How HVAC&R Changed the World

BY BERNARD A. NAGENGAST, LIFE MEMBER ASHRAE

The HVAC&R industry has changed our lifestyles so thoroughly that we take many engineering innovations for granted. Although they have been continuous throughout our industry's history, some developments in the 20th century broadly and directly affect our lives today. This article explores how these innovations developed in relation to one another. Much of the information presented here was published previously in expanded form by the author, and readers who wish to explore the topics more deeply are encouraged to consult the references cited.

The 24-Hour Stationary Engineer—The Electric Motor

Much of what heats, cools and ventilates is operated by an electric motor. The motors used in HVAC&R equipment are reliable, and their energy efficiency is continually improved, but consider that, at the turn of the 20th century, electric motors were a relatively new phenomenon. Also consider that their development and application made HVAC&R technology available unlike it had been before.

Although electric motors had been invented in the 19th century, their use was limited by underdevelopment and limited availability of electric power. That began to change after the 1880s as power distribution systems using the Edison direct current and the Tesla/Westinghouse alternating current approaches began to spread throughout the world (*Figure 1*).

In 1900, it was common for heating-ventilating fans and refrigeration compressors to be driven by heat engines, principally steam-operated, but they were also powered using oil or gasoline. Heat engines had the disadvantages of complicated construction that frequently required skilled operation by an on-site "stationary engineer," and they were noisy, often dirty, and required a large amount of space. Also, they needed the additional boiler or fuel tank. And then there was the inability, or at least great difficulty, of operating them with automatic control.

1880–1910 saw much inventive activity in the electrical industry, with increasing emphasis on alternating current systems and components. It was becoming clear that direct current systems had disadvantages over alternating current systems, especially in the area of transmission over longer distances. Direct current motors with the high starting torque needed for fans and compressors were available, but they required hand-operated "starting boxes," which contained a variable resistance used to bring the motor up to speed.

Bernard A. Nagengast is an HVAC&R engineer and historian in Sidney, Ohio. He is a member of and past chair and consultant for the ASHRAE Historical Committee.

Development of the alternating current motor revolutionized the HVAC&R industry by providing a less complicated, less expensive way to operate equipment, and ac motors could be turned on and off using automatic controls. Also, these motors were developed in smaller sizes, opening the door to packaged equipment development for heating, refrigeration and later, air conditioning.

By 1920, most developed urban areas had ac power available for homes, businesses and factories. Polyphase ac induction motors, as well as synchronous motors, were available for factory and large commercial equipment. Homes and small businesses were served by single-phase electric service within a voltage range of 104 to 230 volts. For those customers, a number of small single-phase induction motors were soon available for appliances, including refrigerators, and for oil burners, ventilating fans, etc. At first the need was served using so-called "split-phase" induction motors; however, the need for higher starting torque for refrigeration compressors, etc. brought about invention of capacitor-start and repulsion-start motors. The repulsion-start induction motor proved to be a solution to a vexing problem when motor-powered HVAC&R equipment was introduced into household use. Well into the 1930s, most homes were wired with 30- or 60-ampere service. With such skimpy capacity, it was common for the locked-rotor (starting) current of a refrigerator to cause the line voltage to drop precipitously, dimming lights and often blowing a branch circuit fuse (which were usually 15-amp quick-blow fuses). The solution was to use the repulsion-start motor, which could develop very high starting torque at low line voltage using less current than other types of motors. Repulsion-start motors were available from 1/8 to 25 horsepower and were the preferred motor type used for HVAC&R in that power range until they began to be supplanted by capacitor-start motors beginning in 1930 (*Figure 2*).

Over time, electric motors were continually improved by reducing weight and relative cost while increasing efficiency, especially in the last 25 years. And now we have variable-frequency drive motors that allow a level of energy efficiency and control that would amaze the engineers of the early 20th century—we are well aware of that within our engineering profession. What about everyone else? Outside the community reading this essay, the "24-hour stationary engineer," i.e., "the electric motor," serves us silently, unobtrusively and with increasing efficiency as applied in heating, refrigeration and air conditioning. And that is quite an accomplishment!

FIGURE 1 125 years ago, electric power was being introduced in cities, replacing gas lighting. (From: author's personal collection, unattributed source).

