

## A History of Air Conditioning in the Home

# Sleeping Soundly on Summer Nights

### The First Century of Air Conditioning

This is the sixth article in our special series to commemorate a century of innovation in the HVAC&R arts and sciences.

By **Mike Pauken, P.E.**  
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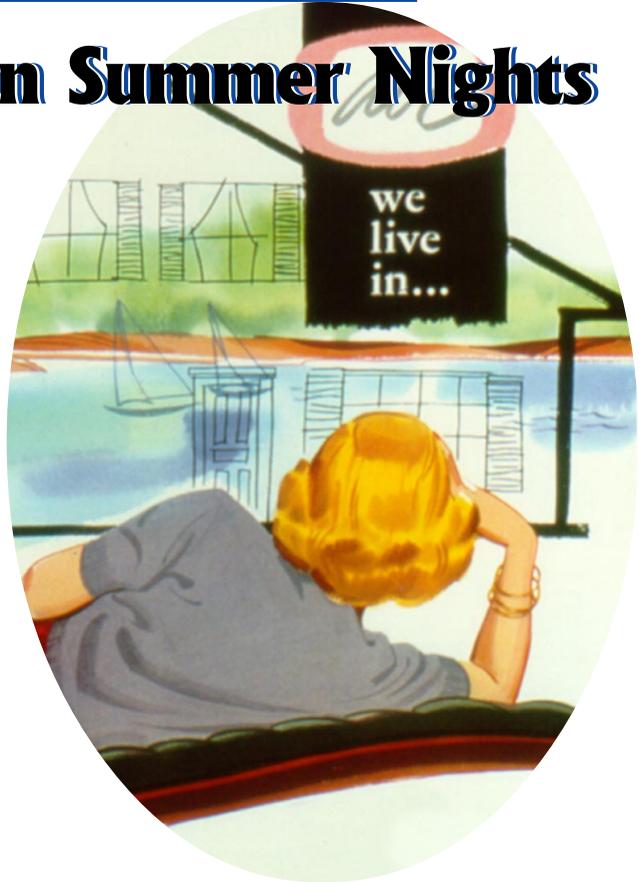
Anyone can drive through their city, town or countryside and see the impact of air conditioning on the home over the years. Houses built prior to the 1950s often were constructed to take advantage of natural cooling as much as possible. Architectural features such as shaded porches, high ceilings, and the liberal use of windows with moveable sashes were used to make occupancy as comfortable as possible during warm weather. The advent of air conditioning brought about architectural changes in home construction that necessitated its use to keep the occupants comfortable even on moderate days.

As a result of air conditioning, the growth of the suburbs after World War II was dominated by single-story houses with low-pitched roof lines, large plate glass windows that were sealed shut, ceilings that were 8 ft (2.4 m) high, and porches that were more ornamental than functional.

Air conditioning also has been responsible for major shifts in the demographics of the United States. Since 1940, eight of the 10 fastest-growing states are located in the Southeast and Southwest portions of the country. The Northeastern and Midwestern states have experienced the slowest growth rates. *Figure 1* shows the number of homes built each decade since 1940 in the United States divided into five major regions.<sup>1</sup> It is evident that the growth of home construction in the Southern portions of the country coincides with the growth and availability of air conditioning to the homeowner.

The taming of hot and humid summer conditions has enabled the rapid growth of large metropolitan areas such as Atlanta, Dallas, Houston and Miami. Business owners and individuals from northern latitudes looked southward to escape severe winter weather when air conditioning made it possible to endure and prosper through summer's heat.

