Refrigeration History

In prehistoric times, man found that his game would last during times when food was not available if stored in the coolness of a cave or packed in snow. In China, before the first millennium, ice was harvested and stored.

Hebrews, Greeks, and Romans placed large amounts of snow into storage pits dug into the ground and insulated with wood and straw. The ancient Egyptians filled earthen jars with boiled water and put them on their roofs, thus exposing the jars to the night's cool air. In India, evaporative cooling was employed. When a liquid vaporizes rapidly, it expands quickly. The rising molecules of vapor abruptly increase their kinetic energy and this increase is drawn from the immediate surroundings of the vapor. These surroundings are therefore cooled.

The intermediate stage in the history of cooling foods was to add chemicals like sodium nitrate or potassium nitrate to water causing the temperature to fall. Cooling wine via this method was recorded in 1550, as were the words "to refrigerate".

Cooling drinks came into vogue by 1600 in France. Instead of cooling water at night, people rotated long-necked bottles in water in which saltpeter had been dissolved. This solution could be used to produce very low temperatures and to make ice. By the end of the 17th century, iced liquors and frozen juices were popular in French society.

The first known artificial refrigeration was demonstrated by William Cullen at the University of Glasgow in 1748. Cullen let ethyl ether boil into a partial vacuum; he did not, however, use the result to any practical purpose.

Ice was first shipped commercially out of Canal Street in New York City to Charleston, South Carolina in 1799. Unfortunately, there was not much ice left when the shipment arrived. New Englanders Frederick Tudor and Nathaniel Wyeth saw the potential for the ice business and revolutionized the industry through their efforts in the first half of the 1800s. Tudor, who became known as the "Ice King", focused on shipping ice to tropical climates. He experimented with insulating materials and built icehouses that decreased melting losses from 66 percent to less than 8 percent. Wyeth devised a method of quickly and cheaply cutting uniform blocks of ice that transformed the ice industry, making it possible to speed handling techniques in storage, transportation and distribution with less waste.

In 1805, an American inventor, Oliver Evans, designed the first refrigeration machine that used vapor instead of liquid. Evans never constructed his machine, but one similar to it was built by an American physician, John Gorrie.

In 1842, the American physician John Gorrie, to cool sickrooms in a Florida hospital, designed and built an air-cooling apparatus for treating yellow-fever patients. His basic principle--that of compressing a gas, cooling it by sending it through radiating coils, and then expanding it to lower the temperature further--is the one most often used in refrigerators today. Giving up his medical practice to engage in time-consuming experimentation with ice making, he was granted the first U.S. patent for mechanical refrigeration in 1851.

Commercial refrigeration is believed to have been initiated by an American businessperson, Alexander

C. Twinning, in 1856. Shortly afterward, an Australian, James Harrison, examined the refrigerators used by Gorrie and Twinning and introduced vapor-compression refrigeration to the brewing and meatpacking industries.

Ferdinand Carré of France developed a somewhat more complex system in 1859. Unlike earlier compression-compression machines, which used air as a coolant, Carré's equipment contained rapidly expanding ammonia. (Ammonia liquefies at a much lower temperature than water and is thus able to absorb more heat.) Carré's refrigerators were widely used, and vapor compression refrigeration became, and still is, the most widely used method of cooling. However, the cost, size, and complexity of refrigeration systems of the time, coupled with the toxicity of their ammonia coolants, prevented the general use of mechanical refrigerators in the home. Most households used iceboxes that were supplied almost daily with blocks of ice from a local refrigeration plant.

Beginning in the 1840s, refrigerated cars were used to transport milk and butter. By 1860, refrigerated transport was limited to mostly seafood and dairy products. The refrigerated railroad car was patented by J.B. Sutherland of Detroit, Michigan in 1867. He designed an insulated car with ice bunkers in each end. Air came in on the top, passed through the bunkers, and circulated through the car by gravity, controlled by the use of hanging flaps that created differences in air temperature. The first refrigerated car to carry fresh fruit was built in 1867 by Parker Earle of Illinois, who shipped strawberries on the Illinois Central Railroad. Each chest contained 100 pounds of ice and 200 quarts of strawberries. It was not until 1949 that a refrigeration system made its way into the trucking industry by way of a roof-mounted cooling device, patented by Fred Jones.

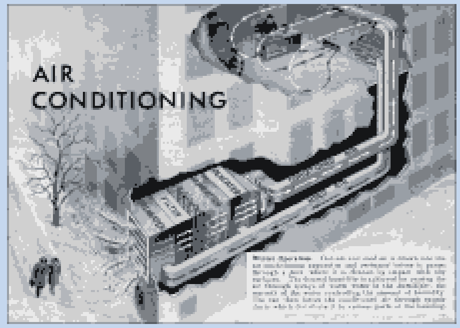
Brewing was the first activity in the northern states to use mechanical refrigeration extensively, beginning with an absorption machine used by S. Liebmann's Sons Brewing Company in Brooklyn, New York in 1870. Commercial refrigeration was primarily directed at breweries in the 1870s and by 1891, nearly every brewery was equipped with refrigerating machines.

Natural ice supply became an industry unto itself. More companies entered the business, prices decreased, and refrigeration using ice became more accessible. By 1879, there were 35 commercial ice plants in America, more than 200 a decade later, and 2,000 by 1909. No pond was safe from scraping for ice production, not even Thoreau's Walden Pond, where 1,000 tons of ice was extracted each day in 1847.