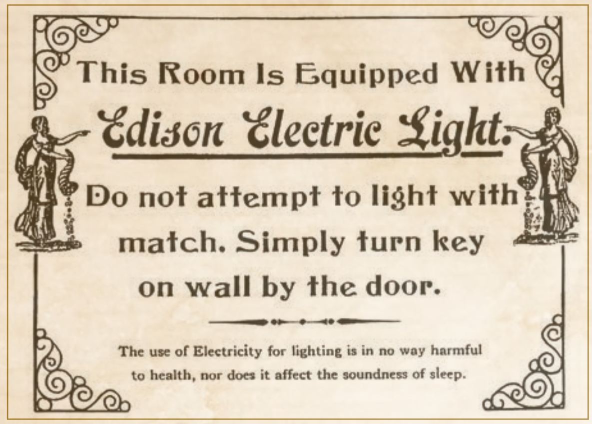
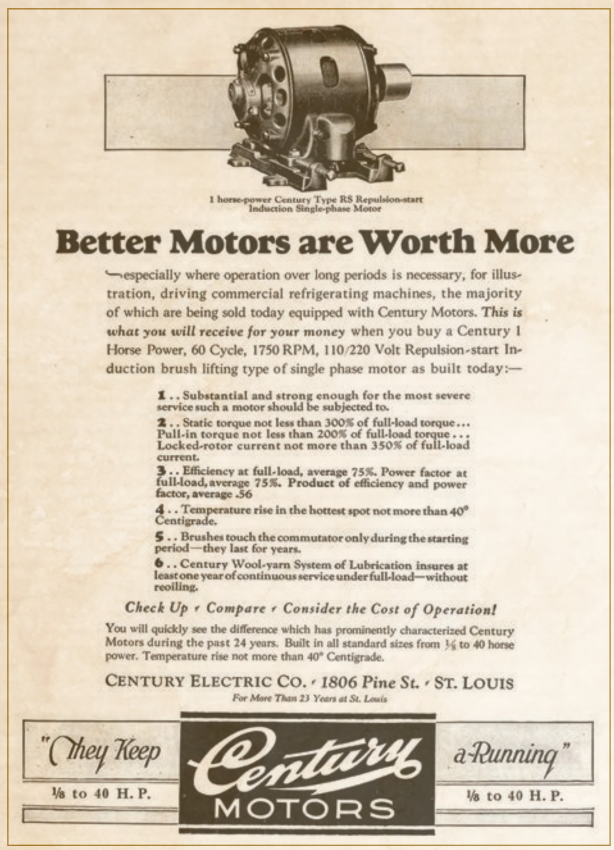


FIGURE 2 The repulsion-start induction motor was widely used until the 1930s for high-starting torque applications such as refrigerators in homes with skimpy electric service. (From: *The Heating and Ventilating Magazine,* July 1927, p. 189).



That progress in electrical development opened the door to more innovations we also can't live without.[1]

Cease Firing by Hand!—Automatic Heating

By 1900, many homes and buildings, particularly in cities, were equipped with central steam, hot water or hot air heating systems. Before the 1920s, most homeowners using central systems heated with hand-fired coal furnaces or boilers. They had to descend into a basement and contend with coal shoveling from a "coal bin," ash clearance and a method of temperature control requiring a judgment of how much coal to use and how much draft to allow for the firebox. Although thermostat-controlled draft regulators had been available since the 1880s, they were seldom used in homes or small businesses. Automatic firing of heating equipment was hampered at first by lack of widespread availability of electric power and reliable electric motors, as previously discussed. Once the motors were available, inventors had to figure out how to apply them to the firing of heating systems. They also had to develop controls that would permit direct control of the equipment. These efforts began before 1900 and accelerated through the next two decades. During WWI, a coal shortage and government initiatives to conserve energy gave a push to automatic system development in the United States.

