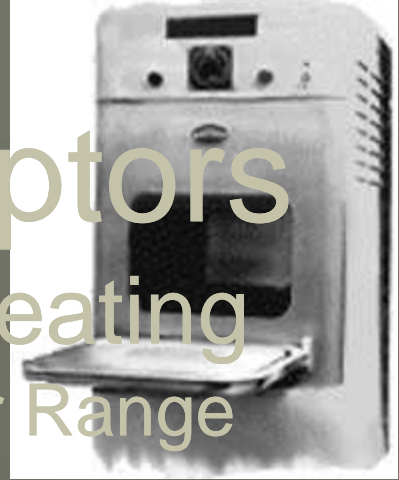




Microwave Susceptors

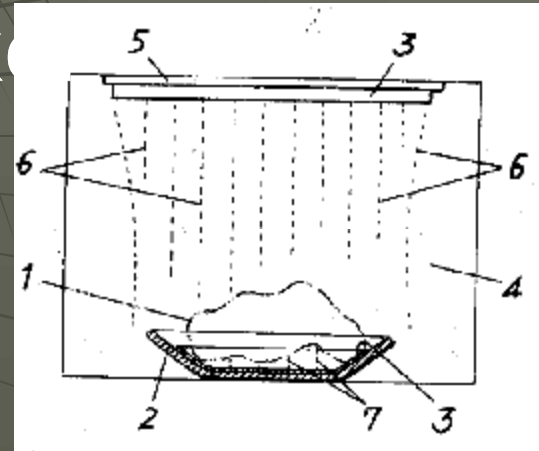
60 years of Microwave Heating
40 years after the Amana Radar Range



1967 Radarange



Wolfgang Deck
VAST FILMS, Ltd.
Darlington, PA



Outline

- ◆ A Short History of the Microwave Oven
 - Legends and Facts
- ◆ The Microwave Susceptor
 - The Early Ideas
 - The Current Format
- ◆ Applications
 - Packaging
 - Patterning
 - Developments

The History of the Microwave Oven

- ◆ Raytheon “Radar Range”
 - Most cited Legend: “Percy Spencer walked by a running magnetron and a Hershey Bar melted in his pocket”
 - Truth much more benign:
 - ◆ In 1945 Laurence Marshal, owner of Raytheon, ordered his engineers to create ideas for products to ensure survival after war’s end
 - ◆ Percy Spencer, chief developer for vacuum tube and magnetron applications, suggested to develop MW range for heating applications
 - ◆ The effect of MW heating was known at the time already! If the “Hershey Bar Incident” indeed happened it may have only reinforced idea of food heating.
 - ◆ Building and Marketing of Equipment to the General Public a new concept for Raytheon.

The History of the Microwave Oven

- Main difficulty: Finding the right Frequency
 - ◆ Penetration Depth into Food Stuff depending on Frequency
 - ◆ Frequency determines size of Cavity
 - ◆ Decision was made by FCC and ITU: Use either 950 MHz or 2.45 GHz.
- First commercial MW Oven was presented in 1947:
 - ◆ Weight: ~ 300 kg
 - ◆ Height: 1.6 m
 - ◆ Power: 220 V
 - ◆ Water Cooled Magnetron
 - ◆ Cost: US-\$ 2,000 (in 1947)
 - Equals ~ US-\$ 20,000 today!!!



The Amana Radar Range

- ◆ 1965: Raytheon bought Refrigerator Company AMANA
 - Goal: Develop a small MW oven, as a small appliance, priced at US-\$ 500
 - ◆ Raytheon's Magnetron Cost: US-\$ 300!!
 - ◆ Solution: New Japan Radio Co. (NJRC) Magnetron for US-\$ 25
 - ◆ No mass production of components available
 - Diodes and High Voltage Capacitors not available!!
- ◆ 1967 the Amana Radar Range was introduced.
- ◆ Massive Sales Campaigns (mimicking Harry Truman's Wistle Stop Train!!)
- ◆ 1975 MW Oven Sales surpassed Gas Oven Sales
- ◆ Today more than 95% of American Households have Microwave Ovens



The Microwave “Susceptor”

- ◆ From the Entries of the Raytheon Development Team:
 - “Refreshing corn popped, takes 20 seconds (!). 80% of kernels popped”
 - “... potatoes flavor was good but potato was not crisp”
 - “Mashed frozen potatoes, the taste was good, but they did not brown. Time required: 1 Minute (!)”
 - “... steak doesn’t brown.”
- ◆ Two conclusions:
 - Raytheon used massive power in their systems
 - Microwave by itself does not provide browning and crisping!

