

How a Microwave Works - Reverse Engineering Challenge

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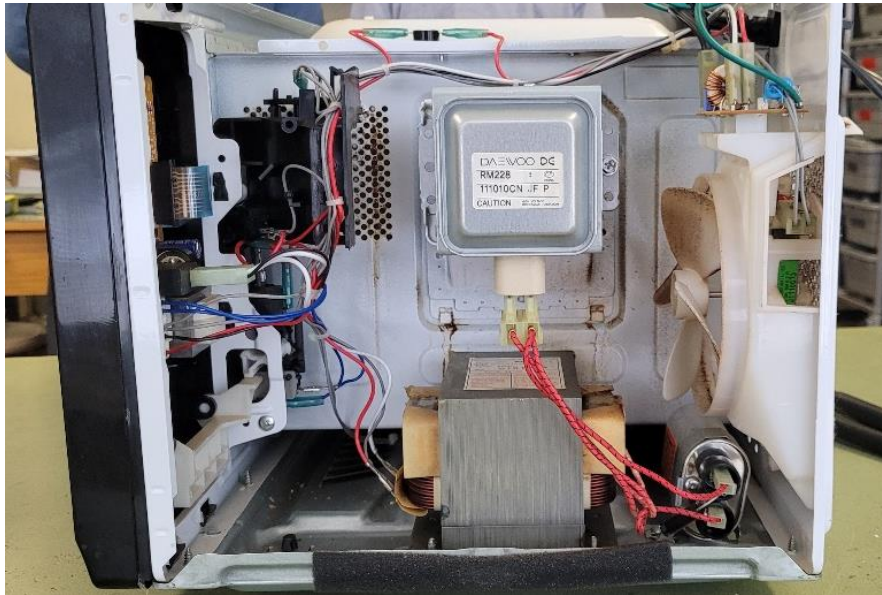
1970Y, Elkhorn, Nebraska

People use the microwave every day, but very few of them understand how it can take electricity and turn it into waves that warm your food. We should want to know how things work because our knowledge of systems will be the key to improving designs and advancing technology in the future. The microwave provided a unique chance to examine how things work.

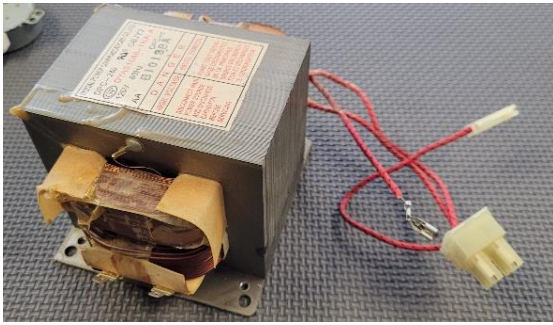
Warning, disassembling microwaves is dangerous. We had supervision and took the necessary steps to be safe. Do not poke around in microwaves unless you know what you're doing.

There are two systems at play here.

The transformer, capacitor, magnetron system and the controlling system.



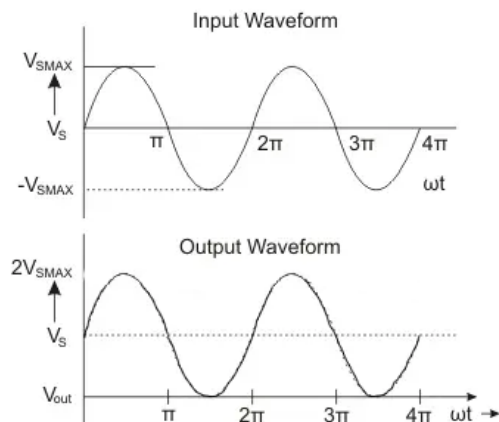
We took the parts out for inspection.



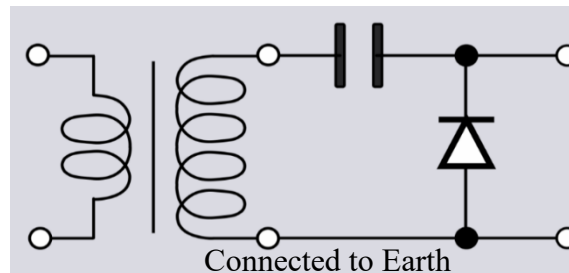
The microwave oven transformer is the foundational part of powering the microwave. Because of the large ratio of primary to secondary windings, our outlet 120 volts is stepped up to 2000 volts for the magnetron.



