y., including the ’New York and Mississippi Valley Printing Telegraph Company’. They start an acquisition spree. &  
1857 & Treaty of Six Nations is signed, creating a national cartel in the U.S. &  
1858 & Burglar Alarm - Edwin T. Holmes of Boston begins to sell electric burglar alarms. Later, his workshop will be used by Alexander Graham Bell as the young Bell pursues his invention of the telephone. Holmes will be the first person to have a home telephone. &  
1859 & First transatlantic telegraph cable attempt is laid from Newfoundland to Valentia, Ireland. Fails after 23 days, having been used to send a total of 4359 words. Total cost of laying the line was $1.2 million. & YES  
1860s & Sea cables improve international telegraph links: The progress in undersea cable development makes it possible for the telegraph to cross oceans in order to link Europe with North America and other continents. The first stable trans-Atlantic cable is laid by the giant British steamer Great Eastern. Two more cables follow the same year through a repair of a previous broken cable and a successful parallel French project. & YES  
1860 & Johann Philipp Reis of Germany demonstrates a make-and-break transmitter after the design of Bourseul and a knitting-needle receiver. Witnesses said they heard human voices being transmitted. & YES  
1861 & Johann Philipp Reis transfers voice electrically over a distance of 340 feet with his Reis telephone. To prove that speech can be recognized successfully at the receiving end, he uses the phrase “The horse does not eat cucumber salad” as an example because this phrase is hard to understand acoustically in German. & YES  
1861 & First transcontinental telegraph completed in the United States, connecting both coasts. There are now 2250 telegraph offices in operation in the U.S. & YES  
1864 & In an attempt to give his musical automaton a voice, Innocenzo Manzetti invents the ’speaking telegraph’. He shows no interest in patenting his device, but it is reported in newspapers. & YES  
1865 & Maxwell mathematically predicts the propagation of electromagnetic waves through space. &  
1865 & Meucci reads of Manzetti’s invention and writes to the editors of two newspapers claiming priority and quoting his first experiment in 1849. He writes “I do not wish to deny Mr. Manzetti his invention, I only wish to observe that two thoughts could be found to contain the same discovery, and that by uniting the two ideas one can more easily reach the certainty about a thing this important.” If he reads Meucci’s offer of collaboration, Manzetti does not respond. & YES  
1866 & First successful transatlantic telegraph line laid on the 27th of July. Prior to the cable, sending messages between the United States and Europe took 11 days. This allows uninterrupted transatlantic communications. & YES  
1866 & Western Union merges with major remaining rivals. &  
1867 & Stock ticker service inaugurated. & YES  
1869 & The Great Northern Telegraph Co, a privately owned company, is established in Copenhagen by Carl Frederik Tietgen to provide telegraph connections across the North Sea between the Nordic countries and England and also across the Baltic to Russia. GNT establishes a cable from Grisslehamn in Sweden to Finland providing a direct connection to Russia. The telegraph cable is terminated at Uusikaupunki (Nystad) and GNT sets up its telegraph gateway there. & YES  
1870s & The telephone starts to compete with the telegraph: Many scientists and inventors work on the problem of transmitting voice signals by electricity over wires. Several claim to be first, but the first patent is awarded to Alexander Graham Bell in the USA in 1876. The news of the invention spreads very quickly over the world and experimental installation are made in many places during the end of the 1870s. The electrical signals are much weaker than in the case of the telegraph, so the telephone remains a relatively short range means of communication in relation to the telegraph for about four decades. The telephone is initially not regarded as a serious competitor by the telegraph operators. & YES  
1870 & Western Union introduces the money order service. &  
1870 & Thomas Edison invents multiplex telegraphy. &  
1871 & Meucci files a patent caveat (a statement of intention to file a patent application) for a Sound Telegraph, but it does not describe an electromagnetic telephone. & YES  
1871 (April 1) & Bell arrived in Boston to start his work in the teaching of the deaf. &  
1872 & Professor Vanderwyde demonstrates Reis’s telephone in New York. &  
1872 & Western Union buys the telegraph equipment manufacturing firm, Gray & Barton (founded by Elisha Gray), and renames it Western Electric. &  
July 1873 & Thomas Edison notes varying resistance in carbon grains due to pressure, and builds a rheostat based on the principle but abandons it because of its sensitivity to vibration. &  
May 1874 & Gray invents an electromagnet device for transmitting musical tones. Some of his receivers use a metallic diaphragm. & YES  
July 1874 & Alexander Graham Bell conceives the theoretical concept for the telephone while vacationing at his parents’ farm near Brantford, Canada. Alexander Melville Bell records notes of his son’s conversation in his personal journal. & YES  
29 December 1874 & Gray demonstrates his musical tones device and transmits “familiar melodies through telegraph wire” at the Presbyterian Church in Highland Park, Illinois. & YES  
1875 (June 2) & Bell’s theory of the telephone confirmed by experiment. & YES  
4 May 1875 & Bell conceives of using varying resistance in a wire conducting electric current to create a varying current amplitude. & YES  
1875 & First words transmitted by telephone. & YES  
2 June 1875 & Bell transmits the sound of a plucked steel reed using electromagnet instruments. & YES  
1 July 1875 & Bell uses a bi-directional “gallows” telephone that was able to transmit “indistinct but voice-like sounds” but not clear speech. Both the transmitter and the receiver were identical membrane electromagnet instruments. & YES  
November 1875 & Thomas Edison experiments with acoustic telegraphy and, in November, builds an electro-dynamic receiver but does not exploit it. & YES  
11 February 1876 & Elisha Gray invents a liquid transmitter for use with a telephone, but he did not make one. & YES  
14 February 1876, about 9:30 am & Gray or his lawyer brings Gray’s patent caveat for the telephone to the Washington, D.C. Patent Office (a caveat was a notice of intention to file a patent application. It was like a patent application, but without a request for examination, for the purpose of notifying the patent office of a possible invention in process). & YES  
14 February 1876, about 11:30 am & Bell’s lawyer brings to the same patent office Bell’s patent application for the telephone. Bell’s lawyer requests that it be registered immediately in the cash receipts blotter. & YES  
14 February 1876, about 1:30 pm & Approximately two hours later Elisha Gray’s patent caveat is registered in the cash blotter. Although his caveat was not a full application, Gray could have converted it into a patent application and contested Bell’s priority, but did not do so because of advice from his lawyer and his involvement with acoustic telegraphy. Over 600 patent suits filed during the next 11 years. Settled in Bell’s favor. The result was that the patent was awarded to Bell. Bell offers his patent to Western Union for $100000. & YES  
7 March 1876 & Bell’s U.S. Patent, No. 174465 for the telephone is granted. & YES  
10 March 1876 & Bell first successfully transmits speech, saying “Mr. Watson, come here! I want to see you!” using a liquid transmitter as described in Gray’s caveat, and Bell’s own electromagnetic receiver. & YES  
16 May 1876 & Thomas Edison files first patent application for acoustic telegraphy for which U.S. patent 182996 was granted October 10, 1876. &  
25 June 1876 & Bell exhibits his telephone at the Centennial Exposition in Philadelphia, where it draws enthusiastic reactions from Emperor Dom Pedro II of Brazil and Lord Kelvin, attracting the attention of the press and resulting in the first announcements of the invention to the general public. &  
10 August 1876 & Alexander Graham Bell makes the world’s first long-distance telephone call, over a distance of about 6 miles, between Brantford and Paris, Ontario, Canada. & YES  
October 1876 & Edison tests his first carbon microphone. & YES  
9 October 1876 & Bell makes the first two-way long-distance telephone call between Cambridge and Boston, Massachusetts. & YES  
1876 & Response from Western Union to Alexander Graham Bell’s original proposal to sell patent to them for $100000 in 1876: In 1876, Alexander Graham Bell and his financial backer, Gardiner G. Hubbard, offered Bell’s brand new patent (No. 174465) to the Telegraph Company - the ancestor of Western Union. The President of the Telegraph Company, Chauncey M. DePew, appointed a committee to investigate the offer. The committee report has often been quoted. It reads in part: “The Telephone purports to transmit the speaking voice over telegraph wires. We found that the voice is very weak and indistinct, and grows even weaker when long wires are used between the transmitter and receiver. Technically, we do not see that this device will be ever capable of sending recognizable speech over a distance of several miles. ”Messer Hubbard and Bell want to install one of their “telephone devices” in every city. The idea is idiotic on the face of it. Furthermore, why would any person want to use this ungainly and impractical device when he can send a messenger to the telegraph office and have a clear written message sent to any large city in the United States? “The electricians of our company have developed all the significant improvements in the telegraph art to date, and we see no reason why a group of outsiders, with extravagant and impractical ideas, should be entertained, when they have not the slightest idea of the true problems involved. Mr. G.G. Hubbard’s fanciful predictions, while they sound rosy, are based on wild-eyed imagination and lack of understanding of the technical and economic facts of the situation, and a posture of ignoring the obvious limitations of his device, which is hardly more than a toy... . ”In view of these facts, we feel that Mr. G.G. Hubbard’s request for $100000 of the sale of this patent is utterly unreasonable, since this device is inherently of no use to us. We do not recommend its purchase."

The amusing thing about this letter, in retrospect, is that Bell obtained controlling interest in Western Union by 1882! &  
1876 (March 7) & The first telephone patent, No. 174465 was issued to Alexander Graham Bell. &  
1876 (March 10) & First complete sentence of speech transmitted by telephone in Boston. &  
1876 (June 25) & Bell exhibited the telephone to the judges at the Centennial Exposi-tion, Philadelphia. &  
1876 (October 9) & Bell conducted the first successful experimental two-way talk over the telephone between Boston and Cambridgeport, Mass., distance of 2 miles. &  
1876 & First conversation by overhead line, 2 miles-Boston to Cambridgeport. &  
1876 & Edison invents the electric motor and the phonograph. &  
1876 & Hungarian Tivadar Puskas invents the telephone switchboard exchange (later working with Edison). & YES  
20 January 1877 & Edison “first [succeeds] in transmitting over wires many articulated sentences” using carbon granules as a pressure-sensitive varying resistance under the pressure of a diaphragm. & YES  
30 January 1877 & Bell’s U.S. Patent No. 186787 is granted for an electromagnetic telephone using permanent magnets, iron diaphragms, and a call bell. & YES  
4 March 1877 & Emile Berliner invents a microphone based on “loose contact” between two metal electrodes, an improvement on Reis’ Telephone, and in April 1877 files a caveat of an invention in process. & YES  
April 1877 & A telephone line connects the workshop of Charles Williams, Jr., located in Boston, to his house in Somerville, Massachusetts at 109 Court Street in Boston, where Alexander Graham Bell and Thomas Watson had previously experimented with their telephone. The telephones became No. 1 and 2 in the Bell Telephone Company. &  
27 April 1877 & Edison files telephone patent applications. U.S. patents (Nos. 474230, 474231 and 474232) were awarded to Edison in 1892 over the competing claims of Alexander Graham Bell, Emile Berliner, Elisha Gray, Amos Dolbear, J.W. McDonagh, G.B. Richmond, W.L.W. Voeker, J.H. Irwin and Francis Blake Jr. Edison’s carbon granules transmitter and Bell’s electromagnetic receiver are used, with improvements, by the Bell system for many decades thereafter. & YES  
4 June 1877 & Emile Berliner files telephone patent application that includes a carbon microphone transmitter. & YES  
9 July 1877 & The Bell Telephone Company, a common law joint-stock company, is organized by Alexander Graham Bell’s future father-in-law Gardiner Greene Hubbard, a lawyer who becomes its first president. Alexander Graham Bell acts as “electrician” and Thomas Watson as “superintendent.” & YES  
6 October 1877 & The Scientific American publishes the invention from Bell - at that time still without a ringer. & YES  
25 October 1877 & The article in the Scientific American is discussed at the Telegraphenamt in Berlin & YES  
12 November 1877 & The first commercial telephone company enters telephone business in Friedrichsberg close to Berlin using the Siemens pipe as ringer and telephone devices build by Siemens. & YES  
1 December 1877 & Western Union enters the telephone business using Edison’s superior carbon microphone transmitter. & YES  
1877 & The first experimental Telephone Exchange in Boston. & YES  
28 January 1878 & The first commercial North American telephone exchange is opened in New Haven, Connecticut, with 21 listings. & YES  
4 February 1878 & Edison demonstrates the telephone between Menlo Park, New Jersey and Philadelphia, a distance of 210 kilometres (130 mi) &  
14 June 1878 & The Telephone Company (Bell’s Patents) Ltd. is registered in London. Opened in London on 21 August 1879, it is Europe’s first telephone exchange, followed a couple of weeks later by one in Manchester. &  
12 September 1878 & The Bell Telephone Company sues Western Union for infringing Bell’s patents. &  
1878 & The first Australian telephone trials were made between Semaphore and Kapunda (and later Adelaide and Port Adelaide) in South Australia. &  
Early months of 1879 & The Bell Telephone Company is near bankruptcy and desperate to get a transmitter to equal Edison’s carbon transmitter. &  
17 February 1879 & Bell Telephone merges with the New England Telephone Company to form the National Bell Telephone Company. Theodore Vail takes over operations. &  
1879 & Francis Blake invents a carbon transmitter similar to Edison’s that saves the Bell company from extinction. & YES  
2 August 1879 & The Edison Telephone Company of London Ltd, registered. Opened in London 6 September 1879. &  
10 September 1879 & Connolly and McTighe patent a “dial” telephone exchange (limited in the number of lines to the number of positions on the dial). &  
1879 & The International Bell Telephone Company (IBTC) of Brussels, Belgium was founded by Bell Telephone Company president Gardiner Greene Hubbard, initially to sell imported telephones and switchboards in Continental Europe. International Bell rapidly evolved into an important European telephone service provider and manufacturer, with major operations in several countries. & YES  
19 February 1880 & The photophone, also called a radiophone, is invented jointly by Alexander Graham Bell and Charles Sumner Tainter at Bell’s Volta Laboratory. The device allowed for the transmission of sound on a beam of light. &  
20 March 1880 & National Bell Telephone merges with others to form the American Bell Telephone Company. & YES  
1 April 1880 & World’s first wireless telephone call on Bell and Tainter’s photophone (distant precursor to fiber-optic communications) from the Franklin School in Washington, D.C. to the window of Bell’s laboratory, 213 meters away. &  
1880 & Bell spoke over a 1300-ft beam of light using his patented Photophone equipment. &  
1880 & 30872 Bell telephone stations in the United States.  Conversation by overhead line, 45 miles-Boston to Providence. &  
1 July 1881 & The world’s first international telephone call is made between St. Stephen, New Brunswick, Canada, and Calais, Maine, United States. & YES  
11 October 1881 & The Sydney telephone exchange opened with 12 subscribers. &  
1881 & Alexander Graham Bell patents the metallic, or two-wire, circuit. &  
1881 & Mr. Eckert who ran a telephone company in Cincinnati said he preferred the use of females to males as operators. “Their service is much superior to that of men or boys. They are much steadier, do not drink beer nor use profanity, and are always on hand.” &  
1881 & Bell Telephone company purchases Western Electric Company. & YES  
1881 & Conversation by underground cable, 3/4 mile. &  
1882 & Bell has controlling interest in Western Union and Western Electric. & YES  
1882 & A telephone company—an American Bell Telephone Company affiliate—is set up in Mexico City. &  
14 May 1883 & The Adelaide exchange was opened, with 48 subscribers. &  
7 September 1883 & The Port Adelaide exchange was opened, with 21 subscribers. &  
1884 & Hard-drawn copper wire begins to replace iron wires. &  
1884 & Paul Nipkow obtains a patent in Germany for TV, using a selenium cell and a mechanical scanning disk. & YES  
1884 (September 4) & Opening of telephone service between Boston and New York, 235 miles. First long distance conversation by overhead line (hard-drawn copper). & YES  
3 March 1885 & The American Telephone & Telegraph Company (AT&T) is incorporated as the long-distance division of American Bell Telephone Company. It will become the head of the Bell System on the last day of 1899. & YES  
1885 & Theodore Vail becomes President of AT&T. Leaves in 1887 to go to South America to install electric traction systems. &  
1885 & The Bell Telephone Company formed a new subsidiary, American Telephone & Telegraph (AT&T). &  
1885 (March 3) & Incorporation of American Telephone and Telegraph Company, New York City. &  
1886 & Gilliland’s Automatic circuit changer is put into service between Worcester and Leicester featuring the first operator dialing allowing one operator to run two exchanges. &  
13 January 1887 & The Government of the United States moves to annul the master patent issued to Alexander Graham Bell on the grounds of fraud and misrepresentation. The case, known as the ’Government Case’, is later dropped after it was revealed that the U.S. Attorney General, Augustus Hill Garland had been given millions of dollars of stock in the company trying to unseat Bell’s telephone patent. &  
1887 & Tivadar Puskás introduced the multiplex switchboard, that had an epochal significance in the further development of telephone exchange. & YES  
1887 & Heinrich Hertz shows that electromagnetic waves exist. & YES  
1888 & Telephone patent court cases are confirmed by the Supreme Court &  
1888 & Heinrich Hertz produces radio waves. & YES  
1889 & AT&T becomes the overall holding company for all the Bell companies. &  
1889 & Almon B. Strowger invents a switch that has line contacts in circular rows inside a cylinder. Controlled by push-buttons on telephone. & YES  
2 November 1889 & A.G. Smith patents a telegraph switch which provides for trunks between groups of selectors allowing for the first time, fewer trunks than there are lines, and automatic selection of an idle trunk. & YES  
1890 & Herman Hollerith gets a contract for processing the 1900 census data using punched cards. His firm was eventually named IBM in 1924. &  
1890 & 211503 Bell telephone stations. &  
1891 & Twisted pairs incorporated into telephone lines by John J. Carty. &  
10 March 1891 & Almon Strowger, the St. Louis undertaker, became upset on finding that the wife of a competitor was a telephone operator who made his line busy and transferred calls meant for him to her husband. “Necessity is the mother of invention” so Strowger developed the dial telephone system to get the operator out of the system. The invention he patents is a 1000 line switch using a disc bank having ten concentric rows of line contacts (the Strowger switch), which provides the first Automatic telephone exchange. This is not used commercially. Formation of Strowger Automatic Telephone Exchange to manufacture step-by-step central office equipment (which is now owned by GTE). & YES  
30 October 1891 & The independent Strowger Automatic Telephone Exchange Company is formed. &  
3 May 1892 & Thomas Edison awarded patents for the carbon microphone based on applications lodged in 1877. & YES  
18 October 1892 & Opening of telephone service between New York and Chicago (950 miles). & YES  
3 November 1892 & The first Strowger switch goes into operation in LaPorte, Indiana with 75 subscribers and capacity for 99. &  
1892 (October 18) & Opening of long distance telephone service, New York to Chicago, 950 miles. &  
1892 & Conversation by overhead line, 900 miles-New York to Chicago. &  
1892 & First commercial Strowger installation; LaPorte, Indiana, USA. Used switcher with 100 line disc-type banks. &  
1893 & An early form of broadcasting was started in Budapest over 220 miles of telephone wires serving 6000 subscribers who could listen at regular schedules to music, news, stock market prices, poetry readings and lectures. &  
30 January 1894 & The second fundamental Bell patent for the telephone expires; period of intense competition begins with independent telephone companies established, and independent manufacturing companies (Stromberg-Carlson in 1894 and Kellogg Switchboard & Supply Company in 1897). &  
1894 & Invention of gear-driven switch with “zither” (piano wire) line banks.  Not used commercially. 200-line “zither” board with ratchet drive installed at LaPorte, Indiana, USA. &  
1895 & Guglielmo Marconi invented the radio. & YES  
1895 & Third installation at LaPorte, Indiana.  Earliest use of switch with semi-cylindrical bank and shaft with vertical and rotary motions. Invention of earliest dial-type calling device. &  
1896 & Invention of selector trunking; first use of dial telephones in large exchange (Augusta, Georgia, USA). &  
1896 & Marconi patents wireless telegraph. & YES  
1898 & Earliest use of relays for switch control instead of direct operation of magnets over line wires. First die cast switch frame. &  
30 December 1899 & American Bell Telephone Company is purchased by its own long-distance subsidiary, American Telephone and Telegraph (AT&T) to bypass state regulations limiting capitalisation. AT&T assumes leadership role of the Bell System. &  
1899 & Strowger Automatic goes abroad (Berlin, Germany). Earliest use of automatic trunk selection with busy test. &  
1899 & Loading Coil theory developed independently by Michael Pupin and George Campbell. &  
1900 & John J. Carty, Chief Engineer of NY Tel (and later AT&T), installs loading coils, invented by Michael Pupin, to extend range and utilises open wire transposition to reduce crosstalk an inductive pickup from ac transmission lines. AT&T paid Pupin $255000 for the use of his patent. There are now about 20000 telcos in business. There are now 856000 telephones in service. &  
1900 & 676733 Bell telephone stations owned and connected. &  
1900 & Basic trunking principles established for large exchanges.  Bank terminals molded in plaster of Paris. &  
25 December 1900 & John W. Atkins, the manager at International Ocean Telegraph Company (IOTC), a subsidiary of Western Union Telegraph Company made the first international telephone call over telegraph cable at 09:55am from his office in Key West to Havana, Cuba. Atkins was reported in the Florida Times Union and Citizen as saying, “For a long time there was no sound, except the roar heard at night sometimes, caused by electric light current.” He continued calling Cuba and finally came back the words, clear and distinct: “I don’t understand you.” & YES  
27 February 1901 & United States Court of Appeal declares void Emile Berliner’s patent for a telephone transmitter used by the Bell telephone system &  
1901 & Formation of Automatic Electric Company to take over Strowger Automatic Telephone Exchange.  Installation at Fall River, Mass., used line banks with fiber insulators and aluminum fillers.  First use of slip multiple. &  
1901 & Guglielmo Marconi transmits first trans-Atlantic radio message (from Cape Cod) on 12th December. & YES  
1902 & First conversation by long distance underground cable, 10 miles - New York to Newark. &  
1902 & First installation in Chicago begun. Earliest use of measured service in automatic exchanges. &  
1902 & Poulsen-Arc Radio Transmitter invented. &  
1902 & The first Australian interstate calls between Mt Gambier and Nelson. &  
1903 & Large Strowger installations placed in service in Grand Rapids, Dayton, Akron, Columbus. &  
1903 & AIEE Committee on Telegraphy and Telephony formed. &  
1904 & First use of multi-office trunking, and connections between automatic and manual offices (Los Angeles, Califonia). &  
1904 & John Ambrose Fleming invents the two-element “Fleming Valve”. &  
1905 & Earliest extended use of party lines and reverting calls.  First system using common battery talking (South Bend, Indiana). &  
1905 & Marconi patents his directive horizontal antenna. &  
1906 & Lee deForest invents the vacuum tube. & YES  
1906 & Conversation by underground cable, 90 miles-New York to Philadelphia. &  
1906 & Invention of Keith Line Switch, resulting in enormous reduction in cost of automatic boards. First used at Wilmington, Delaware. & YES  
1906 & Dr. Lee de Forest reads a paper before an AIEE meeting on the Audion, first of the vacuum tubes that would make long distance radiotelephony possible. Reginald Fessenden broadcasts Christmas Carols on Christmas Eve from Brant Rock, MA. & YES  
1907 & States start to regulate telcos. Mississippi was among the first. (The idea of regulation goes back several centuries, when in England, innkeepers were required to post their charges to prevent gouging. “Common carrier” regulation refers to government approval of tariffs filed by railroads, truck lines, telcos, etc which provide the terms and conditions whereby the public can make use of their services. &  
1907 & Theodore Vail returns as President of AT&T (and Western Union). He is responsible for the concept of “end-to-end” service that guided AT&T and other telcos in providing the C.O., transmission systems, and CPE that lasted until the Carterphone and Specialized Common Carrier Decisions. &  
1907 & First installation in Canada (Edmonton, Alta.).  Invention of small dial and two-wire system eliminating ground at subscribers station. &  
1907 & The world’s first transatlantic commercial wireless services is established by Marconi with stations at Clifden, Ireland and Glace Bay, Nova Scotia. &  
1908 & AT&T gains control of Western Union. Divests itself of Western Union in 1913. &  
1908 & First two-wire system (large dial) installed at Pontiac, Illinois. Earliest use of automatic, intermittent ringing.  Installation at Lansing, Michigan.  Features use of small dial, secondary line switch, and 200-point selectors and connectors. &  
1909 & Western Union and AT&T are closely locked. &  
1909 & Invention of out-going secondary line switch, resulting in economy of inter-office trunks.  First used at San Francisco. &  
1909 & Marconi shares the Nobel Prize in Physics, with Karl Ferdinand Braun for their work in the development of wireless telegraphy. &  
1910 & Peter DeBye in Holland, develops theory for optical waveguides. He was a few years ahead of his time. Interstate Commerce Commission starts to regulate telcos. &  
1910 & The Mann-Elkins Act enacted, putting interstate communications under the purview of the Interstate Commerce commission (ICC) &  
1910 & 5142692 Bell telephone stations owned and connected. &  
1910 & Strowger system introduced in Hawaii and Cuba. Earliest use of dialing over toll lines.  Introduction of revertive ringing tone. &  
1910 & The first commercial radios are sold by Lee de Forest’s Radio Telephone Company. &  
1911 & Conversation by overhead line: 2100 miles, from New York to Denver. &  
1911 & Formation of Automatic Telephone Manufacturing Co., Ltd. For production of Strowger system in England. &  
1911 & Using loading coils properly spaced in the line, the transmission distance for telephone reaches from New York to Denver. &  
1912 & First Strowger installation in England (Epsom Official Switch). &  
1913 & The Kingsbury Agreement. Mr. Kingsbury was an AT&T vice president. In his famous letter to the U.S. Government, AT&T agrees to divest its holdings of Western Union, stop acquisition of other telcos, and permit other telcos to interconnect. &  
1913 & The Kingsbury Commitment precludes un-approved expansion, and permits connections to network. &  
1913 & The U.S. Justice Department filed its first antitrust suit against Bell, charging an unlawful combination to monopolise transmission of telephone service in the Pacific Northwest. &  
1913 & Conversation by overhead line: 2600 miles, from New York to Salt Lake City. Conversation by underground cable: 455 miles, from Boston to Washington. &  
1913 & Strowger system introduced in Australia and New Zealand. Development of key-type impulse sender, and Simplex dialing on toll lines. &  
1914 & Underground cables link Boston, NYC and Washington. &  
1914 (February 26) & Boston-Washington underground telephone cable placed in commercial service. &  
1914 & Automatic Switches used as traffic distributors in manual exchanges (Indianapolis, Indiana and Defiance, Ohio). &  
1914 & The last pole of the transcontinental telephone line is placed in Wendover, Utah, on the Nevada-Utah state line. &  
1915 & E.T. Whitaker develops the sampling theorem that forms the basis of today’s PCM and TCM technologies. & YES  
16 January 1915 & The first automatic Panel exchange was installed at the Mulberry Central Office in Newark, New Jersey; but was a semi-automatic system using non-dial telephones. &  
25 January 1915 & First U.S. transcontinental telephone call (3600 miles), with Thomas Augustus Watson at 333 Grant Avenue in San Francisco receiving a call from Alexander Graham Bell at 15 Dey Street in New York City, facilitated by Harold Arnold’s newly invented vacuum tube amplifier. In opening the service at 4pm, EST, Bell, in New York, repeated his famous first telephone sentence to his former assistant, Mr.Watson, who was in San Francisco, “Mr. Watson, come here, I want you.” Watson replied, “If you want me, it will take me almost a week to get there.” & YES  
1915 (October 21) & First transmission of speech across the Atlantic by radiotelephone, from Arlington, Va. to Paris, France. & YES  
1915 & First conversation by transcontinental line, 3650 miles-Boston to San Francisco. Speed transmitted for the first time by radio telephone from Arlington, Va., across the continent to San Francisco, over the Pacific to the Hawaiian Islands, and across the Atlantic to Paris. & YES  
1915 & Development of modern covered switch with horizontal relays used at St. Paul and Minneapolis.  First use of cast iron switch frame at Hazelton, Pennsylvania. &  
1916 & Earliest community automatic exchange network installed in Wisconsin. &  
1917 & Rapid expansion in the use of private automatic branch exchanges. Development of remote alarm equipment for unattended exchanges. &  
1918 & First installation of carrier circuits, based on work by George Campbell. & YES  
1918 & First installation using rotary primary line switches (Elyria, Ohio). &  
1918 & Edwin Armstrong develops a receiving circuit - the superheterodyne. &  
1919 & Radio Corporation of America (RCA) is formed. &  
1919 & The first rotary dial telephones using Strowger boards installed in the Bell System in Norfolk, Virginia. Telephones that lacked dials and touch-tone pads were no longer made by the Bell System after 1978. & YES  
1919 & AT&T conducts more than 4000 measurements of people’s heads to gauge the best dimensions of standard headsets so that callers’ lips would be near the microphone when holding handsets up to their ears. &  
1920 & Bell introduces its own step-by-step offices that were previously acquired from Automatic Electric. G. Valensi develops the time domain multiplexing concept. &  
1920 (July 16) & World’s first radiotelephone service, between Los Angeles and Santa Catalina Island, opened to the public. & YES  
1920 & 11795747 Bell telephone stations owned and connected. &  
1920 & Beginning of wide-spread adoption of Strowger equipment for metropolitan areas both in the U.S. and abroad. First installation of call-indicator equipment for automatic-manual connections in multi-office areas. &  
1920 & 2 November: the first regular commercial radio broadcasts begin when AM station KDKA of Pittsburgh delivers results of the Harding-Cox election to its listeners. Radio experiences immediate success; by the end of 1922, 563 other licensed stations will join KDKA. & YES  
1921 & The Willis-Graham Act allows telcos to merge with permission of the States and the Interstate Commerce Commission. &  
1921 (April 11) & Opening of deep sea cable: 115 miles, Key West, Florida, to Havana, Cuba. Followed by first conversation between Havana, Cuba, and Catalina Island by submarine cable, overhead and underground lines and radio telephone-distance 5500 miles. Extension of Boston - Philadelphia cable to Pittsburgh - total distance 621 miles. President Harding’s inaugural address delivered by loud speaker to more than 100000 people. Armistice Bay exercises at burial of unknown soldier delivered by means of Bell loud speaker and long lines to more than 150000 people in Arlington, Va., New York and San Francisco. &  
1921 & Wirephoto - The first electronically-transmitted photograph is sent by Western Union. The idea for a facsimile transmission was first proposed by Scottish clockmaker Alexander Bain in 1843. & YES  
1921 & First radio broadcast of a sporting event (Dempsey/Carpentier Heavyweight Championship Prize Fight, 2 July). &  
1922 & Ship-to-shore conversation by wire and wireless between Bell telephones in homes and offices and the S. S. America 400 miles at sea in the Atlantic. & YES  
1922 & Introduction of improved steel wall telephones and improved desk stands (Type 21). &  
1922 & Alexander Graham Bell dies at his summer home in Beinn Breagh, near Baddeck, Cape Breton Island, Nova Scotia (August 2). Telephone service is suspended for one minute (6:25pm-6:26pm) on the entire telephone system in the United States and Canada during the funeral service (4 August). British Broadcasting Corporation (BBC) is formed. (Royal Charter received in 1927). &  
1923 (June 7) & Radio broadcasting networks had their beginning with a hook-up of four radio stations by long distance telephone lines. & YES  
22 December 1923 & Opening of second transcontinental telephone line via a southern route. &  
1923 & 14050565 Bell telephone stations owned and connected.  Successful demonstration of transoceanic radio telephony from a Bell telephone station in New York City to a group of scientists and journalists in New Southgate, England. & YES  
1923 & First British Post Office announces adoption of Strowger system (with Director) for London. &  
1923 & Meetings at New York and Chicago of the American Institute of Electrical Engineers (AIEE) are linked by long distance lines connected to loudspeakers so that both meetings could follow the same program (14 February). &  
1924 & AT&T offers Teletype system. & YES  
1924 & Strowger exchange installed throughout Canal Zone. First Strowger Directors installed in Havana. &  
1924 & Directive short wave antenna is developed by Professor Hidetsugu Yagi and his assistant, Shintaro Uda. &  
1925 & Bell Telephone Laboratories founded. 1.5 million dial telephones in service out of 12 million phones in service. & YES  
1925 (1 October) & Opening of long distance telephone cable, New York to Chicago. &  
1925 & Introduction of the Monophone first hand set telephone of modern type. &  
1925 & The Combined Line and Recording (CLR) method of handling toll calls over long distances (100 miles or more) is introduced experimentally by Bell Systems. It reduces the handling of toll calls from 13 minutes (in 1920) to 7 minutes. &  
1926 & Inauguration of the direct stock ticker circuit from New York to San Francisco. &  
1926 & Baird in Scotland and Jenkins in the U.S. demonstrate TV using neon bulbs and mechanical scanning disks. P.M. Rainey at Western Electric patents the PCM methodology. & YES  
