[Bonus] AFD Ep 357 Links and Notes - Early Air Conditioning [Bill/Rachel] - Record Mar 9

- Intro: This week on the bonus episode we're talking about another industrial monopoly from the later part of the second industrial revolution: Carrier. Last week on the bonus episode we talked about dropped ceilings in offices and we promised to talk about central air conditioning on a future episode, which brought me and Rachel here today. On a recent bonus episode, Nate and I discussed the history of the natural ice trade, which was eventually replaced by a combination of artificial ice and artificial refrigeration. What we didn't discuss was the other offshoot of artificial cooling processes, which was early air conditioning. That's the subject of this week's bonus episode. We alluded in passing to chemical refrigeration originating in Australia as part of an effort to break the American economic dominance of the ice trade, but I didn't talk about how the inventor James Harrison arrived at the idea, which involves chemistry in the printing industry and the basic principles of evaporative cooling that we naturally experience ourselves when we sweat and the evaporating moisture takes the heat away with it. The principle had been demonstrated since the mid-1700s, a century earlier, but not much practical had been attempted with it. Harrison was a newspaper publisher and – at least according to his mythology – his cleaning solution for the type left it cold to the touch after it evaporated, which gave him the idea for using chemical vapor for artificial cooling in the 1850s. Some sources argue he merely studied undeveloped American designs. He developed this (along with other innovators) into the technology for refrigerators that didn't require ice. (That's basically still the premise of refrigeration today: https://en.wikipedia.org/wiki/Vapor-compression_refrigeration) Half a century later, the printing industry would once again be the source of a major leap forward in artificial cooling technology, this time for conditioning the air of entire rooms by means of controlling the humidity level.
- Whereas Harrison in the mid-19th century was accidentally cooling his printing equipment and developed the refrigeration industry, air conditioning as an industry arose in July 1902 as an accidental side effect of trying deliberately to cool down – and more importantly dehumidify – printing equipment. To quote from a June 2019 article on The Smithsonian magazine website: *At the turn of the 20th century, humidity threatened the reputation of Brooklyn's Sackett-Wilhelms Lithographic and Publishing Company's high-quality color printing. After two summers of extreme heat disrupted business and caused swelling pages and blurry prints, the printing company found that a nascent cooling industry could offer help. Willis Carrier, a 25-year-old experimental engineer* [who at the time was working at Buffalo Forge Company which was hired to solve the publishing company's problem]*, created a primitive cooling system to reduce humidity around the printer. He used an industrial fan to blow air over steam coils filled with cold water; the excess humidity would then condense on the coils and produce cooled air.* https://www.smithsonianmag.com/smithsonian-institution/unexpected-history-air-conditioner-180972108/
    - The Smithsonian article and a source it linked to also note that Florida doctor John Gorrie had also attempted to develop vapor compression air conditioning technology in the mid-19th century to benefit his convalescing yellow fever patients but was blocked in this effort by the New England and New York natural ice trade industry that we discussed in depth in our previous episode. They are suspected of having pressured potential investors on the Gulf Coast not to capitalize his project after he patented it, published it, and built a prototype in Ohio. Gorrie's defenders believe James Harrison took the design to develop his Australian artificial cooling machines in a country with a vested trade incentive in destroying the American ice exporters' stranglehold. It's noteworthy to me that Willis Carrier's 1902 air conditioning technology was allowed to emerge because