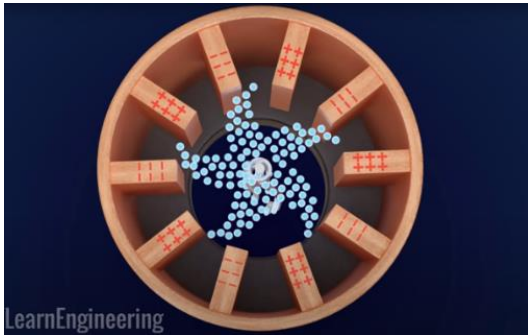
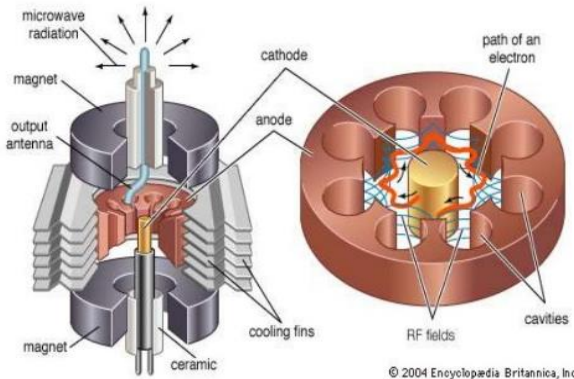
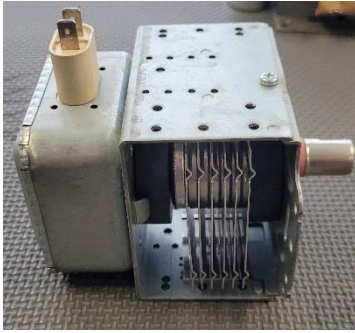
A capacitor is a small reservoir for charge. Its job in the microwave is to double, regulate, and smooth out the voltage from the transformer. The diode attached to it doubles the output of the transformer.



As shown by the waveform graphs on the left, the negative cycle charges the capacitor and during the positive cycle its voltage is added; therefore doubled.



Magnetron cathode and anode



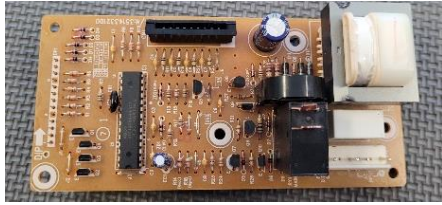
The Magnetron is where electricity becomes a wave.

Since this component has beryllium ceramic insulators that cause cancer upon inhalation of small particles, we elected not to cut it open. Instead, we researched what the inside looks like and what it does.

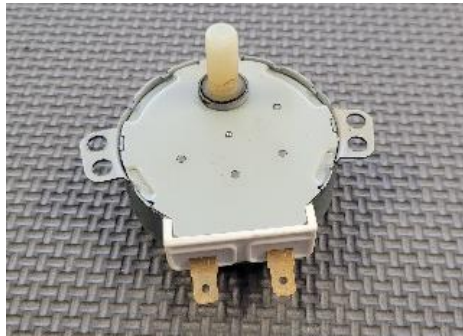
This is a cross section of it. From the 4KV pulses of the transformer and capacitor, the cathode emits electrons, and they take a spiral/oscillating path around the chamber because of the permanent magnet's field.

The cavities have alternating charges as the electrons polarize the edges. These charges in the cavities move at a specific frequency (2.4 GHz) which is a microwave on the electromagnetic spectrum. The waves are directed into the metal chamber of the microwave.

The microwave's interaction with water is what heats up the food. Water is polar and the microwave's changing direction vibrates the water, causing an increase in molecular movement. This movement is what we know as heat!



The other system in a microwave is the electronic controller.



glass table motor

It is responsible for switching the transformer, fans, and plate motor on and off.

It includes switches in the door to ensure the microwave cannot be open and running.

TAKEAWAY

During this endeavor, we learned a lot. For example, we learned the value of safety precautions that protect us from dangerous and possibly fatal components in everyday items, such as beryllium insulators. We also learned how to communicate as a team to disassemble a device. Most importantly, it has taught us how microwaves, although common, use complex components and physics to make life easier.