1926 & Introduction of the Type 24 Dial modern, quiet-running, long-life calling device. Strowger system adopted by Japan. &  
7 March 1926 & First transatlantic telephone call, from London to New York. & YES  
7 January 1927 & Transatlantic telephone service inaugurated for commercial service via radiotelephony (3500 miles). & YES  
17 January 1927 & Opening of third transcontinental telephone line via a northern route. &  
7 April 1927 & World’s first videophone call via an electro-mechanical AT&T unit, from Washington, D.C. to New York City, by then-Commerce Secretary Herbert Hoover. &  
1927 & First Director installation in London. Introduction of line switch with self-aligning plunger. &  
1927 & Television - Philo Farnsworth demonstrates his Television to potential investors by broadcasting the image of a dollar sign. Farnsworth receives backing and applies for a patent, but ongoing patent battles with RCA will prevent Farnsworth from earning his share of the million-dollar industry this invention will create. &  
1927 & First public demonstration of long distance transmission of television. Formal opening of telephone service between the US and Mexico, and also, Mexico to London, via New York. & YES  
1928 & Zworykin files patents on electronic scanning TV using the iconoscope. &  
1928 & First extended use of Strowger 200-point Line finder. Introduction of improved Monophone designs. &  
1928 & A joint meeting of the AIEE and the British IEE is held over radiotelephone channels, with the respective groups assembled in New York and London. &  
8 December 1929 & Opening of commercial ship-to-shore telephone service. & YES  
1929 & Broadband coaxial cable invented by Lloyd Espenschied and Herman Affel. & YES  
1929 & U.S. Navy begins use of Strowger equipment. Monophones made available in colour. &  
1930 & AT&T introduces much higher quality insulated wire. &  
1930 (April 3) & Opening of transoceanic telephone service to Argentina, Chile and Uruguay and subsequently to all other South American countries. & YES  
1930 & Development of new small switchboards of unit type. Networks of small Strowger exchanges installed in Italy. &  
1930 & High-speed tickers can print 500 words per minute. &  
1931 & Development of Strowger Remote Toll Board. First installed in Elyria, Ohio. &  
1931 & Radio Astronomy - While trying to track down a source of electrical interference on telephone transmissions, Karl Guthe Jansky of Bell Telephone Laboratories discovers radio waves emanating from stars in outer space. & YES  
1931 & AT&T inaugurates the Teletypewriter Exchange Service (TWX) November 21. &  
1932 & Development of unattended private automatic branch exchanges. Two-line Monophones introduced. &  
1933 & New small private automatic exchanges introduced. &  
1933 & Edwin Armstrong demonstrates frequency modulation (FM) to Sarnoff. &  
1934 & Congress passes Communications Act of 1934, with a goal of universal service at reasonable charges as its key tenet. Federal Communications Commission founded. Combined functions of RF spectrum allocation previously handled by the Federal Radio Commission and interstate regulation for common carriers. Introduced “value-of-service” pricing which required the subsidisation of residential subscribers to speed the availability of nationwide telephone service. & YES  
1934 & Introduction of new self-contained desk Monophone molded in bakelite (Type 34A3). &  
1935 (April 25) & First around-the-world telephone conversation by wire and radio. About 6700 telcos in operation. & YES  
1935 & New all positions transmitter. New bakelite wall Monophone (Type 35A5). &  
1935 & Western Union’s “Telefax” begins operating. Telefax sent telegrams, manuscripts, line drawings, maps and page proofs for magazines. &  
1936 & Small, compact community automatic exchanges introduced. &  
1936 & BBC begins regular television service. & YES  
1936 & Invention of coaxial cable is announced at a joint meeting of the American Physical Society and the IRE (April 30). & YES  
1937 & Bell introduces the Model 300 improved handset. &  
1937 & The Western Electric type 302 telephone becomes available for service in the United States. &  
8 December 1937 & Opening of fourth transcontinental telephone line. &  
1937 & Seven-hour radio broadcast of the coronation of King George VI and Queen Elizabeth of England. &  
1938 & Bell introduces crossbar central office switches. &  
1938 & The power of radio is demonstrated by Orsen Wells with the broadcast of “War of the Worlds”. This causes telephone traffic to peak in nearly all cities and on long distance lines. & YES  
1939 & WU introduces coast-to-coast fax service. John Atanasoff and Clifford Berry invent the first electronic computer for calculating at the University of Iowa. In 1973 a judge ruled in a patent infringement suit that their research was the source of most of the ideas for the modern computer, but it was not programmable or Turing complete. & YES  
1939 & The Golden Gate Exposition (San Francisco) and New York Worlds Fair are opened. These exhibit the newest technologies, including the Voder (synthesised speech) and television. FM is used by Bell Laboratories in a radio altimeter that uses signal reflections from the surface of the earth. &  
1940 (June 24) & Television transmitted over coaxial cable from Convention Hall in Philadelphia to television studio in Radio City, New York. &  
1940 & FM Police Radio Communications begin in Hartford, CT. &  
1941 & Multi-frequency dialing introduced for operators in Baltimore, Maryland &  
1941 & First U.S. commercial coaxial cable installation, Minneapolis, Minnesota to Stevens Point, Wisconsin. &  
1941 & Konrad Zuse in Germany develops the first programmable calculator using binary numbers and boolean logic. & YES  
1941 & The Japanese attack on Pearl Harbor affects the telephone system of the United States by causing tremendous traffic peaks in all cities, and an increase from 100 to 400 percent in long distance telephoning - which already is at a record high of 3 million messages. (The United States would again experience this phenomenon in 2001, during the 11 September attacks.)  Radar successfully detects the attack on Pearl Harbor, but the warnings are ignored. &  
1942 (December 21) & Opening of first all-cable transcontinental telephone line with completion of buried cable, connecting existing cable systems of East and West. &  
1942 & The first section of telephone line is completed along the Alcan Highway, from Edmonton, Alberta, to Dawson Creek, British Columbia. The Alcan Highway begins at Dawson Creek. &  
1942 & Telephone production is halted at Western Electric until 1945 for civilian distribution due to the retooling of factories for military equipment during WWII. &  
1943 & Philadelphia is the last city to have telephone service supplied by different local carriers (until later deregulatory moves by the U.S. Congress and the FCC). Western Union and Postal Telegraph permitted to merge. &  
1943 (August 22) & First equipment for the dialing of called telephone numbers in distant cities directly by the operator placed in service in Philadelphia. & YES  
1943 & Construction of a telephone line from Calcutta, India to Kunming, China, along Stilwell Road, begins at Ledo, Assam. &  
1944 & A telephone submarine cable is laid across the English Channel. &  
1945 & AT&T lays 2000 miles of coaxial cable. &  
1945 & Arthur C. Clarke proposes communications satellites. & YES  
1945 & Western Union installs the first commercial radio beam system. & YES  
1945 & Western Union and Postal Telegraph Company merge. &  
1946 & AT&T televises Army-Navy game in Philadelphia and transmits it to NYC &  
1946 & AT&T has 8 VF channels on microwave from Catalina Island to Los Angeles. Raytheon has a microwave link transmitting audio from WQXR in NYC to Boston. &  
1946 & FCC’s Recording Devices Docket required telcos to furnish connecting arrangements for conversation recorders. The use of “beep tones” required when conversations are recorded. &  
1946 (February 12) & New York to Washington co-axial cable circuits opened for television transmission on an experimental basis. &  
1946 (June 17) & Opening of experimental mobile radiotelephone service in St. Louis. & YES  
1946 & Mobile telephone service is placed into commercial use in St. Louis, Missouri. The beam traveling-wave tube is announced by Bell Telephone Laboratories. This tube is an important amplifier for broadband communication. & YES  
1946 & National Numbering Plan (area codes) &  
1947 & Bell Telephone Laboratories has a 96-channel PCM experimental system working between Murray Hill, N.J. and NYC and quickly discovers the need for repeaters for long-distance service. & YES  
1947 (August 15) & Opening of commercial telephone service for passengers on certain trains running between New York and Washington, D.C. & YES  
1947 (Nov. 13) & Opening of New York-Boston radio relay system for experimental service. This is the first microwave relay system in the telephone network. &  
1947 & Invention of the germanium point contact transistor by Brattain and Bardeen at Bell Telephone Laboratories (December 23). The following year they develop the alloy junction germanium transistor. & YES  
1947 & December, W. Rae Young and Douglas H. Ring, Bell Labs engineers, proposed hexagonal cells for provisioning of mobile telephone service. Demonstration of mobile telephone equipment from a United Airlines plane to ground stations. & YES  
1948 & Phil Porter, a Bell Labs engineer, proposed that cell towers be at the corners of the hexagons rather than the centers and have directional antennas pointing in 3 directions. &  
1948 & The Hush-A-Phone case begins. The Hush-A-Phone Corp. had developed and was marketing a cup-like device placed on a phone’s mouthpiece to increase privacy of conversations. The Bell System complained to the FCC about this “foreign attachment.” &  
1948 & Invention of the junction transistor. & YES  
30 June 1948 & First public demonstration of the transistor by Bell Telephone Laboratories. &  
1949 & AT&T introduces the famous black rotary Model 500 telephone. & YES  
1949 & Bell Labs publishes Shannon’s seminal theory of relay logic that is critical in the development of modern computers. & YES  
1949 & FCC’s Jordaphone Docket (1949 - 1954). A precursor to Part 68. Jordaphone and three other manufacturers of answering machines sought FCC approval for their use on telco lines. The FCC decision left the matter to the states as only about 1% of telephone calls at that time were interstate. Commissioner Frieda Hennock filed her opposition in favour of the petitioners. &  
1949 & Justice Department files antitrust suit against AT&T. The Department wanted Bell to divest Western Electric, and to separate regulated monopoly services and unregulated equipment supply, among other actions. & YES  
1949 (October 17) & Dialing of transcontinental telephone calls by operators started with the joining of toll dialing networks on East and West coasts. &  
1949 & The volume of telephone calls reaches 180 million a day. &  
1950 & The Western Electric Type 500 telephone becomes available in the United States after announcement in 1949. &  
1950 (Sept. 30) & Television network facilities extended to include 72 television stations in 42 cities, making television available to one half of the United States’ population. &  
10 November 1951 & Direct Distance Dialing (DDD) first offered on trial basis at Englewood, New Jersey, to 11 selected major cities across the United States; this service grew rapidly across major cities during the 1950s &  
1952 & The first database was implemented on RCA’s Bizmac computer. Reynold Johnson, an IBM engineer, developed a massive hard disk consisting of fifty platters, each two feet wide, that rotated on a spindle at 1200 rpm with read/write heads. These were called “jukeboxes”. & YES  
1953 & John Pierce proposes deep space communication. &  
1954 & Gene Amdahl developed the first computer operating system for the IBM 704. Sony introduces the first transistor radio that sold for $49.95. Raytheon introduces the transistor for hearing aids replacing its line of subminiature tubes. Zenith’s highly successful hearing aids using subminiature tubes, about the size of a pack of cigarettes with a separate battery pack sold for about $25.0. The new transistor hearing aids reduced the size of the electronic package to about the size of a box of matches with an internal battery and sold for about $100. The first in-the-ear hearing aids appeared about 1955-1956. &  
1954 & US Air Force’s SAGE system sets precedent for computer communications, including use of modems. & YES  
1955 & The laying of trans-Atlantic cable TAT-1 began - 36 circuits, later increased to 48 by reducing the bandwidth from 4 kHz to 3 kHz & YES  
1955 & According to Ken Krechmer, A.W. Morten and H.E. Vaughan describe the development of a real modem in their BSTJ paper, “Transmission of Digital Information over Telephone Circuits”, May 1955. Reynold Johnson at IBM develops the first disk drive. &  
1955 & Recorded announcements of disconnected and changed numbers begin to be used in some small dial offices. &  
1956 & AT&T’s Consent Decree. In 1949, the Department of Justice wanted AT&T to divest itself of Western Electric. The court ignored the Department of Justice’s request. Instead, as the result of the Consent Decree, AT&T got to keep WE; however, it could only stay in the field of telecommunications and it had to license its patents to others. & YES  
1956 & The Hush-A-Phone case was decided in favor of Hush-A-Phone Corp. It establishes that harmless non-Bell equipment may be attached to the network. Hush-a-Phone permitted the use of acoustically and/or inductively coupled answering machines, such as Jordaphone, and also fax machines. Previously, AT&T permitted only Government and newspaper wire services to connect fax machines and wire photo equipment. & YES  
1956 & The Bell System and the British Post Office inaugurates service on the first transatlantic telephone cable, TAT-1, between Newfoundland and Scotland. & YES  
1956 & The 1956 Nobel Prize in Physics is awarded to the inventors of the transistor: Dr. Walter H. Brattain, Dr. John Bardeen and Dr. William Shockley. & YES  
1957 & Soviet Union launches Sputnik, humanity’s first artificial satellite, on 4th October. & YES  
1958 & AT&T introduces datasets (modems) for direct connection. Jack Kilby, Texas Instruments, developed the first integrated circuit. TI introduces the silicon-based transistor which soon eclipsed germaninum devices in production volume. Seymour Cray at Control Data Corporation develops the first transistorized computer, Model 1604. He later uses liquid nitrogen to enhance the speed of CDC’s line of supercomputers. & YES  
1959 & In the Above 890 ruling, the FCC makes available portions of the radio spectrum to private microwave systems. As a result, AT&T introduces the TH-1 1860-channel microwave system. & YES  
1960s & Bell Labs developed the electronics for cellular phones & YES  
1960 & Bell Labs conducts extensive field trial of an electronic switching system at their central office in Morris, Illinois, known at the Morris System. & YES  
1960 & There are now 3299 telephone companies. & YES  
1960 & ECHO I communications satellite is launched on 12 August. Provides first satellite television broadcast of 1962. & YES  
1960 & Laser is invented. & YES  
1961 & Initiation of Touch-Tone service trials &  
1961 & Bell Telephone Labs release design information for the touch-tone dial to Western Electric. &  
1961 & Len Kleinrock of MIT publishes “Information Flow in Large Communication Nets”, considered a seminal paper on packet-switching theory. & YES  
1962 & Western Union offers Telex for international teleprinting. &  
1962 & AT&T introduces T-1 multiplex service (the first digital transmission system) in Skokie, IL. Telephone cables now start to use plastic insulation. Paul Baron of RAND introduces the idea of distributed packet-switching networks. & YES  
1962 & Comsat formed. American Broadcasting Company requests FCC to allow domestic satellites to distribute TV programs. Approximately 10000 computers are in service. &  
1962 & United States Congress passes the Communications Satellite Act. T1 carrier is put into commercial service. The first transatlantic transmission of a TV signal via the TELSTAR satellite. (July 11).  EES Electronic Switching Systems is introduced. & YES  
1963 & Microwave Communications Inc. (MCI) filed an application with the FCC to offer specialized voice and data services over a microwave system it planned to build between Chicago and St. Louis. &  
1963 & AIEE and IRE merge to form IEEE (January 1).  Paul Baran of RAND publishes “On Distributed Communications Networks,” outlining the operations of packet-switching networks capable of surviving node outages. NASA announces that the new Syncom II communications satellite has been used successfully to transmit voices live between the U.S. and Africa. At the time of the conversations, Syncom II hovers 22000 miles over Brazil. The satellite is the first successful synchronous satellite. This mean that the satellite’s revolution matches the daily revolution of the earth about its axis, so that the satellite seems to remain “stationary” over the same earth location. A telephone hotline connects Soviet and American leaders (August 30). & YES  
1963 & BBN develops the first modem. &  
1963, November 18 & AT&T commences the first subscriber Touch-Tone service in the towns of Carnegie and Greensburg, Pennsylvania, using push-button telephones that replaced rotary dial instruments. & YES  
1964 & IBM releases its famous Model 360 computer that eventually led to $100 billion in sales over its life cycle. George Heilmeier, at RCA’s research labs, invents the liquid crystal display. Douglas Englebart at SRI patented the idea of the mouse. & YES  
1964 & An improved stock ticker tape machine (designed, developed and manufactured by Teletype Corporation) is placed into service at the New York Stock Exchange. The ticker, which transmits stock prices to brokerage houses nearly twice as fast as the previous system, has a capacity of ten million shares a day without incurring delays. (June 22).  IEEE Group on Communication Technology is formed. (July 1) &  
1965 (May 31) & AT&T introduces stored program controlled switching. The world’s first electronic switching system commences commercial service in Succasunna, New Jersey in form of the 1ESS. & YES  
1965 & There are now 2421 telephone companies. &  
1965 & Charles Kao conceives of using light sent over glass fibers as a transmission medium. He works with G. A. Hackham and publishes an influential paper on fiber optics. & YES  
1965 & The first commercial communications satellite, Early Bird, later named Intelsat 1, is launched into orbit from Cape Kennedy and provides 240 circuits or one TV signal. The 85-pound satellite is a synchronous satellite, matching the earth’s rotation to hover over the same spot all the time (April 6). The Soviet Union launches its first communications satellite and carried out transmissions of television programs. The satellite is named “Molniya 1”, which translates to “Lightning 1”. (April 23). & YES  
1966 & Tom Carter sues AT&T to permit connection of his phone patch. Court remands the case to FCC. (One writer stated Tom Carter filed for $1.25 million damages and received $300K. His original complaint had been filed in 1958) &  
1966 & Suggestions made by Kao and Hockham that optical fiber could be used for long distance transmission. & YES  
1966 & Lawrence G. Roberts of MIT publishes “Towards a Cooperative Network of Time-Shared Computers” which outlines the ARPANET plan. Worldwide direct telephone dialing has its first public demonstration, a call from Philadelphia to Geneva, Switzerland. (June 15). & YES  
1967 & Bell Laboratories announces a new solid-state source of high frequency radio waves. The “LSA diodes” emitted millimeter waves, a part of the radio frequency range that could carry about nine times more telephone calls than all lower frequencies combined. An LSA diode and its power supply is about as large as a deck of cards. (February 15). An experimental cordless extension telephone is introduced by Bell Laboratories (June 30). & YES  
1968 & FCC approves Carterphone Decision. AT&T ordered to revise tariffs effective 1/1/69 to permit connection of CPE. (It took about 10 years of legal action to get Part 68 of the FCC rules in place and operational by 1978). AT&T starts development of the Integrated Digital Services Network (ISDN). Gary Englehart at Stanford Research Institute demonstrates the first combination of a keyboard, keypad, mouse, windows and word processor. Dan Noble, IBM, developed the 8-inch floppy disk. Its capacity increased from 33K in 1971 to 1200K in 1977. AT&T starts 56 Kbps service. Pieter Kramer (Philips) invents the compact disk. & YES  
1968 & FCC’s Carterfone decision permits interconnections of non-Bell equipment to telephone lines. &  
1968 & FCC starts proceeding to set aside spectrum for land mobile communications. & YES  
1968 & Bell System adopts the use of “911” as a nationwide emergency telephone number (January 12). Huntington, Indiana became the first U.S. city served by the Bell System to receive the new universal emergency telephone number “911”. (March 1). &  
1969 & FCC asks National Academy of Science to recommend an interconnection policy. The Department of Defense initiates the ARPANet, which led to the development of Internet. Initially computers at Stanford University and UCLA are connected. & YES  
1969 & In its MCI decision, the commission authorises MCI to build and operate private line facilities between St. Louis and Chicago. &  
1969 & ARPANET begins 4-node operation (UCLA, Stanford Research Institute (SRI), UC Santa Barbara and University of Utah) &  
1969 & Video and Audio are transmitted back from the first Moon landing (July 20). UNIX Operating System is developed. & YES  
1970 & AT&T introduces its ESS#2 electronic switch. Intel introduces its popular 4004 4-bit microprocessor which starts the evolution of Intel’s famous line of 386, 486 and Pentium processors. There are now 1841 telephone companies. AT&T permitted to sell its teletype (TWX) service to Western Union. FCC approves the Domestic Satellite Order (which was nine years in the making). &  
1970 & Amos E. Joel, Jr. of Bell Labs invented the “call handoff” system for “cellular mobile communication system” (patent granted 1972). & YES  
1970 & Bell Telephone Labs release design information to Western Electric for the production of Modular Telephone Cords and Jacks. &  
1970 & Corning Glass demonstrate highly transparent fibers, and Bell Laboratories demonstrates semiconductor lasers that could operate at room temperature; these demonstrations help establish the feasibility of fiber-optic communications. & YES  
1971 & AT&T submitted a proposal for cellular phone service to the U.S. Federal Communications Commission (FCC). & YES  
1971 & The NAS Report recommended that an equipment certification program could be established to prevent harm to the network caused by hazardous voltages, excessive signal power, improper network control signaling and line imbalance. FCC establishes the PBX and Dialer and Answering Devices Committees to recommend certification standards based on the NAS Report. Satellite decision nine (Western Union wanted to make use of excess CO computer capacity to do data processing. This decision led to procedures to assure no cross-subsidisation between regulated and unregulated activities.) Gary Starkweather, Xerox, patents first laser printer. A couple of years later HP and Canon jointly introduce the first commercial laser printers. FCC establishes the PBX Advisory Committee and the Dialer and Answering Devices Committee and were terminated on the approval of Part 68. The PBX Committee’s report was turned over to EIA where it eventually as a voluntary standard, 470. The Dialer and Answering Devices meetings were so contentious that no report was published. The Specialised Common Carrier Decision allowed MCI to get its private line service started over its St. Louis - Chicago route. &  
1971 & The Intelsat IV communications satellite goes into commercial operation. Initially it has 830 circuits in service and linked ground stations in 15 countries. The DUV (Data Under Voice) is introduced. It permits signals to “hitch-hike” on existing microwave radio systems by using the lower end of the frequency band not normally used for voice. Ray Tomlinson writes the first email program. The @ sign is used for the first time in an email address. & YES  
1972 & IEEE Communications Society is established on 1 January.  Jon Postel writes the specifications for Telnet. IEEE Proceedings publishes its first issue on computer communications. Guest Editors are Paul Green and Robert Lucky. A demonstration of the ARPANET at the 1972 IEEE International Conference on Computer Communications. &  
1973 & Docket 19419 on Pricing of Datasets opened up the necessary technical background for Docket 19528 which led to the development of Part 68. This docket also established a Federal-State Joint Board. A two-week cross-examination of Larry Hohmann, AT&T’s Director of Engineering by FCC attorney Michael Slomin provides much of the technical information that led to Part 68 of the FCC’s Rules. The Joint Board’s recommendations were adopted in part. A companion docket covered standardisation of physical connectors needed for the interconnection program proceeded in parallel. In Docket 19808, the Telerent Decision, the Commission permitted states to have their own interconnection programs so long as they were no more stringent than the Federal program. This decision was appealed twice to the 4th Circuit Court then went all the way to the Supreme Court for final approval. (As a result telcos when they want to initiate a special intrastate service must file a tariff for the service and a “network disclosure” document that clearly identifies service and equipment requirements.) Docket 20003 was an economic study prepared by the Commission for Congress to show estimated economic effects of permitting private ownership of telephone terminal equipment an permitting competition in interstate telecommunications. &  
1973 & Bell Telephone Labs released design information to Western Electric for production of the Com-Key 416, the first KTU-less key system which was less susceptible to damage caused by lightning storms. &  
1973 & Robert Metcalfe invents Ethernet at Xerox PARC. Ethernet uses a cable rather than a radio channel as the transmission medium. The “Touch-a-matic” telephone is introduced. It can automatically dial a call anywhere in the U.S. at the touch of a single button. Its solid-state memory allows dialing up to 32 pre-coded telephone numbers. Construction of a new, high-capacity coaxial cable system, called L5, is completed between Pittsburgh and St. Louis. It has the capacity of carrying 108000 simultaneous telephone conversations, three times the capacity of any previous system. File Transfer Protocol (FTP) is introduced. & YES  
1973 & Packet switched voice connections over ARPANET with Network Voice Protocol (NVP). & YES  
3 April 1973 & Motorola employee Martin Cooper placed the first hand-held cell phone call to Joel Engel, head of research at AT&T’s Bell Labs, while talking on the first Motorola DynaTAC prototype. & YES  
1974 & First domestic satellites in operation. Western Union places Westar satellite in operation. AT&T introduces the digital subsriber loop. BBN opens the first public packet-switched network. The Department of Justice files its antitrust suit against AT&T. The Consent Decree, resulting therefrom, required AT&T to divest itself of the 24 Bell Operating Companies by 1984. Value-added (packet-switched networks) come on the scene. & YES  
1974 & Vinton Cerf and Robert Kahn publish “A Protocol for Packet Network Interconnection”, in IEEE Communications Magazine, which outlines design of a Transmission Control Program (TCP). This discusses connecting networks together to forn an “internet”. Western Union launches Westar, the nation’s first domestic communications satellite. New York Telephone inaugurated Dial-A-Joke, an addition to the recorded announcement field. During the first month of operation, more than 100000 calls a day are made to the number. & YES  
1975 & Summary of 1975: There are now 1618 telcos and 140 million phones in the U.S. Bell companies supply 85% of the lines; GTE: 10%. Smallest telco had 19 subscribers. About this time the last manual telco switchboard in Maine is retired. &  
1975 & Bell Telephone Laboratories released production design information to Western Electric for electronic key systems. &  
1975 & The First Report and Order in Docket 19528 led to Part 68 of FCC rules. A court stay was lifted on June 16, 1976 to permit the registration program to go into effect for toll restrictors, answering machines and data modems. Popular Electronics features the MITS Altair 8800 computer which is considered the first personal computer. Fiber optics being trialed in the U.S. and Europe. FCC’s Docket 20099 meetings from 1974 through 1983 establishes carrier-to-carrier interconnection standards. After the breakup of the Bell System, this activity was taken over by the Exchange Carriers Standards Association, later known as the Alliance for Telecommmunications Industry Solutions (ATIS). Docket 20774 establishes standard plugs and jacks for the registration program. & YES  
1975 & Bolt, Beranek and Newman (BBN) opens Telenet, the first public packet data service. Viking is launched. Lands on Mars in 1976 and sends back data to Earth. Transmission testing begins on the T4M, highest-capacity, short-haul digital transmission system in the U.S. The new system, linking Newark, NJ to New York City, transmits 274 million “bits” of information per second over a single coaxial tube. & YES  
1976 & Kazuo Hashimoto invents Caller ID & YES  
1976 & Digital radio and time division switching introduced. Alan Shugart, IBM, introduced the 5.25-in floppy in 1976. (Much later, in 1987, SONY introduced the 3.5“ floppy). Floppies were first introduced with IBM’s PCs when they first came on the market in 1981. The telephone companies support ”The Consumers Communications Reform Act of 1976“ H.R. 12323, which was endorsed by more than 90 members of the House. This proposed legislation would have retained the telephone companies’ monopoly. The FCC counters with its Docket 20003, Economic Implications and Interrelationships Arising from Policies and Practices Relating to Cusotmer Interconnection, Jurisdictional Separations and Rate Structures. Resale and sharing of carrier services permitted. Other Common Carriers (OCCs) now have access to telco Foreign Exchange (FX) and Common Control Switching Arrangement (CCSA) private network facilities. &  
1976 & Centennial of the Telephone. IEEE establishes the Alexander Graham Bell Medal to commemorate the centennial of the telephone’s invention and to provide recognition for outstanding contributions in telecommunications. Amos Joel, William Keister and Raymond Ketchledge are the first recipients. COMSTAR is launched and begins commercial service. It is in permanent orbit over the Galapagos Islands. &  
1977 & The Second Report and Order in Docket 19528 survived challenge in the Court of Appeals 4th Circuit. This item provided rules for telephones, key systems and PBXs. The order was challenged again all the way to the Supreme Court, which permitted the registration program to begin on October 17, 1977. The FCC completed program implementation rules by July 1, 1978 in the Third Report and Order. Registration of phones, KTSs and PBXs begin. MCI wins a court challenge to its Execunet Service which permitted the public to make use of its long distance facilities. &  
1977 & Voyager spacecraft is launched. Sends back signals from Jupiter (1979-1980), Saturn (1981), Uranus (1986) and Neptune (1989).  Bell Laboratories announces the development of the MAC-8, a microprocessor suited for a wide range of telecommunications applications. & YES  
1978 & Bell Labs launched a trial of the first commercial cellular network in Chicago using Advanced Mobile Phone System (AMPS). & YES  
1978 & World’s first NMT phone call in Tampere, Finland. & YES  
1978 & Commission rejects telephone companies’ request for the Primary Instrument Concept in which all subscribers would be required to have at least one phone provided by the telephone company. &  
1978 & TAT-1, the world’s first transoceanic telephone cable was retired (November 27). TCP split into TCP and IP. & YES  
1979 & The Fourth Report and Order established rules regarding equipment-to-equipment connections. Docket 79-143 established rules for analog OPS and tie line equipment. GTE requests FCC to convene a special task group to develop recommendations for inclusion of T-1 services into Part 68. Dan Brinklin, while still in college, introduces the Visicalc spreadsheet which becomes a spectacular success. Docket 79-105 requires telcos to stop capitalising premises wiring and the states set up amortisation schedules for the eventual transfer of premises wiring ownership to the premises owners. &  
1979 & A 62000-mile microwave telecommunications system is completed within Saudi Arabia. &  
1979 & VoIP - NVP running on top of early versions of IP &  
1980 & AT&T introduces the DataSpeed 40, a forerunner of the current generation ”smart terminals“ having the capability of doing various forms of data processing rather than serving solely as input terminal to a computer. This led to the Computer II Decision which came up with a binary test: Was the device for ”basic“ service; or was it for ”enhanced“ service? Enhanced services had three subdivisions: Protocol conversion, data processing, and information retrieval. All of this led to the Computer III Decision and the Open Network Architecture concept in 1989. Digital local offices and optical fiber transmission being deployed. Switching System #7 is being gradually deployed. &  
1980 & First use of the ”900“ number. &  
1981 & BT introduces the British Telephone Sockets system. &  
1981 & Docket 81-216, the ”Omnibus Docket“ was so called because it contained about two dozen items, including make-busy, digital systems, more on premises wiring, party lines, reducing dc on-hook resistance requirements and many more. It took several years to clear all of these items. Hayes introduces its landmark 300-bps modem. IBM introduces its PC in August 1981. &  
1981 & Bell Telephone Labs design of a network-embedded database of Personal Identification Numbers (PINs) for calling card customers to be accessed by public telephones over Signaling System 7. (Today, improved architectures of this kind underlie all Intelligent Network services.) &  
1981 & The world’s first fully automatic mobile phone system NMT is started in Sweden and Norway. This is soon followed by Saudi Arabia. &  
1981 & A new telephone service, DIAL-IT allowed a caller to listen to the voice communications between the Space Shuttle Columbia and the ground command center. & YES  
1982 - (January 8) & Antitrust suit dropped after AT&T accepts government’s proposal. & YES  
1982 & First long-distance, fiber-optic transmission system is installed between New York and Washington, D.C. & YES  
1982 & The first full-color two-way video teleconferencing service is offered. The development of TFM (Time Frequency Multiplexing). &  
1982 & FCC approved AT&T proposal for AMPS and allocated frequencies in the 824-894 MHz band. & YES  
1983 & Last manual telephone switchboard in Maine is retired &  
1983 & In the CBEMA Decision, an outgrowth of the Computer II Decision, the Commission requires telcos to publish a ”Network Disclosure“ statement providing information of interconnection and operability requirements for new services. Carolyn Doughty, Bell Telephone Laboratories, files a patent on Caller ID. &  
1983 & The Cleaved Coupled-Cavity (C3) laser was introduced. The single frequency tunable laser emitted a light so pure that over a billion bits of information per second could be sent through a glass fiber. (April). The first U.S. commercial cellular phone system is introduced in Chicago. (October 13). &  
1984 & Breakup of AT&T (January 1): Court orders divestiture of AT&T based on Department of Justice suit. Fred Henck, publisher of Telecommunications Reports and Bernie Strassburg, retired Chief of the Common Carrier Bureau, in their book covering the divestiture of AT&T estimated that legal fees and settlements cost AT&T more than $5 billion. (A Slippery Slope - The Long Road to the Breakup of AT&T). Another book on this subject is ”The Rape of Ma Bell“. & YES  