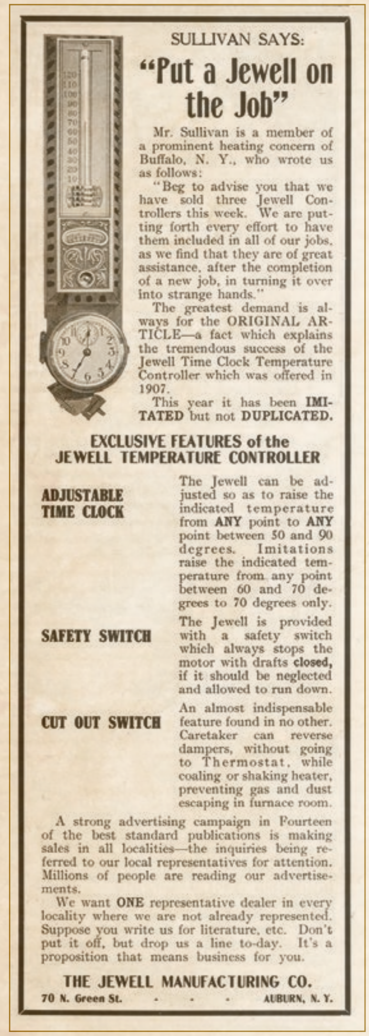
Homeowners and businesses were used to "banking" coal fires at night, waking up early to stoke the fire with fresh coal, opening and adjusting draft dampers, and then waiting for bulky heating systems to respond. Guesswork, weather conditions and experience dictated how much coal and draft to use, but this was inherently wasteful.

The first electric-motor-powered "coal stoker," which mechanically fed coal and removed ash from a boiler or furnace and could be controlled by thermostat, was placed on the market in 1912, and by the 1920s, automatic coal systems were available from many manufacturers. However, this improvement in coal-fired systems soon succumbed to what was seen as better fuels—oil and gas.

Wartime restrictions on and subsequent shortages of coal stimulated the use of oil and gas as substitute energy sources for heating. Certainly oil and gas had been investigated and even used in limited circumstances for heating prior. Before World War I, there were several manufacturers of domestic oil burners. Underwriters Laboratories certified an oil burner in 1912. The first oil burner with high-voltage electric ignition, tradenamed the "ELECTROL," was introduced in 1918. By the mid-1920s, the market for household and commercial oil burners skyrocketed.

Gas heating advanced too. By 1900, there was a well-developed infrastructure for gas distribution in many cities for gas lighting, but there was no real incentive to push the use of gas for heating until the gas utility companies saw their revenue decline as electric lighting advanced. Casting about for a way to increase gas use, they began to investigate its use for heating. For example, the Ohio Gas Light Company installed gas heating systems in 50 homes as an experiment in 1891. After 1900, some furnace and boiler manufacturers added gas-fired equipment to their lines, but gas equipment did not really take off until the World War I coal shortages. By that time, electrically operated gas valves had been developed, so the heating system could be readily controlled by thermostat.

FIGURE 3 The first night setback thermostat was introduced in 1907. (*Engineering Review*, December 1908, p. 104).



Although thermostatic control for heating had been invented in the 1830s in England, it was not until the 1880s that it was improved and extensively promoted by innovators such as Albert Butz, Warren Johnson, William Powers, William Sweatt and others. Various heating thermostat designs were available by 1900. The clock-operated night setback thermostat was first marketed by Jewell Manufacturing Company in 1907 (*Figure 3*). Such thermostats were widely promoted as fuel-saving devices during World War I and ultimately became popular enough that the largest manufacturer of wind up clocks in the world was said to be none other than the Minneapolis Honeywell Regulator Company!

Other appurtenant controls were developed, such as those designed and marketed by Honeywell Heating Specialties Company beginning in 1924 exclusively.

Frankly, many factors were in place for a technical development spurt. In the United States, progress was hampered by the post-war depression that persisted in the early 1920s. As the economy recovered, so did renewed enthusiasm for technological development in HVAC&R. A review of the trade publications of the period shows increases in "new products" announcements, accompanied by expanded advertising (*Figure 4*).

Packaged gas furnaces incorporating a burner, blower, humidifier and filter did not appear until the late 1920s. Probably the first was a gas-fired unit invented by Carlyle Ashley, which was marketed as the "Weathermaker" furnace by Carrier-Lyle Corporation beginning in 1928. Ashley's design was significant because it was the first high-efficiency (91%) gas furnace.

