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EUROPEAN PATENT APPLICATION

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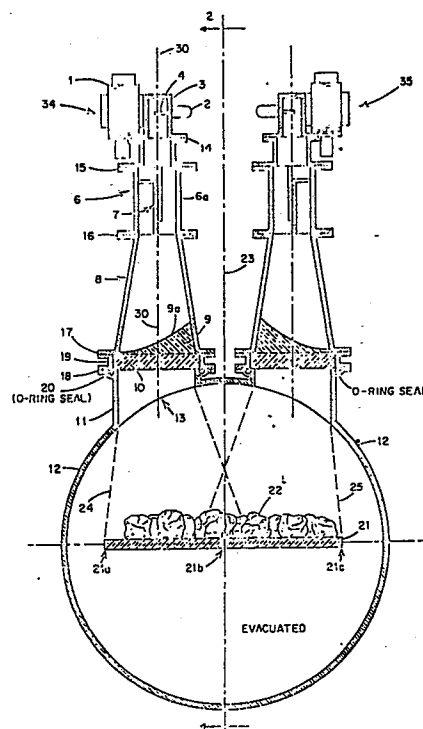
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⑤④ **Microwave heating apparatus.**

⑤⑦ In a microwave heating apparatus for heating process material carried on a belt (21) in a microwave chamber (12), such as a continuous vacuum drying process, there are launched several directional beams (24, 25) of circularly polarized microwave radiation from different positions along the inside walls of the enclosure, the beams each being directed to illuminate the subject material and overlapping each other where suitable.



Background of the Invention

The present invention relates to microwave heating apparatus and particularly to high power heating apparatus for processing material moved by conveyor through a microwave chamber.

5 Heretofore, it is known to provide in industry a continuous process system for heating and drying subject material moved on a conveyor through a microwave chamber that is sealed and evacuated and into which microwave energy is launched. These systems are now of large physical size and launch many kilowatts
10 of continuous microwave energy into the chamber from a multitude of sources. A system of this sort is described in U.S. patent #4,045,639 which issued to Nicolas Meisel, et al on August 30, 1977. The function of such apparatus is to feed microwave
15 energy continuously into the process material with as uniform distribution of the energy as can be achieved, while the material

is moved through the chamber on a conveyor. Large systems of this sort may use six or more magnetrons, each operating continuously and producing many kilowatts of power. Hence, the total microwave power launched into the chamber is large and may be in the
5 range of 50 to 100 kilowatts continuous power.

Operating at such high power levels clearly requires the use of high power sources in order to avoid having an excessively large number of sources. Magnetrons of such high power have a narrow limitation on the allowable amount of power that may
10 reenter them, either as a reflection of the magnetrons' own output or as "cross-talk" from other magnetrons in the system. It has been suggested by some to use circulators to avoid this problem; however, circulators are relatively expensive and they do not solve other problems that accompany high power delivery
15 into a microwave chamber. Also, where vacuum drying is carried on simultaneously with microwave heating, it is very difficult to prevent ionization of gas in the chamber by the microwave electric fields. Ionization permits arcing that wastes the microwave energy and, it can also degrade the quality of the process
20 material and is generally destructive of the apparatus.

It has been suggested to use arc detectors within the chamber that detect the occurrence of an arc and quickly interrupt microwave power to minimize the harm that is done by the arcing. However, frequent interruptions make the heating process
25 very inefficient and in the processing of some materials the interruptions are not at all acceptable.

Some of the objects of the present invention are to overcome these problems of uniform high power, continuous heating, reflection into the magnetrons, as well as cross-talk. Another
30 object is to reduce ionization and arcing problems where microwaves are used within an evacuated chamber.

Summary of the Invention

The uniform distribution of continuous high microwave power into the process material is accomplished by launching, preferably at regular places along the inside of the chamber, defined beams of circularly polarized microwave radiation, each beam being directed to illuminate a prescribed portion of the process material or a prescribed area through which the process material is moved. Microwave beams are weaker near their edges than at the center and so they are overlapped to compensate for this and provide illumination that is essentially uniform across the width of the path of the process material. Overlapping may also be effective to compensate for non-uniform distribution of the process material on the conveyor. Thus, the illumination does not depend upon the use of mode stirrers or turntables or any other equipment designed to reflect the microwave energy about the chamber and it does not depend particularly upon the geometry of the chamber. It permits the chamber to be designed in view of the pressure or vacuum conditions of operation. For example, it permits a long cylindrical chamber which is the preferred shape for withstanding vacuum and still provide for the continuous processing of the subject materials on a conveyor belt.

