Air Conditioning Comes to America

General Electric's advertisement for its Thinline air conditioner, published in *Time* magazine on May 21, 1956.

By Michael A. Martorelli

Visitors to the Museum of American Finance's new home in Boston are experiencing another one of that city's hot and humid summers. Like those visitors, the readers of *Financial History* are undoubtedly thankful for the relief provided by most buildings' air conditioning systems. Air conditioning was introduced in this country at the beginning of the 20th century. It was first intended to improve work efficiency and productivity in the country's factories. But this technology was not routinely used in American homes or offices for another seven decades.

Early Efforts at Indoor Cooling

Air conditioning was not invented by a single person. It did not spring up instantaneously in a particular place. There is a long history of humans using passive techniques to minimize the buildup of heat and humidity in their indoor habitats. In 1842, American physician John Gorrie made the first scientific effort to create an active system for accomplishing that goal. He noticed that patients in his Apalachicola, FL hospital suffered higher fevers than normal in the stifling heat of summer. He devised a way to chill the bedsides of malaria and yellow fever patients by blowing air over buckets of ice suspended from the ceiling. But ice was expensive, and not always available in the quantities needed to maintain that environment. So he began working on a machine to make ice.

Gorrie built on the earlier work of Benjamin Franklin, Scottish physician William Cullen and others who demonstrated how compressing a gas and then expanding its volume would decrease its temperature. In 1845, he installed in his fever ward an awkward-looking contraption that did help cool the patients. After developing it further, in 1851 he obtained US Patent #8,080 for his "Ice Machine." It worked, but it was a bit balky and hardly robust enough to produce the enormous quantities of ice needed to make it a permanent addition to any room.

Gorrie went to New Orleans to seek investment capital to improve the efficiency and reliability of his device. But in doing so, he was challenging the existence of the powerful "Ice Lobby" that had been bringing block ice from New England to Florida for decades. Few investors were interested in the doctor's machine. Without capital, Gorrie could not commercialize his invention. Financing aside, he faced another unusual obstacle. Enlightened citizens who thought nothing of using stoves to heat their indoor environment believed it bordered on the sacrilegious to challenge God's work by using artificial means to create his naturally occurring ice.

The Impact of New Technologies

And yet, more than one putative inventor thought well enough of Gorrie's idea to make their own adjustments to his machine. Frenchman Ferdinand Carrie substituted ammonia for air and patented his own ice-making machine in both France (1859) and the United States (1860). Europeans who thought themselves immune from the negative publicity campaign that "Ice King" Frederic Tudor waged against Gorrie promptly began using ice machines to replace their own ice harvesting programs.

Over time, American businesses took advantage of the opportunity to manufacture so-called "plant ice." Railroads installed compartments of ice in special boxcars; several companies developed specialized ice-making machines for breweries

and meatpacking plants; others built large cold storage facilities for temporarily storing perishables. In 1881, well-meaning officials used more than 500,000 pounds of ice in an elaborate cooling mechanism to lower the temperature in President James Garfield's sickroom while treating him for a gunshot wound.

By 1890, many factories had begun using electric fans, pipes, air ducts and chemicals to bring cool air to their indoor environments. But there was no demand for comfort cooling by homeowners. Manufactured ice, electric fans and steam engines were expensive, making their use for such a personal goal quite impractical. Businesses generally were successful in lowering the temperature of the air in various indoor environments as long as the ice lasted. However, the melting and evaporating of the ice also resulted in a higher level of humidity in those locations.

It seemed the men building these cooling systems had an incomplete knowledge of the principles of air compression, evaporation and condensation—at least until they read German engineer Hermann Rietschel's 1894 book, *Guide to Calculating and Design of Ventilating and Heating Installations*. It identified all the variables involved in using mechanical refrigeration to control both temperature and humidity. By 1896, a handful of engineers started using Rietschel's ideas to design "refrigerated rooms" in a variety of buildings in several American cities. In 1902, Alfred Wolff installed a system for heating and cooling the unusually large trading floor in the building that became the new home of the New York Stock Exchange. It was remarkably effective in both cooling the room and reducing its humidity level.

At the same time, Stuart Cramer was working on a way to reduce the humidity levels in textile mills in North Carolina. Manufacturers of towels, blankets and clothing needed a certain amount of humidity in their factories, since damp fibers were more elastic and easier to work with. But they found it hard to control the humidity levels. In 1904, Cramer patented a system to regulate the wet-bulb and dry-bulb thermometers and thus maintain the proper relative humidity of any room. He coined the term "air conditioning" to describe his process. It was a variation on the term "yarn conditioning"—exposing textile fibers to damp conditions in storage rooms before processing.