Historian Marsha Ackerman noted that "Air conditioning expressed a city's influence and affluence, its aspirations to modernity and ability to control its domain ... air conditioning [was not] uniformly distributed within its largest markets. In hotels and on trains, air conditioning was used first to cool dining areas and public rooms, rather than private guestrooms or passenger compartments. In department stores, basements



*"Air-conditioning...for the Millions not just Millionaires" was the slogan used to sell air conditioning to homeowners in 1954 by Lenox International (from Lenox International and the History Factory).*

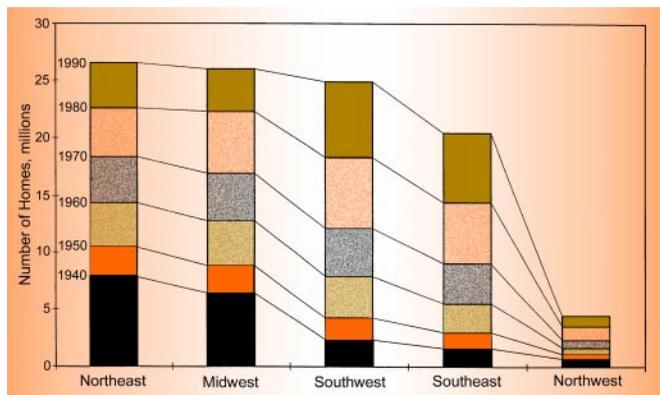
were cooled long before upper floors or workspaces."<sup>2</sup> To appreciate and understand the cause of these changes in demographics and architecture—among many other changes made possible by air conditioning—we now trace the history of the development of air conditioning in the home.

### The Early Days (1870 to 1930)

In 1882, Nikola Tesla and George Westinghouse received a patent for their invention of the electric fan. This was considered a major innovation in helping people feel more comfortable

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**Figure 1: Growth of homes built in the United States by region.**

during hot weather. However, it obviously had limitations on effective cooling. At most, an electric fan makes the air “feel” 7 to 8 degrees cooler by increasing convective heat transfer from the body. It was a logical step for many people to place ice in front of the fan to provide additional cooling. Indeed, physicians used fans and 50,000 lbs (22 700 kg) of ice to cool President James A. Garfield’s bedroom during the summer months of 1881. On July 2, Garfield was wounded in an assassination attempt, and the physicians tried to keep his room cool to help his recovery. Unfortunately, the president died two months later, despite the physicians’ efforts.

Table fans and ceiling fans were a primary means of comfort cooling well into the 20th century (*Figure 2*). Even today, they are found in nearly every home as a means of saving money and energy on days when temperatures are only moderately warm. It was not unusual for office skyscrapers, like the 60-story Woolworth Building in New York, to be decked out in awnings from top to bottom into the 1940s. Although awnings reduced the heat load from direct sunlight into the interior spaces, fans were used to circulate the air. Paperweights were necessary to keep work from moving about.

The earliest high-rise office building that was completely air-conditioned was the Milam Building in San Antonio, Texas, which was built in 1928. A few existing skyscrapers soon were retrofitted for central air conditioning such as the Tribune Tower (1934) and the Wrigley Building (1936) in Chicago.<sup>3</sup>

The roots of air conditioning, as we know it today, are in refrigeration. Early refrigeration plants often were used to make ice as an alternative to naturally harvested ice from frozen lakes. Ice was important in the production of beer and ale and in food preservation. Refrigeration machinery was driven by steam engines, thus its use was limited to industrial installations.

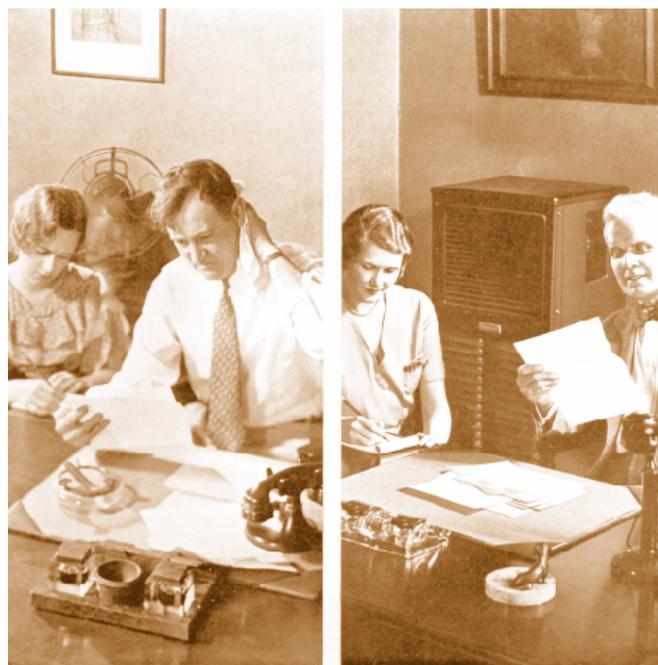
One of the earliest successful vapor compression refrigeration machines was developed by Charles Tellier in France. A New Orleans brewer named George Merz installed one of Tellier’s machines in 1869 to produce cold dry air to preserve the flavor of beer and ale by keeping it at a constant temperature without ice.<sup>4</sup> In the 1870s, important advancements were made by David Boyle who developed an ice machine using ammonia, and Raoul Pictet who developed one using sulfur dioxide.<sup>5</sup>