1984 & FCC decisions released relative to turning over previously installed premises wiring to premises owners; Congressionally mandated hearing aid-compatibility requirements for ”essential“ phones. FCC permits registration of privately owned ”instrument operated“ coin phones. &  
1984 & IEEE Centennial. Local area signaling service is introduced. The service is used to trace nuisance calls, transfer calls, and provide other advanced calling services. (May 20). AT&T and NASA space shuttle Discovery launch its second Telstar 3 satellite. September 1 - Domain Name Service (DNS) is introduced. DNS is used mostly to translate between domain names and IP addresses, and to control Internet email delivery. & YES  
1984 & AT&T completes the divestiture of its local operating companies. This forms a new AT&T (long distance service and equipment sales) and the Baby Bells. &  
1985 & FCC decisions related to registration of CPE for T-1 and subrate digital services &  
1985 & AT&T Bell Laboratories combine 10 laser beams on a single optical fiber demonstrating the capability of lightwave systems to carry 20 billion bits per second (equal to 300000 telephone calls.)  Symbolics.com is assigned on March 15 to become the first registered domain. & YES  
1986 & FCC decision to phase out line-powered channel service units. The National Science Foundation introduces its 56kbps backbone network. &  
1986 & TAT-3 transatlantic cable is retired (Sept. 1)  An Integrated Services Digital Network (ISDN) is deployed, capable of handling voice, data and video. (December 16). &  
1987 & Ameritech files for registration of switched 56 Kbps digital service CPE. This was integrated with the SW Bell petition to include ISDN in the rules in October of 1991 (It took until 1991 for EIA to develop technical standards for this service). SONY introduces the 3.5-in floppy. Philip Estridge, IBM, developed the first hard drive for PCs. It held 10MB. N.J. Bell is the first to implement Caller ID. &  
1987 & Superconductivity is discovered - the transmission of electricity without resistance through low temperature material. & YES  
1987 & TDD (telecommunications device for the deaf) is initiated. &  
1987 & Bellcore introduces the Asymmetric Digital Subscriber Line (ADSL) concept which has the potential of multimedia transmission over communication network’s copper loops. &  
1988 & Western Union Telegraph Company reorganised as Western Union Corporation. The telecommunications assets were divested and Western Union focuses on money transfers and loan services. & YES  
1988 & U.S. Congress passes the Telecom Trade Act of 1988 in response to alleged dumping of telecom systems in the U.S. by foreign manufacturers. One aspect was the requirement of all imported telecom equipment to comply with all applicable FCC requirements. Enforcement is by U.S. Customs. &  
1988 & FCC issues Docket 88-57, based on an EIA petition for clarification of previous premises wiring policies. (An order was released in 1990 which elicited about ten petitions for reconsideration. The final order was released in June 1997 clearing many outstanding issues) &  
1988 & First transatlantic fiber-optic cable, TAT-8, opens between New Jersey, England and France, carrying 40000 circuits. & YES  
1989 & Congressional decision requiring all new customer-owned phones to be hearing aid compatible. The Computer III Decision leading to the Open Network Architecture concept was to allow unbundled access to all enhanced service providers, everyone receives equal quality and pricing, standard accounting guidelines and to have the BOCs determine what services are needed and how to tariff these services (There were 118 different services proposed; about half of them could be offered and about 20% of the proposed would have to wait for new technology). NSF increases its backbone network from 56kbps to T-1. &  
1990 & Analog AMPS was superseded by Digital AMPS. &  
1990 & AT&T filed a petition to strengthen DID rules for prevention of toll fraud. EIA filed a petition to require digital security coding for cordless phones to prevent random dialing that interfered with 911 operations. Docket 90-313 requiring hotels/motels and coin phones to provide equal access to competing long distance carriers was resolved in 1992. &  
1991 & Docket 91-281 establishing nationwide caller ID went into effect in late 1995. There are a number of related issues yet to be resolved. The Telephone Consumers Protection Act, among other things, required the use of ”fax branding“ to identify the source of incoming faxes. There were a couple of court cases which delayed application of fax branding to PC fax cards until 1995. Southwestern Bell files to include ISDN in Part 68. The final rules for ISDN went into effect on November 13, 1996 (Canada had essentially the same rules in place for the preceding five years). Note that AT&T started development of ISDN about the same time that Part 68 was introduced. &  
1991 & The GSM mobile phone network is started in Finland, with the first phone call in Tampere. &  
1992 & The World Wide Web is born - the brain child of CERN physicist Tim Berners-Lee. Congress required all agencies to metricise their rules. A major impact was on Part 68 plug and jack drawings. The first audio and video multicasts are broadcast over the Internet. & YES  
1993 & Telecom Relay Service (TRS) available for the disabled. The NSF network backbone jumps from T-1 to T-3. The Internet browser MOSAIC is introduced at the University of Illinois. &  
1994 & TRS becomes the fastest growing telecom service in the U.S. The Commission requested comments on technology for location of any station behind a PBX that made an E911 call. There were over 120 responses. The Netscape Internet browser is introduced. Canada, Mexico, and the U.S. sign the NAFTA agreement. NSF is working to build a very high-speed backbone called VBNS. Internet is pretty much world-wide with the exception of most of the African interior, Pakistan, Mongolia, Cuba and some areas in South America and Southeast Asia. Real Audio introduced to Internet which allows one to hear in near real time. Radio HK, the first 24-hr Internet only radio station, starts broadcasting. & YES  
1994 & The IBM Simon becomes the first smartphone on the market. & YES  
1995 & There are more than 33.8 million wireless subscribers, representing approximately 13% of the total U.S. population. &  
1995 & Caller ID implemented nationally in USA &  
1996 & TIA files to harmonise Part 68 with Canada’s CS-03 after working five years with Canada’s TAPAC group, and successfully achieves industry concurrence before filing. Canada approved its version on August 14, 1996. Because of the impact of Congress’ revision of the Telecommunications Act, the FCC was swamped with 80 new rulemakings to be completed by August of 1996, and so approval of the harmonised Part 68/CS-03 was delayed. It was approved on July 30, 1997. The Commission instituted a ”negotiated rulemaking“ procedure for requiring phones in the workplace to be hearing aid compatible. As a result, approval took slightly more than a year and was announced in the Federal Register on August 14, 1996. It was subsequently announced that the industry will form a new group (Lockheed) to administer the new North American numbering plan. A waiver process was adopted that allows manufacturers to register stutter dialtone devices. Currently, there are almost 1400 telcos still in business. In 1996, Digital Equipment Corporation introduced its line of Alpha microprocessors using 64-bit RISC architecture and operating up to 533 Mbps. &  
February 1996 & U.S. Congress passes the 1996 Telecommunications Act which requires FCC to develop 80 new rulemakings within a six-month period leading to increased competition is all aspects of telecommunications. ”Central-office implemented coin phones“ are now required to be registered as a result of opening this market to competition. &  
Early 1996 & In early 1996 ANSI approved an ADSL standard for the Discrete Multitone (DMT) version. Another competing concept called Carrierless Amplitude and Phase Modulation (CAP) was developed. The ADSL concept spawned an explosion of related concepts that permit transmission over copper up to close to 100Mbps. New copper fabrication techniques opened the avenue of very high speed data (multimedia) transmission in excess of 100 Mbps over useful ranges for premises wiring. &  
September 1996 & Rockwell announced a 56 kbps modem chip set designed for Internet applications. 56K download (PCM); 33.6 upload (analog). Technical committees start development of standards for this new technology. Ccntroversy erupts over the fact the modulation technology limits the theoretical speed to about 53K because of Part 68’s signal power limitation requirements to prevent crosstalk to third parties. In reality, because of line impairments the fastest practical speed is around 42 to 44K. &  
November 1996 & FCC network protection standards for Switched 56 and ISDN go into effect. USTA Annual Report says there are 170 million copper access loops in service nationwide, increasing at the rate of 5 million annually. Internet 2 is proposed to connect university computers together by means of one gigabyte pipes using SONET and ATM networks. &  
1997 & February 25, 1997 - Lucent announced development of wireless loops with 128K ISDN capability. Rockwell receives FCC registration for its 56K PCM modem to be used by Internet service providers. &  
June 12, 1997 & The U.S and the E.U. reach agreement on mutual recognition of product testing and approval requirements covering everything from lawnmowers, pharmaceuticals, recreational craft to telecom equipment. &  
June 17, 1997 & FCC issues NPRM for BICSI petition to require the use of twisted-pair premises wiring to prevent crosstalk. Many issues outanding from the premises wiring docket 88-57 finally resolved. Micosoft buys WebTV that claims to have 85000 subscribers. Canada releases draft of its proposed ADSL terminal equipment standards covering DMT and CAP/QAM technologies. &  
July 30, 1997 & FCC approves the harmonisation of Part 68 and Canada’s CS-03 network protection standards to be effective April 20, 1998. &  
January 1998 & Rockwell, Nortel, Paradyne and others announce an ADSL-lite program called Consumer ADSL or CDSL which will download at about 1Mbps based on CAP technology. In contrast the T1E1 and international standards seem to be heading for DMT technology with download speeds around 6 to 8 Mbps.  Other competing modes include Rate Adaptive DSL and another called Multiple Virtual Line (MVL) which can offer up to eight virtual phone lines sharing 768 kbps in one or both directions up to 24 kilofeet and working over in-home wiring. &  
February 1998 & V.90 56K standard was approved ending months of difficult negotiations and modem wars. Most of the older 56K modems can be upgraded by software downloading to work with the new standard. &  
1999 & Creation of the Asterisk Private branch exchange &  
11 June 2002 & Antonio Meucci is recognized for ”...his work in the invention of the telephone“ (but not ”...for inventing the telephone") by the United States House of Representatives, in United States HRes. 269. &  
21 June 2002 & The Parliament of Canada responds by passing a motion unanimously 10 days later recognizing Alexander Graham Bell as the inventor of the telephone. &  
2005 & Mink, Louisiana finally receives traditional landline telephone service (one of the last in the United States). & YES

Timeline of lighting (Anon, 2006; Hanna *et al.*, 2015; Almeida *et al.*, 2014; Sandahl *et al.*, 2006; Anon, n.d.; Anon, n.d.)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| 125000 BC | Widespread control of fire by early humans |  |
| 70000 BC | A hollow rock, shell, or other natural found object was filled with moss or a similar material that was soaked in animal fat and ignited |  |
| c. 3000 BC | Candles are invented. Some time later, oil lamps are developed |  |
| 1780 | Aimé Argand invents central draught fixed oil lamp | YES |
| 1784 | Argand adds glass chimney to central draught lamp |  |
| 1792 | William Murdoch begins experimenting with gas lighting and lights his house and office by means of gas | YES |
| 1800 | French watchmaker Bernard Guillaume Carcel overcomes the disadvantages of the Argand-type lamps with his clockwork fed Carcel lamp | YES |
| 1800-1803 | Humphry Davy remarks first carbon arc when using Voltaic piles (battery) for his electrolysis experiments | YES |
| 1802 | Humphry Davy demonstrates arc lighting | YES |
| 1802 | William Murdoch illuminated the exterior of the Soho Foundry with gas |  |
| 1805 | Philips and Lee’s Cotton Mill, Manchester was the first industrial factory to be fully lit by gas |  |
| 1809 | Humphry Davy publicly demonstrates first electric lamp over 10000 lumens, at the Royal Society | YES |
| 1813 | National Heat and Light Company formed by Fredrich Winzer (Winsor) |  |
| 1815 | Humphry Davy invents the miners’ safety lamp |  |
| 1835 | James Bowman Lindsay demonstrates a light-bulb-based electric-lighting system to the citizens of Dundee, Scotland | YES |
| 1840 | First paraffin (kerosene) lamps | YES |
| 1841 | Arc lighting used as experimental public lighting in Paris, France |  |
| 1853 | Ignacy Lukasiewicz invents the petroleum lamp | YES |
| 1854 | Heinrich Göbel invents the first true light-bulb, using a carbonised bamboo filament | YES |
| 1856 | Glassblower Heinrich Geissler confines the electric arc in a Geissler tube |  |
| 1867 | A.E. Becquerel demonstrates the first fluorescent lamp | YES |
| 1874 | Alexander Lodygin patents an incandescent light bulb | YES |
| 1875 | Henry Woodward patents the electric light-bulb | YES |
| 1876 | Paul Jablochkoff invents the Jablochkoff candle, the first practical carbon arc lamp, for public street lighting in Paris |  |
| 1878/9 | Thomas Edison and Joseph Wilson Swan both patent the carbon-thread incandescent lamp, which lasts for approximately 40 hours. Swan successfully sues Edison but eventually sells his patent rights to him | YES |
| 1880 | Edison produces a 16-watt lightbulb that lasts 1500 hours | YES |
| 1882 | Introduction of large scale direct current based indoor incandescent lighting and lighting utility with Edison’s first Pearl Street Station | YES |
| 1885 | Incandescent mantle invented, revolutionising gas lighting | YES |
| 1886 | Great Barrington, Massachusetts demonstration project, a much more versatile (long distance transmission) transformer based alternating current based indoor incandescent lighting system introduced by William Stanley, Jr. working for George Westinghouse. Stanley lit 23 businesses along a 4000 feet length of main street stepping a 500 AC volt current at the street down to 100 volts to power incandescent lamps at each location | YES |
| 1893 | Nikola Tesla uses cordless low-pressure gas-discharge lamps, powered by a high-frequency electric field, to light his laboratory |  |
| 1893 | GE introduces first commercial fully enclosed carbon arc lamp. Sealed in glass globes, it lasts 100h and therefore 10 times longer than previous carbon arc lamps | YES |
| 1893 | Nikola Tesla puts forward his ideas on high frequency and wireless electric lighting which included public demonstrations where he lit a Geissler tube wirelessly | YES |
| 1894 | D. McFarlane Moore creates the Moore tube, precursor of electric gas-discharge lamps |  |
| 1897 | Walther Nernst invents and patents his incandescent lamp, based on solid state electrolytes |  |
| 1903 | Peter Cooper Hewitt demonstrates the mercury vapour lamp, i.e. a fluorescent lamp | YES |
| 1910 | William Coolidge invents a way to make a tungsten filament that outlasts all other types of filament (i.e. the Tungsten light bulb is invented) | YES |
| 1910 | Georges Claude demonstrates neon lighting at the Paris Motor Show | YES |
| 1911 | Georges Claude develops the neon lamp |  |
| 1925 | The first internal frosted lightbulbs were produced |  |
| 1926 | Edmund Germer patents the fluorescent lamp | YES |
| 1932 | The first low-pressure sodium lamp is developed by Philips and used mainly for street lighting |  |
| 1933 | First Fluorescent tubes installed | YES |
| 1937 | Linear Fluorescent Lamps/Lights (LFLs) are first commercialised | YES |
| 1939 | Fluorescents made available for wider sale | YES |
| 1948 | Halophosphor LFLs pioneered |  |
| 1959 | The first tungsten halogen lamp is developed | YES |
| 1962 | Nick Holonyak Jr develops the first practical visible-spectrum LED | YES |
| 1965 | Metal halide HID lamps are commercialised |  |
| 1970 | Commercialisation of high-pressure sodium vapour HID lamps |  |
| 1972 | John Campbell patents first practical CFL | YES |
| 1976 | Compact Fluorescent “Spiral Lamp” design developed by Edward Hammer but GE deems it too fragile to make with existing manufacturing technology |  |
| 1976 | Hollister introduces magnetic-fluorescent lamp (but not manufactured) |  |
| 1976 | Jan Hasker (Philips) developes the ‘Recombinant Structure CFL’ |  |
| 1978 | T8 LFLs are commercialised |  |
| 1979 | Phillips unveils first electronic ballast CFL | YES |
| 1980 | CFLs are commercialised | YES |
| 1980 | Tungsten halogen lamps are commercialised | YES |
| 1981 | Thorn Lighting exhibits the world’s first ceramic metal halide lamp at the Hanover World Light Fair | YES |
| 1981 | Philips sells their first Compact Fluorescent Energy Saving Lamps, with integrated conventional ballast | YES |
| 1982 | Phillips starts using new rare earth phosphors that emit warmer colour of light and increase light output |  |
| 1985 | GE produces first competing product |  |
| 1985 | Osram enters the CFL market with the first electronic Energy Saving Lamps to be very successful |  |
| 1986 | The “White” SON sodium vapor lamp is introduced |  |
| Late ’80s | Utilities start offering CFL bulbs to customers | YES |
| 1990 | April 22, 1990 Earth Day turning point in U.S. consciousness about energy efficiency, climate change, ozone depletion. Three books (50 Simple Things You Can Do to Save the Earth, Consumer Guide to Home Energy Savings, and The Green Consumer) sell millions of copies, and recommend the use of CFLs | YES |
| 1990 | Worldwide sales of CFLs = 83 million |  |
| c. 1990 | “High Brightness” Red, Orange, Yellow, & Green LEDs developed |  |
| 1991 | CFLs have 1% of US bulb sales volume, 2% of world bulb sales |  |
| 1991 | Philips invents a fluorescent lightbulb that lasts 60000 hours. The bulb uses magnetic induction | YES |
| 1992 | Induction lamps are commercialised |  |
| 1992 | In 1992, a visible blue and green InGaN LED was developed by Nichia, attaining 10% efficiency. The InGaN LED was a key milestone leading to white LED lighting | YES |
| 1992-94 | A team at Nela Park, Cleveland, GE, with Jack Strok, creates ceramic metal halide lamps (CMH). Philips follows under W.de Kock and calls their versions CDM Ceramic Discharge Metal. Sales begin 1994. This technology improves to be a superior lighting technology with up to 150 lm/W with good color rendering and 20000 hours life, whilst maintaining very high lumen rating |  |
| 1994 | T5 lamps with cool tips are introduced to become the leading fluorescent lamps with up to 117 lm/W with good color rendering. These and almost all new fluorescent lamps are to be operated on electronic ballasts only |  |
| 1994 | First commercial sulfur lamp | YES |
| 1995 | Spiral lamps appear on the market | YES |
| 1995 | T5 LFLs are commercialised |  |
| 1995 | Shuji Nakamura at Nichia labs invents first blue and, with additional Phosphor, white LED, and starts an LED boom | YES |
| 1995 | “High Brightness” Blue & Green LEDs |  |
| 1996 | First white LED introduced by Nichia | YES |
| 1997 | Philips and TCP introduce dimmable screw-based CFLs | YES |
| 1997 | Worldwide sales of CFLs = 356 million |  |
| 1997 | ENERGY STAR Residential Light Fixtures Program started in the United States. This brought a benchmark of lighting performance and quality as well as a clearly recognisable U.S. brand to the marketplace | YES |
| 1998 | ENERGY STAR torchieres hit the market and sell a million units by Sept 1999 |  |
| 1998 | U.S. DOE’s Sub-compact CFL Technology Procurement program started, administered by PNNL | YES |
| 1999 | The U.S. DOE ENERGY STAR screw base CFL program is launched. This continued to help the utilities and regional market transformation groups to rally their marketing strategies |  |
| 2000 | Beginning of U.S. West Coast Energy Crisis | YES |
| 2000 | Program for Evaluation and Analysis of Residential Lighting (PEARL) started in 2000 as a watchdog organisation in response to complaints received by utility managers about the quality of ENERGY STAR rated products |  |
| 2000 | White LED light demonstrates incandescent efficacy (17 lm/W) | YES |
| 2001 | U.S. DOE launches R-CFL Technology Procurement Project to encourage the development of reflector style CFLs that perform well in high heat applications, such as recessed can fixtures |  |
| 2001 | EU imposes an anti-dumping duty of 66.1 % on CFL-I bulbs, so China turns to U.S. resulting in glut of low-cost CFLs on US market (EU Regulation 1470/2001) |  |
| 2001 | Rolling blackouts in California prompt massive regional CFL promotions and giveaways | YES |
| 2001 | Drought in U.S. Northwest prompts regional CFLs programs due to hydro power shortages |  |
| 2001 | ’Change a Light, Change the World’ campaign launched with nationwide radio, tv and print advertising of ENERGY STAR CFLs in the U.S. | YES |
| 2001 | New ENERGY STAR requirements including third-party testing and interim life testing |  |
| 2001 | U.S. CFL sales surge to fourth quarter highs of 2.1% of U.S. lamp market, to 8.5% in California and to 12% in Northwest |  |
| 2002 | CFL prices are down from $20+ per bulb in 1990 to $9 for a 4-pack without utility subsidy in mass merchandise stores like K-mart, Wal-Mart and Costco around the U.S. |  |
| 2003 | U.S. DOE, American Lighting Association, and Consortium for Energy Efficiency start CFL lighting fixture design competition called “Lighting for Tomorrow” |  |
| 2005 | EU extends the anti-dumping duty from 2001 to include shipments from Philippines, Pakistan, and Vietnam. This was as a result of some Chinese companies affected by the 2001 action that had been shipping “kits” of partially manufactured CFLs to these countries for completion and sales. EU Regulation 866/2005 |  |
| 2005 | U.S. Title 24 (California building code) updates take effect Oct 12005. Requires “high efficacy” lights in nearly every room in house. All CFLs must be pin-based, no screw based allowed |  |
| 2005 | White LED light demonstrates fluorescent efficacy (70 lm/W) | YES |
| 2008 | Ushio Lighting demonstrates the first LED filament light bulb | YES |
| 2008 | Production white LED light exceeds 100 lm/W |  |
| 2010 | White LED exceeds 150 lm/W | YES |
| 2010 | The European Union (including UK) bans the sale of all 100 & 75W incandescent lights. Malaysia bans all 100W incandescents. Australia, Cuba, and the Philippines ban the sale of new incandescents completely. | YES |
| 2011 | Philips wins ’L Prize’ for LED screw-in lamp equivalent to 60W incandescent A-lamp for general use |  |
| 2011 | The European Union (including UK) bans the sale of all 60W incandescent lights. Malaysia bans all 75W incandescents. Argentina bans the sale of new incandescents completely. | YES |
| 2012 | The European Union (including UK) bans all incandescent lights greater than 15W. Malaysia bans all 60W incandescents. China, Mexico, and the United States ban the sale of all 100W incandescents. Japan and South Korea ban the sale of new incandescents completely. | YES |
| 2016 | Philip’s development of the Dubai Lamp defied predictions from the US Department of Energy, which originally claimed that the 200 lumen-per-watt threshold would not be passed until 2025. | YES |

Timeline of nuclear energy (Anon, n.d.)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| 1895 | Wilhelm Roentgen, a German physicist, discovered X-rays. | YES |
| 1897 | J. J. Thomson (England) discovered the electron.  In 1906, he received the Nobel Prize in Physics for this discovery. | YES |
| 1898 | Marie Curie (France), a two-time Nobel Prize winner in Chemistry and Physics, discovered the radioactive elements radium and polonium. | YES |
| 1899 | Ernest Rutherford (Canada) discovered two kinds of rays emitting from radium. He called the first rays, alpha rays; and the more penetrating rays, beta rays. | YES |
| 1900 | Frederick Soddy (England) observed spontaneous disintegration of radioactive elements into variants.  He called these isotopes. | YES |
| 1901 | Rutherford and Soddy published the theory of radioactive decay. | YES |
| 1905 | Albert Einstein wrote the special theory of relativity.  He created a new era of physics when he unified mass, energy, magnetism, electricity, and light. One of the most significant events of the 20th century was Einstein’s developing the formula of E=mc^2 (that is, energy equals mass times the square of the speed of light). | YES |
| 1911 | Rutherford (United Kingdom) discovered the nucleus of the atom. | YES |
| 1913 | Niels Bohr (Denmark) published the theory of atomic structure, combining nuclear theory with quantum theory. | YES |
| 1915 | The general theory of relativity was published by Albert Einstein. He proposed that gravity, as well as motion, could affect the intervals of time and space. | YES |
| 1919 | Rutherford (United Kingdom) bombarded nitrogen gas with alpha radiation.  The transmutation of nitrogen into oxygen was the first artificially induced nuclear reaction. | YES |
| 1925 | Werner Heisenberg, Max Born (Germany) and later Erwin Schrödinger (Austria) formulated quantum mechanics. | YES |
| 1927 | Herman Blumgart (United States), a Boston physician, used radioactive tracers to diagnose heart disease. |  |
| 1929 | Ernest O. Lawrence (United States) conceived the idea for the first cyclotron, a device used to produce high-energy beams for use in nuclear physics experiments. He was awarded the 1939 Nobel Prize in Physics for this invention and for results obtained with it. | YES |
| 1929 | John Cockcroft and E. T. S. Walton (United Kingdom) developed a high-voltage apparatus for accelerating protons, called a linear accelerator. | YES |
| 1932 | James Chadwick (United Kingdom) discovered the neutron as well as studying deuterium (known as heavy hydrogen) for use in nuclear reactors. | YES |
| 1932 | Cockcroft and Walton (United Kingdom) split the atom with protons accelerated with their “linear accelerator.” | YES |
| 1932 | Werner Heisenberg (Germany) was awarded the Nobel Prize in Physics for the creation of quantum mechanics. |  |
| 1934 | Enrico Fermi irradiated uranium with neutrons. He believed he had produced elements beyond uranium, not realizing that he had split the atom, thus achieving the world’s first nuclear fission. He won the Nobel Prize in Physics for this discovery in 1938. | YES |
| 1938 | The process of splitting uranium atoms, called nuclear fission, was demonstrated by scientists Otto Hahn and Fritz Strassman (Germany). | YES |
| 1939 | President Roosevelt received a letter from Albert Einstein on the possibility of a uranium weapon. | YES |
| 1940 | German troops occupied Norway, and seized what was then the world’s only heavy-water production plant at Vemork. | YES |
| 1940 | Philip Abelson and Edwin McMillan (United States) demonstrated that neutrons captured by uranium-238 lead to the creation of elements 93 and 94, neptunium and plutonium. | YES |
| 1940 | A new element (atomic number 94), was found and named plutonium. American physicists confirmed that plutonium was fissionable, thus usable for a bomb. |  |
| 1941 | British scientists reported that a weapon could be made with 22 pounds of pure uranium 235. |  |
| 1942 | The Manhattan Project was formed in the United States to secretly build the atomic bomb for use in World War II. | YES |
| 1942 | The first self-sustaining, controlled nuclear chain reaction led by Enrico Fermi and other scientists at the University of Chicago. | YES |
| 1945 | The first test of a nuclear weapon, code-named Trinity, occurred at Alamogordo, New Mexico. | YES |
| 1945 | The United States dropped an atomic bomb on Hiroshima, Japan, and three days later dropped another one on Nagasaki, Japan. Japan surrendered less than two weeks later, ending World War II. | YES |
| 1946 | The Atomic Energy Act (AEA) of 1946 was passed, establishing the United States Atomic Energy Commission (AEC) to control nuclear energy development and to explore peaceful uses of nuclear energy. | YES |
| 1946 | First demonstrations against nuclear testing were held in Times Square, New York. |  |
| 1946 | The Joint Congressional Committee on Atomic Energy was established to oversee all civilian and military nuclear affairs. | YES |
| 1946 | The Soviet Union achieved its first nuclear chain reaction. |  |
| 1949 | The Soviet Union detonated its first atomic device. |  |
| 1950 | President Truman announced the decision to proceed with the development of the hydrogen bomb. | YES |
| 1950 | Klaus Fuchs confessed to giving atomic secrets to the Soviets while working on the Manhattan Project. |  |
| 1951 | An experimental breeder reactor (EBR Reactor I, or EBR-I) in Idaho produced the first usable electric power from the atom, lighting four light bulbs. Scientists had already known that nuclear power could produce electricity. The purpose of the experimental EBR was to prove that a breeder reactor could produce more fuel than it used. | YES |
| 1953 | The first nuclear-powered submarine, the U.S.S. Nautilus, was launched. | YES |
| 1953 | Eisenhower’s Atoms for Peace Program proposed an international agency to develop peaceful nuclear technologies. | YES |
| 1953 | The first Boiling Reactor Experiment reactor was built in Idaho. It demonstrated that steam bubbles in the reactor core did not cause an instability problem. It was, instead, a rapid, reliable, and effective mechanism for limiting power. This could protect a reactor against “runaway” events. | YES |
| 1954 | The Atomic Energy Act of 1954 was passed. It was the first major amendment of the original Energy Act, which gave the civilian nuclear energy program further access to nuclear technology. | YES |
| 1955 | The AEC announced the beginning of a cooperative program between government and industry to develop nuclear power plants. | YES |
| 1955 | Arco, Idaho, (population 1000) became the first U.S. town powered by nuclear energy. The power was provided by an experimental reactor, BORAX III, at the Idaho National Energy Laboratory. | YES |
| 1955 | The United Kingdom announced the decision to develop thermonuclear weapons. |  |
| 1955 | The United Nations sponsored the first international conference on the peaceful uses of nuclear energy, held in Geneva, Switzerland. | YES |
| 1956 | The world’s first commercial nuclear power station, Calder Hall at Windscale, England, was opened in 1956 with an initial capacity of 50 MW (later 200 MW). | YES |
| 1957 | The first time that power was generated from a U.S. commercial nuclear plant, at Santa Susana, California. | YES |
| 1957 | The Price-Anderson Act enacted. This legislation was designed to limit the financial risk of nuclear plant owners in the event of an accident. |  |
| 1957 | The first full-scale nuclear power plant in the U.S. (Shippingport, Pennsylvania) began service. |  |
| 1957 | The International Atomic Energy Agency (IAEA) was formed with 18 member countries to promote peaceful uses of nuclear energy and to prevent the spread of nuclear weapons. | YES |
| 1957 | The Soviet Union launched the first nuclear-powered surface ship, the Lenin. | YES |
| 1957 - 10th October | Windscale fire: A fire at the British atomic bomb project destroyed the core and released an estimated 740 terabecquerels of iodine-131 into the environment. A rudimentary smoke filter constructed over the main outlet chimney successfully prevented a far worse radiation leak and ensured minimal damage. | YES |
| 1958 | President Eisenhower signed amendments to the 1954 Atomic Energy Act, which led to a bilateral agreement between the United Kingdom and the United States on nuclear weapon design information. |  |
| 1958 | From November 1958 to September 1961, the United States, the United Kingdom, and the former Union of Soviet Socialist Republics (USSR) observed an informal moratorium on nuclear tests. |  |
| 1959 | The United States deployed the first operational intercontinental ballistic missile (ICBM), the Atlas D. |  |
| 1960 | The AEC published its 10-year plan for nuclear energy. |  |
| 1960 | Small nuclear power generators were first used in remote areas to power weather stations and to light buoys for sea navigation. |  |
| 1962 | The first nuclear-powered merchant ship, the N.S. Savannah, was put to sea. Developed as part of President Eisenhower’s Atoms for Peace Program, the Savannah was christened by Mrs. Dwight D. Eisenhower in 1959. | YES |
| 1964 | President Lyndon Johnson signed the Private Ownership of Special Nuclear Materials Act of 1964, which allowed the nuclear energy industry to own the fuel for its units. After June 30, 1973, private ownership of the uranium fuel became mandatory. |  |
| 1964 | The U.S. Navy sent three nuclear-powered surface ships (Enterprise, Long Beach and Bainbridge) on an around-the-world cruise to show their ability to operate away from land bases. | YES |
| 1964 | The AEC issued a construction permit for Oyster Creek nuclear power plant. |  |
| 1965 | The first nuclear reactor, a 500-watt system, operated in space. It operated for 43 days and remains in orbit. | YES |
| 1965 | The AEC gave the liquid metal fast breeder reactor highest priority and decided to build the Fast Flux Test Facility. |  |
| 1965 | The first major electrical blackout occurred in the northeastern United States. |  |
| 1968 | The Treaty on the Non-Proliferation of Nuclear Weapons, also known as the Nuclear Non-Proliferation Treaty (NPT), was adopted. The treaty called for halting the spread of nuclear weapon capabilities. | YES |
| 1970 | The First Earth Day was celebrated. |  |
| 1970 | Electricity “brownouts” hit the Northeast during a heat wave. A “brownout” is a reduction or cutback in electric power, especially as a result of a shortage, mechanical failure, or overuse by consumers. |  |
| 1971 | President Nixon announced a U.S. national goal of completing the liquid metal fast breeder reactor by 1980. | YES |
| 1973 | President Nixon proposed replacing the Atomic Energy Commission with the Energy Research and Development Administration and the Nuclear Regulatory Commission. |  |
| 1973 | The Arab Oil Embargo occurred, in which several Arab nations in the Organization of Petroleum Exporting Countries (OPEC) embargoed oil to the United States and Holland to protest their support of Israel in the Arab-Israeli “Yom Kippur” War. Arab OPEC production was cut by 25%, which caused some temporary shortages and helped oil prices to triple. This contributed to an increased interest in alternatives to petroleum, including nuclear power. | YES |
| 1973 | U.S. utilities ordered 41 nuclear power plants, a one-year record. |  |
| 1974 | The first 1000-megawatt nuclear plant went into service (Commonwealth Edison’s Zion Nuclear Power Plant, Unit 1). | YES |
| 1974 | The Atomic Energy Commission was abolished, and the Nuclear Regulatory Commission (NRC) was created to regulate the nuclear industry. The Joint Congressional Committee on Atomic Energy was also abolished. |  |
| 1975 | The Energy Research and Development Administration began operating. |  |
| 1977 | President Carter combined the Energy Research and Development Administration with the Federal Energy Administration, creating the Department of Energy. |  |
| 1977 | The Voyager 2 spacecraft was launched into space. The spacecraft’s electricity was generated by the decay of plutonium pellets. |  |
| 1979 | The accident at the Three Mile Island Unit 2 (TMI-2) nuclear power plant near Middletown, Pennsylvania, on March 28, 1979, was the most serious in the U.S. nuclear power plant industry’s operating history. Equipment malfunctions, design-related problems, and human error led to led to a partial meltdown of the TMI-2 reactor core but only very minute releases of radioactivity. Although no deaths or injuries resulted, the accident brought about sweeping changes in emergency response planning, reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations. These changes enhanced the safety of the industry. | YES |