In the past where microwave heating has been accomplished in a cylindrical chamber, the process material was not directly illuminated by microwave energy launched into the chambers. As a consequence, the tendency was to concentrate the microwave energy near the walls of the cylindrical chamber and there would be a deficiency of energy along the cylinder axis (along the center of the conveyor). Thus, material carried through the chamber on the conveyor would be heated more along the edges of the conveyor than

at the center. Where the process of microwave heating occurs while at the same time vacuum drying occurs, the vacuum pressure produced in the chamber is often in the range in which ionization by the microwave electric fields and arcing are very difficult to prevent. In the present invention a structure is provided so that the peak values of electric fields of the microwave energy at a window where the microwave energy enters the chamber from the ambient pressure exterior are severely limited. Experience as well as theory show that high intensity microwave electric fields are produced at the "bottle neck" where the microwave is transmitted from the ambient exterior region through some sort of microwave transparent, pressure withstanding window, into the evacuated interior of the chamber. Elsewhere, within the chamber, the intensity of the electric fields is usually much lower and ionization problems are reduced.

In an embodiment of the present invention described herein, a cylindrical microwave chamber is provided through which a conveyor belt moves the process material at about the center of the cylinder. Opposite the material along the walls of the chamber, at regularly spaced places, separate beacons launch beams of microwave energy into the chamber, directed toward the process material. Each beacon beam illuminates a prescribed area of the conveyor belt and the beams overlap particularly along the center of the belt so as to produce a uniform or an intentionally "tailored" heating pattern. The configuration of each beam is formed by a dielectric lens that intercepts the microwave energy just before it enters the chamber through the window and focuses and directs the beam toward the conveyor.

In order to reduce arcing in the microwave chamber, it is necessary to minimize the intensity of the microwave electric fields

and, thereby minimize ionization within the chamber, which occurs when the chamber is evacuated, as in a heating-drying operation. This is done by launching beams of microwave energy that is circularly polarized and in the TE mode over substantially the whole area of the relatively large window through which the microwave beam is launched into the chamber.

In order to heat uniformly and avoid those problems in prior systems where heating is excessive at the edges of the conveyor and deficient at the center, the radiation is formed by the lens and launched directly at the process material, impinging upon the material at the "first pass". Another design feature that contributes to uniform heating is to provide separate microwave power sources for the beacons that are not mutually coherent.

In the preferred embodiment, each of the individual beams is generated outside of the chamber, shaped by the lens and launched into the chamber through a transparent window at the chamber wall. Thus, there are a multitude of lenses and transparent windows arranged along the chamber wall through each of which a formed beam of circularly polarized microwave radiation is launched directly toward the process material. The window is a half wave length of the microwave in thickness to minimize reflections from the window.

In order to minimize the likelihood of ionization around the window on the inside of the chamber, the area of the window is made as large as practical, the beam launched through it is predominantly TE mode waves rather than TM mode waves and is essentially a single mode beam rather than a mixture of modes and the single mode is circularly polarized. One advantage of

circular polarization is that twice as much power is transmitted as for a plane polarized beam for a given peak value of the microwave electric field.

5 It is an advantage in some embodiments of the present invention to provide a dielectric lens or prism near the dielectric window. This allows the beacon apparatus that produces the circularly-polarized, single-mode TE beam spread over the entire area of the relatively large window to be vertically oriented above the chamber (and above the conveyor), with the
10 beacon magnetron upright and not "tipped". Magnetron performance and life is best when operated upright. Furthermore this orientation of the beacon apparatus and the magnetron therein is often preferred from the standpoint of: total floor area required for the heating apparatus; ease and convenience of
15 maintenance; and cost of manufacture.

Vertical orientation of the beacons on top of the cylindrical chamber also facilitates changing the axis of a beacon so that the beam therefrom can be directed to one side or the other of vertical and so pointed as needed at one region or another of
20 the conveyor. The vertical orientation of beacons can be along the axial plane of symmetry of the cylindrical chamber and conveyor therein; or the beacons can be set off to either side of that plane by the effect of a prism lens, and send skewed beams toward the conveyor. The skewed beam does not define a figure of
25 revolution and does not illuminate the conveyor uniformly everywhere it strikes, but equal skewed beams from opposite sides of that plane can balance each other and even provide combined illumination that is uniform across the conveyor.