The Microwave “Susceptor”

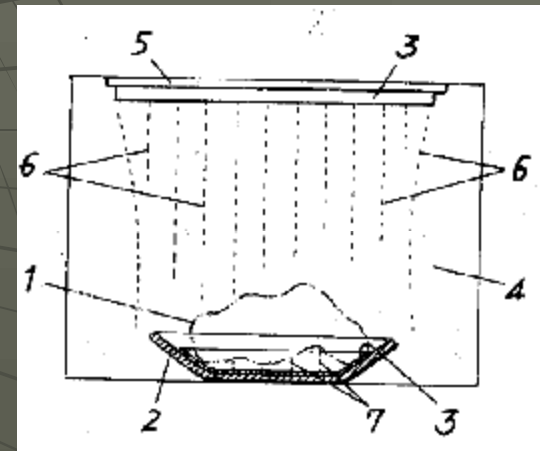
- ◆ Unlike Infrared Radiation MW heats by deep penetration
- ◆ Not enough heat on the outside of foodstuff to “dry the skin”
- ◆ Microwave Susceptors create a hot surface through absorption of MW Energy
- ◆ Surface hot enough to crisp and brown the food.



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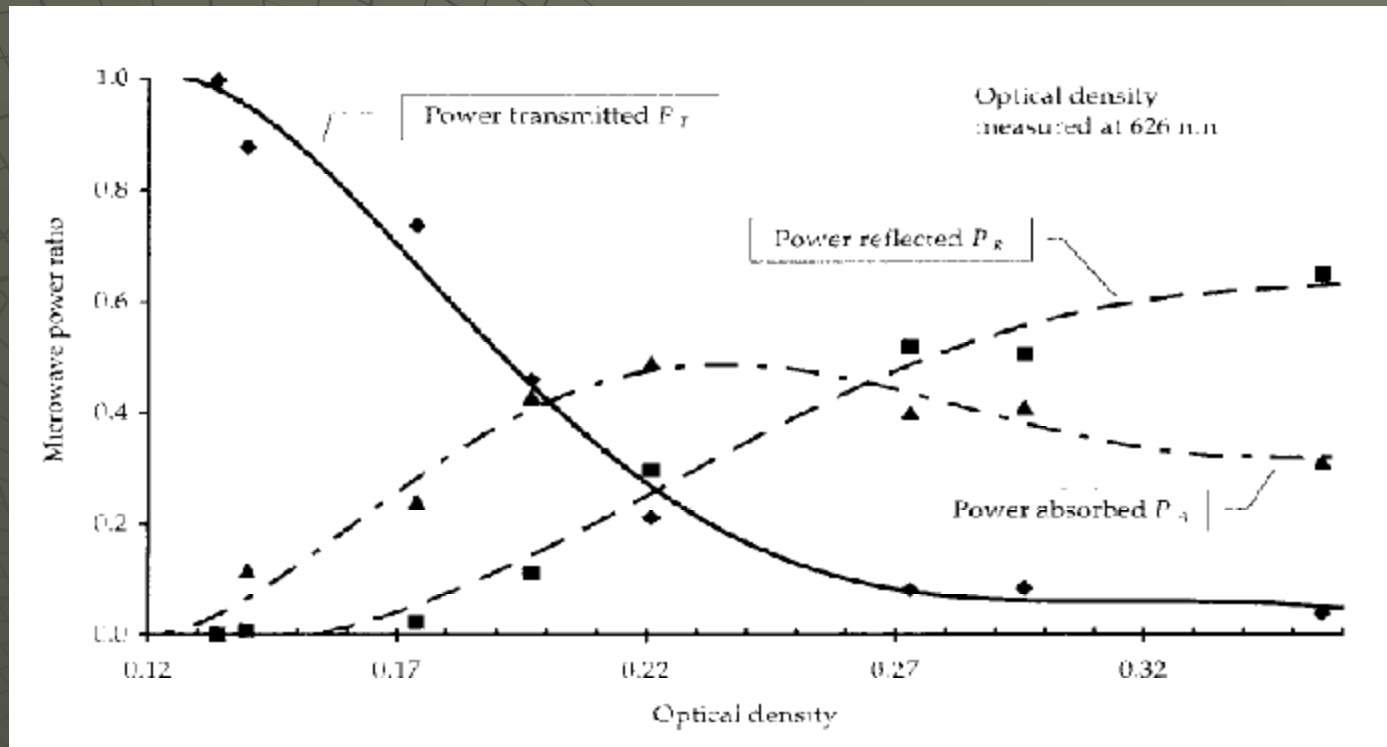
MW Susceptor

