

Oct. 6, 1970

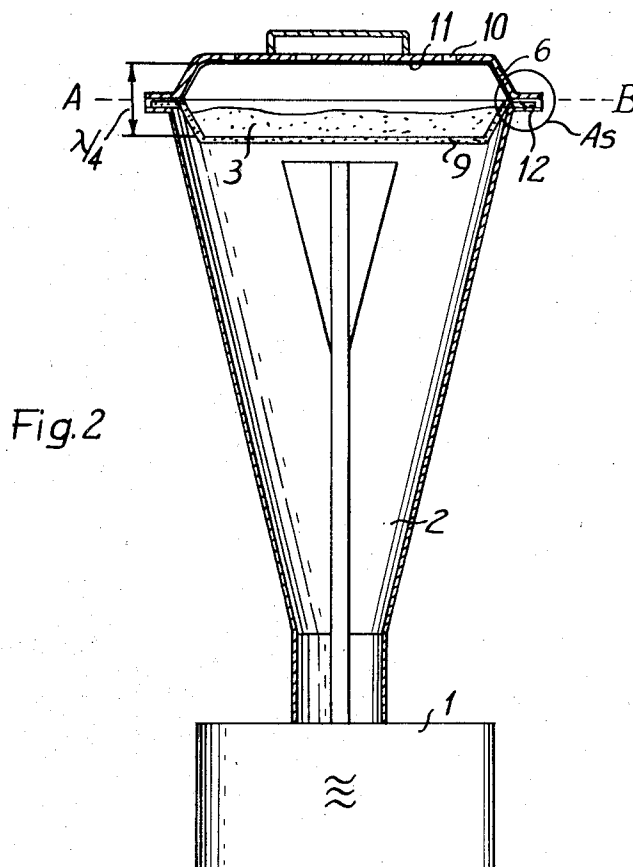
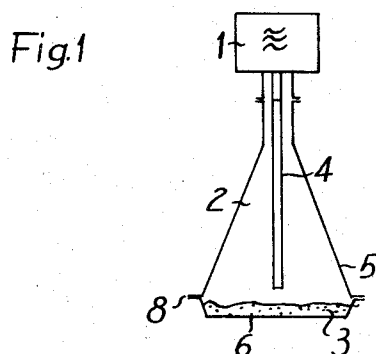
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3,532,847

DEVICE FOR HEATING NON-METALLIC MATERIAL

Filed June 1, 1966

2 Sheets-Sheet 1



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Fig.3

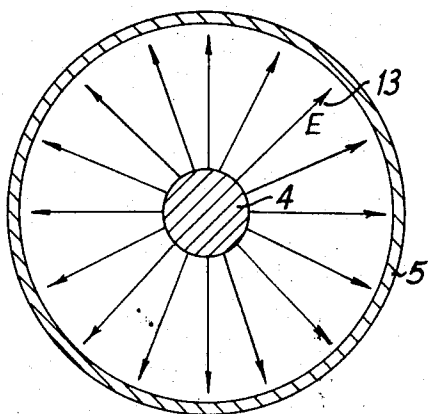


Fig.4

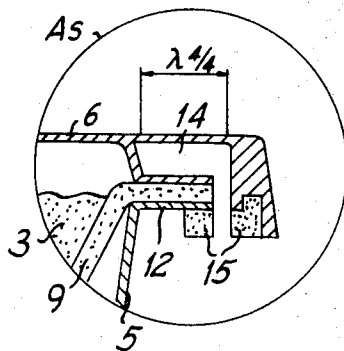


Fig.5

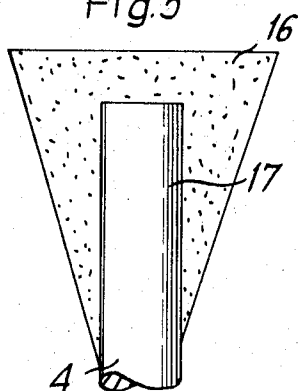


Fig.6

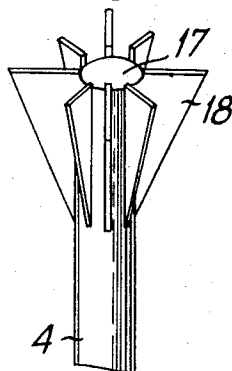


Fig.7

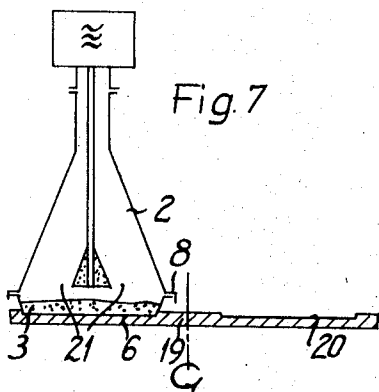
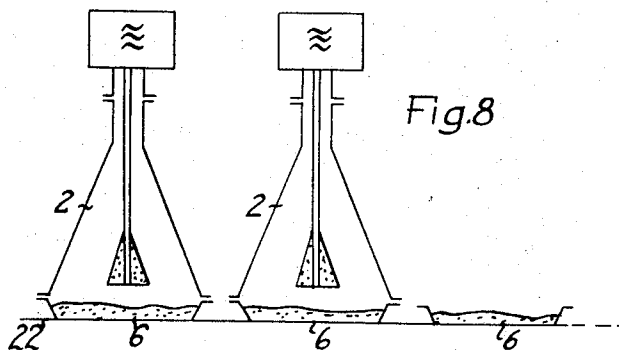