It is an object of the present invention to provide high
30 power microwave apparatus for continuously heating process

material uniformly throughout even when the material is spread over a relatively large surface.

It is another object to provide such apparatus wherein some of the difficulties and problems of the past are avoided.

5 It is another object to provide apparatus for microwave heating and vacuum drying wherein some of the problems of prior apparatus of this sort are avoided.

It is a further object to provide microwave heating and drying apparatus wherein problems of arcing are reduced or avoided.

10 It is another object to provide microwave heating and drying apparatus wherein the problems of reflection into the source of microwave energy, cross-talk, uniform high power continuous heating, inoization and arcing are reduced and/or avoided.

It is another object to provide a microwave lens for shaping and/or directing and focusing a pattern of microwave energy launched into microwave heating apparatus.

15 It is a further object to provide improved microwave heating apparatus.

Description of the Drawings

20 Figure 1 is a cross section of continuous process microwave heating and vacuum drying apparatus for treating a process material;

Figure 2 shows the same apparatus in cross section taken longitudinally through the apparatus;

25 Figures 3 and 4 show in detail the structure 6 for converting linearly polarized radiation to circularly polarized radiation, and:

Figure 5 is a side cross section view of structure for providing a dielectric prism lens adjacent to the outside of the chamber window for directing and/or shaping or focusing the circularly polarized microwave radiation as a skewed beam toward the conveyor.

Figure 6 is the top view of the dielectric prism lens structure 8;

Figure 7 is the top view of the layers of dielectric showing construction of the prism lens; and

Figures 8 and 9 are a side cross section view and top view of the layers of dielectric for another lens configuration for forming a direct focused beam that is not skewed as the beam formed by the lens shown by Figures 5, 6 and 7.

Description of An Embodiment of the Invention

Turning first to the Figures 1 and 2, there is shown a section of cylindrical microwave chamber. The chamber is defined by the chamber wall 12 that is electrically conductive. It is cylindrical in shape, because that shape is intrinsically strong and best able to withstand the pressures produced on the chamber when it is evacuated as, for example, in a microwave heating and vacuum drying process. Within the chamber is a conveyor belt 21, a section of which is shown in the Figures, positioned substantially at the center of the chamber and

extending longitudinally therethrough. The conveyor belt carries the process material 22 usually distributed evenly along and across the belt.

5 Only a section of the complete chamber is shown in these Figures. It is the section where the process material is illuminated by the high power directional microwave beams to heat the material. There are well known structures and techniques for vacuum sealing the ends of such a cylindrical chamber, for mounting and powering a conveyor system within the chamber
10 and for feeding the process material on-to and off-of the conveyor belt. Also, there are many known techniques for sealing the chamber against leakage of microwave energy from the chamber that could be hazardous and/or wasteful. In as much as none of those techniques are the particular subject of the present
15 invention, they are not described herein.

Along the section of the cylindrical chamber disclosed in the drawings, all on the same side of the conveyor belt 21, six beams of microwave energy are launched into the chamber, each beam coming from a different beacon and directed to a specific
20 area of the belt (presuming the belt to be stationary for the moment). The spatial arrangement of the beams is regular; they are uniformly spaced longitudinally along the belt in pairs, each pair including the left beam and the right beam (as viewed in the direction of the moving belt - Fig. 1). Thus, the
25 arrangement of the beams along the chamber is symmetrical about the plane defined by line 23 shown in Figure 1.

The microwave radiation contained within each beam is preferably of substantially uniform intensity across the beam and is circularly polarized. Furthermore, where the beams enter
30 the cylindrical chamber, defined by walls 12, through an opening 13 in the chamber, the beam substantially completely fills that

opening. As shown in Figures 1 and 2, the beams are defined by broken lines and are denoted 24, 26 and 28 along the left side of the chamber 25, 27 and 29 along the right side of the chamber. Each beam preferably overlaps the adjacent beams and so insures that along this microwave heating section of the chamber substantially the whole area of the conveyor belt 21 is illuminated by the beacons. Furthermore, by overlapping the beams, the tendency is to compensate for the reduced intensity of radiation at the edges of the beams.