The electric motor allowed refrigeration plants to become

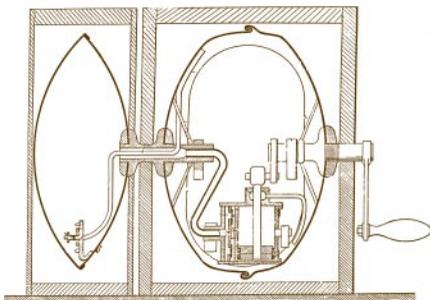
smaller. By 1890, refrigeration systems were available in a wide range of sizes that could serve small applications such as meat markets and soda fountains. It also was the ultimate luxury item for a few wealthy people. St. Louis engineer, Alfred Siebert, installed a 3 ton (10.5 kW) water chiller system in the home of Walter Pierce prior to 1900.<sup>6</sup> Pierce was president of an oil company and used the air-conditioning system to cool his library and billiard room. The same unit was used for refrigeration of a large meat, milk and wine box and several iceboxes in the kitchen.

The domestic refrigerator was the first successful adaptation of refrigeration machinery for use by homeowners. Refrigerators first were made available to homeowners as early as the 1890s, but it was not until the 1920s that they became widespread. Low-cost refrigerators were cooled by blocks of ice delivered to the homeowner by a local ice manufacturer and distributor. It was a luxury to have a refrigerator that used mechanical refrigeration. During this period of development, engineers solved many problems associated with small-scale refrigeration equipment and domestic operation.

The Audiffren-Singrun refrigerating machine was one of the most successful early units made for domestic service. Marcel Audiffren of France was granted a U.S. patent for his refrigeration unit in 1895.<sup>7</sup> Audiffren made improvements, in collaboration with Albert Singrun, to his original refrigeration machine and received another patent in 1908.<sup>8</sup> A group of Americans bought the patent rights and formed the American Audiffren Refrigerating Machine Company. General Electric manufactured the equipment, and the Johns-Manville Company marketed it. The first machine was sold in 1911 and 150 to 200 units were produced each year until 1928.<sup>9</sup>



**Figure 2: This Frigidaire room cooler ad shows the change from using fans in the office to using air conditioning (from the Frigidaire Collection, General Motors Institute Collection of Industrial History, Flint, Mich.).**



**Figure 3:** The Audiffren-Singrun refrigerator was shaped like a dumbbell with the condenser and compressor in one sphere rotating in a tank of cooling water.

The Audiffren-Singrun refrigerator was a sulfur dioxide compression machine that was shaped like a dumbbell with the condenser and compressor in one sphere rotating in a tank of cooling water. The evaporator in the other sphere rotated in a brine tank as shown in *Figure 3*. This allowed the unit to be hermetically sealed and prevented the lubrication oil from mixing with the refrigerant. The bulky design required a remote location for the refrigeration machine, usually in the basement. It was connected to a heat exchanger in the refrigerated cabinet in the kitchen by pipes.

In 1916, General Electric began to design a refrigeration machine that was simpler and cheaper than the Audiffren machine. By 1918, they developed a machine with the motor enclosed in the compressor case, which eliminated the troublesome stuffing box between the motor shaft and the compressor. This enclosed motor was one of the most important technical developments in domestic refrigeration machinery. However, the compressor was still water cooled. In 1923, the compressor and condenser were air cooled, which eliminated the necessity of plumbing connections.