| 1979 | The U.S. nuclear energy industry created the Institute of Nuclear Power Operations to address issues of safety and performance. |  |
| 1979 | Completing a process begun by President Ford, President Carter banned the use of reprocessed uranium in nuclear fuel. The ban’s purpose was to prevent the used fuels from falling into the wrong hands and being used for nuclear weapons. |  |
| 1980 | For the first time, nuclear energy generated more electricity than oil in the United States. | YES |
| 1981 | President Ronald Reagan lifted the ban on reprocessing used nuclear fuel. |  |
| 1983 | The Nuclear Waste Policy Act of 1982 was signed, approving the development of a high-level nuclear waste repository. |  |
| 1983 | Nuclear energy generated more electricity than natural gas. | YES |
| 1984 | Nuclear replaced hydropower as the second-largest source of electricity in the United States, after coal. | YES |
| 1986 | The Perry power plant in Ohio became the 100th U.S. nuclear power plant in operation. |  |
| 1986 | The world’s worst nuclear power accident happened at the Chernobyl plant in the former USSR (now Ukraine). | YES |
| 1987 | Congress selected Yucca Mountain in Nevada for study as the first high-level nuclear waste repository site. |  |
| 1989 | Nuclear power plants provided 19% of the electricity used in the United States; 46 units entered service during the 1980s. |  |
| 1992 | The Energy Policy Act of 1992 reformed the licensing process for nuclear power plants. |  |
| 1993 | Two decades after the first oil embargo, the 109 nuclear power plants operating in the United States provided about one-fifth of the nation’s electricity. |  |
| 1994 | The Nuclear Regulatory Commission (NRC) issued final design approval for the first two of four advanced nuclear power plant designs — General Electric’s Advanced Boiling Water Reactor (ABWR) and ABB Combustion Engineering’s System 80+. |  |
| 1996 | The NRC granted the Tennessee Valley Authority (TVA) a full-power license for its Watts Bar 1 nuclear power plant. This was the last unit to be licensed in the United States in the 20th century. |  |
| 1996 | Kashiwazaki-Kariwa 6, the world’s first Advanced Boiling Water Reactor, began commercial service in Japan. | YES |
| 1997 | The NRC issued General Electric design certification for its Advanced Boiling Water Reactor. |  |
| 1998 | Baltimore Gas and Electric Co. submitted an application to renew the license of its two-unit Calvert Cliffs nuclear power plant—the first U.S. company to apply for a 20-year extension of its 40-year license. |  |
| 2000 | The NRC issued the first-ever license renewal to Constellation Energy’s Calvert Cliffs Nuclear Power Plant, allowing an additional 20 years of operation. |  |
| 2000 | The NRC approved a 20-year extension to the operating license of Duke Energy’s three-unit Oconee Nuclear Station. |  |
| 2001 | The U.S. National Energy Plan was published in May 2001. The Plan included a significant role for nuclear power in meeting energy demand and for reducing air pollution levels. |  |
| 2002 | The U.S. Nuclear Power 2010 Program, developed in 2002, was a joint government/industry cost-shared effort to identify sites for new nuclear power plants, develop and bring to market advanced nuclear plant technologies, evaluate the business case for building new nuclear power plants, and demonstrate untested regulatory processes. | YES |
| 2002 | On April 30, the oldest nuclear power plant in the world, Obninsk (located in Russia), closed down its sole reactor. | YES |
| 2002 | Nuclear power provided about 16% of the world’s electricity. |  |
| 2003 | On August 14, the Unites States’ largest-ever power outage left much of the Northeast and parts of Canada without electricity for several days. A transmission line in Ohio strained the electrical system so much that plants all over the grid, including nine U.S. and eight Canadian commercial nuclear reactors, were shut down. |  |
| 2004 | The British Nuclear Group announced the closing of the Chapelcross nuclear power plant, one of the world’s oldest plants. |  |
| 2005 | On January 3, Lithuania, the world’s most nuclear-dependent nation, began the complete and final shutdown of one-half of its nuclear capacity. Lithuania’s nuclear reactors are being shutdown owing to safety concerns. They have the same design as the reactors at Chernobyl, the site of the world’s worst nuclear accident. |  |
| 2005 | The Polish Government decided to build the Nation’s first nuclear power plant. |  |
| 2005 | On August 8, President Bush signed the Energy Policy Act of 2005, which included measures to encourage the nuclear industry to build new nuclear power plants. (No construction of a nuclear plant has begun since 1971.) |  |
| 2006 | A survey, in the United States, found a high level of support for nuclear energy among the public; with 68% favoring nuclear energy as one way to generate electricity and 49% stating a need to build more nuclear plants. |  |
| 2007 | Browns Ferry Nuclear Power Plant Unit 1 was the first U.S. nuclear reactor to come online in the 21st century. Shut down in 1985, the Tennessee Valley Authority (TVA) decided in 2002 to restart the unit. It had the capacity to supply electricity to about 650000 homes. |  |
| 2011 | The Fukushima Daiichi nuclear disaster is initiated primarily by the tsunami following the T?hoku earthquake on 11 March 2011. The Fukushima Power Plant disaster was the most significant nuclear incident since April 26, 1986 the Chernobyl disaster and the second disaster to be given the Level 7 event classification of the International Nuclear Event Scale. | YES |

Timeline of printing technologies (Anon, n.d.; Anon, n.d.; Anon, n.d.; Anon, n.d.; Clymer & Asaba, 2008)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| 3000 BC and earlier | The Mesopotamians use round cylinder seals for rolling an impress of images onto clay tablets.  In other early societies in China and Egypt small stamps are used to print on cloth. These stamps are gradually replaced by larger wooden blocks. In China such woodblocks are used to print on silk. The earliest known examples consist of flowers printed in three colours. They are likely produced during the Han dynasty (before 220 BC). |  |
| 2600–2000 BC | First printing plates: The printing plates discovered are still being investigated. If they are genuine, the Harappan civilization in the Indus Valley is the first one to use fairly modern printing techniques. One of the plates bears 34 characters, which is the longest known single Indus script inscription. |  |
| 131 BC | First newspapers: The first Acta Diurna (Latin for ‘Daily Acts’) are published in Rome in 131 BC. These are daily official notices of the Roman Empire and can be considered the first ‘newspaper’. The notices are carved on stone or metal, they do not get printed. Scribes sometimes do make copies to be sent to the provinces. |  |
| Second century | Paper is invented: A Chinese man named Ts’ai Lun is credited with inventing paper around 105 AD. He takes the inner bark of a mulberry tree and bamboo fibers, mixes them with water, and pounds them with a wooden tool. This mixture is poured onto a flat piece of coarsely woven cloth and let the dry, leaving only the fibers on the cloth. From China the knowledge of paper making is  passed along to Korea, Samark Baghdad and Damascus. |  |
| Seventh century | Oldest European book: In 687 a small book containing the text of the Gospel of John in Latin is added to the grave of Saint Cuthbert. In 1104 it is recovered from his coffin in Durham Cathedral, Britain. The Cuthbert Gospel is currently the oldest European book still in existence. |  |
| Eighth century | Paper making reaches the arabic world: During the Battle of Talas, near Samarkand in 751 AD, the secret of paper production is made known to the Islamic world, as some of the Chinese prisoners are paper makers. |  |
| Ninth century | First printed book: A copy of the Chinese version of The Diamond S?tra (or Diamond Cutter of Perfect Wisdom) is the earliest surviving example of  a printed book. It is produced in 868 AD using woodcut, a relief printing technique in which text and images are carved into the surface of a block of wood. The printing parts remain level with the surface while the non-printing parts are removed, typically with a knife or chisel. The wood block is then inked and the substrate pressed against the wooden block. |  |
| Tenth century | Invention of screen printing: During the Shang Dynasty the Chinese invent screen printing. |  |
| Tenth century | Arabs create a finer sheet of paper by substituting linen fibers for wood and bamboo. |  |
| Eleventh century | Invention of movable type: In 1023 the Chinese emperor establishes a Bureau of Exchange which is charged with issuing what can be considered the first government-issued banknotes. Chinese merchants had already been issuing banknotes themselves since the Tang Dynasty (618–907). |  |
| Eleventh century | A Chinese man named Bi Sheng (or Pi-Sheng, depending on the source) develops type characters from hardened clay, creating the first movable type in 1041. The fairly soft material hampers the success of this technology. |  |
| Twelfth century | Around 1150 the first European paper mill is established in Xàtiva, a city in Spain. Since paper is mainly produced by Muslims it is frowned upon and there are even laws that forbid the use of paper for government documents. |  |
| Thirteenth century | Since books are copied by hand, they are rare and expensive. A copy of Justinian’s lawcodes costs £40 in 1240, which is as much as a house or eight year’s income for a craftsman. |  |
| Thirteenth century | In 1282 watermarks appear for the first time when they are added to paper in Fabriano, Italy. |  |
| Fourteenth century | Type characters cast from metal (bronze) are developed in Japan and China. The oldest known book printed using metal type dates to the year 1377. It is a Korean Buddhist document, called Selected Teachings of Buddhist Sages and Seon Masters. |  |
| 1424 | Books are still rare since they need to be laboriously handwritten by scribes. The University of Cambridge has one of the largest libraries in Europe – constituting of just 122 books. |  |
| 1430 | First woodcut printing on paper: Even though woodcut is already used for printing on cloth for over a century, the first European woodcut printing on paper happens in the early 15th century. It is used for printing religious images and playing cards. Woodcut is a relief printing technique in which text and images are carved into the surface of a block of wood. The printing parts remain level with the surface while the non-printing parts are removed, typically with a knife or chisel. The wood block is then inked and the substrate pressed against the wood block. The ink is made of lampblack (soot from oil lamps) mixed with varnish or boiled linseed oil. This printing technique is also called block printing. The first block books are produced in Germany and Holland around 1430. |  |
| 1436 | Gutenberg starts working on a printing press: It takes him four years to finish his wooden press which uses movable metal type. It uses relief printing: at the bottom a frame holds the columns of text that get printed. This type consists of individual letters set in lead. After inking the type, a sheet of paper is put on top. Next, the frame is shoved to the right underneath the platen. By moving the large handle pressure is applied to make sure the ink is transferred to the paper. Afterward, the bed is moved back to its original position and the paper can be removed. |  |
| 1448 | Gutenberg sets up a printing shop in Mainz: Among his first publications printed using movable type are the ‘Poem of the Last Judgment’ and the ‘Calendar for 1448’. Around 1450 Gutenberg begins printing bibles. The first edition has 40 lines per page. |  |
| 1453 | Constantinople is captured by the Turks. Many books from the Constantine library are burnt or carried away and sold. |  |
| 1455 | Gutenberg Bible: Gutenberg prints around 180 copies of a 42-line bible which is referred to as the Gutenberg Bible. It is considered the first mass produced book. The text is set in gothic type. Customers can have their copy decorated manually. |  |
| 1455 | Ironically enough Gutenberg goes bankrupt in 1455 when his investor Johann Faust forecloses on the mortgage used to finance the building of the press. Faust gets hold of the printing equipment as well as the copies of the bible that have already been printed. While trying to sell them in Paris Faust tries to keep the printing process a secret and pretends the bibles are hand copied. It is noticed that the volumes resemble each other and Faust is charged with witchcraft. He has to confess his scheme to avoid prosecution. |  |
| 1457 | First colour printing: The first known colour printing is used in ‘Mainz Psalter’, a book containing a collection of psalms.  It is printed by Johann Faust and his son-in-law Peter Schoffer. |  |
| 1461 | First books with woodcut illustrations: Albrecht Pfister prints the first illustrated books using a number of woodcuts that are coloured in manually. Another of his books, the Biblia Pauperum, also contains many hand coloured illustrations. Pfister is also one of the first to print books in the German language. |  |
| 1465 | The first drypoint engravings are created by the Housebook Master, a south German artist. Drypoint is a technique in which an image is incised into a (copper) plate with a hard-pointed ‘needle’ of sharp metal or a diamond point. |  |
| 1467 | First Italian books: The first book is printed in Rome by Ulrich Haan (Udalricus Gallus).  Haan had emigrated to Rome after his letterpress print shop in Vienna was destroyed because he had dared to print a lampoon against the mayor. |  |
| 1469 | Use of roman type: In their print shop in Venice John and Wendelin of Speier are probably the first printers to use pure roman type, which no longer looks like the handwritten characters that other printers have been trying to imitate until then. Another printer in Venice, Nicolas Jenson, produces a more distinguished roman font which still serves as a model for type designers today. |  |
| 1470 | First book in Italian language: Il Canzoniere by Francesco Petrarca is the first book printed in the Italian language. |  |
| 1472 | Book printing takes off in Spain: Sinodal de Aguilafuente is the first book printed in Spain and in the Spanish language. Its printing was ordered by the bishop of Segovia, which is why printing did not take off first in any of the major Spanish cities, like Barcelona or Madrid. |  |
| 1475 | ‘De honesta voluptate’ (On honourable pleasure) is one of the first printed cookbooks. It is as much a series of moral essays as a cookbook. Ten years later ‘Kuchenmeysterey’ (Kitchen Mastery) becomes the first printed German cookbook. |  |
| 1476 | William Caxton introduced metal type in England: William Caxton buys equipment from the Netherlands and establishes the first printing press in England at Westminster. Books printed by Caxton include Chaucer’s ‘The Canterbury Tales’, ‘Fables of Aesop’ and many other popular works. Caxton is also the first English retailer of printed books. |  |
| 1476 | That same year copper engravings are for the first time used for illustrations. With engravings, a drawing is made on a copper plate by cutting grooves into it. |  |
| 1481 | There are around 40 printing shops in both Germany and Italy. In the Netherlands printing takes place in 21 cities and towns. |  |
| 1489 | First print shop in Denmark: Dutch printer Gotfried van Os (Gotfred of Ghemen) establishes the first print shop in Copenhagen. |  |
| 1493 | The Nuremberg Chronicle: Anton Koberger, a publisher and printer in Nuremberg, prints his most famous book, the ‘Nuremberg Chronicle’. It is illustrated with hundreds of woodcuts, many of them portraits. These portraits are all imaginary and the same block is often used to depict different persons. |  |
| 1494 | Das Narrenschiff: Das Narrenschiff (The Ship Of Fools) by Sebastian Brant is published in Basel, Switzerland. This satire about the state of the church is illustrated with woodcuts from the great Renaissance artist-engraver Albrecht Dürer. It quickly becomes extremely popular, with six authorized and seven pirated editions published before 1521. |  |
| 1495 | The first printed books are published in Danish and Swedish. |  |
| 1499 | Printing has become established in more than 250 cities around Europe. Renaissance printing presses can produce 3600 pages per workday, compared to forty by typographic hand-printing and just a few pages by hand-copying. One of the main challenges of the industry is distributing all these works. This leads to the establishment of numerous book fairs. The most important one is the Frankfurt Book Fair which is first held by local booksellers soon after Gutenberg’s invention of the printing press. Frankfurt remains the book capital of the world until the end of the 17th century when the Leipzig Book Fair takes over. After World War II the Frankfurt Book Fair is reestablished and regains its position as the world’s largest trade show for books. |  |
| 1500 | Early aerial map: Painter and engraver Jacopo de’ Barbari publishes a huge 1.3 by 2.8 meter aerial map of Venice, printed using six woodcut blocks. It took him three years to create the spectacular bird’s eye view. The map is so detailed historians still use it today to study 16th century Venice. |  |
| 1502 | Aldus Manutius is the first printer to come up with smaller, more portable books. Until then books are large and heavy, meant to be read while standing at a lectern or reading stand. Manutius’s books are smaller and can be carried around and read anywhere. Manutius was also the first to use Italic type, designed by Venetian punchcutter Francesco Griffo. |  |
| 1507 | Chiaroscuro: Lucas Cranach invents the chiaroscuro woodcut, a technique in which drawings are reproduced using two or more blocks printed in different colours. The Italian Ugo da Carpi is one of the printers to use such woodcuts, for example in Diogenes. In Germany, the technique peaks around 1520, but in Italy, this early form of colour printing remains in use throughout the sixteenth century. |  |
| 1522 | Scribes still publish manuscripts: Even though movable type revolutionized book production, some types of works are still done by scribes. The Tsgrooten Antiphonary is a beautiful example of a hymn book that is created and decorated by hand. |  |
| 1525 | Dürer engravings: The famous painter, wood carver and copper engraver Albrecht Dürer publishes ‘Unterweysung der Messung’ (A Course on the Art of Measurement), a book on the geometry of letters. |  |
| 1543 | Vesalius anatomy books: De humani corporis fabrica libri septem (On the fabric of the human body in seven books) is a book of human anatomy written by Andreas Vesalius. It combines text with numerous illustrations and shows how much printing has evolved during this era. |  |
| 1548 | Pocket atlas: In Venice Giacomo Gastaldi publishes Geography, the first pocket atlas. It is one of the first books to show regional maps of the Americas. |  |
| 1551 | The Historia Veneta (History of Venice) is one of the many books of Pietro Bembo, a Venetian scholar and cardinal who is most famous for his work on the Italian language and poetry. The Bembo typeface is named after him. |  |
| 1555 | Christophe Plantin is one of the most famous printers of his time. In his print shop in Antwerp, he produces fine work ornamented with engravings after Rubens and other artists. |  |
| 1555 | The publishing and printing company of Plantin and his son-in-law Jan Moretus remains in business until 1867. Nowadays it is a museum with an interesting collection of old presses, type and books. |  |
| 1568 | Jost Amman’s woodcuts in Der Buchdrucker (The Printer) show how books are produced in this era. |  |
| 1582 | First specimen type book: Willem Silvius is a printer in Antwerp who publishes the earliest known type specimen book in the low countries, the Leyden Afdrucksel. |  |
| 1605 | First newspaper: Relation aller Fürnemmen und gedenckwürdigen Historien, which is printed from 1605 onwards by Johann Carolus in Strasbourg, is considered the first newspaper. That same year the first German newsletter, the Avisa, is published. |  |
| 1620 | Invention of the Dutch press: In Antwerp Abraham Verhoeven publishes the first regularly illustrated newspaper. Nieuwe Tijdinghen (New Tidings) is also the first paper to print a headline on the front page. |  |
| 1620 | Meanwhile in Amsterdam cartographer, publisher and printer Willem Janszoon Blaeu improves the printing press by adding a counterweight to the pressure bar so that the platen rises automatically. The revised design, called the ‘Dutch Press’, largely remains in use until Stanhope introduces an iron cast press. |  |
| 1622 | The Weekly Newes from Italy is the first news book to carry the date of publication on its title page. |  |
| 1626 | The first facsimile: Plantin Press prints the first facsimile, a copy of the 16th century ‘Martyrologium Hieronymianum’ which gets engraved on copper plates. A facsimile is a reproduction of an old book, manuscript, map, art print or another item that is as true to the original source as possible. |  |
| 1631 | Most famous typesetting error: The word ‘not’ is accidentally left out of Exodus 20:14  in a reprint of the King James Bible. King Charles I and the Archbishop of Canterbury are not amused when they learn that God commanded Moses ‘Thou shalt commit adultery’. The printers, Robert Barker and Martin Lucas, are fined and have their printing license revoked. The King orders all bibles to be destroyed but eleven still exist today. This version of the Bible is referred to as The Wicked Bible and also called the Adulterous Bible or Sinner’s Bible. |  |
| 1640 | In Paris, the Imprimerie Royale du Louvre is established at the instigation of Richelieu. The first book that is published is ‘De Imitatione Christi’ (The Imitation of Christ), a widely read Catholic Christian spiritual book that was first published in Latin around 1418. |  |
| 1640 | In 1640 the Bay Psalm Book becomes the first book printed in British North America. Only eleven copies are known to exist from the first edition, one of them getting sold for $14.2 million at an auction in 2013. |  |
| 1642 | Mezzotint: Ludwig von Siegen invents mezzotint, a technique to reproduce halftones by roughening a copper plate with thousands of little dots made by a metal tool with small teeth, called a ‘rocker’. The tiny pits in the plate hold the ink when the face of the plate is wiped clean. |  |
| 1661 | First printed banknotes: The first European banknotes are issued in Sweden by Stockholms Banco, the precursor to Sveriges Riksbank – the central bank of Sweden. Each note was hand signed by 16 prominent and trustworthy officials to overcome objections that paper money would lead to the downfall of the Swedish monetary system. |  |
| 1660 | Klencke Atlas: Joan Klencke create an atlas measuring 1.78 by 1.05 meter. It remains the largest atlas of the world until 2012 when the Earth Platinum atlas is published. A group of Dutch merchants donate the Klencke Atlas to King Charles II of England as a gift for restoring the monarchy. |  |
| 1662 | Atlas Maior, the most expensive atlas ever: Joan Blaeu, son of Willem Janszoon Blaue, publishes the most expensive printed book of the seventeenth century, the Atlas Maior. The Dutch version consists of 9 and the French version of 12 volumes. The richly decorated atlas contains eleven volumes, 600 double-page maps and 3000 pages of text. The most expensive coloured edition cost around $ 40000 in today’s money. |  |
| 1690 | The first American paper mill is established. |  |
| 1692 | Lloyd’s News: Lloyd’s News is the forerunner of Lloyd’s List, a journal containing maritime news. It is one of the world’s oldest continuously-running journal. Issue 60850 from 2013 was the last one to appear in print. Since then it has become a digital publication. |  |
| 1702 | The first daily newspaper: The Daily Courant is the first British daily newspaper. The single page two column newspaper only focusses on foreign news. It has advertisements on the reverse side and is published until 1735 when it merges with the Daily Gazetteer. |  |
| 1704 | The Boston News-Letter: The Boston News-Letter is the first newspaper that is published on a continuous basis in British North America. It is subsidized and controlled by the British government and has only limited circulation. |  |
| 1709 | First modern copyright legislation: The Statute of Anne is the first modern copyright law. It originates in the United Kingdom. |  |
| 1710 | Colour engravings: The German painter and engraver Jakob Christof Le Blon produces the first engraving in several colours. He uses the mezzotint method to engrave three metal plates. Each plate is inked with a different colour, using red, yellow and blue. Later on, he adds a fourth plate, bearing black lines. This technique helped form the foundation for modern colour printing. Le Bon’s work is based on Newton’s theory, published in 1702, which states that all colours in the spectrum are composed of the three primary colours blue, yellow and red. |  |
| 1716 | William Caslon is an English typographer whose foundry operates in London for over 200 years. His Caslon Roman Old Face is cut between 1716 and 1728.  The letters are modeled on Dutch types but they are more delicate and not as monotonous. Caslon’s typefaces remain popular, digital versions are still available today. |  |
| 1721 | The New England Courant is published by James Franklin, the older brother of Benjamin Franklin. The market for such newspapers is still very limited with press runs (the total number printed) of 300 or less. |  |
| 1725 | Duplicating printing plates using stereotyping: The Scottish goldsmith William Ged invents stereotyping. In this process, a mixture of plaster is poured on a tray of completed type to make a mold from it. Hot metal is poured into this mold and allowed to set. The resulting stereotype or cliché is a printing plate that is an exact copy of the original. From 1848 onwards molds are created from papier-mâché instead of plaster. The stereotyping process makes larger press runs as well as reprints much cheaper. It is used extensively for printing books and newspapers until the late 1800s when it is gradually getting replaced by electrotyping which delivers sharper copies in which finer detail can be preserved. |  |
| 1727 | Miniature bibles: In London the Biblia or ‘a Practical Summary of ye Old & New Testaments’ is printed. This tiny 4 by 3-centimeter shortened version of the Bible is bound in leather with reliefs. It contains 284 pages with 14 wood engravings. Tiny books like this are popular collector’s items to this day. |  |
| 1731 | The first magazine: The Gentleman’s Magazine, considered to be the first general interest magazine,  is published for the first time. The publication runs uninterrupted until 1922. |  |
| 1732 | Poor Richard’s Almanac: In the American colonies Benjamin Franklin, who had learned to print from his brother, establishes his own printing office and becomes the publisher of the Pennsylvania Gazette. Among his publications, Poor Richard’s Almanac, a yearly publication containing a calendar, weather, poems, sayings and astronomical and astrological information, becomes the most famous. He sells the business again in 1748 to devote his time to his literary, journalistic and civic activities. He does keep promoting the print industry in the colonies. |  |
| 1760’s | The first jigsaw puzzles: English cartographer John Spilsbury starts making jigsaw puzzles of engraved maps. These were used as teaching tools, alongside map board games which J. Jeffreys had started producing a few years before. |  |
| 1765 | Rise of American newspapers: The average press run of American newspapers has risen to between 600 and 800. The aggregate circulation of all newspapers in America is estimated to be 14000 on a weekly basis. |  |
| 1772 | Patents for coloured inks: In England, the first patent is issued for making coloured inks. Full colour printing, as we know it today, is still a far way off as the pigments of those inks are not pure. |  |
| 1796 | Invention of lithography: Alois Senefelder invents lithography and uses it as a low-cost method for printing theatrical works. Lithography is a printing technique in which an image is drawn on a stone (a lithographic limestone) using a coating of wax or another greasy substance. This makes those areas hydrophobic (water repellent but ink accepting) while the slightly roughened remaining parts are hydrophilic (water accepting). The stone is then moistened with water which the hydrophilic parts suck up. Next, an oil-based ink is rolled onto the stone. Only the greasy parts pick up the ink. Finally, a piece of paper is pressed onto the stone and the ink transfers from the stone to the paper. Lithography is still the dominant printing technique today. Meanwhile, the stone has been replaced by an aluminum or plastic plate and the image to be printed is created digitally, not by hand. |  |
| 1798 | Giambattista Bodoni creates a series of typefaces that carry his name and that are still frequently used today. They are characterized by the sharp contrast between the thick vertical stems and thin horizontal hairlines. |  |
| 1798 | Initially, Bodoni ran a state-owned printing house in Parma, Italy but his success enabled him to start his own company, Officina Bodoni. During his lifetime Bodoni designed and engraved 298 typefaces. A facsimile of Il Manuale tipografico (The Manual of Typography), which shows many of his designs, is still available today. |  |
| 1799 | Invention of the paper making machines: The Frenchman Louis-Nicolas Robert invents a continuous paper making machine, based on a specially woven bronze mesh conveyor belt called ‘the wire’. An improved version is developed by his financial backers, the English brothers Sealy and Henry Fourdrinier whose Fourdrinier Machines become operational from 1803 onwards. Pulp, made from linen or hemp rags, is poured on a woven wire conveyor belt. Water leaks away through the belt. Heated rollers smooth and dry the paper which is then rolled up. Modern papermaking machines are still based on this concept. |  |
| 1800 | Iron presses: Charles Stanhope, the third Earl Stanhope, builds the first press which has an iron frame instead of a wooden one. It can print around 200 impressions per hour. Because this Stanhope press is also more durable and can print larger sheets, other press manufacturers soon switch to a similar type of construction. |  |
| 1810 | History of Printing in America: Isaiah Thomas creates the two-volume History of Printing in America which is one of the best resources on colonial printing in the United States. |  |
| 1814 | First cylinder presses: Friedrich Gottlob Koenig and Andreas Friedrich Bauer build their first cylinder press, which is much faster than the existing flatbed presses. One of the first customers is John Walter of The Times. The first issue of The Times that is printed with the new presses is published in 1814. The press is installed in secret to avoid sabotage by disgruntled pressmen operating the existing Stanhope presses. The machine is capable of printing over 1100 double-sided sheets per hour. In 1817 Koenig & Bauer return to Germany and start building presses in an abandoned monastery in Würzburg. Their company is nowadays known as KBA. |  |
| 1816 | Columbian Press: The cast iron Columbian Press, invented by George Clymer, can produce 250 prints per hour. The Eagle mounted on top is not just a decorative element, it also serves as a counterweight. |  |
| 1817 | Cardboard boxes: The first cardboard box packaging is produced. The Kellogg Company is the first to use it for packaging cereals in the late 19th century. |  |
| 1826 | Dandy roll: John Marshall invents the dandy roll which makes it much easier for paper manufacturers to add a watermark to paper. |  |
| 1827 | Baedeker travel guides: Verlag Karl Baedeker is founded by Karl Baedeker. It publishes travel guides and becomes such a household name that such guides are often referred to as ‘Baedekers’. |  |
| 1827 | That same year Rudolphe Töpffer creates the world’s first comic strip in Switzerland. |  |
| 1829 | Braille is invented: Louis Braille publishes his Braille alphabet, a tactile reading system for the blind. |  |
| 1832 | Automating binding: Philip Watt invents the sewing machine, a major step forward in automating binding. |  |
| 1837 | Chromolithography: In France, Godefroy Engelmann is awarded a patent on chromolithography, a method for printing in colour using lithography. Chromolithographs or chromos are mainly used to reproduce paintings. In the United States, A. Hoen & Co in Baltimore is one of the first printing companies to use the technology. |  |
| 1840 | The first adhesive postage stamp: The Penny Black is the first adhesive postage stamp.  It allows UK citizens to send letters of up to 14 grams to any location in the country at a flat rate of one penny. |  |
| 1841 | Anastatic printing: Anastatic printing is a process to create a facsimile or identical copy of a document. As such, it is an early forerunner of photocopying. Its most well-known proponent is Edgar Allan Poe, the American poet and writer who publishes an article on the potential and dangers of the technique. |  |
| 1842 | The first illustrated weekly newspaper: The Illustrated London News is the world’s first illustrated weekly newspaper. It costs five pence. From 1861 onwards such newspaper becomes a lot cheaper in the United Kingdom because of the abolition of paper duty. |  |
| 1843 | First use of photos in a book: Photographs of British Algae: Cyanotype Impressions by English botanist and photographer Anna Atkins is the first book ever to be illustrated exclusively with photographs. The 389 photos are all made by placing algea directly onto photographic paper and exposing them using sunlight. |  |
| 1843 | Printed Christmas cards: Sir Henry Cole commissions the English painter John Callcott Horsley to do the artwork of (arguably) the first commercial Christmas card. Around 1000 cards are printed and hand-coloured. Ten of these are still in existence today. The card was fairly controversial in its day because it featured a child taking a sip from a glass of wine. |  |
| 1843 | That same year the American inventor Richard March Hoe builds the first lithographic rotary printing press, a press in which the type is placed on a revolving cylinder instead of a flatbed. This speeds up the printing process considerably. Printing gets even faster in 1870 when Hoe builds a rotary press that prints both sides of a page in a single operation. This roll-fed press has a speed of 240 meters (800 ft) per minute. It is used for printing newspapers and includes a built-in cutting unit and separate folder. |  |
| 1844 | Using wood to produce paper: The Canadian inventor Charles Fenerty and his German counterpart  F.G. Keller simultaneously invent a new papermaking technique based on pulping wood. Until then all paper was made from pulped rags. Cotton fiber is still used today but only for specialty applications such as currency. |  |
| 1844 | Carl Buz and Carl August Reichenbach, a nephew of Friedrich Koenig, establish the Reichenbach’sche Maschinenfabrik and build their first press, the ‘Schnellpresse’. Their factory will later become a part of manroland, currently one of the largest manufacturers of printing presses. |  |
| 1846 | Five daily newspapers in New York City create The Associated Press (AP) to share the cost of transmitting news of the Mexican-American War by boat, horse express, and telegraph. Other news agencies from the same era are Agence France-Presse or AFP (France, 1835), Agenzia Stefani (Italy, 1853) and Reuter’s Telegram Company (UK, 1857). |  |
| 1846 | Friedrich von Martini begins manufacturing folding and stitching machines. Martini introduced its Book Sewing Machine in 1897 and for 37 years also builds automobiles. It is now part of Muller Martini. |  |
| 1858 | Gordon Jobber: George Phineas Gordon produces the Franklin press, which is also known as the Gordon Jobber. Once the patents on this design expired other companies build presses based on Gordon’s design, such as the Chandler & Price letterpress. |  |
| 1860 | Photozincography: A reproduction of the Domesday Book is the first publication that is printed using photozincography, a lithographic printing technique that uses zinc plates instead of stones. It is developed by the team of Henry James of the British Ordnance Survey. These plates are the precursor to today’s aluminum offset printing plates. |  |