The uniform arrangement of equal beams is preferred. If unequal beams are used and/or the beam spacing is not regular, particular heating effect should be achieved; however the problem becomes complicated. The particular embodiment described herein suggests using equal beams all of the same intensity and size, uniformly spaced along the chamber and overlapping where they illuminate the conveyor belt just enough to insure complete illumination along and from side to side thereof in the microwave heating section of the apparatus. Furthermore, each of the beams is from a different beacon or source wherein the microwave energy is generated, converted to a linearly polarized TE mode, then converted to circular polarization, spread, redirected and launched into the chamber. The separate beacons or sources, denoted 34, 36 and 38 on the left side and 35, 37 and 39 on the right (one for each beam), may be constructed substantially identical to each other as a matter of convenience.

The process material is carried through the microwave heating section shown in Figures 1 and 2 on the conveyor belt and heated by the direct radiation of the beams. Thus, the process material is primarily heated by the first pass of microwave energy from the microwave sources and there is no primary dependance upon

reflections of the microwave energy within the chamber to direct it to the process material. Hence, there is no need of microwave mode stirrers within the chamber. In the preferred embodiment, each beam is derived from a different beacon or source and, there is no phase coherence between the beams so, again, there is no need for mode stirrers within the chamber. In the preferred embodiment there is no direct radiation from one beacon into another beacon and since the beacon radiation is circularly polarized, a negligible amount of radiation from a beacon that may reflect within the chamber will re-enter the beacon it came from.

Thus, reentrant, cross-talk and moding problems that have occurred with prior systems are avoided.

Beacons

The beams 24 through 29 are produced by beacons or sources 34 through 39 respectively. These beacons may be constructed substantially all the same and so only one of them, beacon 34 is described in detail herein below.

The beacon generator consists of a microwave power source and polarization convertor and a microwave beam forming assembly which includes a sealed transparent dielectric window in the chamber and a dielectric lens. The microwave power source is magnetron 1. The coaxial output section 2 from the magnetron feeds a standard wave guide section 3, also called a launcher, that launches the microwave energy into the polarizing and beam forming portions of the beacon generator.

The polarizing section of the beacon includes a quarter wave length transformer section 5 between the launcher 3 and

the polarization converter 6. The converter 6 consists of a square waveguide and means, denoted 7, within the square waveguide for converting linearly polarized radiation from the launcher into circularly polarized radiation. Thus, the microwave radiation flowing out of the convertor 6 is circularly polarized and flows into the beam forming section of the beacon at the square top end of conical wave guide coupling 8 that transforms to the conical shape at the bottom end thereof and contains a dielectric lens 9 at the wide circular bottom end thereof. The lens is immediately adjacent and above the dielectric window 10 that is larger diameter than the lens and seals to holder 19 that, in turn, seals to cylindrical channel 11, connected directly to an opening 13 in the wall of the chamber 12. Suitable flanges at 14, 15, 16, 17 and 18 connect these various parts and sections together as shown in the Figures. All of these flanges must provide contiguous conductive connections between the parts to insure ideal operation without arcing or leakage of microwave energy or mode transformation. In addition, flange 18 must seal against the vacuum within the chamber when the equipment is used for vacuum drying and microwave heating and, as mentioned above, the window must be sealed to its holder 19.

The curve 9a of the dielectric lens, the electrical thickness of the dielectric window 10 and the dimensions of the cylindrical chimney 11 are all designed to produce the particular beam direction and shape that is desired. More particularly, it is generally desired that the beam 24 from beacon 34 be directed to uniformly illuminate an area of the conveyor 21 that begins at the outside edge 21a of the conveyor and extends across the conveyor past the center at 21b. Similarly, beacon 35 produces the beam 25 that uniformly illuminates the conveyor from the opposite edge 21c somewhat past the middle at 21b; and so at the

middle, the two beams 24 and 25 overlap to some extent. This insures complete illumination from side 21a to side 21b of the conveyor.

Beacon 35 can be constructed identical to beacon 34, but would be a mirror image of it, as viewed in Figure 1. Thus, these beacons tend to produce beams directed radially inward from the edge of the cylindrical chamber 12 toward the center of the chamber and the subsequent pairs of beacons, 36 and 37 and 38 and 39 do the same. Clearly, beacons 34, 36 and 38 can be constructed identical to each other and beacons 35, 37 and 39 can be constructed identical to each other and the even numbered beacons are mirror images of the odd numbered beacons.