While comfort cooling rarely was applied to individual homes before 1920, it was a steadily growing industry serving commercial and industrial markets. By 1911, air conditioning proved itself to be of great economic value in “lithography, the manufacture of candy, bread, high explosives and photographic films, and the drying and preparing of delicate hygroscopic materials such as macaroni and tobacco” according to Willis Carrier’s

experience.<sup>10</sup> In these industries where air conditioning was used to facilitate manufacturing, it was observed that workers in such plants were often more comfortable, more productive and less prone to absenteeism.

Most Americans’ first exposure to air conditioning was in movie houses and theaters during the 1920s and 30s. Without air conditioning, most theaters were closed during the summer months. Air conditioning was an economic boom to the theater and movie industries (*Figure 4*). Theater operators found that they were able to recover the cost of their air-conditioning equipment in just one summer. Many theaters would leave their doors wide open to allow the cool air to entice passersby into their establishments.

Still, comfort cooling in the home was a luxury. Many remaining technical difficulties made air conditioning unaffordable for the average homeowner.

### Overcoming Technical Hurdles

In 1924, General Electric introduced the first domestic refrigerator with a hermetically sealed motor and compressor. Until that time, compressors were belt driven and shaft seals on the compressor were prone to leaking refrigerant. The direct

drive compressor resulted in a significant reduction in compressor size because it operated at 1,740 rpm. Typical belt-driven units used for larger commercial refrigerators operated at speeds of 300 rpm to 600 rpm. This compressor configuration would have been suitable for a room air conditioner, except that it was virtually impossible to meet the safety code limitations on the refrigerant charge size for the home.

Larger size compressors operated at speeds of 200 rpm to 400 rpm, with a capacity of 2 tons to 20 tons (7 kW to 70 kW) of refrigeration. These could only be used in commercial applications such as restaurants, cocktail lounges, butcher shops and drug stores.<sup>11</sup>

The condensers of nearly all air-conditioning and large refrigeration units in the 1920s and early 1930s were water cooled and thus required a plumbing connection and a sewer hookup. This presented a serious problem for municipal water suppliers concerned with providing adequate water to their customer base as the size of the air-conditioning market grew. Furthermore, it required additional expenditure by the homeowner to install the necessary plumbing. In Chicago, 5,200 tons (18 300 kW) of air-condition-



**Figure 4:** Most Americans’ first exposure to air conditioning was in movie houses and theaters during the 1920s and 30s. Air conditioning was an economic boom to the theater and movie industries.

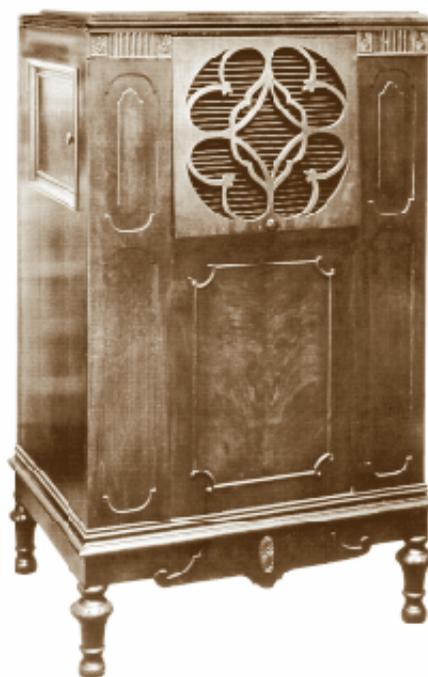
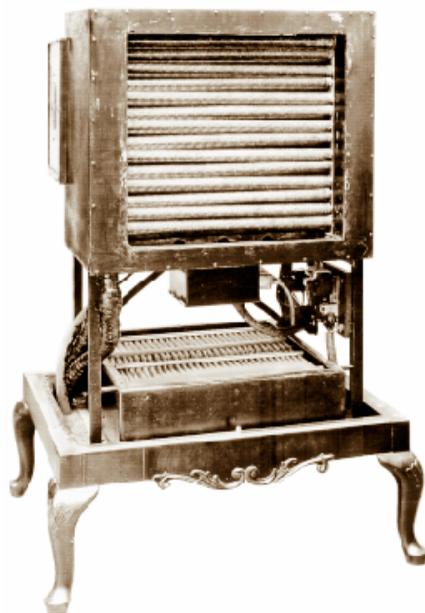
ing capacity existed in the central business district by 1932. Sixteen years later, the air-conditioning capacity had increased to more than 28,000 tons (98 500 kW). It is estimated that the water-cooled condensers of air conditioning alone could have consumed well over half of the peak water consumption in Chicago of 75 million gallons (280 million liters) per day in 1948.<sup>12</sup>