| 1865 | Faster web presses: William Bullock perfects Hoe’s rotary press. His web press prints on both sides, folds the paper and cuts sheets at a speed of up to 12000 sheets an hour. Bullock dies during an operation to amputate his leg that accidentally got crushed in one of his presses. |  |
| 1867 | Agfa, the Aktiengesellschaft fur Anilinfabrikation, is founded in Rummelsburg, Germany. Originally the company focuses on producing colour dyes but it will gradually become one of the leading manufacturers of film and printing plates. |  |
| 1874 | Production of corrugated board: Mass production of corrugated board starts. It is initially used to package bottles and glass lantern chimneys. |  |
| 1875 | Printing on tin: In England, Robert Barclay patents the first rotary offset lithographic printing press for printing on tin. As the name offset implies, in this press the tin substrate does not come into direct contact with the printing cylinder. In between is an offset cylinder covered with specially treated cardboard that transfers the printed image to the recipient. Cardboard later gets replaced by rubber, which is still the most commonly used material today. |  |
| 1876 | Duplicating documents with the Mimeograph: Thomas Edison receives a patent for a printing mechanism that around 1890 will result in the mimeograph or stencil duplicator. The Mimeo name is a trademark of Albert Blake Dick who licenses Edison’s patents. European manufacturers such as Gestetner develop similar machines. They allow anyone to inexpensively print dozens or hundreds of copies of a typed page. These small duplicators remain popular until photocopying becomes affordable. |  |
| 1876 | Wilhelm Koenig designs the first KBA web-fed rotary press. It is installed at the Magdeburgische Zeitung. By 1895 the company delivers its 5000th cylinder press. |  |
| 1876 | Golding & Co. introduce the Pearl letterpress, a small printing press that is available in two sizes. It has no throw-off or depressible grippers and two ink rollers. The press sells well but many commercial printers only consider it suitable for ‘bedroom printers’. |  |
| 1878 | Invention of photogravure: The Czech painter Karel Klí? invents photogravure, a process to faithfully reproduce the detail and continuous tones of photographs. To do so a copper plate is coated with a light-sensitive gelatin tissue which has been exposed to a film positive. The plate is then etched so that when ink is applied to the plate and wiped off, some ink will remain in the etched grooves and can then be transferred to paper. |  |
| 1883 | First British photogravure: T. & R. Annan in Glasgow is the first photogravure in Britain. |  |
| 1884 | Mechanical sewing machines: Hugo Brehmer develops the first mechanical thread-based sewing machine for bookbinding. |  |
| 1885 | Automating punch cutting: Linn Boyd Benton invents the pantographic punch cutter. With this machine, an operator can trace the brass pattern of a letter with one arm of the device. A cutting tool is mounted on another arm and it engraves the letter on the punch in a reduced size. The punch cutter can be adjusted to cut a complete series of sizes from one set of patterns. Those letters have a more uniform shape than the type that previously always had to be carved manually. |  |
| 1885 | Frederick and Samuel Goss found the Goss Printing Press Company in Chicago, with the financial backing of Jacob Walser. Their first product is the Clipper, a press that can print double-sided by reversing one of its cylinders. After a few difficult years the Straightline Newspaper Perfecting Press, which debuts in 1892, firmly establishes the company as a leading manufacturer of newspaper presses. |  |
| 1886 | Invention of the Linotype: Ottmar Mergenthaler invents the Linotype composing machine. With this typesetter, an operator can enter text using a 90-character keyboard. From a stock of letter form molds, the machine assembles a line containing the typed text. Molten lead is then poured over this line to create a slug, a line of metal type. Once the operation is finished the matrices are returned to the type magazine from which they came. The machines are built in New York by the Mergenthaler Linotype Co. The name ‘line-o’-type’ is a pretty good description of what the machine does. It is widely regarded as one of the greatest advances in printing since the development of movable type 400 years earlier. |  |
| 1886 | Around that same time the Swiss company Orell Gessner Füssli patents the ‘Aac process’ that is used to create photochroms, also called photochrome prints. In this process colourised images are produced from black and white photographic negatives via the direct photographic transfer of a negative onto a lithographic stone. Six to fifteen tint stones, each bearing an appropriate retouched image, are used to create the colour print. The photochrom technique is very popular in the 1890s and mainly used for printing postcards of city scapes. |  |
| 1889 | Early pop-up books: Lothar Meggendorfer’s International Circus is a pop-up book that contains six pop-up scenes of circus acts, including acrobats, clowns, and daredevil riders. Unfolded they form a circus complete with orchestra and spectators. It is not the first pop-up book to be published but thanks to reproductions, it is still available today. |  |
| 1890 | First flexo press: Bibby, Baron, and Sons build the first flexographic press.  This type of press uses the relief on a rubber printing plate to hold the image that needs to be printed. Because the ink that is used in that first flexo press smears easily, the device becomes known as Bibby’s Folly. Later improvements in the technology do make flexography one of the most used industrial printing processes. |  |
| 1890 | That same year Robert Gair accidentally invents the pre-cut cardboard box. |  |
| 1892 | Eastman Kodak Company is founded: George Eastman changes the name of his company to Eastman Kodak Company, which later becomes Kodak. |  |
| 1893 | Addressograph: Addressograph International starts manufacturing the Addressograph, a machine that allows business to quickly print a series of addresses on envelopes, invoices, quotes or other documents. The system uses a chain with rubber stamps that are inked and then pressed on the substrate. |  |
| 1894 | First European Linotypes: De Nederlandsche Financier in Amsterdam, Holland is the first newspaper on the European continent to start using a Linotype. Two years later the  Mergenthaler Setzmaschinenfabrik is founded in Berlin to cater for the European market. |  |
| 1895 | Harris presses: Charles and Alfred Harris found the Harris Automatic Press Company to market the first printing press with an automatic sheet feeder.  The press is nearly ten times faster than handfed presses and the brothers have to understate its capabilities in order to get prospects to believe them. The company will produce many innovative presses before moving into the semiconductor business and selling off its printing division in 1983. |  |
| 1895 | ‘Yellow Kid’ by Richard Outcault is the first comic strip to use text balloons. |  |
| 1896 | The Lanston Monotype Machine Company, founded by Tolbert Lanston in Washington D.C. in 1887, builds its first hot metal typesetting machine. In contrast to the Linotype which casts complete lines of type, the Monotype machine forms individual letters. That makes it easier to correct spelling mistakes by adding or removing an individual letter. This is an advantage for less time critical work, such as typesetting books. The Monotype system consists of two components: the keyboard and the composition caster. Text entered using the keyboard is output on a paper tape which can be fed into the caster which output slugs of metal type. Such a configuration allows multiple operators to typeset text that will be output on a single caster. |  |
| 1896 | In 1896 Monotype issues its first typeface, Modern Condensed. |  |
| 1898 | First car ad: The July issue of Scientific American includes an advertisement for the Winton Motor Carriage. This is generally considered to be the first ad for an automobile. |  |
| 1900 | Kolbus starts producing bindery machines: The KOLBUS ‘Rupert’ is a book spine rounding and surface pressing machine that will remain in production for 55 years. It is the first in a long line of KOLBUS book bindery machines. |  |
| 1902 | The first electric typewriter was produced by the Blickensderfer Manufacturing Company, of Stamford, Connecticut, in 1902. | YES |
| 1903 | Offset lithography is born: Two years earlier American printer Ira Washington Rubel accidentally discovers that printing from the rubber impression roller instead of the stone plate of his lithographic press produces a clearer and sharper printed page. Based on this finding and after further refinement, the Potter Press Printing Company in New York produces the first lithographic offset press for paper. |  |
| 1906 | Le Petit Larousse Illustré, a single-volume encyclopedia, is published for the first time. |  |
| 1907 | Using silk for screen printing: The Englishman Samuel Simon is awarded a patent for the process of using silk fabric as a printing screen. Screen printing quickly becomes popular for producing expensive wallpaper and printing on fabrics such as linen and silk. Screen printing had first appeared in China during the Shang Dynasty (960–1279 AD). |  |
| 1910 | By about 1910, the “manual” or “mechanical” typewriter had reached a somewhat standardised design. There were minor variations from one manufacturer to another, but most typewriters followed the concept that each key was attached to a typebar that had the corresponding letter molded, in reverse, into its striking head. When a key was struck briskly and firmly, the typebar hit a ribbon (usually made of inked fabric), making a printed mark on the paper wrapped around a cylindrical platen. The platen was mounted on a carriage that moved left or right, automatically advancing the typing position horizontally after each character was typed. The paper, rolled around the typewriter’s platen, was then advanced vertically by the “carriage return” lever (at the far left, or on the far right for left handed typewriters) into position for each new line of text. A small bell was struck a few characters before the right hand margin was reached to warn the operator to complete the word and then use the side lever to shift the paper back to the beginning of the next line. | YES |
| 1910 | The next step in the development of the electric typewriter came in 1910, when Charles and Howard Krum filed a patent for the first practical teletypewriter. | YES |
| 1911 | Roland presses: The first offset press to bear the name Roland appears on the market. It is manufactured in Offenbach, Germany by Faber & Schleicher AG. The company had been founded in 1871 and started shipping its first Albatros press 4 years later. Their 1922 single-colour Klein-Roland 00 offset press can print up to 5000 sheets per hour. |  |
| 1911 | Intertype typesetters: US newspaperman Hermann Ridder founds the International Typesetting Machine Company which manufactures the Intertype. This typesetter has a simpler design than the Linotype. Late 1912 the first machine is installed at the New York Journal of Commerce. It costs $2150 which is over $50000 in today’s currency. |  |
| 1912 | Offset printing takes off: There are already 560 offset presses in operation in the United States. By the 1930s it is the dominant form of lithography. |  |
| 1914 | Early graphic arts trade shows: The Bugra trade show takes place in Leipzig, Germany. Bugra stands for ‘Internationale Ausstellung für Buchgewerbe und Graphik’. Around 2.3  million people visit the show which sees its visitor count reduced dramatically after the outbreak of the first World War. This is the precursor to the drupa trade shows that take place in Düsseldorf after Leipzig becomes part of East Germany after the second World War. |  |
| 1914 | In the USA demand for coil stamps is so high that Benjamin R. Stickney designs a dedicated press for stamp production. Stickney presses are manually controlled, single-colour, web-fed printing press and gumming machines. They remain in use at the Bureau of Engraving and Printing until 1957. |  |
| 1915 | Hallmark, founded in 1910, creates its first Christmas card. Forty years earlier Boston printer Louis Prang had been the first to offer a line of Christmas cards in the USA. |  |
| 1922 | Book and type designer William Addison Dwiggins coins the term ‘graphic designer’ to describe his activities as an individual who brings structural order and visual form to printed communications. The term only achieves widespread usage after the Second World War. |  |
| 1923 | KBA prints banknotes & Komori is founded: The four-colour Iris press from Koenig & Bauer can be used for printing banknotes. Over time security printing becomes one of the main focus points of the company. |  |
| 1923 | Komori Machine Works is founded in Kitashinmachi, near Tokyo. Their first lithograph roll printing press is developed in 1925. A 32-inch manual sheetfed offset press follows in 1928. |  |
| 1925 | Rudolf Hell invented the Hellschreiber, an early facsimile-like dot matrix-based teletypewriter device, patented in 1929 | YES |
| 1930 | IBM releases Model 01 electric typewriter | YES |
| 1932 | Addressograph International merges with American Multigraph to form the Addressograph-Multigraph Corporation. For decades this company will dominate the market for addressing and duplicating machines. |  |
| 1935 | First paperbacks and adhesive labels: The first commercially successful series of paperback books is published by Penguin Books in the UK. Earlier in 1931 German publisher Albatross Books had already tried to market a series of lower-priced books with a paper cover and glue binding. Penguin copied many of the concepts of their failed attempt, such as the use of colour-coded covers. The books cost sixpence each – the same price as a packet of cigarettes. |  |
| 1935 | Ray Stanton Avery invents the first self-adhesive label, meant to make it easier for stores to price their products. In 1990 his company, Avery International, will merge with Dennison Manufacturing to become Avery Dennison. |  |
| 1938 | Xerography is invented: Xerography, a dry photocopying technique, is invented by Chester F. Carlson. In 1947 Haloid Company, now known as Xerox, obtains a license to commercialize the technology. | YES |
| 1938 | In 1938 the Dresden-Leipziger Schnellpressenfabrik AG changes its name to Planeta. Six years earlier the company had introduced the world’s first four-colour web offset press. After World War II Planeta becomes the largest press manufacturer of the DDR. It is acquired by Koenig & Bauer (KBA) in 1991. |  |
| 1939 | Cold-glueing takes off: Emil Lumbeck is the first one to successfully use cold-glue binding for books (Lumbeck-Kaltklebebindung). |  |
| 1942 | Marjory Collins photographs the production of the New York Times in order to document home front activities for the U.S. Office of War Information. |  |
| 1947 | Polar starts building electrically powered cutters: Polar build the Einmesser-Schnellschneider, their first electrically powered cutting machine. In 1954 they build the first cutters with an optical cutting line indicator and air cushion table. |  |
| 1948 | First prototype of photocopier by Battelle and The Haloid Co. | YES |
| 1948 | Shinohara Machinery Company, the Japanese machine tool manufacturer which had been established in 1919, begins manufacturing flatbed letterpress machines. |  |
| 1949 | First scans of colour images: The July issue of Fortune magazine contains the first commercial scanned colour image. It is produced using a scanner built by the Austin Company. |  |
| 1951 | EAI develops analog flatbed pen plotter | YES |
| 1951 | Drupa trade show: The first drupa trade show is held in Dusseldorf, Germany. drupa, which stands for ‘Druck und Paper’ (print & paper), is a specialist trade fair for the printing industry. |  |
| 1952 | Security printing: In Lausanne, Switzerland, Gualtiero Giori founds Organisation Giori to develop and sell technology, equipment and services for printing banknotes. This includes a center to train state printing plant staff in the best practices in banknote design and production. |  |
| 1952 - 1954 | Fritz Karl Preikschat filed five patent applications for his teletype writer 7 stylus 35 dot matrix aka PKT printer, a dot matrix teletypewriter built between 1954 and 1956 in Germany. | YES |
| 1954 | The second drupa fair is a major success with 226388 visitors. The show highlights are engraving machines for letterpress printing. Grapha, which gets renamed to Grapha Maschinenfabrik Hans Müller A. G a year later, exhibits the BSV, its first fully automatic saddle stitcher with in-line trimmer, as well as its adhesive binder. |  |
| 1957 | IBM introduces the first dot-matrix printer | YES |
| 1957 | Transfer printing discovered | YES |
| 1957 | Dye sublimation process invented | YES |
| 1957 | First Komori four-colour press: Komori develops its first four-colour offset press, the UM-4C. |  |
| 1959 | Haloid-Xerox plain-paper copier: The Xerox 914 is the first successful plain paper copier. It can make six copies per minute and had been preceded in 1949 by the ‘Model A’, the first commercial xerographic copier. | YES |
| Early 1960s | Stanford - developed technology for ink droplets using pressure wave patterns | YES |
| 1960s | Gerber Scientific produces plotters for printed circuit boards | YES |
| 1962 | Hell HelioKlischograph: Dr. Ing. Rudolf Hell introduces the HelioKlischograph K190 – the first in a series of systems for gravure printing. Subsequent models have separate scanning and engraving units ( the 1965 HelioKlischograph K193) or digital electronics (the 1974 HelioKlischograph K200). The product family still exists today. |  |
| 1962 | Andy Warhol popularizes screen printing, also called serigraphy, as an art form. His ‘Turquoise Marilyn’ is produced using acrylic paint and a silkscreen print on linen. |  |
| 1962 | Kolbus introduce a fully automatic book finishing system that is capable of producing 36 books a minute on a continuous production line. |  |
| 1967 | Océ enters the office printing market with an electro-photographic process for copying documents using a special chemically-treated type of paper. Its first plain-paper office copier follows in 1973. Instead of a xerographic process, this copier uses a developer free technology that later on will also be used in Océ’s high volume printers. |  |
| 1967 | ISBN is started in Britain. The International Standard Book Number is a unique numeric identifier for commercial books. |  |
| 1967 | Japanese press manufacturer Sakurai exhibits for the first time at drupa, showing off their Monarch full-automatic screen press. |  |
| 1968 | The Japanese manufacturer OKI introduced its first serial impact dot matrix printer (SIDM), the OKI Wiredot. The printer supported a character generator for 128 characters with a print matrix of 7×5. It was aimed at governmental, financial, scientific and educational markets. | YES |
| 1968 | Using silicone for pad printing: Tampoprint in Germany replace the low-endurance gelatine pads used in pad printing presses by silicone pads. This allows such presses to print much longer runs on an industrial scale. |  |
| 1969 | Gary Starkweather, at Xerox’s research facility in Webster, New York, demonstrates using a laser beam with the xerography process to create a laser printer. | YES |
| 1969 | Grapha Maschinenfabrik Hans Müller A. G and Martini merge and become Muller Martini. |  |
| 1970s | Direct thermal printer | YES |
| 1970 | Xerox plain-paper colour copier: Xerox patents expire, allowing other manufacturers such as Canon to create xerographic copiers. Xerox does, however, continue to dominate the market and launches its first plain paper colour copier, the Xerox 6500, in 1973. | YES |
| 1970 | Water-based inks are introduced. | YES |
| 1972 | Presses with an integrated ink control system: The ROLAND 800 is the first sheetfed offset press with an integrated ink control system. It can print up to 10000 sheets per hour. It is one of the highlights of the drupa 1972 show. |  |
| 1973 | HP 9862A plotter released for 9800 desktop calculator |  |
| 1973 | All time high newspaper readership: Newspaper circulation reaches its highest level ever in the US. It will remain fairly steady until a gradual decline sets in during the mid-’80s. | YES |
| 1974 | The DECwriter LA36 becomes one of the first dot-matrix printers to achieve commercial success, and for a time becomes the standard dot matrix computer terminal. | YES |
| 1974 | Stored energy dot matrix printer | YES |
| 1974 | Shinohara Machinery Company builds its first offset press, the Fuji 58. |  |
| 1974 | The first Lonely Planet travel guide is published. Below it is shown next to the 2016 edition. |  |
| 1975 | The first laser printers, such as the Xerox 9700, hit the market. They are prohibitively expensive but useful for applications such as cheque printing. | YES |
| 1976 | IBM introduces the IBM 3800 laser printer, capable of printing 20000 lines per minute. | YES |
| 1976 | Drop-on-demand inkjet technology developed | YES |
| 1977 | Siemens PT-80 uses drop-on-demand inkjet technology |  |
| 1977 | Benny Landa founds Indigo, initially a research company that licenses its technology to other manufacturers. This changes in the mid-80’s when the company develops ElectroInk, a liquid ink that the company uses in the E-Print 1000 digital press from 1993. |  |
| 1978 | Piezoelectric inkjet printer | YES |
| 1978 | First commercially successful dot matrix printer for personal computers - Epson’s TX-80 | YES |
| 1979 | Canon files the first thermal ink jet patents in Europe and the US | YES |
| c. 1979 | Siemens PT-80i introduced in Europe |  |
| 1979 | Canon introduces the first low-cost desktop laser printer, the Canon LBP-10. | YES |
| 1979 | MAN Roland Druckmaschinen AG is formed as a result of the merger of the printing press division of Maschinenfabrik Augsburg-Nürnberg and Roland Offsetmaschinenfabrik Faber & Schleicher. In 2008 the company will be renamed to manroland. |  |
| Late 1970s | Ballistic wire dot matrix printers | YES |
| 1980s and early 1990s | Dot matrix printing is the leading technology for inexpensive desktop applications |  |
| 1980 | IBM releases 5215 golf ball printer | YES |
| 1981 May | Xerox unveils the Star 8010 (the first laser printer designed for office use), at the National Computer Conference. Many features that were developed on the Alto are incorported. It includes a bitmapped screen, WYSIWYG word processor, mouse, laser printer, Smalltalk language, Ethernet, and software for combining text and graphics in the same document. At a starting price of US$16-17000, the computer is not a commercial success. During its lifetime, 100000 units are produced. |  |
| 1982 | Thermal wax printer | YES |
| 1982 | Plastic banknotes: The American Bank Note Company prints the first plastic banknotes using DuPont’s Tyvek polymers.  Australia is the first country to use polymer banknotes for general circulation from 1992 onwards. |  |
| 1983 | Hewlett-Packard and Canon negotiate ink-jet cross-licensing agreement |  |
| 1984 | First disposable inkjet cartridge | YES |
| 1984 | Hewlett-Packard introduces the ThinkJet printer (thermal ink-jet) | YES |
| 1984 | The Mac is born: The Apple Macintosh is a ground-breaking computer which for the first time combines a graphical user interface and a mouse with a ‘reasonable’ price tag of $2490 (taking inflation into account that is over $5000 today). | YES |
| 1984 | Adobe launches PostScript, a page description language that can be used to control output devices like laser printers. The Linotronic 300 imagesetter is the first 2400 dpi output device to ship with a PostScript RIP. |  |
| 1984 | Apple Computer gives LaserWriter printer prototypes to Lotus Development, Microsoft, and Aldus, in hopes of their developing application support for it. |  |
| 1984 | Hewlett-Packard introduces the LaserJet laser printer, featuring 300dpi resolution, for US$3600. This is the first laser printer intended for mass-market sales. | YES |
| 1985 | Desktop publishing takes off: Steve Jobs convinces John Warnock from Adobe to create a PostScript controller for their Apple LaserWriter, allowing it to output ‘typesetter quality’ pages. Apple and Adobe are fortunate enough that the small start-up Aldus creates an application to utilise the Mac and LaserWriter to their full extent. Aldus’ software product is PageMaker. | YES |
| 1985 | Apple Computer commercially releases the Apple LaserWriter laser printer, using the newly released PostScript page-description language (PostScript allowed the use of text, fonts, graphics, images, and colour largely independent of the printer’s brand or resolution). |  |
| 1986 Jan | Apple Computer introduces the LaserWriter Plus printer. |  |
| 1986 | Hewlett-Packard introduces the QuietJet ink-jet printer |  |
| 1986 | Wapping dispute: 5500 employees of News International go on strike in a dispute over new working conditions and the proposed move from Fleet Street to new premises in the London Docklands. Despite a long and bitter battle between the strikers and the police, The Times, the Sunday Times, The Sun and the News of the World get published every single day. This Wapping dispute is a key event in the development of the British newspaper industry. |  |
| 1986 | At drupa 1986 MAN Roland Druckmaschinen AG introduces its LITHOMAN commercial web offset printing press. Polar show off the POLAR Compucut, a system for computer assisted, external generation of cutting programs with automatic transfer to the cutting machine. |  |
| 1987 | First colour inkjet printer - HP Paintjet | YES |
| 1988 | Hewlett-Packard introduces the DeskJet ink-jet printer (widely regarded as the ’Model T’ of the industry) | YES |
| c. 1988 | Xaar’s basic patents for piezoelectric-shear print heads are filed | YES |
| 1990 | Hewlett-Packard’s introduction of the LaserJet IIP breaks the US$1000 street price barrier. | YES |
| 1990 | Xerox Docutech: Xerox launches its first DocuTech system, known as the DocuTech Production Publisher. The system is based on a 135 page-per-minute black & white 600 dpi xerographic print engine with attached scanner and finisher modules. It is arguably the first affordable ‘print-on-demand’ publishing system. |  |
| c. 1990 | Canon BJ-10e & 10v ink-jet printers introduced |  |
| 1990/1991 | Peak dot matrix printer sales achieved (with seven-to-one ratio of dot matrix printers to ink-jet at this time) | YES |
| 1991 | On-press imaging: The Heidelberg GTO-DI uses Presstek plates which are imaged on the press itself. This direct imaging technology looks promising but even though other vendors start offering similar solutions it never really catches on. In 2006 Heidelberg abandons the technology. |  |
| c. 1992 | Hewlett-Packard introduces the DeskJet 1200C ink-jet printer |  |
| 1992 Autumn | Hewlett-Packard introduces the HP LaserJet 4 laser printer. |  |
| 1993 | First digital presses: The Indigo E-Print 100 is a digital press that uses ElectroInk, a kind of fluid ink which in its first incarnation can actually be rubbed off the paper. Competing systems such as the Xeikon DCP-1, introduced the same year, rely on toner. In 2002 Indigo is acquired by HP while Punch Graphix buys Xeikon. |  |
| 1993 June | Hewlett-Packard introduces the LaserJet 4ML laser printer. |  |
| 1993 | QMS introduces the ColorScript Laser 1000 colour laser printer, for US$12499. | YES |
| c. 1993 | Seiko Epson files critical ink-jet piezo print head patents in the US | YES |
| 1994 | Epson introduces the MJ-700V2C (a.k.a. Stylus Color) ink-jet printer which shifted away from thermal ink-jet print heads to piezoelectric print heads. Piezoelectric print heads are better at generating multiple sized ink-jet drops, and suitable for a wider range of ink formulations. This raised the overall quality of ink-jet printers, getting close to photographic quality. | YES |
| 1995 June | Apple Computer introduces its first colour laser printer, the Color Laser Printer 12/600PS. The 600x600 dpi printer comes with 12 MB of RAM, uses a Canon-based engine, and costs about US$7000. |  |
| 1995 | At drupa MAN Roland Druckmaschinen AG launches the ROLAND 900, an innovative large format sheetfed offset press. |  |
| 1995 | The very first post appears on Craigslist. Within a few years, this web service has an enormous impact on US newspapers because they lose a major part of their classified ads income to the site. |  |
| 1995 | Vistaprint is founded in Paris, France by Robert Keane who believes in the potential of offering short run, high-quality printing to small businesses. |  |
| 1996 April | Hewlett-Packard begins shipping the HP LaserJet 5 line of laser printers. |  |
| c. 1996 | Hewlett-Packard and Lexmark settle infringement suit with new cross-licensing agreement |  |
| c. 1996 | Manufacturers introduce photo quality printers | YES |
| 2000 | Cortina waterless offset & NexPress: For press manufacturers drupa is an incredible success. Many of the big vendors, such as Heidelberg and Manroland, report an unprecedented number of sales. One of the highlights of the show is the KBA Cortina, a waterless web press for newspapers and semi-commercials. Among the digital presses the NexPress, a joint development from Heidelberg and Kodak, and the Manroland DICOweb get most of the attention. The DICOweb is, however, a short-lived commercial failure. |  |
| 2001 | Market consolidation: HP acquires Indigo. Scitex sells off Vio and Karat, which is bought by KBA. |  |
| 2002 | In March Belgian electronics specialist Punch buys Xeikon, which had been declared bankrupt earlier that month. The other bidders were Manroland and Yam International. |  |
| 2003 | Kodak forms a dedicated commercial printing business unit. The division includes its NexPress joint venture with Heidelberg. |  |
| 2003 | Decline of offset printing: The overall volume of sheetfed offset print revenues reaches its lowest point in the decade. 2007 will be the best year. |  |
| 2004 | Heidelberg sells off its web press division to Goss and its NexPress digital arm to Kodak. It intends to focus uniquely on sheetfed presses. |  |
| 2005 | The market for digital presses keeps expanding with the launches of the Konica Minolta Bizhub and Canon Imagepress. |  |
| 2005 | EFI acquires VUTEk and enters the wide format inkjet market. It will later also acquire Jetrion, Raster Graphics, and Cretaprint, making it a dominant leader in this market. |  |
| Mid 2000s | The emergence of cloud storage services that let you store 1000s of albums that can be accessed/retrieved on demand, as well as tablets and smartphones that put high-resolution images at users fingertips, begins to reduce demand for desktop printers | YES |
| 2007 | Shortrun on-demand bookprinting: The Espresso Book Machine is a print-on-demand system that combines a printer, such as the Xerox WorkCentre 4112, with a collating, binding and cutting unit. A small colour printer is used for covers. The EBM can print a 300-page book in 4 minutes. It costs from $97000 plus printer. |  |
| 2008 | Printing industry is hit hard by financial crisis: A financial crisis followed by a worldwide economic turndown put a lot of pressure on the printing industry. The overall volume of print drops significantly. The newspaper industry seems to suffer the most, mainly due to higher paper prices, declining advertising revenue and increasing competition from the web. |  |
| 2008 | One of the largest printing companies in the world, Quebecor World, files for Chapter 11 bankruptcy protection. |  |
| 2008 | At drupa, the focus lies on inkjet printers with much attention going to high-speed, high-quality roll-fed inkjet printers from companies like HP (the T300), Screen (the Truepress Jet2500UV), Infoprint, Oce, Fujifilm (whose Jetpress 720 is the first sheetfed B2-press) and Kodak (the Stream concept press). HP introduces its latex inkjet technology, aiming to combine the ability to print durable graphics onto uncoated materials with high image quality and eco-friendliness. |  |
| 2009 | Press manufacturers suffer from the crisis: The financial crisis continues. According to estimates of the American Forest & Paper Association newsprint production falls by 30% in 2009 and magazine print by 25%. Folio reports that 596 magazines disappear from the US market. One of the first cost-cutting measures that many companies take is reducing their capital expenditures. Press manufacturers suffer the most from this. According to some estimates over 30% of their deals closed at the 2008 drupa show get canceled. Heidelberg has to apply for a 300 million Euro state loan to survive. A planned merger with Manroland is called off by the latter due to its rival’s poor financial results. Oddly enough some vendors, like KBA, do not seem to suffer that much from the crisis. |  |
| 2009 | Goss International installs a Goss Sunday 5000, the world’s first 96-page web press, at Italian magazine printer Grafiche Mazzucchelli. Three years later manroland will announce its solution with a web width of 2.86 meters, the 96-page LITHOMAN S. |  |
| 2009 | Canon buys Océ for US $1.1bn. |  |
| 2009 | Competition among printers remains fierce. A look at some typical prices shows how much these have dropped over the past years: In 1995 1000 4 colour business cards went for $125. In 2009 they cost around $9.95. In 1995 customers paid around $450 for 1000 4 colour brochures. A similar job now costs $99. |  |
| 2009 | Chinese companies produce 85 million tons of paper, up from 40 million tons in 2000 and 15 million tons in 1990. |  |
| 2010 | At the IPEX 2010 show in Birmingham, UK the largest booths are no longer those of press manufacturers like Heidelberg or Man Roland but of printer manufacturers like HP,  Xerox, and Canon. Digital inkjet printing technology is the hot topic, along with web-to-print and cross-media publishing. Among the new devices that are launched are the Prosper 5000XL, Kodak’s flagship colour continuous-feed press, and the Konica Minolta Bizhub C8000 digital press. Many see the success of the show as a clear indicator of the revival of the graphic arts market. |  |
| 2010 | The focus on digital print is also visible at Graph Expo 2010 where Heidelberg and Komori are absent while manroland and KBA aren’t showing any presses. Even though digital printing grows, it still represents only around 3% of the total print volume and 6% of the print value. According to a KBA report issued the same year, China becomes the biggest market for litho presses. |  |
| 2010 | When asked what he thinks about the suggestion that the New York Times might print its last edition in 2015, its publisher Arthur Sulzberger Jr says he sees no point in making such predictions and that all he can say is that “We will stop printing the New York Times sometime in the future, date TBD”. |  |