artificial ice and chemical refrigerants had already broken the total control of the natural ice industry.
    - Carrier kept working on improving his designs and built a base of support with industrial enterprise customers who needed to control the temperature and humidity to keep their machinery working properly. Workers and employees might have enjoyed the more comfortable working environments of these air-conditioned spaces, but their comfort was still not the primary focus. People-oriented air conditioning (known as “comfort air conditioning” as opposed to “process air conditioning”) did not become a thing until movie theaters started opening in the 1920s with air conditioning as a special draw.
    - *In 1945, Life magazine published a four-page spread about air conditioning, entitled “Air Conditioning/ After the War it Will be Cheap Enough to Put in Private Homes.” The technology was described as a prewar luxury that was being manufactured in large quantities and sold at a moderate cost in the postwar mass market.* [Did the sunbelt migration become possible due to postwar AC? Some say yes, see below, but the Smithsonian piece doesn’t even mention it.]
    - *The technology that was initially envisioned as a tool to enhance industrial productivity is now a near necessity for American homes and transportation. Though humans in hot climates around the world have cooled themselves with fans, fountains and natural ventilation systems for centuries, only the U.S. consumes energy for air conditioning to the extent it does—more than the rest of the nations in the world combined. In 2016, the United States used about 616 terawatt hours (TWh) of electricity for air conditioning, while the European Union with a population one and a half times larger, used just 152 TWh for the same purpose.*
    - This level of energy usage, even after we at least got less ozone-damaging chemicals for air conditioners, is obviously bad for climate change but probably not going anywhere. (But our focus for today is on the early air conditioning.)
- Here’s some more details on specifically the science:
    - A liquid refrigerant is used to absorb heat and then eject the heat to air or water outside of the cooled area. The refrigerant enters a compressor, where it is pressurized (vaporized) and absorbs heat. It is then sent to a condenser where cooled air or water is sent over the coil or tubes, returning it to a liquid state. The refrigerant ejects the heat and it is sent away by the air or water. The condensed liquid then enters an expansion valve, where it quickly drops in pressure (vapor/liquid mix). This drop in pressure also cools it to sub-ambient temperatures. It is then sent to an evaporator, where a fan circulates air over the vapor/liquid mix. The warmer air of the fan evaporates the liquid part of the refrigerant, and cool air is circulated to the room. The vapor part of the refrigerant is then sent back to the compressor, starting the cycle over.
- http://www.williscarrier.com/m/1903-1914.php centrifugal chiller: http://www.williscarrier.com/m/1923-1929.php
- Willis Carrier (https://en.wikipedia.org/wiki/Willis_Carrier) spent the first decade of the 1900s researching, experimenting, and theorizing on the physics and mechanics of air conditioning. (He also emphasized air filtration, not just cooling.)
    - *In 1911, Carrier's research and development efforts came together in the single most famous and enduring document ever prepared on air conditioning. His "Rational Psychrometric Formulae," called the "Magna Carta of Psychrometrics," was presented on December 8, 1911, at the annual meeting of the American Society of Mechanical Engineers (ASME). The Chief's invitation to this meeting recognized air conditioning as a legitimate branch of engineering and Willis*

Carrier as its leader. His psychrometric chart, used to correlate temperature and humidity in the design of air-conditioning systems, would be reproduced in college textbooks and translated into many languages. It is the predecessor of the charts used today. At the age of 35, Willis Carrier had become internationally recognized. http://www.williscarrier.com/m/1903-1914.php

- http://www.williscarrier.com/m/1903-1914.php As early as 1906, he was promoting a dizzying array of potential uses for air conditioning, most of which came to pass within a few decades. By 1907, his designs were already popular enough in the silk industry in the US to enter the Japanese market, which would remain a longstanding connection for Carrier. By 1909, Buffalo Forge Company had separated out a Carrier subsidiary.
    - More examples: *Carrier immediately landed an important contract with the Celluloid Company, a firm making film for the new motion picture industry. As business in the textile industry expanded, the company also won contracts to install air conditioning to reduce rust on razor blades at the Gillette Safety Razor Company, in factories producing rubber, rayon, flour and baked goods, and in a Pittsburgh hospital ward for premature babies. In 1913 a system was sold to an American Tobacco Company facility in Richmond, Virginia. "I never saw such a dusty atmosphere," the Chief recalled. Going to work on the problem, he devised the first "pan outlet" to distribute air gently from the ceiling. "The results were wonderful," Carrier reported, and employees from other parts of the plant began eating lunch in the cool, clean air.*
- In 1915, he and a handful of engineers from Buffalo Forge Company left to launch an air conditioning-focused company after the parent company decided to shut down the subsidiary and narrow its own operations. **World War I provided new opportunities to air condition defense industry production. (And in the interwar years the Navy solicited on-board air conditioning for its ships. The Pentagon would be built with Carrier AC in the early 1940s.)** (http://www.williscarrier.com/m/1915-1922.php) We discussed earlier Carrier's focus on first industrial air conditioning and then commercial consumer-facing air conditioning in the 1920s, which was a goal from the beginning. In addition to movie theaters, Carrier began air conditioning department stores to keep crowded shoppers from fainting. Later they would do the same for convention center crowds (http://www.williscarrier.com/m/1923-1929.php). The mid-1920s also saw Carrier begin air conditioning office buildings in sunbelt cities in California and Texas. But in 1930, under pressure from the Great Depression, Carrier Engineering Corporation merged with two other companies in the heating, ventilation, and cooling industry to form Carrier Corporation, which Willis Carrier was still the head of. The merger also helped the company provide year-round air services to customers, particularly winter heating, rather than just cooling. And the new company adopted a dealership model for some of its sales. http://www.williscarrier.com/m/1930-1940.php Hospitals and hotels also became a major customer for air conditioning and especially air filtration. Carrier became a major force in upstate New York, especially around Syracuse, after 1937.
- Carrier would end up largely monopolizing the air conditioning market with only a couple minor early competitors, but surprisingly this was achieved more through tight control of technical knowledge and custom production of tailored air conditioning in the first half of the 20th century, rather than emphasizing mass production manufacturing, although obviously that would change when mass-market home air conditioning became a bigger thing. (At that point, competitor appliance-manufacturers like General Electric and Frigidaire under General Motors entered the AC market.) The constituent parts of an industrial air conditioning system were often still manufactured in mass production, but how they were assembled was customized to the client, and the sales team could basically pitch a concept to a client and then the engineers would work backward to