One obstacle to the room air-conditioner market was the limited electrical service available in most residences. The typical home in 1930 had only a 30-ampere capacity with a 15-ampere limit on each two-wire branch circuit. The National Electrical Code specified that motor-operated appliances could not exceed 50% of the rating of a branch circuit. Hence, it was virtually impossible to produce a room air conditioner that operated on less than 7.5 amperes on a 110-volt circuit.

Customers desiring to install room air conditioners with adequate cooling capacity had to upgrade their electrical service, although it was common knowledge that many homeowners were in violation of code specifications. Typical upgrades to 60-ampere service allowed for dedicated branch circuits that could carry a motor current load of up to 12 amperes at 208 volts or 220 volts solved many problems.

## Products Coming to Market

Prior to 1930, comfort-cooling applications were central station units and were too expensive for a typical homeowner to install in an existing structure. These installations required plumbing and sewer connections, ducting for air distribution and upgraded electrical service. Because the domestic refrigerator market had been developing for many years, it was a natural extension to introduce a self-contained or “portable” appliance that could be installed in any room in a house. The Frigidaire division of General Motors introduced its first room cooler in 1929. This was a water-cooled console type air conditioner that modeled refrigerator designs of that era (Figure 3). Over the next three years, several manufacturers began to offer room coolers including Carrier, Copeland, General Electric, Kelvinator, Strang, Universal Cooler and York among several others.



**Figure 5: The first General Electric room coolers were housed in specially designed decorative walnut wood cabinets resembling radios (from General Electric Hall of History, Schenectady, N.Y.).**

One of the first air-cooled console units was produced by the De La Vergne company in 1931. This unit not only provided cooling, but also could operate in a heat pump mode. Although this unit was

classified as portable, it was never moved from room to room since it weighed about 1,200 lbs (544 kg).

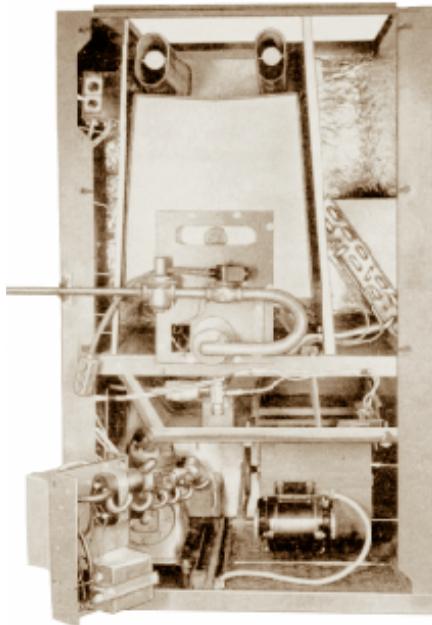
The first window air conditioner was introduced by the Thorne company in 1932, although it is doubtful that it was ever mass produced. In 1936, Philco-York introduced a 3,675 Btu/h (1077 W) window unit that used a single motor to drive the compressor and the fans for the evaporator and the condenser. Westinghouse sold the first hermetically sealed window air conditioners in 1941. It also featured a heat pump cycle providing up to 92,000 Btu/h (26 700 W) in heating mode and 6,000 Btu/h (1760 W) in cooling.<sup>11</sup>

## The Post War Period (1945 to 1960)

After World War II, comfort air conditioning became increasingly popular and affordable to the growing middle class. Advertising of air-conditioning systems moved from the engineering and architectural trade journals to popular magazines such as *House Beautiful* and *House & Home*. General Electric and Carrier, among many other smaller manufacturers, began advertising that air conditioning was now affordable to the masses in suburban neighborhoods where homes were built with almost factory-like efficiency and cost.