Figures 3 and 4 show details of construction of the polarization converter 6. It consists of a square wave guide section 6a in which are mounted dielectric plates 7a and 7b congruous to each other across a diagonal of the square. These plates are longitudinally staggered along the length of the square wave guide. They are the same length, (L1 plus L2) and one is staggered ahead of the other by the dimensions L2. L1 is of such a length that:

$$(m + \pi) - (n + 2p) = \frac{\pi}{2}$$

where $m = \frac{2\pi L1}{\lambda g'(1)}$, $n = \frac{2\pi L1}{\lambda g'(1)}$, $p = \frac{2\pi L2}{\lambda g'(1)}$ and m is greater than n.

The dielectric prism lens 9 may be constructed as illustrated by Figures 5, 6 and 7. The experimentally shaped curve 9a of this lens is established by a stack of dielectric plagues 9a to 9j, shown in the side cross section view by Figures 5 and a plan view by Figures 7. The purpose of the dielectric lens in the beacon is to form and direct the beam launched from the conical wave guide 8, skewed toward the center of the chamber.

This prism lens structure is clearly not a figure of revolution about the beacon axis 30. It is symmetrical with

0014121

respect to the plane through the beacon axis, perpendicular to the chamber axis. The thickness of this lens varies around the edge or periphery of the stack. Thus, it is generally prism-shaped. It is thicker at the inside edge toward the chamber plane of symmetry 23, than at its edge away from plane 23. The effect of this lens is to form or focus the beam so that it is directional and direct it to one side of the beacon axis 30, toward the center 21b of the conveyor in the chamber.

The dielectric lens is immediately adjacent dielectric window 10. The thickness D_{10} of the window is one half wave length of the microwave radiation in the dielectric material of which the window is made. Hence, D_{10} is expressed as follows:

$$D_{10} = \frac{\lambda}{2\sqrt{K}} \quad \text{where } K = \text{relative dielectric permittability of the material}$$

The conical wave guide connects to the dielectric window by flange 17 and the window connects to the cylindrical chimney 11 by flange 18. At flange 18 the window seals to the chimney by an O-ring gasket vacuum seal 20 and so the interior of the chamber is vacuum sealed from the exterior ambient and is also sealed from the beacon structure.

Between the flanges 17 and 18, completely enclosing the dielectric window, the holder 19 provides electrical continuity between the wide end of the conical wave guide and the cylindrical chimney 11. Thus, microwave currents conducted by the conical wave guide 8, holder 19 and chimney 11 bound the propagating fields of the microwave energy that flows into the cylindrical treatment chamber 12, and is launched as the beam 24. By this construction, the beam of microwave radiation is substantially all in a single TE mode, circularly polarized and fully blankets the dielectric window. As a consequence of these conditions, the instantaneous peak value of the microwave electric field at the dielectric window on the vacuum side (the chamber

side) is maintained low. It is maintained sufficiently low that is does not cause ionization of the gas inside the chamber even at the low operating pressures desirable for vacuum drying.

Another dielectric lens structure is shown by Figures 8 and 9. This structure is symmetrical with respect to all planes through the beacon axis 30. It defines a figure of revolution about the axis 30 and so the axis of the pattern of radiation that defines the beam issuing from this lens is a continuation of the axis 30. This lens is spherical and has no prism. Using this lens to direct the beam toward the center of the conveyor may require that the beacon be located or oriented with its axis toward the center of the conveyor and so the beacon axis would be substantially axial with respect to the cylindrical chamber in which the center of the conveyor is at the center of the chamber cylinder.

Beacons each with a lens constructed as in Figures 8 and 9 are preferably all in line along the cylindrical chamber directly above the conveyor and so all such beacons would have the beacon axis in the symmetrical plane 23 of the cylindrical chamber. This lens is made up of a stack of dielectric plates 31a, b, c and d each being ring-shaped. The outer peripheries of these plates are all about the same and their inner peripheries are successively larger and so the stack defines the dielectric lens curve 32 and focuses the radiation into a rather narrow highly directional beam directed along the beacon axis 30.

The embodiment of the invention described hereinabove includes and incorporates all of the features of the invention and this embodiment is capable of microwave heating of materials in a continuous process, while, at the same time, (or at least in the same chamber), exposing the materials to a low pressure for vacuum drying. Thus, the apparatus is suitable for microwave

heating and vacuum drying and many of the features of construction provide an advantage for both heating by microwave and vacuum drying. However, it should be kept in mind that some of these features can be applied in other equipments intended only for
5 microwave heating and in processes that are not continuous, all without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

CLAIMS

Claim 1. Microwave heating apparatus for heating a subject material in a process comprising,

- 5 (a) a microwave energy enclosure containing the subject material,
- (b) a source of circularly polarized microwave energy, and
- (c) means for launching said circularly polarized microwave energy into the enclosure as a directional beam directed to illuminate the subject material.

