

## AFD Ep 451 Links and Notes - Microwave Oven [Bill/Rachel] - Recording Dec 3, 2022

- [Intro] This week on the show we're discussing that kitchen appliance many of us know and love and some among us still haven't adopted even now: the microwave oven. It is another in a long line of consumer technologies we have covered that emerged in the United States out of military and defense research.
- [Bill] Some sources used throughout this episode
  - *The Invention That Changed the World: How a Small Group of Radar Pioneers Won the Second World War and Launched a Technological Revolution* by Robert Buder
  - *The Way Kitchens Work: The Science Behind the Microwave, Teflon Pan, Garbage Disposal, and More* by Ed Sobey
  - *Scientific American Inventions and Discoveries: All the Milestones in Ingenuity - From the Discovery of Fire to the Invention of the Microwave Oven* by Rodney Carlisle
  - [https://en.wikipedia.org/wiki/Microwave\\_oven](https://en.wikipedia.org/wiki/Microwave_oven)
  - And we also mention in the notes at various points a few other sources used more narrowly.
- [Rachel] What began as post-WWII research into particle acceleration and electromagnetic wave generation became a convenient way to heat and reheat food in the home.
- [Rachel] After World War II, equipment used for radar systems was used for research purposes. One of those components, magnetrons, was used to generate small electromagnetic - or "micro" - waves. These waves had a high-enough energy to accelerate particles to never-before-seen levels.
- [Rachel] The story of the discovery that microwaves could heat up food has a veneer of incredibility and seems to sound like most cutesy stories about an inventor stumbling upon his creation: While studying magnetrons for Massachusetts-based defense contractor Raytheon in 1945, engineer Percy Spencer noticed his hand growing warm, and a bar of chocolate in his pocket had melted. After Spencer put two and two together, he then tried putting a bag of popcorn near the magnetron; the kernels popped accordingly. His third experiment wasn't a culinary success, but it is a common one for the naive microwave oven cook: he tried to cook a raw egg, which subsequently exploded, but the concept of microwaves' ability to cook food had been thoroughly proven.
- [Rachel] Raytheon President Laurence K. Marshall launched an initiative to bring magnetron-based ovens to industrial kitchens, as well as a contest to give the new appliance a name. The winning name was two words: Radar Range, which later was shortened to the snappier Radarange. Raytheon released the Radarange in 1947, but it was a behemoth, weighing in at 750 pounds. It also was very expensive, and it consumed three times the electricity of modern microwave ovens. The first Radarange was a marketing flop. Raytheon licensed its patents for a home-use oven to Tappan, which introduced their model in 1955, but it was still too cumbersome and expensive for wide adoption. Although some commercial food businesses did acquire microwave ovens over the intervening years to help speed up food service, it wasn't until 1967, with the introduction of Raytheon subsidiary Amana Corporation's first countertop model, featuring the modern short and wide box configuration, that microwave ovens were commercially popular for domestic use. As microwave ovens became more affordable in the following decades, adoption in the United States and abroad increased rapidly.
- [Bill] As more American women were joining the workforce at the end of the 1960s and into the 1970s, particularly as inflation eroded the purchasing power of household income and the reactionary postwar pressure against middle class white women working

was weakening, microwave oven marketing in the United States honed in on these potential customers, who were presumably desperate to save time in preparing meals. The suburban mom and wife demographic had already been heavily sold on flash-frozen [TV dinners](#) since the end of the 1940s, some two decades earlier, but those meals still often required a half hour or more to prepare with a traditional oven. Now the microwave oven would be able to heat up those same pre-packaged meals in just a few minutes. Those prepared meals continued to take off in popularity and market share as microwave ovens made them even more convenient.