G.E. portrayed homes costing \$12,500 in Dallas’ East Ridge subdivision in a series of advertising in 1952. These homes, like most homes in that day, were not well designed for air conditioning. Therefore, in 1952, the Carrier Corporation commissioned an architectural firm to design a new mass-producible house that optimized the firm’s Weathermaker air-conditioning system.

In 1953, Carrier followed up with a nationwide Weathermaker Home Competition advertised in *House & Home*, *Progressive Architecture* and *Architectural Record*. There were 861 entrants competing for a \$5,000 grand prize and 30 smaller awards based on region, house size and roof style. The grand prize went to two Argentinean architects based in Raleigh, N.C. Their design, which was later built, was a 1,000 ft<sup>2</sup> (93 m<sup>2</sup>) house with huge areas of fixed glass on the north and south exposures, a flat roof and a wide overhang. *House & Home* complained that “most contestants only showed a rudi-



**Figure 6: Interior view of 2 ton central plant unit for the all-year air conditioning of residences, showing functional elements.**

mentary understanding of how to take advantage of air conditioning.” Furthermore, it stressed that flat roofs absorb heat and release it slowly and that sealed windows necessitate air conditioning to make the house livable. While these features require air conditioning, they “ride roughshod over most people’s desire to keep windows open part of the year.”<sup>13</sup> Most contestants failed to consider strategies such as shading to provide more natural cooling.

Despite *House & Home*’s initial disapproval of these types of houses, the people living in them praised the houses, especially during the hot summer of 1953. In its March 1954 issue, *House & Home* hailed the benefits of air conditioning. One article featured a homeowner in Dallas who said, “Our outdoor terrace received little use because it was pleasanter inside. Not only is it cooler inside but there are no mosquitoes or other insects to bother you.”<sup>14</sup> Air conditioning was gaining wide acceptance and was on the path to becoming a common appliance and not a luxury.

In 1955, homebuilder William Levitt signed a contract with Carrier to install their units as standard equipment in hundreds of new homes. This was the largest contract to date for residential air condi-

tioning. Levitt stated, “It doesn’t make sense to heat a home in the winter and not cool it in the summer ... before long we hope to be able to install central air-conditioning equipment in every home we produce. Air conditioning will be a basic feature of modern home development.”<sup>2</sup>

In the early 1950s, homeowners and builders had several options for air conditioning. Central air conditioning was manufactured as either a combination heating and cooling unit or as a separate cooling unit. The combination unit was designed primarily for new homes and had several advantages over the separate cooling unit. A single blower was used to handle air distribution through the heating or cooling coils and the ductwork. The system could be changed over from heating to cooling by a single thermostat and switch. All of them used a water-cooled condenser that required either a cooling tower or a connection to the house water supply and sewer (*Figure 6*).

These units were large because the cabinets contained the blower, the furnace, the evaporator and condenser and the compressor. Separate central air-cooling units were designed to be added to existing forced-air heating systems and to increase flexibility in locating the air-conditioning system. One problem with adding a separate cooling unit to an existing heating system was that the blower and the ducting often were smaller than that required for a cooling system.

In areas of the country where water supplies were tight, cooling towers were used to remove heat from air-conditioning condensers. There were two kinds of towers, forced draft and natural draft. The forced-draft tower had a fan and could be located inconspicuously near the house or behind a fence or hidden with vines. The natural-draft tower required open access to wind and could not be easily concealed. The natural-draft towers were typically one-third the cost of a force-draft unit.

One innovative twist on the cooling tower was the development of the cooling fountain. Building materials dealer C.C. Rouse of Houston developed a decorative fountain that cost about the same as a forced-draft tower for a 5 ton (17 kW) cooling system.