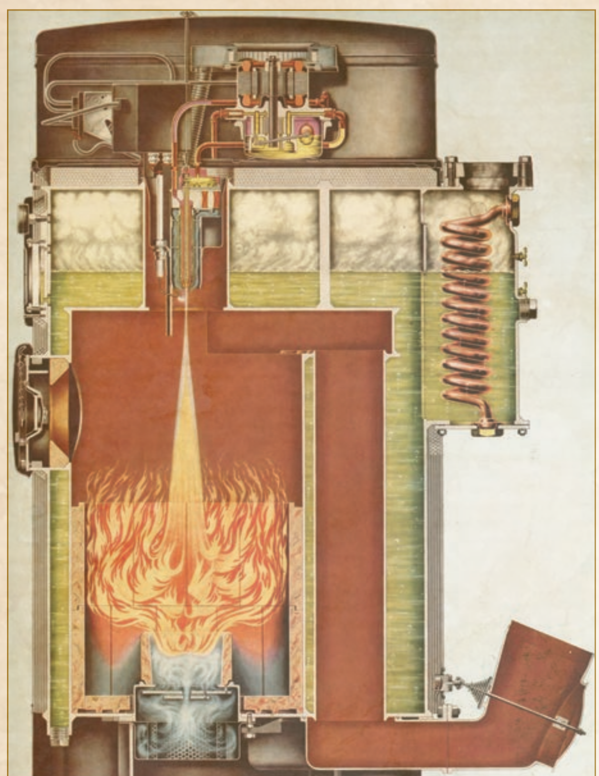
From the early 1930s on, advertisements and announcements for packaged heating units with steel cabinets began to appear in the trade press. Often these units were promoted as being so clean and quiet that they were suitable for placement in a home living area. Such was the case with General Electric's oil-fired boiler introduced in 1932.

GE's packaged boiler featured all the latest innovations for comfort, safety and style. The unit included a high temperature limit, pre- and post-purge of the combustion chamber, automatic control by a night setback thermostat and were suitable for steam or forced hot-water systems. And the unit included a built-in heat exchanger for domestic hot water with separate thermostatic control. The GE boiler could be combined with air-cooling using a heat exchanger for a forced-air residential air conditioning system. A similarly designed gas-fired boiler, as well as a hot-air furnace, was also available[2] (*Figure 5*).

The newest technology was a sensation. Complete home heating and cooling systems were prominently displayed at the World's Fairs of 1933 and 1939 by a

FIGURE 4 Successful development of automatic heating systems led to industry promotion, as exemplified by a mid-1930s campaign by an industry trade journal. (From: *Automatic Heat and Air Conditioning*, October 1936, p. 32).

FIGURE 5 The oil-fired boiler that was introduced by General Electric in the mid-1930s incorporated the latest heating technology. (From: *Automatic Heating With Oil*, General Electric Co., 1936, form FP-108, p. 12).



number of manufacturers, and it seemed that a new era of modern convenience was dawning—until it didn't.

The "Great Depression" and the World War that immediately followed stifled the surge in heating technology. The innovative systems of companies like Carrier and General Electric were discontinued from lack of sales. The period of the late 1930s through the 1960s saw slow change in packaged furnaces, boilers and systems. The limited progress included cabinet size reduction as blowers evolved from belt-driven to direct drive. During this period, the product mix steadily shifted from oil toward gas-firing and from steam and hot water to forced-air systems that could easily incorporate central air conditioning. A renewed focus on energy efficiency revived after the "oil shocks" of the 1970s. Then the heating industry responded with "reinventing the wheel" of high-efficiency furnaces and boilers using modern technology that was unavailable 50 years earlier. This new burst of innovation has continued to this day. Today, few can remember a central heating system that did not work automatically. Does anybody in a modern, economically well-developed city or country worry about waking up to a cold house? Firing a heating system by hand has indeed ceased.

Freedom from the Shackles of Ice–The Mechanical Refrigerator

A survey in 1999 asked more than 1,000 people which appliance would be hardest to live without—the answer: their refrigerator. The household mechanical refrigerator was one of the 20th century's greatest inventions, allowing housewives to "strike off the shackles of ice" (*Figure 6*). Previously, refrigerators were cooled with block ice, delivered directly to homes or businesses by local merchants. The "ice man" roved city streets just like the "milk man," calling on one place after another. But unlike the milk man, the ice man delivered the product right to where it was used—in the kitchen—to the so-called "icebox," where he placed a block of ice in the top of the refrigerator. The invasion was at least a necessary nuisance. More problematic, iceboxes could not maintain a constant storage temperature, which was frequently too high for proper food storage. With a mechanical refrigerator, consumers didn't buy ice—they could even make it. With better temperature control, they had new freedom in their kitchens to store a wider variety of foods for a longer time. And frozen foods? Forget it—how could you keep

FIGURE 6 Servel Corporation was one of the early entrants in the mechanical refrigerator industry. (Note: SERVEL was an acronym for "Serve Electrically.") (From: *Good Housekeeping*, November 1925).

frozen foods in an icebox? But that became a possibility with mechanical refrigeration. And no more waiting for the ice man to come. The mechanical refrigerator has made our lives safer and richer—can anyone now imagine life without it?