<https://microwave.umwblogs.org/cultural-significance/> And eventually as marriage itself declined in the following decades, divorced dads presumably became a target market for microwave ovens as well. As a side note, I did read various conflicting articles and books about the role of microwave ovens in women's lives and home workloads in the 20th century United States, but I didn't really land on any conclusive insights because a lot of the research has conflicting results or conclusions, sometimes because of the author or researcher's ideological objectives either way and sometimes because there were differences among women by class or race that were overly flattened for the sake of a simpler study. Academics in different fields couldn't agree on how much time women were devoting to housework in various generations, and so their conclusions on the role of technology would obviously differ as well. One book seemed to assume earlier generations all had servants, while a different article seemed to assume no American women had ever worked outside the home before a certain era; obviously both of these assumptions don't make much sense. We might come back to this issue of time-saving technologies and feminist implications (or not) in a wider look at home housework technologies in general, but microwave ovens were usually only given as a passing example of that broader question anyway.

- [Rachel] How do microwave ovens work? The oven bombards the food with electromagnetic radiation. The microwaves have a wavelength of 5 inches, which pass through glass and plastic much like visible light, which is why the food is heated faster than the container. Similarly, the microwaves can pass through the glass in the door, which is why the metal screen is used on the door. Visible light, with its shorter wavelength can pass through the openings in the screen, but the longer microwaves are stopped. Water, fats and sugar molecules absorb the microwave radiation, which causes them to vibrate at a high speed. These molecules are polar, with a positive and negative end, and they align with the electric field created by the microwaves. The electric field changes millions of times per second, and this realignment causes the motion of the molecules, which generates heat and cooks the food.
- [Rachel] Modern microwave ovens still use a magnetron, which is a type of vacuum tube, to generate the microwaves by emitting a controlled flow of electrons. The magnetron requires a high-voltage direct current of 2000-3000 volts. To get the current that high, the oven includes a transformer, which constitutes the majority of the weight of the appliance. Inside the magnetron, the voltage is applied to a filament, which generates a stream of electrons down the inside of the tube. As the electrons are emitted from the filament, circular magnets force the flow of electrons to spiral. The spiraling beam of electrons passes by cavities in the inside of the tube, inducing a high-frequency radiation that is emitted from the end of the tube into the cooking chamber. In some microwave oven models, a stirrer rotates above the food at a speed of about 60 rpm. The fanlike blades of the stirrer interrupt the flow of radiation and scatter it evenly throughout the cooking chamber to heat the food more evenly. The turntable that the food sits on rotates the food during heating, to also heat food more evenly.
- [Rachel] One common myth of microwaves is that it cooks from the inside out. Anyone who has ever cooked a frozen burrito in the microwave knows that's not the case. What

does affect the heat penetration is the composition of the different layers of food. If an inner layer of food has more water molecules than a dryer outer layer, the inner layer can get hotter due to the vibration of the water molecules. If an inner layer has a lower heat capacity than an outer layer, it can reach a higher temperature during the cooking time. However, in most cases, the microwave penetrates through the outer layers evenly, and food is cooked from the outside in.

- [Rachel] While microwave cooking is a convenient cooking or heating method for many foods, there are many limitations. This method of cooking doesn't produce a high enough temperature to produce a Maillard reaction, so it isn't effective for browning or caramelizing foods, such as steak or other cuts of meats. Bacon, with its high fat content, can be cooked quite effectively in the microwave oven. Baking often requires time to create the desired structure and crumb of the final result, which makes microwave cooking less than optimal. One exception is mug cake, where the volume of batter is smaller and the structure is provided by the mug.
- [Rachel] While it was once thought that microwave cooking made foods less nutritious, that is not the case. The increased speed of cooking means that water-soluble nutrients have less time to leach out into cooking water. *Spinach retains nearly all its folate when cooked in a microwave oven; when boiled, it loses about 77%, leaching nutrients into the cooking water. Bacon cooked by microwave oven has significantly lower levels of nitrosamines than conventionally cooked bacon. Steamed vegetables tend to maintain more nutrients when microwaved than when cooked on a stovetop. Microwave blanching is 3–4 times more effective than boiled-water blanching for retaining of the water-soluble vitamins, folate, thiamin and riboflavin, with the exception of vitamin C, of which 29% is lost (compared with a 16% loss with boiled-water blanching).*
- Safety
  - [Bill] According to the FDA.gov website, "*The Food and Drug Administration (FDA) has regulated the manufacture of microwave ovens since 1971. Microwave oven manufacturers are required to certify their products and meet safety performance standards created and enforced by the FDA to protect the public health. On the basis of current knowledge about microwave radiation, the Agency believes that ovens that meet the FDA standard and are used according to the manufacturer's instructions are safe for use.*" <https://www.fda.gov/radiation-emitting-products/resources-you-radiation-emitting-products/microwave-oven-radiation> The big risk is from the hot food or liquids, not from radiation or electromagnetic signals, but that's because of how much regulation there is on the design of microwave ovens to ensure there is not leakage or malfunctions. *Through its Center for Devices and Radiological Health (CDRH), the FDA sets and enforces standards of performance for electronic products to assure that radiation emissions do not pose a hazard to public health. A Federal standard (21 CFR 1030.10) limits the amount of microwaves that can leak from an oven throughout its lifetime to 5 milliwatts (mW) of microwave radiation per square centimeter at approximately 2 inches from the oven surface. This limit is far below the level known to harm people. Microwave energy also decreases dramatically as you move away from the source of radiation. A measurement made 20 inches from an oven would be approximately 1/100th of the value measured at 2 inches from the oven. The standard also requires all ovens to have two independent interlock systems that stop the production of microwaves the moment the latch is released or the door is opened. In addition, a monitoring system stops oven operation in case one or both of the interlock systems fail. All ovens must have a label stating that they meet the safety standard. In addition, the FDA requires that all ovens have a label explaining*