Statue of American physician John Gorrie by C.A. Pillars, located in the Hall of Columns at the US Capitol. Gorrie is credited with the early efforts to create mechanical refrigeration and patented his "ice machine" in 1851.

Willis Carrier's Breakthrough

Wolff passed away in 1909 and Cramer retired in 1918, so history records Willis Haviland Carrier as the most effective pioneer and promotor of air conditioning in America. In 1902, he was an engineer at the Buffalo Forge Company, designing heating and drying systems for commercial clients. The Sackett-Wilhems Lithographing Company in Brooklyn, NY asked him to design a ventilating system that would overcome a problem—high humidity in their factory was causing the lithograph paper to swell and shrink with each pass through the printing press. Carrier's first effort helped the situation, but it was not sufficiently robust to solve the problem completely. He then found that using an air washer with chilled-water sprays allowed him to bring the humidity down to an appropriate level.

Carrier continued to both examine and then explain the scientific rationale behind his processes. In 1906, he was granted a patent for his "Apparatus for Treating Air." In 1908, he became the head of Buffalo Forge's new subsidiary, the Carrier Air Conditioning Company of America. In 1911, he detailed his description of air conditioning in a paper titled "Rational Psychrometric Formulae: Their Relation to the Problems of Meteorology and of Air Conditioning," published in *Transactions of the American Society of Mechanical Engineers*. He explained the importance of controlling the temperature and humidity in factories making products such as textiles, food products, high explosives, photographic film and tobacco (all of which tend to absorb moisture from the air), and he described the procedures to deliver the proper levels.

In 1915, Carrier left Buffalo Forge to form the Carrier Engineering Corporation (CEC). It was soon providing humidity and temperature controlling systems to several dozen manufacturing firms. As his firm gained experience, Carrier realized the importance of tailoring each air conditioning system to the specifics of the materials used to make each product, as well as the location, size and layout of each factory. He also had to understand the way the workers were performing the various tasks involved in their production processes. Carrier designed each system with commonly available parts, but he configured them in specific ways for each customer. In doing so, this innovator blended the science of mechanical engineering with the art of understanding how each building's attributes and operations affected the nature and configuration of an effective air conditioning system.

While CEC was the leader in developing air conditioning systems, entrepreneurial companies such as Kroeschell Brothers Ice Machine Company and established corporations such as General Electric were quick to incorporate the known aspects of air washing, centrifugal chilling and refrigerant selection to develop air conditioning systems of their own. Throughout the 1920s, these firms continued to add diverse types of manufacturing firms to their client lists.

Effective Cooling Becomes a Reality

Throughout the Roaring Twenties, motion picture theaters were springing up all over the country, multi-story department stores were transforming the world of retailing and luxury hotels were adding exhibit halls and meeting rooms to their premises. The owners of these and other consumer-facing businesses were quite aware of the engineering industry's success in lowering the temperature and/or humidity in various types of factories. Many expressed their interest in the applicability of air conditioning to their own facilities. So CEC and its competitors began to address this new appreciation for comfort cooling. Carrier's firm designed and installed air

conditioning systems for buildings including New York's Rivoli Theatre (1922), Fresno's T.W. Patterson Building (1926) and San Antonio's Milam Building (1928). They were among the earliest of their type to boast of having an effective air conditioning system, indeed of creating "manufactured weather" within their walls.

In 1929, after years of studying the problem and debating various solutions, the United States Congress hired Carrier to install air conditioning in both the House and Senate chambers. That same year, the Frigidaire division of General Motors developed a split-system room cooler meant to look like a radio cabinet and designed for use in office buildings, banks and restaurants. In 1930, both General Electric and Carrier introduced their versions of a similar appliance. The latter used a new refrigerant, Freon, to replace the poisonous and explosive refrigerants sulfur dioxide and methyl chloride. In 1932, engineers H.H. Schultz and J.Q. Sherman patented an air conditioner better suited to an individual room and capable of fitting on a windowsill. Early adopters purchased small numbers of each of the aforementioned products, suggesting at least a decent level of demand even during the Great Depression.