The mechanical refrigeration industry before the 20th century had shown remarkable progress in perfecting the technology of ice manufacture and cold storage. This technology worked well in those high-capacity applications, but it was a challenge to transfer it to the small-capacity requirement for homes. This turned into a quest—one that John Starr, the first president of the American Society of Refrigerating Engineers, likened to the pursuit of the dream of the old practitioners of alchemy—discovering the "Philosopher's Stone" that would turn base metal into gold.

By 1930, the household refrigerator was a reality, and no stone was required. The solutions were found in electric motors, sealed systems, automatic control and non-toxic, non-flammable refrigerants. But these solutions required a slow and expensive evolution. Before WWI, there were scattered attempts to introduce household mechanical refrigerators—and there were a lot of good ideas, even some breakthroughs—but these were disjointed, undercapitalized efforts. Mass production of a low-cost, low-maintenance refrigerator was needed.

That challenge was soon met. Refrigeration engineers introduced eccentric shaft, closed-crankcase reciprocating compressors, replacing open-frame crosshead or crank types and allowing higher operating speeds and smaller size. Leaky stuffing boxes were replaced with rotary mechanical shaft seals that minimized leaks. By the late 1920s, using improved electric motors, externally driven systems began to be replaced with hermetically sealed motor-compressors that reduced size, weight and cost further, all but eliminating refrigerant leaks. Effective methods of refrigerant control, such as the constant superheat (thermostatic) expansion valve and the capillary tube, were developed. Temperature and pressure controls were applied to refrigerating systems, making them responsive to the vagaries of system load that varied with room temperature, product load, frequency of door opening and so on.

Until 1930, engineers had only toxic or flammable refrigerants to choose from for their systems. Sulfur dioxide, methyl chloride, ethyl chloride or isobutane were used in virtually all household systems until chlorofluorocarbon refrigerants (discussed next in this article) were developed in 1928. The new refrigerant family's use for household systems began in the 1930s and accelerated the acceptance of the new technology.

But this new technology for the home required a considerable engineering effort and a great deal of money to make it a reality. The advances previously mentioned saw practical reality only after two industrial sectors committed engineering talent and a great deal of capital. The two sectors were the automotive and electrical industries in the United States.

As World War I was ending, two corporations, General Motors and General Electric, began pursuing introduction of refrigeration into the home. GM was worried that a post-war depression would cause auto sales to plunge and sought to find something else that dealers could sell. GE had already begun expansion beyond electric lighting—into electrical items such as electric irons, toasters and so on—and saw an electric refrigerator as a logical addition to its "string of appliances."

Both corporations had large, diversified engineering staffs as well as considerable financial capital. Both were willing to endure the unavoidable development failures and the associated costs to ensure a successful product that they assumed would later lead to a substantial market for their products as well as a decent profit.[3]

The application of engineering and capital from these two industrial giants, as well as others that joined them, spawned a surge of technical development. And the competition between many manufacturers resulted in leap-frog technology, where one company's advance was soon topped by another, better innovation. The result: the increasingly reliable, energy-efficient and affordable mechanical refrigerator (*Figure 7*). The ice man is gone—no longer needed—replaced by the "can't live without" refrigerator, that, like the benefits of automatic heating, we just take for granted.

FIGURE 7 By the 1930s, household mechanical refrigerators were becoming an important part of homes. (From: *Good Housekeeping*, May 1931).