| 2010 | The World Wildlife Fund attempts to launch a ‘green‘ file format. The WWF format is simply a PDF that cannot be printed out to ‘stop unnecessary printing and encourage a new awareness about the use of paper’. The WWF initiative never gets any traction but positioning print as a sustainable industry does become a trend. & 2011 & Online advertising takes over the number two spot from newspapers in the US advertising market. & 2011 & Equipment manufacturers realize that their world is changing rapidly. Many of them cooperate with other vendors to try and build a presence in the digital printing market. This leads to a series of interesting partnerships: Heidelberg & Ricoh, Manroland & Océ, KBA & RR Donnelley & Son and last but not least Kodak & Konica Minolta. & 2011 & Declining sales and a resulting debt of $94 million force the Japanese press manufacturer Shinohara to file for bankruptcy protection. Its sales had dropped from $60 million in March 2009 to $26 million in March 2010. In November German press manufacturer Manroland AG also files for insolvency. They state their dramatic drop in incoming orders is caused by customers having difficulty in obtaining financing for purchasing printing presses. & 2011 & Xerox launches the CiPress 500 high-speed waterless inkjet press. & 2011 & In its London headquarters, Stroma starts printing colour editions of international newspapers on an Océ JetStream 1000. This digital inkjet press can print in excess of 1000 36-page tabloid newspapers per hour. & 2011 & In the US overall sales of ebooks pass sales of paperbacks. Seven months earlier, in  July 2010, web shop Amazon’s US digital book sales had already eclipsed the sales of hardcover books. & 2012 & Benny Landa announces a range of nanographic printing presses that combine the versatility of digital printing with the low cost and quality of offset. These presses are the buzz of the show but it takes another 5 years before even the first beta site to test the technology is started. & 2012 & Among the other announcements is Xeikon’s Quantum toner technology. Three new B2-size sheetfed digital presses are announced: the HP Indigo 10000, Screen Truepress Jet SX & Konica Minolta KM-1. Despite the upbeat mood during the show itself, attendance decreases to 314500 visitors. & 2012 & Many press manufacturers change ownership: Manroland is split up.  Langley Holdings purchases the sheet-fed division and the web division is acquired by Prossehl. Hans-Gronhi purchases Shinohara. Wifag buys Solna. & 2012 & After 244 years the Encyclopædia Britannica discontinues its print edition. & 2013 & China Print shows the growth of the chinese printing market: China Print, the largest Chinese graphic arts trade show, draws 180000 visitors and has almost as much floor space as drupa. & 2013 & Xerox acquires Impika to extend its foothold in high-speed inkjet. & 2013 & According to HP, the users of its production inkjet presses print enough pages each month to circle the earth more than 14 times. & 2013 & Heidelberg announces it will phase out production of its Printmaster GTO 52 from March 2014. Since its launch in 1972 106000 units have been sold worldwide. The press manufacturer intends to focus sales on its Speedmaster SM 52 and SX 52 devices and its Linoprint C 901 and C 751 digital printers. & 2014 & Vistaprint acquires the Dutch Drukwerkdeal.nl as well as a 97% stake in Italian web-to-print business Pixartprinting and a $25 million stake in Brazilian web-printing startup Printi. & 2014 & French press manufacturer MGI uses the British Ipex trade show as the global launchpad its new Meteor DP8700 XL+ digital press, DF Pro inline finishing unit, and JETvarnish digital spot coater. The Ipex show itself is smaller than previous editions because Heidelberg, Agfa and several digital press vendors decide to no longer attend it. & 2014 & Xerox launches the Versant 1200 digital press, to compete with the Konica Minolta C8000 and Ricoh C901 in the mid-range segment of the digital printing market. & 2014 & Heidelberg stops manufacturing saddlestitchers and perfect binders but it continues its line of Stahlfolder folding machines. & 2014 & In the USA print keeps getting less attention from the average consumer. Packaging, sign & display and other markets are as healthy as ever. & 2014 & At Graph Expo 2014 in Chicago, one of the show highlights are the digital die-cutting devices of Highcon, an Israeli company. & 2015 & At the Labelexpo Europe trade show Gallus showcases the first modular digital inline label printing system, the DCS 340, which is later relabeled as the Labelfire 340. & 2015 & Müller Martini stops making printing presses and shifts its focus entirely to finishing machines. & 2015 & Flint Group acquires Xeikon and uses the press and consumables manufacturer as the basis of a new digital division, Flint Group Digital Printing Solutions. & 2016 & At the drupa trade show digital printing in general and specifically inkjet printing on corrugated packaging board attracts a lot of attention. Among the presses shown or previewed are the EFI Nozomi C18000, the HP PageWide C500,  and the Durst Rho 130 SPC. & 2016 & Several vendors showed digital embellishing and finishing equipment. A prime example is the Scodix E106 which can be used, among others, to add foils to short or medium run folding cartons. & 2016 & Bertelsmann creates the Bertelsman Printing Group, Europe’s biggest printing group with revenues of €1.7 billion and nearly 9000 employees. & |  |

Timeline of solar technologies (Anon, n.d.; Anon, n.d.; EIA, 2008; Anon, n.d.; Anon, n.d.; Anon, n.d.)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| 1767 | The Solar Oven: Swiss physicist, alpine explorer, and aristocrat Horace de Saussure is credited with inventing the first working solar oven, amongst other discoveries. Constructed from 5 layers of glass and measuring around 12 inches across, the oven worked by allowing light to pass through the glass before being absorbed by the black lining and turned into heat. The heat is then reflected by the glass, therefore heating the space inside the box up to 87.5 degrees Celsius. He wrote that “Fruits… exposed to this heat were cooked and became juicy.” | YES |
| 1839 | The Photovoltaic Effect: Edmond Bequerel, born in Paris in 1820, discovered that when two electrodes were placed in an electrolyte (electricity-conducting solution), a voltage developed when light fell upon the electrolyte. This provided the basic principles for solar power. | YES |
| 1860 | Auguste Mouchout (France), a mathematics instructor, was able to convert solar radiation directly into mechanical power. | YES |
| 1873 | Selenium: An English Electrical engineer, Willoughby Smith, discovered the photoconductivity of selenium entirely by accident. He was developing a method for continually testing underwater telegraph cables as they were being laid and chose selenium rods as a semi-conductor with high resistance for his test circuit. Although selenium appeared to be up to the job, inconsistent results kept occurring. Smith realised that the conductivity of selenium was affected by the amount of light it was exposed to. He described the effect in a paper published in Nature in February of that year. | YES |
| 1876 | Electricity from Light: A King’s College Professor, William Grylls Adams, and his student, Richard Evans Day, found in 1876 that solidified selenium produced electricity when exposed to light. They attached platinum electrodes to selenium and observed a current in the electrodes when the selenium was exposed to light. Although there was not enough electricity to power anything, they had shown that electricity could be generated from light without the use of any moving parts. They published a paper on the selenium cell: ’The action of light on selenium,’ in “Proceedings of the Royal Society, A25, 113 in 1877. & YES 1878 & Augustin Mouchot displays a solar power generator at the Universal Exhibition in Paris. & YES 1878 & William Adams (England) constructed a reflector of flat-silvered mirrors arranged in a semicircle. To track the sun’s movement, the entire rack was rolled around a semicircular track, projecting the concentrated radiation onto a stationary boiler. & YES 1883 & The First Working Solar Cell: American inventor Charles Fritts developed the first solar cell, applying selenium to a thin layer of gold. This method was only able to achieve 1 to 2% efficiency, making it impractical for general use. & YES 1883–84 & John Ericsson (United States) invented and erected a solar engine that used parabolic trough construction. & YES 1887 & Heinrich Hertz investigates ultraviolet light photoconductivity and discovers the photoelectric effect & YES 1887 & James Moser reports dye sensitised photoelectrochemical cell. & 1888 & Edward Weston receives patent US389124, ”Solar cell,“ and US389125, ”Solar cell.“ & YES 1888-91 & Aleksandr Stoletov creates the first solar cell based on the outer photoelectric effect & YES 1894 & Melvin Severy receives patent US527377, ”Solar cell,“ and US527379, ”Solar cell.“ & 1897 & Harry Reagan receives patent US588177, ”Solar cell.“ & 1901 & Philipp von Lenard observes the variation in electron energy with light frequency. & 1904 & Wilhelm Hallwachs (German) discovered that a combination of copper and cuprous oxide was sensitive to light. & YES 1905 & Einstein’s Paper on Light & Electrons: In the paper “On a Heuristic Viewpoint Concerning the Production and Transformation of Light” Einstein set out for the first time the photoelectric relationship between light and electrons on a quantum basis. Although controversial at the time, it was gradually accepted by the scientific community and led to his winning of the Nobel Prize in 1921. & YES 1913 & William Coblentz receives US1077219, ”Solar cell.“ & 1914 & Sven Ason Berglund patents ”methods of increasing the capacity of photosensitive cells.“ & 1916 & Robert Millikan experimentally proves Einstein’s theory of the photoelectric effect. & 1918 & Accidental Crystals: Jan Czochralski, a polish scientist, discovers a method for creating single-crystal silicon entirely by accident — he mistakenly dipped his pen in a crucible of molten tin rather than an inkwell. The result was a thin thread of solidified metal. Single-crystal semi-conductors and metals became important throughout electronics — their efficiency and stability not only contributing to the development of silicon solar cells, but also crucial to the creation of transistors for microprocessor units. & YES 1920s & Solar water-heating systems, utilizing ”flat collectors“ (or ”flat-plate collectors“), relied upon in homes and apartment buildings in Florida and southern California. & YES 1921 & Albert Einstein wins the 1921 Nobel Prize in Physics for his theories that explained the photoelectric effect. & YES 1932 & Audobert and Stora discover the photovoltaic effect in Cadmium selenide (CdSe), a photovoltaic material still used today. & YES 1935 & Anthony H. Lamb receives patent US2000642, ”Photoelectric device.“ & 1941 & Russell Ohl files patent US2402662, ”Light sensitive device.“ & 1947 & Energy was scarce during World War II so passive solar buildings became popular in the United States. & 1947 & Libbey-Owens-Ford Glass Company published a book titled, Your Solar House, which profiled 49 of the nation’s greatest solar architects. & 1948 & Gordon Teal and John Little adapt the Czochralski method of crystal growth to produce single-crystalline germanium and, later, silicon. & YES 1950s and 60s & The Space Race: The burgeoning space industry’s need for a sustainable power source in the earliest satellites led to investment and development in solar technology. Satellites such as Explorer VI and VII and the first telecommunications satellite Telstar 1 (launched by Bell Labs) utilised the most cutting edge (at the time) solar cells, achieving up to 14 watts from their photovoltaic arrays. & 1953 & Gerald Pearson begins research into lithium-silicon photovoltaic cells. & 1954 & A Major Breakthrough: Three researchers at Bell Labs — Daryl Chapin, Calvin Fuller, and Gerald Pearson — invent of the first practical silicon solar cells, announced by Bell Labs on the 25th of April. Chapin had for several years been experimenting with selenium-based solar cells but was unable to achieve an efficiency above 1% (for comparison, internal combustion achieves around 20%). At the same time, Fuller and Pearson were developing silicon transistors and found that one of these, when exposed to light, generated electricity. The three scientists joined forces and in 1954 presented their ‘solar battery’, powering a small toy windmill and a radio, at an efficiency of 6%. The key to this was their ability to diffuse boron into silicon, a process known as doping. The New York Times forecasts that solar cells will eventually lead to a source of ”limitless energy of the sun“. This first solar cell was the size of a small coin, and although not commercially viable, is the basis for solar cell development ever since. & YES 1955 & Western Electric began to sell commercial licenses for silicon photovoltaic technologies. Hoffman Electronics-Semiconductor Division creates a 2% efficient commercial solar cell for $25/cell or $1785/watt. Early successful products included PV-powered dollar bill changers and devices that decoded computer punch cards and tape. & 1956 & In the mid-50s, engineer Don Paxton and architect Frank Bridgers designed the world’s first commercial solar building at 213 Truman N.E., Albuquerque, NM. Utilising a south-facing glass wall tilted to 30 degrees, alongside mechanical and “passive” solar technologies, the structure was well ahead of its time. Relying on mechanical solutions where computer control would nowadays be used, they achieved a remarkable level of efficiency through solar heating and thermal storage. The template that they created is still utilised in creating energy-efficient homes and commercial premises today. & YES 1957 & AT&T assignors (Gerald L. Pearson, Daryl M. Chapin, and Calvin S. Fuller) receive patent US2780765, ”Solar Energy Converting Apparatus.“ They refer to it as the ”solar battery.“ Hoffman Electronics creates an 8% efficient solar cell. & YES 1958 & T. Mandelkorn, U.S. Signal Corps Laboratories, creates n-on-p silicon solar cells, which are more resistant to radiation damage and are better suited for space. Hoffman Electronics creates 9% efficient solar cells. Vanguard I, the first solar powered satellite, was launched with a 0.1W, 100 cm² solar panel. & YES Late 1950s & Increasing Efficiency: Throughout the late 50s, Hoffman electronics developed increasingly efficient solar cells. It started out initially at an 8%-efficient cell in 1957, before eventually increasing to a 14%-efficient, commercially available cell in 1960. & YES 1961 & ”Solar Energy in the Developing World“ conference is held by the United Nations. & YES 1962 & The Telstar communications satellite is powered by solar cells. & YES 1963 & Sharp Corporation produces a viable photovoltaic module of silicon solar cells. & 1964 & Farrington Daniels’ landmark book, Direct Use of the Sun’s Energy, published by Yale University Press. & 1967 & Soyuz 1 is the first manned spacecraft to be powered by solar cells & 1967 & Akira Fujishima discovers the Honda-Fujishima effect which is used for hydrolysis in the photoelectrochemical cell. & YES 1968 & Roger Riehl introduces the first solar powered wristwatch. & 1969 & A ”solar furnace“ was constructed in Odeillo, France; it featured an eight-story parabolic mirror. & YES 1970s & Commercial Viability: Despite the great advances over twenty years or so, solar technology was still too expensive to be commercially viable in terrestrial installations. In the early 70s, Dr. Elliot Berman (with funding from Exxon Corp.) designed a much lower cost solar cell, using lower-grade silicon and cheaper housings which brought the cost per watt down from $100 to just $20. Installations far from mains electricity (i.e. oil rigs) used the cells over expensive and cumbersome batteries, giving terrestrial solar technology the capital boost it needed to become a viable mainstream solution. & YES 1970 & First highly effective GaAs heterostructure solar cells are created by Zhores Alferov and his team in the USSR. & 1971 & Salyut 1 is powered by solar cells. & 1972 & The Institute of Energy Conversion: The first laboratory dedicated to the development of PV research is established at the University of Delaware. & YES 1973 & Skylab is powered by solar cells. & 1973 & The University of Delaware builds ”Solar One,“ a PV/thermal hybrid system, and the world’s first PV-powered houses. Roof-integrated arrays fed surplus power through a special meter to the utility during the day; power was purchased from the utility at night (the model known today as the solar ‘feed-in’). In addition to providing electricity, the arrays were like flat-plate thermal collectors; fans blew warm air from over the array to heat storage bins. & YES 1973 & The Arab Oil Embargo occurred, in which several Arab nations in the Organization of Petroleum Exporting Countries (OPEC) embargoed oil to the United States and Holland to protest their support of Israel in the Arab-Israeli “Yom Kippur” War. Arab OPEC production was cut by 25%, which caused some temporary shortages and helped oil prices to triple. This contributed to an increased interest in alternatives to petroleum, including nuclear power. & YES 1973 & Spurred by the oil embargo, interest in space applications of photovoltaics grows. & YES 1974 & Florida Solar Energy Center begins. & 1974 & J. Baldwin, at Integrated Living Systems, co-develops the world’s first building (in New Mexico) heated and otherwise powered by solar and wind power exclusively. & 1974 & The Solar Energy Industries Association (SEIA) was formed. The organization represents the interests of the solar industry and acts as a lobbying group in Washington, DC. & YES 1976 & David Carlson and Christopher Wronski of RCA Laboratories create first amorphous silicon PV cells, which have an efficiency of 1.1%. & 1977 & Global Photovoltaic manufacturing production exceeds 500 kilowatts for the first time & 1977 & The Solar Energy Research Institute (SERI) was formed (now the National Renewable Energy Laboratory [NREL]), a national laboratory that provides research and development support for solar and photovoltaic technologies. & YES 1978 & First solar-powered calculators. & 1978 & First Feed-In Tariff Implemented: The first form of feed-in tariff was implemented in the US in 1978 under President Jimmy Carter, after signing the National Energy Act (NEA). Its purpose was to encourage energy conservation and the development of new energy resources, including renewables such as solar, wind, and geothermal power. & 1978 & The Public Utility Regulatory Policies Act (PURPA) of 1978 mandated the purchase of electricity from qualifying facilities that meet certain standards on energy source and efficiency. & YES 1978 & The Energy Tax Act of 1978 established a 10-percent investment tax credit for photovoltaic applications. & YES 1978 & A 15% energy tax credit was added to an existing 10% investment tax credit, providing incentive for capital investment in solar thermal generation facilities for independent power producers. & YES 1978 & The Solar Photovoltaic Energy, Research, Development and Demonstration Act of 1978 committed $1.2 billion, over 10 years, to improve photovoltaic production levels, reduce costs, and stimulate private sector purchases. & YES 1978 & Photovoltaic energy commercialisation program accelerated the procurement and installation of photovoltaic systems in Federal facilities. & 1979 & President Jimmy Carter Installs 1st White House Solar Panels. & Late 1970s & By the late 1970s, a program for the development of distributed photovoltaics was established by the U.S. Government at the Massachusetts Institute of Technology, focusing on design and demonstration issues for the buildings sector. & 1980s & Solar Hits the Mainstream: Throughout the 1980s, solar developments continued at apace. Thin-film solar cells allowed for smaller, cheaper, and more-efficient solar installations, on buildings, vehicles, and consumer items (such as hand-held calculators). & 1980 & John Perlin and Ken Butti’s landmark book A Golden Thread published, covering 2500 Years of Solar Technology from the Greeks and Romans until the modern day & 1980 & The Carlisle house (Massachusetts) was completed with participation from MIT, DOE, and Solar Design Associates. It featured the first building-integrated photovoltaic system, passive solar heating and cooling, superinsulation, internal thermal mass, earth-sheltering, daylighting, a roof-integrated solar thermal system, and a 7.5-peak-watt photovoltaic array of polycrystalline modules from Solarex. & 1980 & The Crude Oil Windfall Profit Tax Act of 1980 was enacted, raising the residential tax credit to 40% of the first $10000 for photovoltaic applications, and the business tax credit to 15%. The Act also extended the credit to the end of 1981. & YES 1980 & Boeing, Kodak, and the Institute of Energy Conversion at University of Delaware fabricated the first thin-film photovoltaic cells with efficiencies greater than 10% using Cu2S/CdS technology. & YES 1981 & President Ronald Reagan Orders Solar Panels on the White House Removed. & 1981 & California enacted a 25% tax credit for the capital costs of renewable energy systems. & YES 1982 & Kyocera Corp is the first manufacturer in the world to mass-produce Polysilicon solar cells using the casting method, today’s industry standard. & 1982 & Solar-Powered Vehicles: German automobile manufacturer Volkswagen start testing solar PV arrays on the tops of Dasher station wagons. An array generate approximately 160 watts for the vehicle’s ignition system. & 1982 & Solar One (solar tower, not to be confused with previous PV house), a 10-megawatt central receiver demonstration project, was first operated and established the feasibility of power tower systems. In 1988, the final year of operation, the system achieved an availability of 96%. & YES 1983 & Worldwide photovoltaic production exceeds 21.3 megawatts, and sales exceed $250 million. & 1983 & California’s Standard Offer Contract system provided renewable electric energy systems with a relatively firm, stable market for their output. This system allowed the financing of capital-intensive technologies such as solar thermal-electric. & YES 1983 & The SEGS I plant (13.8-megawatt) was installed, the first in a series of Solar Electric Generating Stations (SEGS). SEGS I used solar trough technology to produce steam in a conventional steam turbine generator. Natural gas was used as a supplementary fuel for up to 25% of the heat input. & YES 1984 & 30000 SF Building-Integrated Photovoltaic [BI-PV] Roof completed for the Intercultural Center of Georgetown University. Eileen M. Smith, M.Arch. took 20th Anniversary Journey by Horseback for Peace and Photovoltaics in 2004 from solar roof to Ground Zero NY World Trade Center to educate public about BI-PV Solar Architecture. Array was still generating an average of one MWh daily as it has since 1984 in the dense urban environment of Washington, DC. & 1984 & Advanco and McDonnell Douglas systems demonstrated the potential for the high-efficiency 25-kilowatt solar dish. & YES 1984 & Dish/engine systems convert the thermal energy in solar radiation to mechanical energy and then to electrical energy — in much the same way that conventional power plants convert thermal energy from combustion of a fossil fuel to electricity. & 1984 & The Sacramento Municipal Utility District commissioned its first 1-megawatt photovoltaic electricity-generating facility. & YES 1985 & 20% efficient silicon cells are created by the Centre for Photovoltaic Engineering at the University of New South Wales. & YES 1985 & The 6-megawatt Carissa Plains plant was added to Southern California Edison’s system. The project was later dismantled. & 1986 & ’Solar-Voltaic DomeTM’ patented by Lt. Colonel Richard T. Headrick of Irvine, CA as an efficient architectural configuration for building-integrated photovoltaics. & 1986 & Kramer Junction: World’s largest solar thermal facility scheduled to be built in Kramer Junction, California. The facility consisted of rows of mirrors that concentrated energy from the sun into a system of pipes that circulated a heat transfer fluid. This fluid was then used to produce steam, which would power a conventional turbine with which to generate electricity. & YES 1988 & The Dye-sensitized solar cell is created by Michael Grätzel and Brian O’Regan (chemist). These photoelectrochemical cells work from an organic dye compound inside the cell and cost half as much as silicon solar cells. & YES 1988–1991 & AMOCO/Enron used Solarex patents to sue ARCO Solar out of business. & 1989 & Reflective solar concentrators are first used with solar cells. & YES 1989 & Federal regulations that govern the size of solar power plants were modified to increase maximum plant size to 80 megawatts from 30 megawatts. & YES 1989 & The Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989 sought to improve the operational reliability of photovoltaic modules, increase module efficiencies, decrease direct manufacturing costs, and improve electric power production costs. & 1989 & PV for Utility Scale Applications (PVUSA), a national public-private partnership program, was created to assess and demonstrate the viability of utility-scale photovoltaic electric generating systems. PVUSA participants include the DOE and other agencies, the Electric Power Research Institute, the California Energy Commission, and Pacific Gas & Electric (PG&E) and eight other utilities. & 1990 & The Magdeburg Cathedral installs solar cells on the roof, marking the first installation on a church in East Germany. & 1990 & Start of the 1000 Roof Program in Germany, Accompanied by the National Power Feed-in Law: As in the case of the Carter feed-in tariff scheme, the tariffs were below end-consumer prices, with the high cost of PV at that time, and it did much for PV development. & YES 1990 & Siemens A.G. of Munich, West Germany, acquired California-based ARCO Solar, the world’s largest photovoltaic company. & 1990 & The PV Manufacturing Technology (PVMaT) project began. A government-industry research and development partnership between DOE and members of the U.S. photovoltaic industry was designed to improve manufacturing processes, accelerate manufacturing cost reductions for photovoltaic modules, improve commercial product performance, and lay the groundwork for a substantial scale-up of manufacturing capacity. & 1991 & Efficient Photoelectrochemical cells are developed & YES 1991 & President George H. W. Bush directs the U.S. Department of Energy to establish the National Renewable Energy Laboratory (transferring the existing Solar Energy Research Institute). & 1991 & Luz International went bankrupt while building its tenth SEGS plant. SEGS I through IX remained in operation. & 1992 & A 7.5-kilowatt dish prototype system became operational, using an advanced stretched-membrane concentrator, through a joint venture of Sandia National Laboratories and Cummins Power Generation. & 1992 & The Energy Policy Act of 1992 restored the 10% investment tax credit for independent power producers, using solar technologies. & YES 1992 & The University of South Florida fabricated a 15.89% efficient thin-film cell, breaking the 15% barrier for the first time & YES 1993 & The National Renewable Energy Laboratory’s Solar Energy Research Facility is established. & 1993 & Pacific Gas and Electric completed the installation of the first grid-supported photovoltaic system in Kerman, California. The 500-kilowatt system was the first effort aimed at “distributed power,” whereby a relatively small amount of power is carefully matched to a specific load and is produced near the point of consumption. & 1993 & New world-record efficiencies in polycrystalline thin film and in single-crystal devices, approaching 16% and 30%, respectively, were achieved in 1993. & 1994 & The first solar dish generator, using a free-piston Stirling engine, was tied to a utility grid. & YES 1994 & The Corporation for Solar Technology and Renewable Resources, a public corporation, was established to facilitate solar developments at the Nevada Test Site. & 1994 & 3M Company introduced a new silvered plastic film for solar applications. & 1994 & The National Renewable Energy Laboratory (NREL) developed a solar cell made of gallium indium phosphide and gallium arsenide; it was the first one of its kind to exceed 30% conversion efficiency. & 1995 & Federal Energy Regulatory Commission (FERC) prohibits qualifying facility contracts above avoided costs. & 1995 & An Amoco-Enron joint venture announced its intention to use amorphous silicon modules for utility-scale photovoltaic applications. & 1996 & The National Center for Photovoltaics is established. Graetzel, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland achieves 11% efficient energy conversion with dye-sensitized cells that use a photoelectrochemical effect. & 1996 & Flight of the Icare: The Icare, which at the time was the world’s most advanced solar-powered plane, flew over Germany in 1996. Over 3000 super-efficient solar cells covered the wings and tail surfaces of the plane. & YES 1996 & Development began on Solar Two, an upgrade of its 1973 Solar One (PV-hybrid houses, not to be confused with later solar tower project of the same name) project. Solar Two was a huge advancement in that it demonstrated the ability to produce power even when the sun is not shining. This also helped foster commercial interest in power towers. & YES 1998 & Subhendu Guha, a scientist noted for his pioneer work in amorphous silicon, led the invention of flexible solar shingles, a roofing material and state-of-the-art technology for converting sunlight into electricity on buildings. & 1999 & Total worldwide installed photovoltaic power reaches 1000 megawatts. & 1999 & 32.3% Efficiency: Spectrolab, Inc. worked with the National Renewable Energy Laboratory to develop a photovoltaic solar cell that converted 32.3 percent of received sunlight into electricity by combining three layers of photovoltaic materials into a single cell. & YES 1999 & 100000 Solar Roofs Program Starts in Germany: A “100000 Solar Roofs” program was started in Germany with the goal of creating a PV power capacity of 300 MW within six years. The program was initiated by Dr. Hermann Scheer, member of the German Parliament and president of EUROSOLAR. & YES 1999 & Construction was completed on Four Times Square in New York, New York. The office building had more energy-efficient features than any other commercial skyscraper and included building-integrated photovoltaic panels on the 37th to 43rd floors, on the south- and west-facing facades, to produce part of electricity needed for the building. & 1999 & Researchers at the NREL developed a record-breaking prototype solar cell that measured 18.8% efficiency, topping the previous record for thin-film cells by more than 1%. Worldwide, installed photovoltaic capacity reached 1000 megawatts. & 2000s & Largest Residential Solar Installation Complete: A family in Colorado installed largest residential installation to be registered under the ‘Million Solar Roofs’ program. The system is measured at 12 kilowatts, providing most of the energy for the 6000-square-foot home. & 2000 & Hermann Scheer Introduces the National Renewable Energy Act in German Parliament: It’s unique property were technology-dependent feed-in tariffs. For PV, the tariff levels were way above end-consumer prices. This created an (artificial) market that allowed the PV industry to grow from a niche player to a mature industry. The second unique part is the continuous reduction in the tariffs baked into the law that forces the industry to stay on its toes. & YES 2000 & A 12-kilowatt solar electric system, in Colorado, was the largest residential installation in the United States to be registered with the U.S. Department of Energy’s Million Solar Roofs Initiative. The system provided most of the electricity for the family of eight’s 6000-square-foot home. & 2000 & First Solar began production at the Perrysburg, Ohio, photovoltaic manufacturing plant. Each year, it could produce enough solar panels to generate 100 megawatts of power. & 2000 & Astronauts began installing solar panels at the International Space Station, on the largest solar power array deployed in space. Each ”wing“ of the array consisted of 32800 solar cells. & 2001 & Home Depot began selling residential solar power systems in three stores in San Diego, California. & 2001 & NASA’s solar-powered aircraft, Helios, set a new world altitude record for non-rocket-powered craft: 96863 feet (more than 18 miles). & 2001 & BP and BP Solar announced the first BP Connect gasoline retail and convenience store in the United States. The Indianapolis, Indiana, service station features a solar-electric canopy. The canopy contains translucent photovoltaic modules made of thin-film silicon integrated into glass. & 2002 & Students from the University of Colorado built an energy-efficient solar home for the Solar Decathlon, a competition sponsored by the Department of Energy. Student teams integrated aesthetics and modern conveniences with maximum energy production and optimal efficiency. The houses were transported to the National Mall in Washington, DC, where the student team took first prize overall. & 2003 & George Bush has a 9 kW PV system and a solar thermal systems installed on grounds keeping building at the White House & 2004 & Kansas Governor Kathleen Sebelius issued a mandate for 1000 MW renewable electricity in Kansas by 2015 per Executive Order 04-05. & YES 2004 & 1 GW of PV Installed in Germany & YES 2004 & One Million Solar Roofs: California Governor Arnold Schwarzenegger proposes Solar Roofs Initiative for one million solar roofs in California by 2017. & YES 2006 & California Public Utilities Commission approved the California Solar Initiative (CSI), a comprehensive $2.8 billion program that provides incentives toward solar development over 11 years. & YES 2006 & Polysilicon Use in Photovoltaics Exceeds All Other Polysilicon Use for the First Time: Contributing to this is the lower cost of manufacture than monocrystalline counterparts. & 2006 & New world record achieved in solar cell technology when a new solar cell breaks the “40 Percent Efficient” sunlight-to-electricity barrier. & YES 2007 & Construction of Nellis Solar Power Plant, a 15 MW PPA installation. & YES 2007 & The Vatican announced that in order to conserve Earth’s resources they would be installing solar panels on some buildings, in ”a comprehensive energy project that will pay for itself in a few years." & 2007 & Google solar panel project begins operation. & 2007 & Nanosolar ships the first commercial printed CIGS, claiming that they will eventually ship for less than $1/watt. However, the company does not publicly disclose the technical specifications or current selling price of the modules. & 2007 & 42.8% Efficiency: University of Delaware claims to achieve new world record of 42.8% in solar cell technology without independent confirmation. & YES 2007 & The Technische Universität Darmstadt won the 2007 Solar Decathlon. The team won the architecture, lighting, and engineering contests. & 2007 & Boeing Spectrolab and the NREL created the High-Efficiency Metamorphic Multijunction Concentrator Solar Cell, or HEMM solar cell, which achieved the highest efficiency level of any photovoltaic device to date. The HEMM solar cell broke the 40% conversion efficiency barrier, making it twice as efficient as a typical silicon cell. However, it was only under the concentrated energy of 326 suns that this was achieved. The inverted metamorphic triple-junction solar cell was designed, fabricated and independently measured at NREL. & YES 2010 & US President Barack Obama orders installation of additional solar panels and a solar water heater at the White House & 2011 & Fast-growing factories in China push manufacturing costs down to about $1.25 per watt for silicon photovoltaic modules. Installations double worldwide. & YES 2012 & 3D PV-cel with 30% more energy efficiency & 2013 & After three years, the solar panels ordered by President Barack Obama were installed on the White House. & 2016 & University of New South Wales engineers established a new world record for unfocused sunlight conversion to electricity with an efficiency increase to 34.5%. The record was set by UNSW’s Australian Centre for Advanced Photovoltaics (ACAP) using a 28 cm² four-junction mini-module – embedded in a prism – that extracts the maximum energy from sunlight. It does this by splitting the incoming rays into four bands, using a four-junction receiver to squeeze even more electricity from each beam of sunlight. & YES 2016 & First Solar says it has converted 22.1 percent of the energy in sunlight into electricity using experimental cells made from cadmium telluride—a technology that today represents around 5 percent of the worldwide solar power market. & 2nd August 2017 & Tesla completes its first solar roof installations for company employees and opens up pre-orders & YES |  |

Timeline of tide, wave, and ocean electricity (Tester *et al.*, 2012)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| BC-AD | References to use of tides in classical Greece, possibly dating back to the time of Aristotle |  |
| 960 AD | Reference to tide mills at Basra in southern Iraq |  |
| 1041, 1078 | First references to European tide mills (around Venice) | YES |
| 1100 - 1900 | Waterwheel-driven mills powered by tidal impoundments and currents operational in England, western Europe, and colonial Boston, among other places |  |
| 1135 - WWII | Bromley-by-Bow Tidal Mill near London |  |
| 1734 | Slade’s Tidal Spice Mill, Chelsea, Massachusetts |  |
| 1799 | Girard files first patent on wave-energy device in France | YES |
| 1800 - 1900 | 25 tide mills cited in Britain |  |
| 1871 | Jules Verne’s fictional Captain Nemo posits thermoelectricity from ocean water in the novel 20000 Leagues under the Sea |  |
| 1881 | D’Arsonval proposes concept of ocean thermal energy conversion (OTEC) | YES |