figure out how to make that feasible. This custom design approach was often necessary not just to fit in with existing architecture of a building but because the processes happening within a building and the number of people within a space generated unique heat and humidity signatures that needed to be reviewed on site in order to build a viable system. This was more expensive for clients but Carrier's engineers in the early years could always provide vastly more reliable systems through customization than competitors, which could end up saving enormous sums for factory owners by protecting their machinery and their goods from unstable humidity levels. The knowledge-driven approach of Carrier ended up being as valuable as the actual patents. https://www.jstor.org/stable/3106257?seq=1 ("Custom Design, Engineering Guarantees, and Unpatentable Data: The Air Conditioning Industry, 1902-1935" by Gail Cooper - Technology and Culture Vol. 35, No. 3 (Jul., 1994), pp. 506-536)

- As noted before, air conditioning's true rise to dominance in the US was in the postwar boom after the hardships of the Great Depression and World War II, although the company had been expanding internationally during that time too. By 1940, Willis Carrier was speculating that air conditioning was likely to become a public utility, rather than a privately provided service, but this rarely happened. http://www.williscarrier.com/m/1951-1978.php
- Willis Carrier himself passed away in 1950 but the company he founded in 1915 endures today as Carrier Global Corporation, although it has recently shifted from being based out of upstate New York to being based out of Florida. (Side note: For several decades until last year, 2020, it was a subsidiary of defense contractor United Technologies but it was spun off as its own company. You might also remember the early Trump Administration brouhaha about whether or not Carrier would agree to keep jobs in Indiana or move them to Mexico.) https://en.wikipedia.org/wiki/Carrier_Global
    - A further note (besides the WW1/interwar notes mentioned earlier) on the defense industry role of Carrier before it joined United Technologies: *While conversion to* [World War 2] *war production meant radical changes for many manufacturers, Carrier's standard equipment, including central air conditioning for productivity and refrigeration for food preservation, required little modification. The military also took advantage of the company's exceptional engineering talent, which set about producing classified equipment like airplane engine mounts, sight hoods for guns, tank adapters and the "hedgehog," a highly successful anti-submarine bomb discharger. Ironically, war production also benefited from the work Carrier engineers had done in the 1920s and '30s to bring comfort air to department stores. Tiffany & Co., Macy's, Lord & Taylor and Gimbels in New York all sacrificed their air-conditioning installations to the war, as did Sears, Roebuck & Co. in Washington, D.C., Marshall Field's in Chicago and J.L. Hudson in Detroit. Nearly 7,000 tons of air conditioning was removed from comfort air installations and reinstalled to support production by companies like B.F. Goodrich in Texas and Pratt & Whitney in Kansas City, which would become sister companies to Carrier decades later under United Technologies.* http://www.williscarrier.com/m/1941-1950.php
- Why wasn't Carrier subject to the same kind of early antitrust action as the other industrial monopolies? I'm not sure but I have some guesses that seem reasonable. Timing seems to be a factor since it did not form until near the end of the Taft trust-busting years and it was then closely tied into the defense sector almost immediately due to world war 1. After ww2, it was in a more competitive market. There were apparently some trust concerns in the later era of trust-busting i.e. the same time period as the Ma Bell breakup and others, but that was related to the United Technologies acquisition:

https://www.washingtonpost.com/archive/business/1978/11/14/us-files-antitrust-suit-to-halt-takeover-of-carrier/bafba904-edce-4d6a-a275-41f5579cc613/

- Miscellaneous historical points not related to Carrier: https://en.wikipedia.org/wiki/Air_conditioning
    - *In 1906, Stuart W. Cramer of Charlotte was exploring ways to add moisture to the air in his textile mill.* ***Cramer coined the term "air conditioning"****, using it in a patent claim he filed that year as analogous to "water conditioning", then a well-known process for making textiles easier to process. He combined moisture with ventilation to "condition" and change the air in the factories, controlling the humidity so necessary in textile plants.* ***Willis Carrier adopted the term and incorporated it into the name of his company****.*[28] (This is backed up in the 1994 paper referenced earlier that I pulled from JSTOR.)
    - *Shortly thereafter, the first private home to have air conditioning was built in Minneapolis in 1914, owned by Charles Gates.*[29] *Realizing that air conditioning would one day be a standard feature of private homes, particularly in regions with warmer climate,* ***David St. Pierre DuBose (1898-1994) designed a network of ductwork and vents for his home Meadowmont, all disguised behind intricate and attractive Georgian-style open moldings.***[when?] *This building is believed to be one of the first private homes in the United States equipped for central air conditioning.*[30]
    - *In 1945, Robert Sherman of Lynn, Massachusetts invented a portable, in-window air conditioner that cooled, heated, humidified, dehumidified, and filtered the air.*[31]