It All Depended on a Guinea Pig—The Chlorofluorocarbon Refrigerants

At the dawn of the 20th century, the dominant refrigerant was ammonia. Why? Because for almost 40 years, it had proven to be the best refrigerant to use—its attributes included a high refrigerating effect and low cost. But it had some notable disadvantages too, such as toxicity. Since most refrigeration applications were industrial, any disadvantages were mitigated, or even tolerated, using technology that was well-developed by 1900. After 1900, refrigeration took some new courses into specialized applications like households (as discussed above), retail groceries or butcher shops, and air conditioning. Ammonia proved unsuitable for household or merchant uses, and although some existing refrigerating machinery manufacturers did try to enter that field, downsizing their industrial equipment proved difficult. Besides, they were satisfied providing for the expanding demand for cold storage and ice making. And there was the new technology of air conditioning for industrial processes, as well as for personal comfort. These applications potentially exposed building occupants to a toxic refrigerant leak. For air conditioning, ammonia, as well as the other toxic or flammable refrigerants mentioned previously, would not be acceptable. What to do?

Obviously the solution was to use a different refrigerant. Previously used alternatives to ammonia, such as methyl chloride and sulfur dioxide, had been used in Europe and proved technically suitable for low-capacity systems. Some others, such as ethyl chloride and isobutane were also used. For air-conditioning applications, carbon dioxide, dichloroethylene and methylene chloride were used. All these refrigerants, except CO_2, were problematic—toxic and/or flammable.

By the late 1920s, household refrigerators were reliable but still costly. Apartment houses, with a concentration of tenants, proved to be a potentially lucrative market for refrigerator manufacturers. Apartment dwellers balked at purchasing a high-priced refrigerator, but apartment owners, when constructing new buildings and competing for tenants, often opted for a new idea—VRF! Yes, VRF, Variable Refrigerant Flow systems, the concept recently popular in the air-conditioning industry. At that time, the concept was used by placing a central refrigeration condensing unit in the apartment house basement, directly connected with multiple liquid and suction lines to small refrigerators in each apartment. The VRF aspect was accomplished by using "low-side float" refrigerant controls in each apartment, with the central system maintaining constant evaporator pressure (and therefore temperature) with a preset pressure controller, connected to the system low side, which would cycle the condensing unit. A float metered refrigerant into a flooded-type evaporator that responded to the changing load. These VRF systems had become fairly widespread by the late 1920s, particularly in larger cities. Most used sulfur dioxide or methyl chloride refrigerant and contained a large refrigerant charge that sometimes let loose into the building if a line ruptured—with spectacular result if sulfur dioxide was involved. With searing lungs and stinging eyes, occupants would flee to the streets, even in the middle of the night. However, a methyl chloride leak produced a more subdued—but deadly—situation. Methyl chloride has a sweet, ethereal odor, not irritating like sulfur dioxide. In sufficient concentration, it has both an anesthetic and toxic effect. There were a number of instances where a methyl chloride system leaked enough refrigerant at night to kill entire families. These tragedies were sensationalized in newspapers, and the public, with the battlefield deaths from poison gas used in WWI still fresh in their minds, demanded action to prohibit "death gases" from being used in refrigeration systems. City health departments responded with restrictions on use of large refrigeration systems as well as refrigerants[4] (*Figure 8*).

FIGURE 8 Before the chlorofluorocarbon refrigerants, service on many household refrigerators required a gas mask! (From: *Frigidaire Installation and Service Manual*, April 1927, p. 4).

Improved reliability and lower cost had propelled household refrigerator sales into the millions by 1928, and refrigerator manufacturers became alarmed that private and public concern and restrictions would affect their burgeoning market. The Frigidaire Corporation division of General Motors had been using sulfur dioxide refrigerant since 1918, even touting the refrigerant's advantage as being non-toxic because it was "self-alarming" and a leak would compel a user to get out before any serious health effects occurred. Frigidaire management was concerned enough about their business that they asked the newly formed General Motors Research Laboratory to develop a completely new refrigerant that would be non-toxic, non-flammable and chemically stable. Thomas Midgley, a research engineer, was assigned to that task. With his

FIGURE 9 The chlorofluorocarbon FREON could be safely used in packaged air-conditioning equipment located in private or public places. (From: Kinetic Chemicals ad, *Heating Piping and Air Conditioning*, July 1934, p. 67).

FIGURE 10 Before comfort air conditioning, one had to resort to using an electric fan. (From: Bulletin of the Philadelphia Electric Company, June 1914, pp. 12-13).

assistants, chemist Albert Henne and chemical engineer Robert McNary, a new refrigerant was proposed after a remarkable Saturday afternoon brainstorming marathon. Midgley had thought that it was unlikely that one compound could fulfill the specified requirements and that some type of blend would be needed. However, the team decided to try for a single compound using an unusual approach. The Periodic Table of the Elements was consulted to explore relationships between elements that might yield something useful. The thought processes resulted in one compound, dichlorodifluoromethane, which seemed to be an ideal refrigerant.