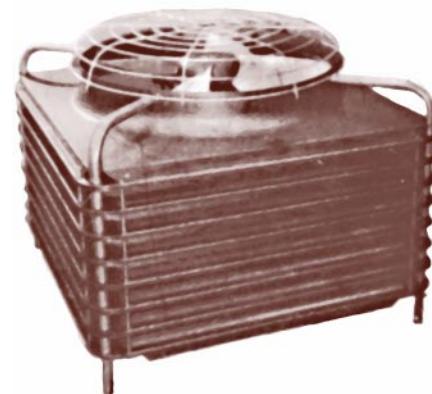
Air-cooled condensers for central systems were rare in the early 1950s. Most

manufacturers did not sell these kinds of split systems until 1955. An early example of a split system is shown in *Figure 7*.

Another option for cooling existing homes was the window or console cooler. The console cooler resembled a household refrigerator until the mid-1930s. Because many of these units were sold to wealthy customers, the console design began to appear as a fine piece of furniture like a radio to blend in with the usual living room decor (*Figure 5*). By the 1950s, the window units had grown in popularity, with sales approaching 300,000 units in 1952. The window units had air-cooled condensers, while many of the console units used water-cooled condensers. An advantage of water cooling was that the console could be placed into a closet and kept out of the way.

Although window units were functional, they were not considered upscale. Anyone hoping to reach middle class had to have central air conditioning. Sociologist William Whyte Jr. studied patterns of window-mounted air conditioner installations on blocks of town houses in Philadelphia to demonstrate how in 1954 neighbors influenced each other to purchase certain kinds of goods. What he found was “the more similar things are, the more important the minor differences.”

Of the nearly 5,000 houses surveyed, Whyte found that roughly 20% of them had at least one window air conditioner compared to an estimate of only 3% nationwide. Whyte found that houses with window air conditioners tended to be grouped into clusters. As air conditioner-equipped clusters emerged, Whyte said,



**Figure 7: Early split system featuring air-cooled condensers in 1956.**

# Some of the best results are the ones you don't hear.

## Application of Manufacturers' Sound Data

Edited by Charles Ebbing and Warren Blazier

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DECIBELS  
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“on a hot night, the whirl of the motors would become ‘psychologically deafening’ to those who still needed to open their windows.” A delicate balance existed between the unseemly ostentation of being the first on the block to buy an air conditioner and the unwillingness to buy one after everyone else had done so.<sup>15</sup>

Like any technology, air conditioning had its detractors. Some people considered the use of technology to satisfy private wants, while public needs were ignored, a deformation of American values. In 1958, John Kenneth Galbraith’s *The Affluent Society* argued that once wants had been created by producers and advertising, it was foolish to believe that the public would ever willingly “un-want” them again, even in times of national crisis. He was not the only moralist to antagonize the new “affluent” class. Vance Packard, a magazine journalist turned social critic, “spoke to a middle class ready to be horrified and titillated by its own indulgence.” Packard’s 1960 book, *The Wastemaker*, spent 31 weeks on the New York Times Bestseller list. America had become a nation of indulgence.

### The Energy Crisis (1973 to 1989)

The July 1973 issue of *Consumer Reports* magazine set a tone for resentment against air conditioning. In its annual survey of air conditioning, it stated: “the true price of comfort was energy waste and environmental degradation.” The article said that the multitude of appliances providing air-conditioned comfort for the home and office might make a significant contribution to overall discomfort by heating up the outdoors. Apparently, neither the author nor the editors figured out that the total amount of energy expended by air-conditioning condensers is minuscule compared to the total energy the earth receives from the sun.

By 1975, *Consumer Reports* recommended abstinence from air conditioning noting that, “electric rates are zooming, the nation’s energy resources continue to shrink and prices for air conditioners are up 20% to 30%. If you must buy an air conditioner, economy deserves extra emphasis.”<sup>16</sup>

Although air conditioning was not the predominant user of energy resources, it was one of many targets set for reducing energy consumption. President Richard Nixon urged Americans in 1974 to set their thermostats to 68°F (20°C) or lower in the winter. President Jimmy Carter asked Americans to turn their thermostats down to 65°F (18°C) two days after his inauguration in January 1977.