| 1892 | Stahl notes 19 wave-power concepts in American Society of Mechanical Engineers (ASME) transactions |  |
| 1910 | Bochaux-Praceique lights and powers his house at Royan, near Bordeaux in France, using wave power - first oscillating water-column type of wave-energy device | YES |
| 1934 | Claude tests open-cycle OTEC in Cuba | YES |
| 1935 - 1977 | Succession of studies of Passamaquoddy/Bay of Fundy tidal power stations |  |
| 1940s | Pioneering of modern scientific pursuits in wave energy by Yoshio Masuda’s experiments in the 1940s | YES |
| 1950s | Yoshio Masuda’s concept for extracting power from the angular motion at the joints of an articulated raft |  |
| 1959 | First of a number of small (<1 MWe) tidal power plants reported in China | YES |
| 1966 | Rance River tidal power plant operational in France | YES |
| 1969 | Experimental tidal unit constructed in Kislaya Guba, Russia | YES |
| 1972 - 1984 | US OTEC program | YES |
| 1973 | Renewed interest in wave energy was motivated by the oil crisis in 1973 | YES |
| 1974 | Stephen Salter’s ’nodding duck’ is invented (a.k.a. Edinburgh Duck). In small scale controlled tests, the Duck’s curved cam-like body can stop 90% of wave motion and can convert 90% of that to electricity giving 81% efficiency. | YES |
| 1976 - 1982 | British launch, then suspend, their wave-power program; revised post-2000 | YES |
| 1977 | Wells invents turbine which rotates in same direction when airflow is reversed | YES |
| 1978 | Japanese install 125 kWe wave-power unit off Honshu |  |
| 1979 | Mini-OTEC operated in Hawaii by the US and by Japanese off Shimane |  |
| 1984 | 20 MW Annapolis tidal station operational in Nova Scotia |  |
| 1985 | KVAERNER wave-energy converter deployed in Norway; later succumbs to storm |  |
| 1986 - 2000 | Decline, on the average, of fossil energy prices in constant dollars saps motivation for vigorous pursuit of the more expensive categories of alternatives, e.g., anything out at sea. This is then reinvigorated by post-2000 oil price escalation | YES |
| 1995 | 2 MWe OSPREY wave-power station wrecked during installation |  |
| 2003 | European Marine Energy Centre established in the Orkney Islands off northern Scotland (world’s first marine energy test facility) | YES |
| 2007 | Pelamis devices operational at first commercial wave-power stations off Orkney and Portugal, where more are planned | YES |
| 2007 | Underwater tidal stream turbines installed in New York City’s East River |  |
| 2008 | Scottish government offers $20 million Saltaire Prize for best demonstrated innovation in wave or tidal power |  |
| 2009 | Wave Hub project off Cornish coast in England; scheduled to test multiple concepts |  |

Timeline of turbojets [(REPORT: Commercial En…,](https://www.authorea.com/users/161287/articles/277773-appendices#2015) [(Firm) 1990,](https://www.authorea.com/users/161287/articles/277773-appendices#ge1990eight) [Boyne 1979,](https://www.authorea.com/users/161287/articles/277773-appendices#boyne1979jet) [Gunston 1998,](https://www.authorea.com/users/161287/articles/277773-appendices#gunston1998world) [Anderson Jr 1999,](https://www.authorea.com/users/161287/articles/277773-appendices#anderson1999history) [Jet Engines)](https://www.authorea.com/users/161287/articles/277773-appendices#engines)

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| --- | --- | --- |
| Year | Event | Major event |
| Prehistoric times | Ordovician period: the first known cephalopods: they swim by a natural built-in reciprocating hydrojet. |  |
| 120-150 BC | Hero of Alexandria demonstrates the principles of jet reactions in the Aeolipile (a steam jet/rocket engine on a bearing). | YES |
| 1232 | The Chinese begin to use rockets as weapons. |  |
| 1500 | Leonardo da Vinci sketched a contraption, the chimney jack, that rotated due to the effects of hot gases flowing up a chimney. |  |
| 1629 | Giovanni Branca develops a stamping mill that utilized jets of steam to operate the machinery. |  |
| 1687 | Sir Isaac Newton presents his three laws of motion. These form the basis for modern propulsion theory. | YES |
| 1791 | John Barber applies and receives the first patent for a simple turbine machine. This is British patent #1833 for ’A Method for Rising Inflammable Air for the Purposes of Producing Motion and Facilitating Metallurgical Operations’. In it he describes a turbine. | YES |
| 1872 | First true gas turbine engine designed by Dr. F. Stolze. |  |
| 1884 | Charles Algernon Parsons patents the steam turbine. In the patent application he notes that the turbine could be driven “in reverse” to act as a compressor. He suggests using a compressor to feed air into a furnace, and a turbine to extract power to run the compressor. Although intended for factory use, he is clearly describing the gas turbine. | YES |
| 1887 | Gustaf de Laval introduces nozzles design of small steam turbines. |  |
| 1897 | Steam turbine used to power a ship for the first time. |  |
| 1900 | Sanford Alexander Moss publishes a paper on turbocompressors. He builds and runs a testbed example in 1903. | YES |
| 1903 | Ægidius Elling builds a gas turbine using a centrifugal compressor which runs under its own power. By most definitions, this is the first working gas turbine. | YES |
| 1903-1906 | The team of Armengaud and Lemale in France build a complete gas turbine engine. It uses three separate compressors driven by a single turbine. Limits on the turbine temperatures allow for only a 3:1 compression ratio, and the turbine is not based on a Parsons-like “fan”, but a Pelton wheel-like arrangement. The engine is so inefficient, at about 3% thermal efficiency, that the work is abandoned. |  |
| 1908 | Hans Holzwarth starts work on extensive research on an “explosive cycle” gas turbine, based on the Otto cycle. This design burns fuel at a constant volume and is somewhat more efficient. By 1927, when the work ended, he has reached about 13% thermal efficiency. |  |
| 1908 | René Lorin patents a design for the ramjet engine. | YES |
| 1909 | Marconnt proposes a modification of Lorin’s design using a resonant compression chamber, creating the pulsejet. |  |
| 1910 | Romanian inventor Henri Coand? builds the Coand?-1910 which he exhibits at the International Aeronautic Salon in Paris. It uses a ducted fan for propulsion instead of a propeller. Years later he claimed that it burned fuel in the duct and was thus a motorjet, but historians debate this claim, and his claims that the aircraft flew in December 1910 before crashing and burning. |  |
| 1916 | Auguste Rateau suggests using exhaust-powered compressors to improve high-altitude performance, the first example of the turbocharger. |  |
| 1917 | Sanford Alexander Moss starts work on turbochargers at General Electric, which goes on to be the world leader in this technology. | YES |
| 1917 | James Stocker Harris patents a “Motor Jet” design on behalf of his brother inlaw Robert Alexander Raveau Bolton. | YES |
| 1918 | General Electric (GE) starts gas turbine division. | YES |
| 1920 | W.J. Stern reports to the Royal Air Force that there is no future for the turbine engine in aircraft. He bases his argument on the extremely low efficiency of existing compressor designs. Stern’s paper is so convincing there is little official interest in gas turbine engines anywhere, although this does not last long. | YES |
| 1921 | Maxime Guillaume patents the axial-flow turbine engine. It uses multiple stages in both the compressor and turbine, combined with a single very large combustion chamber. Although sightly different in form, the design is significantly similar to future jet engines in operation. |  |
| 1923 | Edgar Buckingham at the United States National Bureau of Standards publishes a report on jets, coming to the same conclusion as W.J. Stern, that the turbine engine is not efficient enough. In particular he notes that a jet would use five times as much fuel as a piston engine. |  |
| 1925 | Wilhelm Pape patents a constant-volume engine design. |  |
| 1926 | Alan Arnold Griffith publishes his groundbreaking paper ’Aerodynamic Theory of Turbine Design’, changing the low confidence in jet engines. In it he demonstrates that existing compressors are “flying stalled”, and that major improvements can be made by redesigning the blades from a flat profile into an airfoil, going on to mathematically demonstrate that a practical engine is definitely possible and showing how to build a turboprop. | YES |
| 1927 | Aurel Stodola publishes his “Steam and Gas Turbines” - basic reference for jet propulsion engineers in the USA. |  |
| 1927 | A testbed single-shaft turbocompressor based on Griffith’s blade design is tested at the Royal Aircraft Establishment. Known as Anne, the tests are successful and plans are made to build a complete compressor-turbine assembly known as Betty. |  |
| 1929 | Frank Whittle’s thesis on future aircraft design is published. In it he talks about the needs for high-speed flight and the use of turbojets as the only reasonable solution to the problem of propeller efficiency. | YES |
| 1929 | Boris Stechkin publishes first theory of supersonic ramjet, based on compressible fluid theory. |  |
| 1930 | Whittle presents a complete jet engine design to the Air Ministry. They pass the paper to Alan Griffith at the Royal Aircraft Establishment, who says the idea is impracticable, pointing out a mathematical error, noting the low efficiency of his design, and stating that Whittle’s use of a centrifugal compressor would make his proposal useless for aircraft applications. | YES |
| 1930 | Whittle receives official notice that the Air Ministry is not interested in his concepts, and that they do not even feel that it is worthy of making secret. He is devastated, but friends in the Royal Air Force convince him to patent his design for a gas turbine for jet propulsion anyway. This turns out to be a major stroke of luck, because if the Air Ministry had made the idea secret, they would have become the official owners of the rights to the concept. In his patent, Whittle cleverly hedges his bets, and describes an engine with two axial compressor stages and one centrifugal, thus anticipating both routes forward. | YES |
| 1930 | Schmidt patents a pulsejet engine in Germany. |  |
| 1931 | Secondo Campini patents his motorjet engine, referring to it as a thermojet. (A motorjet is a crude form of hybrid jet engine in which the compressor is powered by a piston engine, rather than a turbine) |  |
| 1933 | Hans von Ohain writes his thesis at the University of Göttingen, describing an engine similar to Frank Whittle’s with the exception that it uses a centrifugal “fan” as the turbine as well as the compressor. This design is a dead-end; no “centrifugal-turbine” jet engine will ever be built. | YES |
| 1933 | Yuri Pobedonostsev and Igor Merkulov tests hydrogen powered GIRD-04 ramjet engine. First supersonic flight of a jet propelled object achieved with artillery-launched ramjets later that year. |  |
| 1934 | Hans von Ohain hires a local mechanic, Max Hahn, to build his a prototype of his engine design at Hahn’s garage. |  |
| 1934 | Secondo Campini starts work on the Campini Caproni CC.2, based on his “thermojet” engine. |  |
| 1935 | Whittle allows his patent to lapse after finding himself unable to pay the £5 renewal fee. Soon afterward he is approached by ex-RAF officers Rolf Dudley-Williams and James Collingwood Tinling with a proposal to set up a company to develop his design and Power Jets Ltd is created. | YES |
| 1936 | Hans von Ohain and Max Hahn of Germany develop and patent their own design. | YES |
| 1936 | Hans von Ohain is introduced to Ernst Heinkel by a former professor. After being grilled by Heinkel engineers for hours, they conclude his idea is genuine. Heinkel hires Hans von Ohain and Max Hahn, setting them up at their Rostock-area factory. |  |
| 1936 | Junkers starts work on axial-flow turboprop designs under the direction of Herbert Wagner and Adolf Müeller. |  |
| 1936 | Junkers Motoren (Jumo) is merged with Junkers, formerly separate companies. |  |
| 1936 | A stationary gas turbine is installed at the Sun Oil refinery in Marcus Hook, Pennsylvania |  |
| 1936 | French engineer René Leduc, having independently re-discovered René Lorin’s design, successfully demonstrates the world’s first operating ramjet. The Armée de l’Air orders a prototype aircraft, the Leduc 010, a few months later. | YES |
| 1937 | Hayne Constant, Griffith’s partner at the RAE, starts negotiations with Metropolitan-Vickers (Metrovick), a British heavy industry firm, to develop a Griffith-style turboprop. | YES |
| 1937 | At Junkers, Wagner and Müller decide to re-design their work as a pure jet. |  |
| 1937 | April: Whittle’s experimental centrifugal engine is tested at the British Thomson-Houston plant in Rugby | YES |
| 1937 | September: The Heinkel HeS 1 experimental hydrogen fuelled centrifugal engine is tested at Hirth. |  |
| 1937 | September: Hans von Ohain’s Heinkel HeS 1 is converted to run on gasoline. Ernst Heinkel gives the go-ahead to develop a flight-quality engine and a testbed aircraft to put it in. | YES |
| 1938 | April: Hans Mauch takes over the RLM rocket development office. He expands the charter of his office and starts a massive jet development project, under Helmut Schelp. Mauch spurns Heinkel and Junkers, concentrating only on the “big four” engine companies, Daimler-Benz, BMW, Jumo and Bramo. Mauch and Schelp visit all four over the next few months, and find them uninterested in the jet concept. |  |
| 1938 | Metrovick receives a contract from the Air Ministry to start work with Constant. |  |
| 1938 | György Jendrassik starts work on a turboprop engine of his own design. |  |
| 1938 | A small team at BMW led by Hermann Östrich builds and flies a simple thermojet quickly prompting them to design a true jet engine. |  |
| 1938 | The Heinkel He 178 V1 jet testbed is completed, awaiting an engine. |  |
| 1938 | The Heinkel HeS 3 “flight quality” engine is tested. This is the first truly usable jet engine. The engine flies on a Heinkel He 118 later that year, eventually becoming the first aircraft to be powered by jet power alone. This engine is tested until it burns out after a few months, and a second is readied for flight. | YES |
| 1938 | Wagner’s axial-flow engine is tested at Junkers. |  |
| 1938 | Messerschmitt starts the preliminary design of a twin-engine jet fighter under the direction of Waldemar Voight. This work developed into the Messerschmitt Me 262. |  |
| 1939 | Arkhip Mikhailovich Lyulka develops early turbofan engine at Kharkov Aviation Institute. |  |
| 1939 | A stationary gas turbine is installed in a new electrical generating plant in Neuchâtel, Switzerland. |  |
| 1939 | A 2200 horsepower (1600 kW) gas turbine is built by Asea Brown Boveri and used to power an experimental train in Switzerland. |  |
| 1939 | BMW’s team led by Hermann Östrich tests their axial-flow design. |  |
| 1939 | Bramo starts work on two axial-flow designs, the P.3301 and P.3302. The P.3301 is similar to Griffith’s contrarotating designs, the P.3302 using a simpler compressor/stator system. |  |
| 1939 | Bramo is bought out by BMW, who abandon their own jet project under Östrich, placing him in charge of Bramo’s efforts. |  |
| 1939 | Summer: Jumo is awarded a contract to develop an axial-flow engine, starting work under Anselm Franz. Müller decamps with half the team to Heinkel. |  |
| 1939 | Frank Whittle’s patent drawing for his engine is published in the German magazine Flugsport. | YES |
| 1939 | August: the Ernst Heinkel Aircraft company flies the first gas turbine jet plane, the HE178 V1, powered by the HeS 3B. | YES |
| 1939 | September: A team from the Air Ministry visits Power Jets once again, but this time Frank Whittle demonstrates a jet engine at full power for a continuous 20-minute run. They are extremely impressed, quickly contracts are offered to Whittle to develop a flyable design, and production contracts are offered to practically every engine company in England. These companies also set up their own design efforts, reducing the possibility of financial rewards for Power Jets. | YES |
| 1939 | September: The Air Ministry also contracts Gloster to build an experimental airframe for testing Whittle’s engines, the Gloster E.28/39 | YES |
| 1939 | After hearing of Whittle’s successful demonstration, Hayne Constant realises that exhaust thrust is practical. The Metrovick efforts are quickly reworked into a turbojet design, the Metrovick F.2. | YES |
| 1939 | November: Müller’s team restarts work on their axial-flow design at Heinkel, now known as the Heinkel HeS 30. |  |
| 1939 | René Anxionnaz of France’s Rateau (fr) company received a patent on an advanced jet design incorporating bypass. |  |
| 1939 | Leist joins Daimler-Benz and starts work on an advanced contra-rotating turbofan design, the Daimler-Benz DB 007 |  |
| 1939 | A shakeup at the RLM’s engine division places Helmut Schelp in control, and results in development contracts for all existing engine designs. The designs are also given consistent naming, the Heinkel HeS 8 becoming the 109-001, the HeS 30 the -006, BMW’s efforts the -002 and -003, and Jumo’s the -004. Porsche’s project becomes the -005, although work never starts on it. DB gets -007. Numbers starting in the 20s are saved for turboprops, and 500 and up for rockets. |  |
| 1940 | The Campini Caproni CC.2 flies for first time. The flights were highly publicised, and for many years the Italians were credited with having the first jet-powered aircraft. | YES |
| 1940 | NACA (National Advisory Committee for Aeronautics) starts work on a CC.2 like motorjet for assisted takeoffs, and they later design an aircraft based on it. This work ends in 1943 when turbojets start to mature, and rockets take over the role of JATO, or jet assisted takeoff. |  |
| 1940 | Hans von Ohain’s larger Heinkel HeS 8 (-001) engine is tested. |  |
| 1940 | BMW’s P.3302 (-003) axial-flow engine is tested |  |
| 1940 | September: Glider testing of the Heinkel He 280 twin-jet fighter begins, while it waits for the HeS 8 to mature. |  |
| 1940 | September: Henry Tizard visits the United States to show them many of the advanced technologies the British are working on and looking for US production (the Tizard Mission). Among many other details, Tizard first mentions their work on jet engines. | YES |
| 1940 | October: Rover is selected to build the flight-quality Power Jets W.1. They set up shop at a disused mill in Barnoldswick, but also set up a parallel effort at another factory in Clitheroe staffed entirely by their own engineers. Frank Whittle is incensed. | YES |
| 1940 | November: The Junkers Jumo 004 axial-flow engine is tested. |  |
| 1940 | November: Gloster Aircraft Company’s proposal for a twin-engine jet fighter is accepted, becoming the Gloster Meteor. | YES |
| 1940 | December: Whittle’s flight-quality W.1X runs for the first time. | YES |
| 1940 | The Lockheed Corporation starts work on the L-1000 axial-flow engine, the United States’s first jet design. |  |
| 1940 | The Northrop Corporation starts work on the T-37 Turbodyne, the United States’s first turboprop design. |  |
| 1940 | After only two years of development, the Jendrassik Cs-1 turboprop engine is tested. Designed to produce 1000 horsepower (750 kW), combustion problems limit it to only 400 horsepower (300 kW) when it first runs. Similar problems plagued early Whittle designs, but the industry quickly provided assistance. It appears that György Jendrassik had to draw upon any similar talent pool. |  |
| 1941 | Sir Frank Whittle and the Gloster Aircraft Company design the first successful turbojet, the Gloster Meteor. | YES |
| 1941 | February: The Air Ministry places an order for 12 Gloster Meteor aircraft. |  |
| 1941 | February: NACA starts testing their “Propulsive duct engine”, a ramjet, unaware of earlier similar efforts. Since ramjets need to be moving in order to work, NACA engineers take the simple step of mounting it at the end of a long arm and spinning it. |  |
| 1941 | April: The He 280 flies under its own power for first time, powered by two Heinkel HeS 8 (-001) engines. The HeS 8’s continue to have reliability issues. |  |
| 1941 | May: The Gloster E.28/39 flies for the first time. Over the next few weeks, the top speed soon passes any existing propeller aircraft. | YES |
| 1941 | Müller’s Heinkel HeS 30 (-006) axial-flow engine runs for first time. |  |
| 1941 | General Electric is awarded a USAAF contract to develop a turboprop engine, leading to the TG-100 / TG-31 / XT-31 series, and later the J35. | YES |
| 1941 | Work on the Jendrassik Cs-1 ends. Intended to power a twin-engine heavy fighter, the factory is selected to produce Daimler-Benz DB 605 engines under license for the Messerschmitt Me 210 instead. |  |
| 1941 | October: A Power Jets W.2B is sent to General Electric to start production in the US. Sanford Alexander Moss is lured out of retirement to help on the project. | YES |
| 1941 | The Switzerland turbine-powered train enters testing. |  |
| 1942 | Dr. Franz Anselm develops the axial-flow turbojet, Junkers Jumo 004, used in the Messerschmitt Me 262, the worlds first operational jet fighter. | YES |
| 1942 | The Metrovick F.2 is given test rating delivering between 1800 and 2000 lbf (8.9 kN) |  |
| 1942 | Metrovick start on “thrust augmentation” adding a turbine and propellors to a F2/2 which will lead to the F.3 (a high bypass design) with an extra 1600 lbf (7100 N) over the F2/2. |  |
| 1942 | Work on the BMW 002 is stopped as it is proving too complex. Work continues on the 003. |  |
| 1942 | Work on the HeS 8 (-001) and HeS 30 (-006) is stopped, although the later appears to be reaching production quality. Heinkel is ordered to continue on the more advanced Heinkel HeS 011. |  |
| 1942 | The Messerschmitt Me 262 flies for the first time (later to become the first jet powered combat aircraft to enter service), powered by a Junkers Jumo 211 piston engine in the nose. The BMW 003 has been selected to power the production versions, but is not yet ready for flight tests. The design, offering more internal fuel capacity than the He 280, is selected over its now 003-powered competitor for production. | YES |
| 1942 | A Jumo 004 flies, fitted to a Messerschmitt Me 110 |  |
| 1942 | The Daimler-Benz 007 axial-flow engine is tested, similar to Griffith’s “contraflow” design that uses two contra-rotating compressor stages for added efficiency. |  |
| 1942 | The “production-quality” BMW 003 is first tested. |  |
| 1942 | March. The Rover W2B/26 experimental engine (STX) is first run, this was the straight-through design made by Rover without the knowledge of Whittle. This design was to be adopted by Rolls-Royce as the basis for their Derwent engine after they took over from Rover (by which time four more W2B/26 engines were under test). |  |
| 1942 | The British order a single-engined jet design from de Havilland |  |
| 1942 | July 18, 1942: The Messerschmitt Me 262, the first jet-powered fighter aircraft, flies for the first time under jet power. | YES |
| 1942 | July: Frank Whittle visits the United States to help with General Electric’s efforts to build the W.1. The engine is running soon after, known as the “General Electric Type 1”, and later as the I-16, referring to the 1600 lbf (7100 N) thrust. They also start work on an improved version, the I-40, with 4000 lbf (18 kN) thrust. The majority of United States jet engines from this time through the mid-1950s are licensed versions of British designs. | YES |
| 1942 | Whittle returns to Power Jets and starts development of the improved Power Jets W.2/500 and /700 engines, so named for their thrust in kilograms-force (kgf). |  |
| 1942 | Westinghouse starts work on an axial-flow engine design, the WE-19. |  |
| 1942 | October: The Bell XP-59 flies, powered by a General Electric Type I-A (W.1). | YES |
| 1942 | The Fieseler Fi 103 V-1 pulsejet powered “flying bomb” (cruise missile) flies for the first time. | YES |
| 1942 | Armstrong Siddeley starts work on an axial-flow design, the ASX. |  |
| 1942 | December: After a meeting held at a pub, Rover agrees to hand over the jet development to Rolls-Royce, in exchange for their Rolls-Royce Meteor tank engine factory. | YES |
| 1943 | January 1: Rolls takes over the Rover plants, although the official date is several months later. Stanley Hooker leads a team including Fred Morley, Arthur Rubbra and Harry Pearson. Several Rover engineers decide to stay on as well, including Adrian Lombard, leader of Rover’s “offshoot” design team. They focus on making the W.2B production quality as soon as possible. |  |
| 1943 | After only a few short months since Rolls-Royce took over from Rover, the W.2B/23, soon to be known as the Rolls-Royce Welland, starts production. |  |
| 1943 | The parallel Rover design effort, the W.2B/26, is adopted by Rolls-Royce for further development and becomes the Rolls-Royce Derwent. |  |
| 1943 | The de Havilland Goblin engine is tested, similar in most ways to the Derwent. |  |
| 1943 | March: A license for the Goblin is taken out in the United States by Allis-Chalmers, later becoming the J36. Lockheed is awarded a contract to develop what would become the P-80 Shooting Star, powered by this engine. |  |
| 1943 | Production of Jumo 004B starts. |  |
| 1943 | Production of BMW 003A starts. |  |
| 1943 | First running turbofan the German Daimler-Benz DB 670 (aka 109-007) operated on its testbed on April 1, 1943 | YES |
| 1943 | Throughout 1943, the Jumo 004 and BMW 003 continue to destroy themselves at an alarming rate due to turbine failures. Efforts in the United Kingdom, at one point years behind due to official indifference, have now caught up due to the availability of high temperature alloys which allowed for considerably more reliable high-heat sections of their designs. |  |
| 1943 | Design work on the BMW 018 starts. |  |
| 1943 | The US decides to rename all existing jet projects with a single numbering scheme. The L-1000 becomes the J37, GE’s Type I the J31, and Westinghouse’s WE-19 the J30. Newer projects are fitted into the remaining “30’s”. Turboprop designs become the T series, also starting at 30. |  |
| 1943 | June: Metrovick F.2/1 tested, fitted to Avro Lancaster |  |
| 1943 | September: Allis-Chalmers runs into difficulty on the J36, and the Shooting Star project is re-engined with the General Electric J33, a licensed version of the W.2B/26, or Rolls-Royce Derwent. GE later modifies the design to produce over twice the thrust, at 4000 lbf (18 kN). |  |
| 1943 | Frank Whittle’s W.2B/700 engine is tested, fitted to a Vickers Wellington Mk II bomber. |  |
| 1943 | March: Westinghouse’s X19A axial-flow engine is bench tested at 1165 lbf (5180 N). |  |
| 1943 | Miles Aircraft test an all-moving tailplane as part of the Miles M.52 supersonic research aircraft design effort. |  |
| 1943 | A Welland-powered prototype Gloster Meteor flies. |  |
| 1943 | The Goblin-powered de Havilland Vampire flies. |  |
| 1943 | Lyul’ka VDR-2 axial-flow engine tested, the first Soviet jet design. | YES |
| 1943 | The General Electric J31, their version of the W.2B/23, is tested. |  |
| 1943 | November: The Metrovick F.2 is tested on a modified Gloster Meteor. Although more powerful, smaller and more fuel efficient than the Welland, the design is judged too complex and failure prone. In his quest for perfection, Griffith instead delivers an impractical design. Work continues on a larger version with an additional compressor stage that over doubles the power. |  |
| 1943 | The Armstrong Siddeley ASX is tested. |  |
| 1943 | Metrovick F2/3 delivers 2700 lbf (12000 N) but not developed further, moving on to 10 stage F2/4 |  |
| 1944 | BMW tests the 003R, a 003 with an additional rocket engine for them and produce an even more powerful engine. In a short 6-month period they design and build the Rolls-Royce Nene at 5000 lbf (22 kN), but it sees only limited use in the United Kingdom. |  |
| 1944 | April: With internal design efforts underway at most engine companies, Power Jets have little possibility of profitability, and are nationalised, becoming a pure research lab as the National Gas Turbine Establishment. | YES |
| 1944 | June: Design work on a gas turbine engine for powering tanks begins under the direction of Müller, who left Heinkel in 1942. The first such system, the GT 101, is completed in November and fit to a Panther tank for testing. | YES |
| 1944 | June: A Derwent II engine is modified with an additional turbine stage powering a gearbox and five-bladed propeller. The resulting RB.50, or Rolls-Royce Trent, is not further developed, but is test flown on a modified Gloster Meteor. |  |
| 1944 | The Junkers Ju 287 jet bomber is tested. |  |
| 1944 | The BMW 018 engine is tested. Work ends soon after when the entire tooling and parts supply are destroyed in a bombing raid. |  |
| 1944 | The Junkers Jumo 012 engine is tested, it stands as the most powerful engine in the world for some time, at 6600 lbf (29000 N). |  |
| 1944 | The J35, a development of an earlier turboprop effort, runs for the first time. |  |
| 1944 | Ford builds a copy of the V-1’s engine, known as the PJ-31-1. |  |
| 1944 | The Ishikawajima Ne-20 first runs in Japan. Originally intending to build a direct copy of the BMW 003, the plans never arrived and the Japanese engineers instead built an entirely new design based on a single cutaway image and several photographs. | YES |
| 1944 | The Doblhof WNF-4 flies, the first ramjet-powered helicopter. | YES |
| 1944 | April 5: The nearly complete prototype of the Leduc 010 ramjet-powered aircraft, under construction at the Montaudran airfield near Toulouse, France unbeknownst to German occupation authorities, is heavily damaged by a Royal Air Force bombing raid. |  |
| 1944 | April: The Messerschmitt Me 262 first enters combat service in Germany. | YES |
| 1944 | June: The Messerschmitt Me 262 enters squadron service in Germany. |  |
| 1944 | July: The Gloster Meteor enters squadron service in the United Kingdom. | YES |
| 1944 | 27 July: First combat mission flown by a Gloster Meteor | YES |
| 1944 | 4 August: Gloster Meteors shot down two pulsejet-powered V-1 flying bombs | YES |
| 1944 | An effort starts in Germany to build a simple jet fighter, the Volksjäger. The contract is eventually won by the Heinkel He 162, to be powered by the BMW 003. |  |
| 1944 | December: Northrop’s T-37 turboprop is tested. The design never matures and work is later stopped in the late 1940s. |  |
| 1945 | The Nakajima Kikka flies for the first time on August 7, 1945, powered by two Ishikawajima Ne-20 turbojets, making it the first Japanese jet aircraft to fly. | YES |
| 1945 | Stanley Hooker scales the Nene down to Gloster Meteor size, producing the RB.37, also referred to, confusingly, as the Derwent V. A Derwent V powered Meteor sets the world speed record at 606 mph at the end of the year. The importance of this incident relegates the development of more powerful engines unimportant. | YES |
| 1945 | The Junkers 022 turboprop runs. |  |
| 1945 | An afterburner equipped Jumo 004 is tested. |  |
| 1945 | Lyul’ka VDR-3 axial-flow engine tested. |  |
| 1945 | Lyul’ka TR-1 axial-flow engine tested. |  |
| 1945 | The RB.39 Rolls-Royce Clyde turboprop runs, combining axial and centrifugal stages in the compressor. Rolls-Royce abandon development, preferring to focus on the turbojet. A carrier-based naval strike aircraft, the Westland Wyvern, having already changed from its original Rolls-Royce Eagle piston engine, uses the alternative turboprop, the Armstrong Siddeley Python. |  |
| 1945 | The Avia S-92, a version of the Me 262, is built in Czechoslovakia. |  |
| 1946 | January: A dispirited Frank Whittle resigns from what is left of Power Jets. Gradually the company is broken up, with only a small part remaining to administer its patents. | YES |
| 1946 | Development of the Rolls-Royce Dart starts. The Dart would go on to become one of the most popular turboprop engines made, with over 7000 being produced before the production lines finally shut down in 1990. |  |
| 1946 | Metrovick F2/4 Beryl delivers 4000 lbf (17.8 kN). Metrovick jet turbines sold to Armstrong Siddeley. |  |
| 1948 | First turbojet breaks sound barrier. | YES |
| 1949 | First use of turbojet for commercial service. | YES |
| 1949 | April 21: The Leduc 010, the world’s first ramjet powered aircraft, finally completes its maiden flight in Toulouse, France. The aircraft’s rate of climb exceeds that of the best contemporary turbojet powered fighters. | YES |
| 1949 | 22 June: Vickers VC.1 Viking flew with Rolls-Royce Nene turbojets: the world’s first pure jet transport aircraft. | YES |
| 1950 | Late 1950: Rolls-Royce Conway the world’s first production turbofan enters service, significantly improving fuel efficiency and paving the way for further improvements. | YES |
| 1952 | 2nd of May: Powered by the Rolls-Royce Avon (first axial flow jet engine), the De Havilland Comet is the first commercial jetliner to enter service with British Overseas Airways Corporation (BOAC) | YES |
| 1953 | The de Havilland Gyron, Halford’s last jet design, runs for the first time. Before cancellation 2 years later it has evolved to 25000 lbf (110000 N) using reheat. Other comparable turbojet engines are developed at the same time including the Canadian Orenda Iroquois. |  |
| 1955 | First use of reheat to increase thrust of turbojet. | YES |
| 1956 | 15 September: the Tu-104 medium range jet airliner enters service with Aeroflot, the world’s first jet airliner to provide a sustained and successful service. The Tu-104 was the sole jetliner operating in the world between 1956 and 1958. |  |
| 1958 | October: the Boeing 707 enters service with Pan American. This aeroplane is largely credited with ushering in the Jet Age having huge commercial success with few operating problems unlike its competitors. This plane helped establish Boeing as one of the leading makers of passenger aircraft in the world. | YES |
| 1959 | Sud Aviation Caravelle enters service: claimed as the first short/medium range jet airliner, first flight 27 May 1955. |  |
| Late 1950s | The General Electric CJ805 and Pratt & Whitney JT3C are the first low-bypass turbofan engines on offer on commercial aircraft including the Convair 880, Boeing 707 and Douglas DC-8 |  |
| 1968 | 30 June: TF39 high bypass turbofan of 43300 lbf (193 kN) enters service on the C-5 Galaxy transport ushering in the age of wide-body transports. |  |
| 1968-70 | The GE TF39 high bypass turbofan fitted on the Lockheed C-5 Galaxy is developed into the CF6 |  |
| 1969 | 2 March 1969: First flight of Concorde | YES |
| 1970 | The Rolls-Royce RB211 engine which features titanium fan blades & three-spool technology enters service on the Boeing 747 and the Lockheed L-1011 TriStar |  |
| 1974 | The CFM International joint venture between General Electric and Snecma (Safran) is founded | YES |
| 1975 | 26 December 1975: Tu-144S the first supersonic jet airliner went into mail and freight service between Moscow and Alma-Ata in preparation for passenger services, which commenced November 1977. | YES |
| 1976 | The Rolls-Royce/Snecma Olympus 593-powered supersonic airliner Concorde enters service |  |
| 1976 | 21 January: Concorde, the supersonic jet airliner, enters passenger service with British Airways and Air France. | YES |
| 1978 | 1 June: Tu-144 withdrawn from scheduled passenger service after 55 passenger flights due to reliability and safety problems. |  |
| Early 1980s | The CFM56 is selected for the Boeing 737 Classics - 300/400/500 |  |
| 1983 | 4 October 1983: Thrust2 turbojet-powered car gets the land speed record to 1149 km/h. | YES |
| Late 1980s | Open rotor experiments are conducted by GE on the GE36 and P&W/Allison on the 578DX featuring unducted fan (UDF) technology |  |
| 1995 | The Boeing 777 powered by the GE90 which features composite fan blades enters service with United Airlines |  |
| 1997 | 15 October 1997: ThrustSSC first supersonic car, powered by two turbofans takes the land speed record to 1228 km/h. | YES |
| 2002 | HyShot scramjet ignited and operated. | YES |
| 2003 | 31 January - GE90-115B receives FAR 33 certification; currently holds the world record for thrust and engine (fan) size for a gas turbine powered engine at 127900 lbf of thrust and 128 inches, respectively |  |
| 2003 | 26 November: Concorde retires from service |  |
| 2004 | Hyper-X first scramjet to maintain altitude | YES |
| 2007 | Hyper-X first airbreathing (scram)jet to attain Mach 10 | YES |
| Late 2000s | The Pratt & Whitney PW1000G geared turbofan is developed |  |
| Late 2000s | The Leap-1A features CMC technology on its turbine shroud |  |