*precautions for use. This requirement may be dropped if the manufacturer has proven that the oven will not exceed the allowable leakage limit even if used under the conditions cautioned against on the label. To make sure the standard is met, FDA tests microwave ovens in its own laboratory. The FDA also evaluates manufacturers' radiation testing and quality control programs at their factories.*

- [Rachel] While microwaving food is mostly safe, some factors should be taken into consideration. The container must be marked as microwave-safe. Of most concern is whether microwave cooking in plastic containers leaches toxic chemicals into foods. Plastic containers marked as microwave-safe have been determined to withstand microwave oven temperatures with no ill effect to the material. It is not recommended to re-use one-time-use plastic containers, such as microwavable soup containers, or containers that aren't marked as microwave-safe, such as butter or yogurt containers.
- [Rachel] Another safety concern is internal cooking temperature. As previously discussed, food is cooked from the outside in. Often, microwave cooking directions advise allowing the food to remain in the microwave after cooking for a few minutes. This is to allow the heat to penetrate all the way to the center of the food and raise the temperature up to a safe level. Failure to do so will not ensure that any food-borne bacteria in the food has reached a temperature that will kill it.
- [Bill] The other thing people tend to worry about these days with microwave ovens is their carbon footprint, in terms of both the day to day power usage and the production and disposal lifecycles. There have been various studies over the years on these questions, but it can be a bit hard to assess in comparative terms, because other kitchen cooking methods like induction stoves, gas ranges, and charcoal burners all have their own various greenhouse emission consequences.
- [Rachel] On another note, the rise of the office job has elevated the microwave oven to an essential appliance for lunch hour efficiency. Rather than eating cold leftovers, going out for lunch, or getting takeout being the only options, the microwave has opened up a world of breakroom fine dining. But with great cooking power comes great responsibility. Microwaves are often the nucleus around which office battles over etiquette are formed. One cardinal sin: not cleaning up after making messes. It is universally stated that if you make a mess with food spatters or spills in the microwave, you are tasked with cleaning it up before it petrifies into a film that requires industrial solvents and a chisel to remove. However, the experts disagree on one commandment that used to be etched into stone: Thou Shalt Not Microwave Fish or Other Fragrant Foods. [Bon Appetit's](#) Alyse Whitney is firmly in the No camp, while [Washington Post's](#) Jacob Brogan argues that rules about microwaving fragrant foods often hides an antipathy towards non-Western cuisines. With that said, *overheating* fragrant foods might just end up rendering them inedible. Heating up fish for more than a minute at most will result in sad, rubbery fish. Overheating broccoli, cauliflower and other cruciferous veggies will leave you with unpalatable mush. And everyone can agree that burnt microwave popcorn is a crime against offices and should be abolished.