Then, in May 1979, Congress passed a law requiring thermostats to be set at no less than 80°F (27°C) during the summer. One month later, numerous complaints from museums, restaurants, department stores and other commercial establishments forced the government to concede to setting thermostats to 78°F (25°C). There was sporadic compliance with the new law. Federal judges in Texas and New Mexico set thermostats in their courtrooms at 74°F and 70°F (23°C and 21°C) respectively.

The adversities brought about by the so-called energy crisis produced numerous benefits. Manufacturers of air-conditioning equipment sought ways to improve energy consumption of their products in response to state and federal energy conservation statutes. In 1974, the Commerce Department’s National Bureau of Standards required air conditioners to be the first

appliances labeled with energy consumption information.

A significant focus of the residential air-conditioning industry in the 1970s was on the promotion of heat pumps. While heat pumps had been available since the early 1950s, they served only a very small segment of the air-conditioning and heating market. A massive marketing campaign was started to increase public awareness of the benefits of using a heat pump over separate heating and cooling systems.

### New Advances

Advances in manufacturing technology made it possible to produce the elegant scroll compressor. The continuous compression provided by the scroll compressor eliminated the need for valves, which were used in old reciprocating compressors. The result was a much quieter and more reliable compression system for air conditioning.

In the area of cooling fins, some manufacturers are developing smaller and thinner tubing, more fins per inch, different fin configurations and stronger and lighter materials.<sup>17</sup> In the past, fins were made from stock that was up to 0.010 in. (0.25 mm) thick. Now, material is 0.0045 in. (0.11 mm) thick. One future improvement will be coating the fins to increase heat transfer. This will allow even more downsizing of fins than at present, due to decreased pressure drop. Another benefit of the coatings is they can contain antifungal and antibacterial agents.

Another improvement in air conditioning is the use of heat pipes. The idea is to place two sets of pipe in an air-conditioning system before and after the cooling coils. The first set of pipes precool the incoming air, making the cooling coils work more efficiently. A second set of pipes downstream from the evaporator reheats the air to an acceptable level. This process reduces the relative humidity of the air. While the reheat process is not new, it replaces power-consuming devices such as electric heaters.

Recent developments in electronics have made significant improvements in the control of home appliances. A family can turn down their air conditioning or heating while they are on vacation and turn it on a few hours before they return. A small computer controls household functions using preprogrammed settings. An air conditioner may be set to regulate the bedroom temperatures at one setting and to regulate the remainder of the house at a different setting. Controls also may be accessed remotely via a phone line.

Air-conditioning control is not the only improvement in home systems. The National Association of Home Builders is developing a wiring system that would allow AC power, audio, video and high-speed data signals at every outlet in the house. An appliance could be plugged into the outlet, and the outlet would determine whether to deliver a dial tone or 120 volts.<sup>18</sup>

### Conclusion

Air conditioning has been a significant shaping influence in our homes and cities. Like most other modern technologies it has had its share of supporters and detractors. Nevertheless, air conditioning is taken for granted these days. Most people now can afford to sleep comfortably on the hottest summer nights and feel refreshed throughout the day thanks to the

efforts of countless people working in the air-conditioning and related industries.

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# Design Guide

## Combustion Turbine Inlet Air Cooling Systems

This design guide is intended to be an introduction to the design of combustion turbine inlet air cooling systems. Increasing the combustion turbine inlet airflow rate is a common modification to increase the power and net efficiency of power-generating equipment, with many design options available. This design guide is intended to provide some of the information that needs to be considered in applying technologies to CTIAC systems. This book provides the user with an understanding of the benefits and limitations and assists in the successful design and implementation of a combustion turbine inlet air cooling system. This book was developed with ASHRAE sponsorship under Project 902. Dual units of measurement. Author: William E. Stewart, Jr. 1998; 96 pp. Code: 90385 Price: \$39.00 (Member: \$26.00)

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