One of the most important requirements was that any new refrigerant be non-toxic. Prevailing thought was that any compound containing fluorine would likely be toxic. A small batch of the new refrigerant was prepared and tested on a guinea pig, with no ill effects. Another batch was prepared, but this time the guinea pig died. Investigation showed that the catalyst used to prepare the new sample was contaminated, resulting in deadly phosgene gas being mixed with the refrigerant. In fact, another four vials of the catalyst, antimony trifluoride, were found to be contaminated. The fact that only five vials of catalyst had been available to the researchers—four of them contaminated with a phosgene-producing agent—meant that the odds were greatly against a successful toxicity test.[5] Would testing of dichlorodifluoromethane proceed if the first guinea pig had died? Thomas Midgley later commented, "… I often wonder if the sudden death of our first guinea pig would not have so completely shaken our confident expectation that our new compound could not possibly be toxic, that—well, I still wonder if we would have been smart enough to have continued the investigation."[6]

In fact, experimentation with the new refrigerant did continue, and it was publicly announced in 1930. The new refrigerant, Freon, was manufactured by Kinetic Chemicals Inc., a stock company owned jointly by General Motors and DuPont. Freon was considered

FIGURE 11 The first successful window air conditioners were marketed in the late 1930s. (From: *Collier's*, July 1, 1939, p. 52).

such an important discovery that the new refrigerant was sold not just to Frigidaire, but to any manufacturer who wanted to use it. Freon 12, the first CFC sold, was shortly followed by other chlorofluorocarbons for various refrigeration applications, and before long, the other toxic and flammable refrigerants disappeared from use. One significant advantage of the chlorofluorocarbons was that they could be used in direct expansion systems for air conditioning (*Figure 9*). The new availability of a safe refrigerant did spur development of central and packaged air conditioners beginning in the 1930s, which accelerated after World War II ended. The chlorofluorocarbons came to dominate non-industrial refrigeration until scientists discovered that chlorofluorocarbons damage stratospheric ozone. This environmental hazard was not foreseen in 1928 when the concern for safety was close at hand. No doubt the rapid expansion of refrigeration and air conditioning in homes and public buildings was surely in large part due to this new, safe refrigerant. You could say it happened because a guinea pig didn't die!

The Model T in the Window–The Window Air Conditioner

"Cooling of rooms … bids fair to be at some time an industry of considerable importance," wrote Rolla Carpenter, Cornell University professor of experimental engineering in 1896 in his book, *Heating and Ventilating Buildings*. The idea that room air should be "refrigerated" for comfort (the term "air conditioning" did not exist before 1906) seemed farfetched to all but a small number of undaunted engineers. The best folks could do then was use an electric fan! (*Figure 10*)

In the 20th century, comfort air conditioning would become of such considerable importance that daily life, and even population trends, would be affected. At first, the technology was used in commercial situations where the cost and complexity could be justified. But, just like with refrigerators, an interest developed for application of refrigeration to comfort cooling in residences.

Frigidaire introduced the first successful "room cooler" in 1929, a bulky split-system that used sulfur dioxide refrigerant. By the 1930s, such companies were beginning to combine cooling and heating technology for central home air-conditioning systems that were automatic, circulating filtered, tempered air to all of the rooms in a house, office or business. But these central systems were still too expensive for most folks. Then there was a solution. The window air conditioner was introduced in the late 1930s, a relatively low-cost way to spot-cool rooms in a home.