**Sources:** (Anon, n.d.; Firm), 1990; Boyne *et al.*, 1979; Gunston, 1998; Anderson Jr, 1999; Anon, n.d.)

Timeline of wind energy (Anon, n.d.)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| 500–900 AD | The first windmills were developed in Persia for pumping water and grinding grain. |  |
| 1185 | Earliest confirmed reference to a windmill, in Weedley, Yorkshire |  |
| c. 1300 | The first horizontal-axis windmills (i.e. pinwheel) appeared in Western Europe. |  |
| 14th century | Dutch windmills used to drain areas of the Rhine River delta | YES |
| 18th century | Windmills used to pump water for salt making on the island of Bermuda and on Cape Cod during the American revolution |  |
| 1850s | Daniel Halladay and John Burnham worked to build and sell the Halladay Windmill, designed for the American West. It had an open tower design and thin wooden blades. They also started the U.S. Wind Engine Company. | YES |
| Late 1880s | Thomas O. Perry conducted over 5000 wind experiments trying to build a better windmill. He invented the mathematical windmill, which used gears to reduce the rotational speed of the blades. This design had greater lifting power and smoother pumping action, and the windmill could operate in lighter winds. Perry also started the Aermotor Company with LaVerne Noyes. | YES |
| Late 1880s | The development of steel blades made windmills more efficient. Six million windmills sprang up across America as settlers moved west. Homesteaders purchased windmills from catalogs or traveling salesmen or, otherwise, built their own. Mills were used to pump water, shell corn, saw wood, and mill grain. |  |
| 1887 | The first windmill used for the production of electricity was built in Scotland in July 1887 by Prof James Blyth of Anderson’s College, Glasgow. | YES |
| 1888 | Charles F. Brush created the first large windmill to generate electricity in the U.S. in Cleveland, Ohio. Windmills that produce electricity started to be called wind turbines. In later years, General Electric acquired Brush’s company, Brush Electric Co. | YES |
| 1891 | The Danish scientist Poul la Cour constructed a wind turbine to generate electricity, which was used to produce hydrogen by electrolysis to be stored for use in experiments and to light the Askov High school. He later solved the problem of producing a steady supply of power by inventing a regulator, the Kratostate. | YES |
| 1893 | In Chicago, Illinois, the World’s Columbian Exposition (also known as the Chicago World’s Fair) highlighted 15 windmill companies that showcased their goods. |  |
| 1895 | Poul la Cour converts his windmill into a prototype electrical power plant that was used to light the village of Askov | YES |
| Early 1900s | Windmills in California pumped saltwater to evaporate ponds. This provided gold miners with salt. |  |
| 1927 | Brothers Joe and Marcellus Jacobs open a factory, Jacobs Wind in Minneapolis to produce wind turbine generators for farm use | YES |
| 1931 | Darrieus wind turbine invented, with its vertical axis providing a different mix of design tradeoffs from the conventional horizontal-axis wind turbine. The vertical orientation accepts wind from any direction with no need for adjustments, and the heavy generator and gearbox equipment can rest on the ground instead of atop a tower. | YES |
| 1936 | The U.S. starts a rural electrification project that removes the natural market for wind-generated power, since network power distribution provided a farm with more dependable usable energy for a given amount of capital investment. | YES |
| 1941 | For several months during World War II, the Smith-Putnam wind turbine supplied power to the local community at “Grandpa’s Knob,” a hilltop near Rutland, Vermont. Its blades were 53 meters (175 feet) in diameter, and this became the world’s first windmill to provide utility scale (i.e. greater than 1 MW) power levels. | YES |
| 1943 | The Smith-Putnam wind turbine broke down, and the machine was shut down. |  |
| 1945 | The Smith-Putnam machine was restarted, but small cracks in the blade caused one blade to break; the turbine was shut down forever. |  |
| 1950s | Most windmill companies in the United States went out of business. | YES |
| 1973 | The Organization of Petroleum Exporting Countries (OPEC) oil embargo caused the prices of oil to rise sharply. High oil prices increased interest in other energy sources, such as wind energy. | YES |
| 1974–82 | With funding from the National Science Foundation and the U.S. Department of Energy, the National Aeronautics and Space Administration (NASA) led an effort to increase wind power technology at the Lewis Research Center in Cleveland , Ohio. NASA developed 13 experimental wind turbines with four major designs: 1. the MOD-0A (200 kilowatts) 2. the MOD-1 (2 megawatts, the first U.S. turbine in 1979 over 1 megawatt) 3. the MOD-2 (2.5 megawatts) 4. the MOD-5B (3.2 megawatt). | YES |
| 1978 | Congress passed the Public Utility Regulatory Policies Act (PURPA) of 1978 to encourage the use of renewable energy and cogeneration facilities (plants that have another purpose besides producing electricity). PURPA requires utility companies to buy extra electricity from renewable and cogeneration facilities that meet certain qualifications, called qualifying facilities (QFs). The amount that a utility pays a QF must be equal to the cost that it would have taken the utility to produce the same amount of electricity, called the avoided cost. | YES |
| 1978 | The world’s first multi-megawatt wind turbine was constructed by teachers and students of the Tvind school in Denmark. | YES |
| 1979 | The first U.S. wind turbine rated over 1 megawatt (MOD-1) began operating; MOD-1 had a 2-megawatt capacity rating. | YES |
| 1979 | The cost of electricity from wind generation was about 40 cents per kilowatt hour. |  |
| 1980 | The Crude Oil Windfall Profits Tax Act of 1980 further increased tax credits for businesses that used renewable energy. The Federal tax credit for wind energy reached 25%, rewarding those businesses choosing to use renewable energy. | YES |
| 1983 | Because of a need for more electricity, California began using a contract system that allowed certain renewable and cogeneration facilities (or in other words, QFs) to lock into rates that would make electricity generated from renewable technologies, like wind farms and geothermal plants, more cost competitive. Prices were based on the costs saved by not building planned coal plants. | YES |
| 1985 | Many wind turbines were installed in California in the early 1980s to help meet growing electricity needs and to take advantage of government incentives. By 1985, California wind capacity exceeded 1000 megawatts, enough power to supply 250000 homes. These wind turbines were very inefficient. |  |
| 1987 | The MOD-5B was the largest wind turbine operating in the world — with a rotor diameter of nearly 100 meters (330 feet) and a rated power of 3.2 megawatts. | YES |
| 1988 | Many of the hastily installed turbines of the early 1980s were removed and later replaced with more reliable models. |  |
| 1989 | Throughout the 1980s, DOE funding for wind power research and development declined, reaching its low point in 1989. | YES |
| 1990 | More than 2200 megawatts of wind energy capacity was installed in California — more than half of the world’ s capacity at the time. |  |
| 1992 | The Energy Policy Act of 1992 called for increased energy efficiency and renewable energy use and authorized a production tax credit of 1.5 cents per kilowatt hour for wind-generated electricity. It also reformed the Public Utility Holding Company Act to help make smaller utility companies more able to compete with larger ones. | YES |
| 1993 | U.S. Windpower developed one of the first commercially available variable-speed wind turbines, the 33M-VS. The development was completed over five years, with the final prototype tests completed in 1992. The $20-million project was funded mostly by U.S. Windpower, but also involved Electric Power Research Institute (EPRI), Pacific Gas & Electric, and Niagara Mohawk Power Company. | YES |
| 1995 | In a ruling against the California Public Utility Commission, the Federal Energy Regulatory Commission (FERC) refused to allow utilities to pay qualifying renewable facilities (QFs) rates that were higher than the utilities’ avoided cost, the amount that it would cost the utility to produce the same amount of electricity. |  |
| 1995 | The U.S. Department of Energy’s (DOE) Wind Energy Program lowered technology costs. DOE’s advanced turbine program led to new turbines with energy costs of 5 cents per kilowatt hour of electricity generated. | YES |
| Mid-1990s | Ten-year Standard Offer contracts written during the mid-1980s (at rates of 6 cents per kilowatt hour and higher) began to expire. The new contract rates reflected a much lower avoided cost of about 3 cents per kilowatt hour and created financial hardships for most qualifying renewable and cogeneration facilities (QFs). |  |
| Mid-1990s | Kenetech, the producer of most of the U.S.-made wind generators, faced financial difficulties; it sold off most of its assets and stopped making wind generators. |  |
| 1999 | Wind generated electricity reached the 2000 megawatt mark. |  |
| 1999–2000 | Installed capacity of wind-powered, electricity-generating equipment exceeded 2500 megawatts. Contracts for new wind farms continued to be signed. |  |
| 1999–2001 | The cost of electricity from wind generation was from 4 to 6 cents per kilowatt hour. |  |
| 2003 | Installed capacity of wind-powered, electricity-generating equipment was 4685 megawatts as of January 21. |  |
| 2004 | The cost of electricity from wind generation was 3 to 4.5 cents per kilowatt hour. |  |
| 2005 | The Energy Policy Act of 2005 strengthened incentives for wind and other renewable energy sources. | YES |
| 2006 | DOE’s budget for wind subsidies was about $500 million — about 10 times as much as the 1978 level. |  |
| 2007 | Wind power provided 5 percent of the renewable energy used in the United States. |  |
| 2007 | U.S. wind power produced enough electricity, on average, to power the equivalent of over 2.5 million homes. |  |
| 2007 | Installed capacity of wind-powered, electricity-generating equipment was 13885 megawatts as of September 30 — more than four times the capacity in 2000. |  |
| 2009 | The world’s first operational deep-water large-capacity floating wind turbine, Hywind, became operational in the North Sea off Norway in late 2009 at a cost of some 400 million kroner (around US$62 million) to build and deploy. | YES |
| 2011 | In late 2011, Japan announced plans to build a multiple-unit floating wind farm, with six 2-megawatt turbines, off the Fukushima coast of northeast Japan where the 2011 tsunami and nuclear disaster has created a scarcity of electric power. |  |
| 2015 | Largest wind turbines measure 8MW capacity. These are the Vestas V164 for offshore use. |  |

Timeline of wireless data transfer (Anon, n.d.)

|  |  |  |
| --- | --- | --- |
| Year | Event | Major event |
| 1896 | Guglielmo Marconi develops the first wireless telegraph system | YES |
| 1927 | First commercial radiotelephone service operated between Britain and the US | YES |
| 1946 | The first commercial mobile radiotelephone service is introduced in St. Louis | YES |
| 1947 | The transistor is invented by scientists John Bardeen, Walter Brattain and William Shockley who later share the Nobel Prize. The transistor replaces vacuum tubes, serving as the foundation for the development of modern electronics and makes possible the marriage of computers and communications. | YES |
| 1947 | Engineers at Bell Labs develop the concept of cellular technology. | YES |
| 1948 | Claude Shannon publishes two benchmark papers on Information Theory, containing the basis for data compression (source encoding) and error detection and correction (channel encoding). | YES |
| 1950 | TD-2, the first terrestrial microwave telecommunication system, is installed to support 2400 telephone circuits. |  |
| 1962 | The first communication satellite, Telstar, is launched into orbit. | YES |
| 1964 | The International Telecommunications Satellite Consortium (INTELSAT) is established. | YES |
| 1964 | AT&T’s Improved Mobile Telephone Service (IMTS) eliminates the need for push-to-talk operation and offers automatic dialing |  |
| 1965 | INTELSAT launches the Early Bird geostationary satellite. |  |
| 1968 | The Defense Advanced Research Projects Agency – US (DARPA) selects BBN to develop the Advanced Research Projects Agency Network (ARPANET), precursor of the modern Internet | YES |
| 1968 | The Federal Communications Commission (FCC) opens Docket 18262 to set aside sufficient spectrum to meet the demand for land mobile communications.  Congestion on the frequencies then available was approaching unacceptable levels, with a waiting period of several years in some markets to get a mobile phone. | YES |
| 1970 | The FCC allocates 75 MHz for common carrier cellular systems out of the UHF spectrum | YES |
| 1971 | June: ALOHAnet connected the Hawaiian Islands with a UHF wireless packet network. ALOHAnet and the ALOHA protocol were early forerunners to Ethernet, and later the IEEE 802.11 protocols, respectively. | YES |
| 1971 | The FCC modifies its 1970 decision to allow non-wireline carriers (non-telephone companies)  as well as wireline (telephone) carriers to access the 75 MHz allocated for common carrier radio cellular systems. | YES |
| 1974 | The FCC revises it cellular allocation from 75 MHz to 40 MHz, restricts eligibility to wireline carriers, and adopts a one system per market policy because of its belief that technical complexity and expense would make competing systems in a market unviable.  The FCC also decides to license developmental systems. |  |
| 1977 | FCC authorizes developmental cellular systems launch in Chicago and the Washington, D.C./Baltimore region. |  |
| 1981 | FCC issues Cellular Communications Systems Order, determining the cellular industry should have two carriers per market and creates cellular “A” and “B” licenses for each area of the country. |  |
| 1982 | AT&T settles its antitrust lawsuit with the U.S. Government, agreeing to divest itself of local phone service and its cellular licenses. |  |
| 1982 | In June, the FCC accepts 190 applications for the 30 largest market in the United States.  Only three applications were received for Boston, the smallest number for the major markets |  |
| 1982 | In November, the FCC accepts 353 applications for markets 31 -60 |  |
| 1983 | In January, TCP/IP is selected as the official protocol for the ARPANET | YES |
| 1983 | Motorola introduces the DynaTAC mobile telephone unit, the first truly “mobile” radiotelephone. The phone, dubbed the “brick,” had one hour of talk time and eight hours of standby. | YES |
| 1983 | In March, the FCC accepts 567 applications for markets 61-90.  The FCC states this is too many applications to handle effectively by comparative hearings, and in October issues a rulemaking seeking authority to award licenses by lottery. |  |
| 1983 | On October 13, the first commercial cellular system begins operating in Chicago. In December 1983, the second system is activated in the Baltimore/Washington, D.C. corridor. | YES |
| 1984 | In February 1984, cellular service launches in Indianapolis as the third U.S. market with coverage. |  |
| 1984 | The Cellular Telecommunications Industry Association is founded in May. |  |
| 1984 | In July, the FCC is inundated with 5182 applications for markets 91-120, after having received only 1110 applications for the 90 largest markets in the country |  |
| 1984 | The divestiture of AT&T is finalised, with cellular operations going to the seven Regional Bell Operating Companies. AT&T National AMPS company is divided among the RBOCS. |  |
| 1985 | The FCC releases the ISM band for unlicensed use, paving the way for wireless local area networking. These frequency bands are the same ones used by equipment such as microwave ovens and are subject to interference. |  |
| 1985 | At year’s end, there are 340213 cell phone subscribers. |  |
| 1986 | In February, the FCC receives 8007 applications for markets 121-135 and 7436 applications for markets 136-150 |  |
| 1986 | In March, the FCC receives 6367 applications for markets 151 – 165 |  |
| 1986 | In April, the FCC receives 8471 applications for markets 166-180, and 25018 for markets 181-240 |  |
| 1986 | In May, the FCC accepts 37650 applications for markets 241 – 305. At some point during this year, the shelves in the FCC filing room allegedly collapse due to the weight of the 100000 applications in storage. |  |
| 1987 | One millionth cellular subscriber is added in October. | YES |
| 1988 | FCC’s Auxiliary Cellular Services Order adopts technical flexibility rules for cellular radio without mandating specific standards, which promotes the introduction of advanced cellular technologies by the industry. | YES |
| 1989 | The “technology wars” among competing digital cellular standards begin. | YES |
| 1989 | The Motorola MicroTAC is introduced, the smallest and lightest phone available at the time, weighing 12.3 ounces. |  |
| 1990 | Cellular subscribership surpasses 5 million. |  |
| 1990 | Fleet Call, announces plans to build digital market-wide systems, functionally equivalent to cellular but on adjacent frequencies formerly reserved for private radio systems, in Chicago, Dallas, Houston, LA, New York and San Francisco and asks the FCC for rule waivers. |  |
| 1991 | NCR Corporation with AT&T Corporation invented the precursor to 802.11, intended for use in cashier systems, under the name WaveLAN. | YES |
| 1991 | The industry Fraud Task Force is launched. |  |
| 1991 | CTIA begins the Certification Seal program for cellular equipment. |  |
| 1992 | The number of cellular users passes the 10 million milestone. | YES |
| 1992 | World’s first commercial text message is sent by employees of Logica CMG. | YES |
| 1992 | One-millionth host connected to the Internet, with the size now approximately doubling every year. | YES |
| 1992, 1996 | The Australian radio-astronomer Dr John O’Sullivan with his colleagues Terence Percival, Graham Daniels, Diet Ostry, John Deane developed a key patent used in Wi-Fi as a by-product of a Commonwealth Scientific and Industrial Research Organisation (CSIRO) research project, “a failed experiment to detect exploding mini black holes the size of an atomic particle”. Dr O’Sullivan and his colleagues are credited with inventing Wi-Fi. In 1992 and 1996, CSIRO obtained patents for a method later used in Wi-Fi to “unsmear” the signal. | YES |
| 1993 | Congress adopts Omnibus Budget Reconciliation Act of 1993, which establishes national framework for wireless regulation and authorizes FCC to auction spectrum for the first time. | YES |
| 1993 | The first smart phone (IBM’s Simon) is released to the public and offers consumers a calendar, address book, calculator, email, faxing services and games. | YES |
| 1993 | Internet Protocol version 4 (IPv4) established for reliable transmission over the Internet in conjunction with the Transport Control Protocol (TCP) | YES |
| 1994 | FCC begins licensing Personal Communication Services (PCS) spectrum (1.7 to 2.3 GHz). The license auction raises $7.7 billion for the U.S. Treasury. |  |
| 1995 | There are more than 33.8 million wireless subscribers, representing approximately 13% of the total U.S. population. |  |
| 1995 | Sprint Spectrum launches the first PCS system in the United States in Washington, D.C. |  |
| 1996 | The Telecommunications Act of 1996 becomes law, in part designed to open other communications markets to competition. | YES |
| 1997 | Original version of the standard IEEE 802.11 protocol for wireless local area networking is released, providing up to 2 Mbit/s link speeds. | YES |
| 1997 | The wireless industry unveils its “Safety – Your Most Important Call” to help educate drivers about the dangers of distracted driving. |  |
| 1997 | Balanced Budget Act of 1997 calls for auctioning additional commercial spectrum by Sept, 2002. Advanced Wireless services (AWS-1) auction concludes Sept. 18, 2006, raising nearly $14 billion for U.S. Treasury. |  |
| 1998 | Ericsson, IBM, Intel, Nokia, and Toshiba announce they will join to develop Bluetooth for wireless data exchange between handheld computers or cellular phones and stationary computers |  |
| 1998 | The first “bucket” of minutes plan is offered. |  |
| 1999 | 802.11 protocol was updated in 1999 with 802.11b to permit 11 Mbit/s link speeds, which proved to be popular. |  |
| 1999 | Wi-Fi Alliance® founded by six companies as a trade association to hold the Wi-Fi trademark under which most products are sold: 3Com, Aironet, Intersil, Lucent Technologies, Nokia and Symbol Technologies. | YES |
| 1999 | Wi-Fi® brand adopted for technology based upon IEEE 802.11 specifications for wireless local area networking. |  |
| 1999 | With the Wireless Communications and Public Safety Act of 1999, Congress designates 911 as the universal emergency number of wireline and wireless service and promotes the use of technologies that help public safety service providers locate wireless 911 callers. |  |
| 2000 | Wireless subscribership in America exceeds 100 million, totaling approximately 38% of the U.S. population. |  |
| 2000 | Digital wireless users outnumber analog subscribers. | YES |
| 2000 | The Cellular Telecommunications Industry Association™ merges with the Wireless Data Forum to become the Cellular Telecommunications & Internet Association™. |  |
| 2001 | The average wireless consumer uses his or her phone for 320 minutes per month. |  |
| 2001 | November 8, FCC votes to raise CMRS spectrum limits for individual carriers from 45 MHz to 55 MHz, and subsequently eliminate cap in January 2003. |  |
| 2002 | Camera phones are first introduced in the U.S. market. | YES |
| 2003 | With the Secondary Markets Order, the FCC creates a “secondary market” which permits licensees to lease any amount of their spectrum. |  |
| 2004 | The Cellular Telecommunications & Internet Association™ changes its name to CTIA-The Wireless Association®. |  |
| 2004 | Congress enacts the Commercial Spectrum Enhancement Act, creating the Spectrum Relocation Fund to recover the costs associated with relocating radio communication systems from certain bands. |  |
| 2005 | Spurred by the Hurricane Katrina disaster, the wireless industry, together with the American Red Cross, develops the national Text 2Help Initiative, which allows customers to donate $5 via text message in the event of a major disaster. |  |
| 2005 | Deficit Reduction Act of 2005 enables Digital TV Transition and directs auctioning of 700 MHz of spectrum licenses. Auction concludes March, 2006, raising almost $19 billion for the U.S. Treasury. |  |
| 2005 | Subscribership reaches nearly 208 million, which is approximately 69% of the total U.S. population. |  |
| 2005 | Subscribers use more than 1.5 trillion voice minutes and send and receive more than 81 billion SMS messages. |  |
| 2005 | Wi-Fi chipset shipments top 100M annually. | YES |
| 2006 | Aircell successfully bids $31.3 million for FCC air-to-ground broadband frequency license. |  |
| 2006 | Google announces on October 9 that it has bought YouTube for $1.65 billion. |  |
| 2007 | iPhone launches, spurring dramatic handset innovation. | YES |
| 2008 | There are more than 270 million wireless subscribers who use more than 2.2 trillion minutes; more than 1 trillion SMS messages are sent and received in the U.S. |  |
| 2008 | iTunes Application Store (July) and Android Market (October) open. | YES |
| 2008 | October 13 marks the 25th anniversary of commercial wireless communications and the launch of the Wireless History Foundation. |  |
| 2009 | Wi-Fi uses a large number of patents held by many different organizations. In April 2009, 14 technology companies agreed to pay CSIRO $1 billion for infringements on CSIRO patents. This led to Australia labeling Wi-Fi as an Australian invention, though this has been the subject of some controversy. | YES |
| 2009 | There are more than 285.6 million U.S. wireless subscriber connections which is approximately 91% of the total U.S. population. |  |
| 2009 | Wireless subscribers use more than 6.2 billion minutes per day and send and receive more than 5 billion SMS messages per day. |  |
| 2009 | Palm Software Store (January), BlackBerry App World (April), Nokia Ovi Store (May), Palm App Catalog (June) and Windows Mobile Marketplace (July) app stores open. |  |
| 2009 | One billionth Wi-Fi chipset is sold. | YES |
| 2010 | First 4G handset is introduced at International CTIA WIRELESS show. |  |
| 2010 | After the devastating January earthquake in Port-au-Prince, Haiti, a record-breaking $35 million is donated via text message. |  |
| 2010 | FCC proposes National Broadband Plan, recommending 500MHz of spectrum be allocated for commercial use by 2020. |  |
| 2010 | In June, President Barack Obama signs a memorandum committing to freeing up 500 MHz of spectrum for the wireless industry. | YES |
| 2010 | In October, the Inaugural Wireless Hall of Fame dinner is held in San Francisco to induct new members and recognise previous inductees for their substantial contributions to the wireless industry. |  |
| 2012 | CSIRO won a further $220 million settlement for Wi-Fi patent-infringements in 2012 with global firms in the United States required to pay the CSIRO licensing rights estimated to be worth an additional $1 billion in royalties. |  |
| 2016 | The wireless local area network Test Bed was chosen as Australia’s contribution to the exhibition ’A History of the World in 100 Objects’ held in the National Museum of Australia. |  |
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