- ◆ US Patent 3,783,220 to Tanizaki, filed June 1971, describes a plate with a thin conductive absorber on a plate or dish to provide a heating surface for crisping or browning in the MW.
 - Proposes Tin-Oxide, Silicon Carbide or other conductive materials on Glass or Ceramic Plates
 - "In operation, an electronic vortex current is generated in the film by the action of the electromagnetic waves causing the thin film to heat and become an infrared source."
 - Patent even describes the required composition of the plate to prevent cracking or crazing!



The Microwave Susceptor

- ◆ US-Patent 4,230,924 to Brastad, filed October 1978, describes the use of thin film aluminum on PET.



Absorption of MW in Thin Aluminum Coatings on PET

Source: /4/

The Microwave Susceptor

- ◆ Most common susceptor construction today:
 - PET film metallized with Al
 - ◆ Optical Density 0.20 to 0.30, depending on application
 - ◆ Resistivity Range from 10 to 100 Ω/f

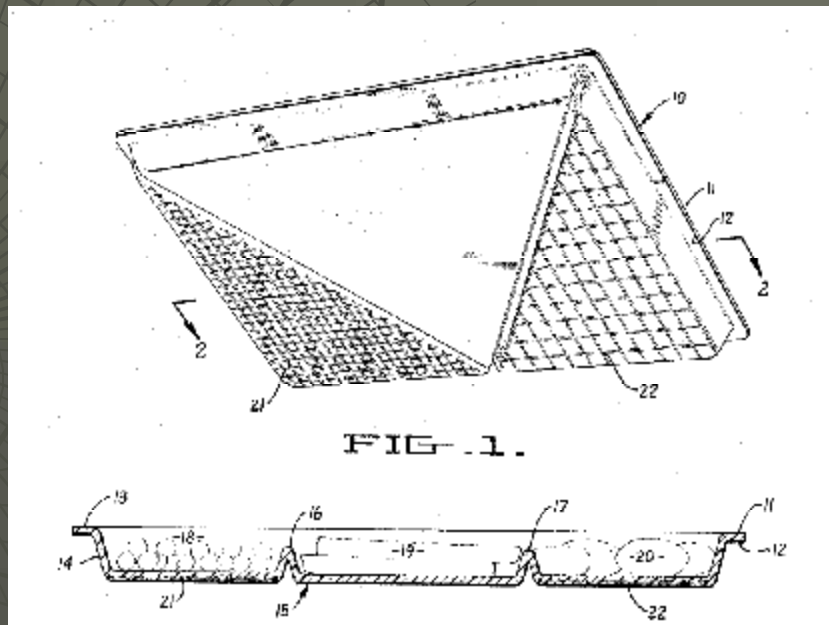


- Lamination to Support
 - ◆ Required to prevent susceptor film from melting
 - ◆ Typically paper of various caliper
 - ◆ Occasionally also Cellophane is used



Patterned Susceptors

- ◆ Goal of Patterned Susceptor
 - Additional Functionality
 - ◆ e.g. differential cooking
 - ◆ US Patent 3,302,632 to Fichtner describes a "Microwave Utensil" using Metal Mesh with different mesh sizes to absorb different amounts of MW energy for different food types



Patterned Susceptors

- ◆ Patterned Susceptors used to control MW Energy absorbed by food and susceptor
 - e.g. Marie Calendar's Pot Pie