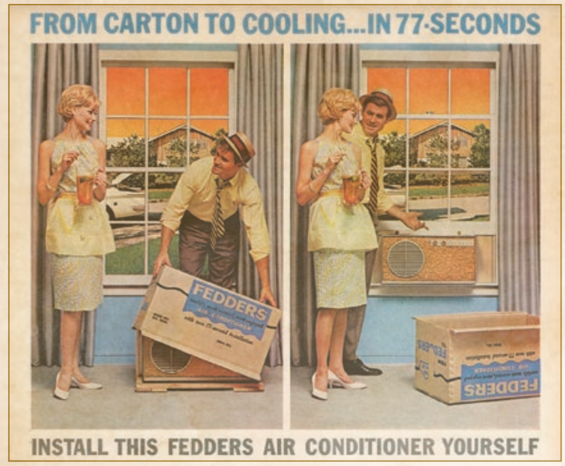
How did that happen? This article has discussed electric motors, automatic systems, household refrigerators and chlorofluorocarbon refrigerants. In fact, all those innovations played a part in the story of the window air conditioner. Automatic control by thermostat could and was applied to central AC systems, providing comfort cooling, and that technology was downsized and simplified for packaged equipment. The previously mentioned sealed motor-compressors, initially developed by the household refrigeration industry after 1918 or so, were adapted for packaged air conditioning. The development of the safe chlorofluorocarbon refrigerants opened the possibility of placing air-conditioning equipment directly into a living space. Industry was enthusiastic over the prospects, having noted the success of the household refrigerator.

The economic depression of the 1930s stymied the nascent packaged air-conditioning industry, but the depression's end saw renewed interest. Although the first successful window air conditioners were being sold by the late 1930s (*Figure 11*), again industry development was halted, this time by World War II. When wartime restrictions ended in 1946, the idea of a window air conditioner was pursued with a new vigor. Designs for packaged air conditioners that could be placed in a window proliferated. Competition and mass production steadily brought the cost down such that comfort air conditioning was affordable for more folks—you could call it the democratizing of air conditioning, as the Model T Ford did for automobiles.[7] Forty-eight thousand units were sold in 1946, as pent-up consumer demand began to be satisfied by industry rapidly converting back to peacetime production. Annual sales have increased steadily since then, and today, in aggregate, more than 100 million units have been produced in the United States. And worldwide, almost that many room air conditioners are now sold each year.[8] Window air conditioners in our age are inexpensive, reliable, increasingly efficient and portable (*Figure 12*)—another engineering triumph most folks don't consider at all as they flip the switch to get cool!

Summary

As ASHRAE celebrates its 125th anniversary, we are looking back at what we have accomplished in our profession. This article explored some technology we invented, used or improved so well that, outside our technical community, pretty much no one appreciates how good that technology works to keep us warm or cool or provide a vast variety of safe food at our fingertips, efficiently and affordable. Everyone takes it all for granted. Insulted? Don't be—it means we HVAC&R engineers have done our job very well!

FIGURE 12 By the 1960s, window air conditioners were easy to purchase and install. (From: *Life*, June 2, 1961, p. 114).



References

1. Donaldson, B. and B. Nagengast. 1994. *Heat & Cold: Mastering the Great Indoors*, pp. 189-193. Atlanta:ASHRAE.

2. Nagengast, B. 2001. "An early history of comfort heating." *Air Conditioning, Heating and Refrigeration News* (November 12):10-26. Note: This issue of *ACHR News* was titled "Celebrating 75 years of heating" and has much historical information on heating industry development. See also: Donaldson, Nagengast 1994, pp. 193-199, 245-261.

3. Donaldson, B. and B. Nagengast. 1994. *Heat & Cold: Mastering the Great Indoors*, pp. 204-243. Atlanta: ASHRAE.

4. Donaldson, B. and B. Nagengast. 1994. *Heat & Cold: Mastering the Great Indoors*, pp. 137-147. Atlanta: ASHRAE.

5. Bhatti, M.S. 1999. "A historical look at chlorofluorocarbon refrigerants." *ASHRAE Transactions* 105 (Pt.1): 1186-1206.

6. Haynes, W. 1961. "Thomas Midgley, Jr." *Great Chemists*, Edited by E. Farber, pp. 1587-1597. New York: Interscience Publishers.

7. Early room and window air conditioning history is covered in: Morgan, R.W. 1950. "Room air conditioners—Past and present." *Refrigerating Engineering*, 58(1):34-41. And also: Galson, Edgar and Allen. 1995. "Henry L. Galson – pioneer designer of self contained air conditioning equipment." *ASHRAE Transactions* 101:758-767.

8. 1994. "World air conditioner demand by region." *Japan Air Conditioning, Heating, and Refrigeration News, p.5*. As quoted in Galson, Edgar and Allen. 1995. "Henry L. Galson – pioneer designer of self contained air conditioning equipment." *ASHRAE Transactions* 101:765. ■

Advertisement formerly in this space.