In 1932, the new 36-story headquarters of the Philadelphia Savings Fund Society (PSFS) in Philadelphia was the first of a new generation of skyscrapers to feature air conditioning throughout the building. Manufacturers sold $8 million worth of commercial air conditioning systems that year. In 1936, *Heating, Piping and Air Conditioning* documented the use of air conditioning in 76% of Chicago's movie theaters. In a 1939 survey, *Chain Store Age* found air conditioning in 30% of drug stores, 21% of restaurants and 15% of shoe and apparel stores. Also that year, Willis Carrier himself dedicated the "Carrier Igloo of Tomorrow" display at the New York World's Fair. That air-conditioned exhibit exposed many Americans to this cooling technique for the first time. In 1940, the Edison Electric Institute suggested that 90% of the country's air conditioning capacity involved commercial comfort cooling, rather than industrial process cooling. Despite the growth of air conditioning in various business establishments, by the end of 1941 none of the dozen companies offering those systems had produced a practical, efficient and cost-effective appliance to cool and dehumidify the typical home.

Carrier Corporation

Portrait of Willis Carrier, 1915. His company, Carrier Engineering Corporation (CEC), was the leader in developing air conditioning systems.

Early in 1942, War Production Board Order L-38 strictly controlled what was already a limited production of both commercial and residential air conditioners. The Board asked major retailers and other commercial establishments to lend 7,000 tons of air conditioning equipment to factories making war materials. During the war years, Carrier Corporation and others generated about half their revenue from providing air conditioning systems for factories, mines and blast-iron furnaces. They also developed specialized products for temperature-sensitive sections of submarines and battleships. Meanwhile, the limited availability of refrigerants and spare parts caused commercial establishments and consumers with existing air conditioning units to renew their interest in ice.

Air Conditioning in Post-War America

The manufacturers of air conditioning products certainly participated in the post-war economic boom. But studies examining the rate of diffusion across business sectors and geographic locations show how that technology spread unevenly across the country.

Retailers that experienced meaningful sales declines in the summer months and those that typically involved a leisurely visit by the consumer adopted air conditioning more quickly than other stores. By 1955, the prevalence of air conditioning in restaurants exceeded 75%. At that time, surveys suggested that only 25% of grocery stores and 15% of hardware stores were air conditioned.

Only 10% of office buildings were air conditioned in 1941. That rose to 16% in 1951 as architects and builders began to develop new methods and materials to retrofit existing buildings with air conditioning and equip new construction with that feature. By 1955, air conditioning was present in about 30% of office buildings nationwide. Offering personal comfort enabled workers to become more productive, so having central air conditioning started its decades-long shift from being a competitive advantage to an absolute necessity.

In 1946, homeowners purchased 48,000 window air conditioners. Manufacturers such as Carrier, Frigidaire and Fedders introduced improved models in the early 1950s. The industry sold one million units in 1953 and twice that number in 1957. Central home air conditioning evolved in a slow but steady manner. When Levitt & Sons built its Levittown housing development on Long Island between 1947 and 1951, they did not find much demand for that option. In planning the second Levittown to be built in 1955 in Bucks County, PA, however, Levitt made a Carrier central air system a standard feature.

Geographically, air conditioning spread more quickly in the South than in other sections of the country. By 1955, one in 22 homes nationwide had it; in the South, the ratio was closer to one in 10. By 1960, 12% of all homes nationwide had either a window unit or central air; in the South, about 18% had one or the other. In Washington, DC, the ownership rate was 21%. Indeed, that capital city had more air conditioning units per capita than any other metropolis, possibly because of the extensive use of central air by the federal government. In 1956, after conducting a study of its impact on worker productivity, the General Services Administration (GSA) had mandated the addition of central air to all new federal buildings.

From Luxury to Necessity

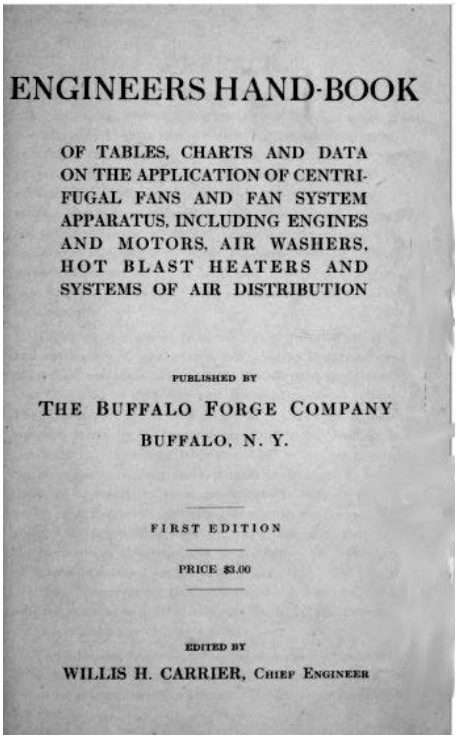
In 1959, the chairman of Carrier Corporation opined that after a lengthy period of adolescence, air conditioning was finally ready to "come of age." Throughout the

next two decades, users of all types continued to increase their reliance on air conditioning. Across the country, most new office buildings, hotels, hospitals and retail stores featured central air systems. In the South, the percentage of residences with that feature increased from the aforementioned 18% in 1960 to more than 50% in 1970. Indeed, the widespread availability of air conditioning throughout the Sunbelt (the South, spanning from the East to West Coasts) was an important enabling factor behind that region's economic growth in the period.