Fig.8



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DEVICE FOR HEATING NON-METALLIC MATERIAL

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10 Claims

ABSTRACT OF THE DISCLOSURE

Microwave apparatus for cooking and heating food-stuffs includes a coaxial transmission line energized with microwave energy at one end and having a flared outer conductor with a wide mouth adjacent to the food to be heated. The inner conductor also extends for nearly the entire length of the outer conductor so that the inner and outer conductors coact to support essentially only the coaxial line wave.

This invention relates to a microwave apparatus for cooking and heating foodstuffs in an electromagnetic radiation field, preferably in the microwave range, wherein the wave coming from a generator in a widening waveguide heats the food at the end of the waveguide, which is closed therebehind in a radiation-proof manner by a detachable metal wall.

Known devices of this type have the disadvantage that irregular field distribution and consequently unnecessarily long treatment times are entailed. In addition, in known devices the treatment space is large in relation to the wavelength and consists of a cavity resonator into which the microwave energy is fed through coupling apertures. Standing waves in which the food is heated irregularly are thus formed in the resonator. In order to achieve more uniform heating, it has been proposed to provide one or more rotating oscillatory type-converters in the cavity resonator.

In another form of construction of the known apparatus, the high frequency energy fed by coupling into a waveguide is radiated by way of a pyramidal or conical horn radiator from below into a parallelepipedic or hemispherical metal cover, where the food to be heated rests on a plate of low-loss dielectric material. In the hemispherical construction the cover is lifted as a whole by a conveyor device, while in the parallelepipedic construction the cover is provided with a door.

In all constructions of the type described, a plurality of dishes filled with food to be heated can be placed on a support plate. Although the devices thus have a large volume, they have low energy utilisation. In addition, high wall losses reducing overall efficiency occur through skin effect on the inner wall of the cavity.

The invention aims at obviating the foregoing disadvantages and to achieve a rapid and homogeneous heating in a constructionally simple and compact arrangement.

To this end, the present invention consists in a microwave apparatus for cooking and heating foodstuffs in an electromagnetic radiation field, preferably in the microwave range, wherein the wave coming from a generator in a widening waveguide heats the food at the end of the waveguide, which is closed therebehind in a radiation-tight manner by a detachable metal wall, characterised in that the waveguide is constructed as a coaxial line the inner conductor of which ends in front of the food to be heated.

The use of a coaxial line itself to form the treatment chamber has probably not been contemplated hitherto be-

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cause a line of this type is restricted to relatively small dimensions if only the line wave is formed. It has, however, been found that restriction to such a smaller treatment chamber entails considerable advantages for many purposes, especially for kitchen use; in particular, homogeneous treatment and therefore also rapid, uniform heating and good energy utilisation are thereby obtained even without the use of oscillatory type-converters. With an apparatus of this type it is easy to achieve treatment chamber sizes which correspond to the area of usual containers for complete meals. In the opening of the coaxial line the ratio of external diameter of the inner conductor to internal diameter of the outer conductor can be so proportioned, in a manner known per se, that only the line wave is formed. In the case of larger quantities of food having to be treated, according to a feature of the invention a plurality of units of such dimensions can be grouped together to form a continuous apparatus. Uniform energy distribution can reliably be obtained by enclosing the end of the inner conductor by one or more rings of low loss dielectric material or by disposing at the end of the inner conductor short projecting metal arms which are spaced apart radially at equal angular distances, and the height of which in the peripheral direction may vary periodically.

If the coaxial line is disposed above the food to be heated, the cover closing the coaxial line may conveniently form the container for the food to be heated.

Both in respect of dimensions and in respect of performance the new apparatus is particularly suitable for combining with normal electric hotplates to form an electric cooker having a common working surface. In this case the coaxial line will be disposed beneath the food to be heated, which in this case will be situated in a manner known per se in a container of low-loss plastics material.