No absorption on the rim to prevent charring

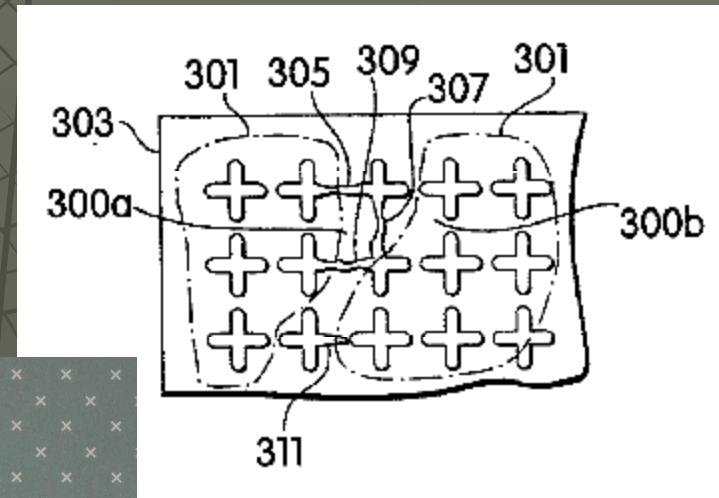
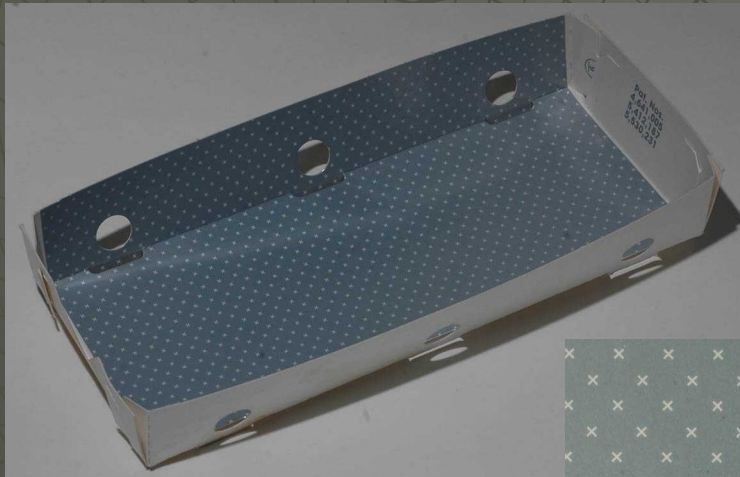


High absorption on the wall to ensure crispy side

Reduced absorption in the bottom to balance crisping and bulk heating

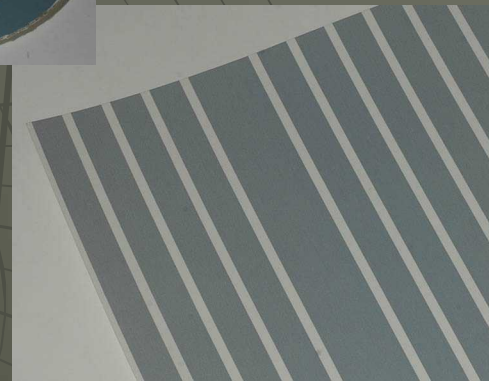
Patterned Susceptor

- ◆ Used as a Safety Device
 - e.g. Graphic Packaging Safety Susceptor
 - ◆ US-Patent 5,412,187 "Fused MW Structure"
 - ◆ Areas between crosses work like fuses and deactivate zones that absorb too much MW energy



Patterned Susceptor

- ◆ Patterned Susceptor to achieve “Grill Effect”
 - e.g. Stouffer’s Bistro Sandwich
 - ◆ Die Cut Susceptor laminated to fluted board
 - ◆ Same effect can be achieved with striped susceptor laminated to C1S ovenable paper



Patterned and Formed Susceptor

- ◆ 3-D shaping of Susceptor to better adapt to specific food item
 - e.g. DiGiorno's Microwave Crust Pizza

Press Shape rises
Pizza to allow better
ventilation and release
of moisture => better
crisping



Additional
Susceptor Ring
place on top of
Pizza Edge to allow
better crisping

No susceptor on outside wall
to allow MW to penetrate
underneath the food item

MW Susceptors – The Future

- ◆ Most important: Adding Convenience
 - Finding ways to reduce consumer action
 - ◆ Certain Foods still require stirring
 - Further Reduce Cooking Times
 - ◆ Large Food Items (Lasagna Family Pack)
 - Adapt to other Food Items
 - ◆ A full menu in the Microwave
 1. The Appetizer being warm enough to eat immediately
 2. The Entrée nicely cooked and hot
 3. The Dessert is icecream, still frozen



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- ◆ /4/ J. Cesnak et al.: "Properties of Thin Metallic Films for Microwave Susceptors", Czech J. Food Science, Vol. 21, No. 1:34-40 (2003)
- ◆ /5/ E. C. Fichtner: "Microwave Cooking Utensil", US Patent 3,302,632, filed December 6, 1963, issued February 7, 1967
- ◆ /6/ G. Walters: "Fused Microwave Conductive Structure", US Patent 5,412,187, filed January 5, 1994, issued May 2, 1995



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