However, as time went on, ice, as a refrigeration agent, became a health problem. Says Bern Nagengast, co-author of Heat and Cold: Mastering the Great Indoors (published by the American Society of Heating, Refrigeration and Air-conditioning Engineers), "Good sources were harder and harder to find. By the 1890's, natural ice became a problem because of pollution and sewage dumping." Signs of a problem were first evident in the brewing industry. Soon the meatpacking and dairy industries followed with their complaints. Refrigeration technology provided the solution: ice, mechanically manufactured, giving birth to mechanical refrigeration.

Carl (Paul Gottfried) von Linde in 1895 set up a large-scale plant for the production of liquid air. Six years later he developed a method for separating pure liquid oxygen from liquid air that resulted in widespread industrial conversion to processes utilizing oxygen (*e.g.,* in steel manufacture).

The Development of Air-Conditioning



Willis Carrier, a Cornell graduate with a degree in engineering, noticed at a Brooklyn plant that a magazine printing process worked less efficiently in summer time due to the temperature and humidity. In 1911, he delivered a paper to the American Society of Mechanical Engineers that articulated the theory of air-conditioning — the use of refrigeration for comfort cooling — that we know today. Going beyond the theoretical, Carrier devised a new centrifugal compressor for refrigeration in 1923. At first, air-conditioning was limited to office and industrial applications. Soon patrons found comfort in public buildings like theaters, hotels and restaurants.

Says Bern Nagengast, co-author of a definitive history of refrigeration for the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE), "Without refrigeration, air-conditioning wouldn't have gotten off the ground. Mechanical refrigeration made it possible and it has drastically changed the way we live and work. Many geographic areas were virtually uninhabitable without air-conditioning."

Though meat-packers were slower to adopt refrigeration than the breweries, they ultimately used refrigeration pervasively. By 1914, the machinery installed in almost all American packing plants was the ammonia compression system, which had a refrigeration capacity of well over 90,000 tons/day.

Despite the inherent advantages, refrigeration had its problems. Refrigerants like sulfur dioxide and methyl chloride were causing people to die. Ammonia had an equally serious toxic effect if it leaked. Refrigeration engineers searched for acceptable substitutes until the 1920s, when a number of synthetic refrigerants called halocarbons or CFCs (chlorofluorocarbons) were developed by Frigidaire. The best known of these substances was patented under the brand name of Freon. Chemically, Freon was created by the substitution of two chlorine and two fluorine atoms for the four hydrogen atoms in methane (CH_4); the result, dichlorodifluoromethane (CCl_2F_2), is odorless and is toxic only in extremely large doses.

Though ice, brewing, and meatpacking industries were refrigeration's major beneficiaries, many other industries found refrigeration a boon to their business.

In metalworking, for instance, mechanically produced cold helped temper cutlery and tools. Iron production got a boost, as refrigeration removed moisture from the air delivered to blast furnaces, increasing production. Textile mills used refrigeration in mercerizing, bleaching, and dyeing. Oil refineries found it essential, as did the manufacturers of paper, drugs, soap, glue, shoe polish, perfume, celluloid, and photographic materials.

Fur and woolen goods storage could beat the moths by using refrigerated warehouses. Refrigeration also helped nurseries and florists, especially to meet seasonal needs since cut flowers could last longer. Moreover, there was the morbid application of preserving human bodies. Hospitality businesses including hotels, restaurants, saloons, and soda fountains, proved to be big markets for ice.

In WWI, refrigeration in ammunition factories provided the required strict control of temperatures and humidity. Allied fighting ships held carbon-dioxide machines to keep ammunition well below temperatures at which high explosives became unstable.

In 1973, Prof. James Lovelock reported finding trace amounts of refrigerant gases in the atmosphere. In 1974, Sherwood Rowland and Mario Molina predicted that chlorofluorocarbon refrigerant gases would reach the high stratosphere and there damage the protective mantle of the oxygen allotrope, ozone. In 1985 the "ozone hole" over the Antarctic had been discovered and by 1990 Rowland and Molina's prediction was proved correct.

The basic components of today's modern vapor-compression refrigeration system are a compressor; a condenser; an expansion device, which can be a valve, a capillary tube, an engine, or a turbine; and an evaporator. The gas coolant is first compressed, usually by a piston, and then pushed through a tube into the condenser. In the condenser, the winding tube containing the vapor is passed through either circulating air or a bath of water, which removes some of the heat energy of the compressed gas. The cooled vapor is passed through an expansion device to an area of much lower pressure; as the vapor expands, it draws the energy of its expansion from its surroundings or the medium in contact with it. Evaporators may directly cool a space by letting the vapor come into contact with the area to be chilled, or they may act indirectly--*i.e.* by cooling a secondary medium such as water. In most domestic refrigerators, the coil containing the evaporator directly contacts the air in the food compartment. At the end of the process, the warmed gas is drawn toward the compressor.

Further Information

History of Sealed Refrigeration Systems

Refrigerant History
Air Conditioning
FREDERICK M. JONES (1893-1961) Refrigeration Technology
The Refrigeration Research Museum (1890 - 1960)