In order that the invention may be more readily understood, reference is made to the accompanying drawings which illustrate diagrammatically and by way of example several embodiments thereof, and in which:

FIG. 1 shows a microwave apparatus having a treatment chamber disposed beneath the coaxial line;

FIG. 2 shows an apparatus having a treatment chamber disposed above the coaxial line;

FIG. 3 is a cross-section on the line A-B of FIG. 2; FIG. 4 is a detail in section of the portion as of FIG. 2, drawn on a larger scale;

FIG. 5 shows on a larger scale the end of the inner conductor of the coaxial line illustrated in FIG. 2, with dielectric attachment;

FIG. 6 is a similar view of the end of the inner conductor provided with metal ribs;

FIG. 7 shows an apparatus of the type illustrated in FIG. 1, with a turntable as food support; and

FIG. 8 is an apparatus of the type illustrated in FIG. 1, with a conveyor belt as food carrier.

In FIG. 1, the line wave coming from a microwave generator 1 is transmitted through a continuously widening coaxial line 2 to the food 3 to be heated, and adsorbed by the latter. The inner conductor 4 ends in front of the food 3, while the outer conductor 5 is closed behind the food by a removable cover 6. In the plane of division 7 between the coaxial line 2 and the cover 6 there is provided a contact-free short circuit 8 known per se.

FIG. 2 illustrates an exemplified embodiment in which the food 3 is heated from below. The food 3 is contained in an interchangeable dish 9 of low-loss dielectric, for example of polytetrafluoroethylene. The cover 6 situated thereabove is constructed as a lid which has apertures 10 for discharge of steam, and for the purpose of making it safe when empty is coated with lossy material. The bottom of the food container 9 is at a distance of $\lambda/4$

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(λ =wavelength) from the cover 6 and the depth of the food container 9 amounts to about half that distance. Beneath the dividing plane the apparatus has a flange 12 for incorporation in a working surface.

Referring to the cross-section illustrated in FIG. 3, the electric field lines 13 are shown as solid lines.

The contact-free short circuit 8 may be constructed as illustrated in FIG. 4. Annular, short-circuited links of waveguide 14 have a length of $\lambda H/4$ of the wave type propagated in this length of waveguide. Complete HF-tightness is ensured by damping material 15 provided behind a suppression filter.

In order to weaken the electric field concentration on the inner conductor, a conical attachment 16 of low-loss dielectric is mounted on the end 17 of the inner conductor as shown in FIG. 5.

The same effect may be achieved in the arrangement illustrated in FIG. 6 by providing thin metal strips or arms 18 projecting radially from the inner conductor and beyond the end of the latter. The height of the metal arms 18 in the peripheral direction varies periodically.

In FIG. 7 the device is of the type illustrated in FIG. 1, the cover 6 of the coaxial line 2 being constructed as a metal dish in which the food 3 is packed. The metal dish 6 stands on a turntable 19 in a depression 20. The turntable 19 transports the dish 6 beneath the opening 21 of the coaxial line 2 and presses it against the contact-free short-circuit 8.

In the embodiment illustrated in FIG. 8, metal dishes 6 are successively brought by a conveyor belt 22 beneath the coaxial line in a timed movement.

In the opening of the coaxial line 2 the ratio of the external diameter of the inner conductor to the internal diameter of the outer conductor is so proportioned, in a manner known per se, that only the line wave can be formed. Therefore, in case of larger quantities of food having to be treated a plurality of units of such dimensions are combined to form a continuous apparatus. As shown in FIG. 8, these units may be connected in series, whereby a more rapid output of the first portion of a portion series is achieved than in case of a connection in parallel.

I claim:

1. Microwave apparatus for cooking and heating food-stuffs in an electromagnetic radiation field comprising, a source of electromagnetic heating energy, a coaxial line waveguide having an inner conductor and an outer conductor that increases in width from an input end to an output end, means for coupling said source to said input end, and conducting cover means detachably secured to said output end, said inner conductor extending almost the length of said outer conductor to coact with said outer con-

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ductor to support substantially only the coaxial line wave and to coact with said cover means to define a food heating compartment between the end of said inner conductor and said cover means.

2. A device according to claim 1, wherein in the opening of the coaxial line the ratio of the external diameter of the inner conductor to the internal diameter of the outer conductor is so proportioned, that only the line wave can be formed.

3. A device according to claim 1, wherein the end of the inner conductor is enclosed by one or more rings of low-loss dielectric material.

4. A device according to claim 1, wherein short, projecting metal arms are disposed at spaced equal angular distances apart, at the end of the inner conductor.

5. A device according to claim 4, wherein the height of the metal arms in the peripheral direction varies periodically.

6. A device according to claim 1, wherein the coaxial line is disposed above the food to be heated, while said cover means closing the coaxial line forms the container for the food to be heated.

7. A device according to claim 6, wherein a horizontally movable carrier is provided for the food compartment and in the working position is pressed against the opening of the coaxial line.

8. A device according to claim 7, wherein the carrier is constructed as a turntable.

9. A device according to claim 7, wherein the carrier is constructed as a conveyor belt which moves in a timed movement.

10. A device according to claim 1, wherein the bottom of the food compartment is at a distance of $\frac{1}{4}$ wavelength from the cover and that the depth of the food compartment amounts to about half that distance.

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U.S. Cl. X.R.

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