The region first labeled the Sunbelt in 1969 had long been the home to many military installations and defense contractors' manufacturing facilities. During the next two decades, the availability of central air conditioning was an important factor in encouraging other types of manufacturers to relocate existing plants from other states and/or establish new facilities throughout that region. In cities such as Dallas, Houston and New Orleans, developers began building air-conditioned office skyscrapers to attract white collar businesses as well. From 1960 to 1980, both population and employment numbers grew faster in the southern tier of the country than in the northern tier. By 1980, the Census Bureau showed air conditioning in 58% of all homes in the country, but in an average of 75% of all homes in the three southern census divisions. But the penetration rate remained uneven throughout the period. It was closer to 5% in older, low-income neighborhoods in cities such as Chicago and New York, where the existing electrical wiring systems made the addition of air conditioning units quite problematic.

Problems Emerge

In addition to providing relief from heat and humidity, air conditioning helped reduce the nationwide mortality rate from heat-related conditions and improved worker productivity in both offices and factories. But it was not without side effects. In 1962, the Federal Power Commission estimated that the peak load of electricity demand would reach 494 million kilowatts by 1980. In 1969, it updated that forecast to 555 million kilowatts, largely due to the increasing use of air conditioning. Throughout the 1960s, that increased usage put a serious drain on the electric infrastructure in cities across the country, leading to numerous brownouts or dim-outs during periods of unusually hot weather.


ENGINEERS HAND-BOOK

OF TABLES, CHARTS AND DATA ON THE APPLICATION OF CENTRIFUGAL FANS AND FAN SYSTEM APPARATUS, INCLUDING ENGINES AND MOTORS, AIR WASHERS, HOT BLAST HEATERS AND SYSTEMS OF AIR DISTRIBUTION

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WILLIS H. CARRIER, CHIEF ENGINEER

Title page of the first edition of the *Engineers Hand-Book,* edited by Willis Carrier while at the Buffalo Forge Company, 1914.

The decade of the 1970s was a tough one for the air conditioning industry. The 1973 Arab oil embargo that caused the nationwide energy shortage led Presidents Richard Nixon and Jimmy Carter to order limits on air conditioning in public buildings. In 1974, the Commerce Department required manufacturers of air conditioners to include information about their energy consumption.

Perhaps not coincidentally, the environmental movement began in the early 1970s. Scientists examining changes in the Earth's upper atmosphere implicated chlorofluorocarbons (CFCs) as major contributors to the thinning of the protective ozone layer. They also identified Freon (the most widely used refrigerant in air conditioners) as a particularly damaging CFC. The government removed that propellant from aerosol cans in 1978. But it took another dozen years before manufacturers stopped using Freon in new air conditioners.

And in one final insult, in January 1977, officials at the Center for Disease Control discovered that a previously unknown bacteria they labeled *Legionella pneumophilia* had been quietly and invisibly reproducing in the cooling water of an air conditioning system in the Bellevue-Stratford Hotel in Philadelphia. But the discovery occurred six months after that organism's circulation had been responsible for more than 200 cases of pneumonia and 34 deaths among the 2,000 men attending the annual convention of the American Legion at that location. Investigators then discovered that previous outbreaks of the pneumonia later termed Legionnaires' disease had occurred from 1965 to 1974, resulting in more than 100 infections and 18 deaths. Building superintendents nationwide thus became acquainted with problems related to the overly mechanical production of air that they labeled "Sick Building Syndrome."

By 1980, air conditioning was present not only in the great majority of homes and commercial buildings, but also in automobiles, airplanes, trains and even subways. Over the next several decades, manufacturers developed units that were more energy efficient, less environmentally damaging and more affordable than before. Users of all types acknowledged the technology's negative aspects and learned to pair its usage with passive cooling techniques. Living without this method of producing "manufactured weather" is no longer a viable or desirable option. $

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