10 Claim 2. Apparatus as in Claim 1 wherein there are a plurality of said beams of circularly polarized radiation launched into the enclosure, all as directional beams and all directly illuminating the subject material.

Claim 3. Apparatus as in Claim 2 wherein, a separate source
15 of circularly polarized microwave energy is provided for each of said beams.

Claim 4. Apparatus as in Claim 3 wherein, for each beam a separate means for launching circularly polarized microwave energy into the enclosure is provided.

20 Claim 5. Apparatus as in Claim 4 wherein, said plurality of beams overlap where they illuminate the subject material.

Claim 6. Apparatus as in Claim 5 wherein, said separate means for launching said beams are uniformly spaced from each other on the inside wall of the enclosure

Claim 7. Apparatus as in Claim 1, wherein,

(a) said means for launching includes a window in the wall of said enclosure transparent to said microwave energy and

5 (b) said circularly polarized microwave energy is transmitted through said window as a substantially single TE mode.

Claim 8. Apparatus as in Claim 7 wherein, the intensity of said microwave energy transmitted through said window is substantially
10 uniform over the whole area of the window.

Claim 9. Apparatus as in Claim 8 wherein, said microwave energy launched through said window is circularly polarized and highly directional.

Claim 10. Apparatus as in Claim 9 wherein, the window is of
15 uniform thickness throughout and is circular as viewed perpendicular to the plane of the window.

Claim 11. Apparatus as in Claim 1 wherein, a plurality of such beams are so launched and directed into the enclosure to illuminate the subject material and said plurality of beams overlap where
20 they illuminate the subject material.

Claim 12. Apparatus as in Claim 1 wherein,

(a) a material conveyor is provided in the enclosure,

(b) the material is carried in the enclosure on the conveyor, and

25 (c) the conveyor carries the material through the beam.

Claim 13. Apparatus as in Claim 12 wherein, a plurality of such beams are so launched and directed into the enclosure to illuminate the subject material and said plurality of beams overlap where they illuminate the subject material.

- 5 Claim 14. Apparatus as in Claim 3 wherein,
- (a) the enclosure defines an elongated space,
 - (b) the conveyor moves the material from one end to the other end longitudinally through said elongated space and
 - (c) the beam illuminates at least a portion of the
 - 10 conveyor,
 - (d) whereby substantially all material carried by the conveyor is illuminated by the beam.

Claim 15. Apparatus as in Claim 14 wherein a plurality of such beams are so launched and directed into the enclosure to

15 illuminate the subject material and said plurality of beams overlap where they illuminate the subject material.

Claim 16. Apparatus as in Claim 15 wherein, said separate means for launching said beams are uniformly spaced from each other on the inside wall of the enclosure.

- 20 Claim 17. Apparatus as in Claim 16 wherein,
- (a) said means for launching includes a window in the wall of said enclosure transparent to said microwave energy and
 - (b) said circularly polarized microwave energy is transmitted
 - 25 through said window in a substantially single TE mode.

Claim 18. Apparatus as in Claim 17 wherein, the intensity of said microwave energy transmitted through said window is substantially uniform over the whole area of the window.

Claim 19. Apparatus as in Claim 18 wherein, said microwave
5 energy launched through said window is circularly polarized and highly directional.

Claim 20. Apparatus as in Claim 19 wherein, the window is of uniform thickness throughout and is circular as viewed perpendicular to the plane of the window.

10 Claim 21. Apparatus as in Claim 1 wherein a dielectric lens situated in the path of the beam near the region of entry of the beam into the enclosure is provided for modifying the beam.

Claim 22. Apparatus as in Claim 21 wherein the lens modifies the beam pattern.

15 Claim 23. Apparatus as in Claim 21 wherein the lens modifies the beam direction.

Claim 24. In microwave heating apparatus for heating a subject material in a process wherein a microwave energy enclosure contains the subject material and microwave energy is launched
20 into the enclosure as a directional beam, the improvement comprising,

- (a) a microwave radiation lens that intercepts the energy before it illuminates the subject material and focuses the energy toward the subject material as a beam,
- 25 (b) the lens including a body of dielectric material that varies in its dimension in the beam direction across the body transverse to the beam direction.

Claim 25. Apparatus as in Claim 24 wherein said body dimension is thickness and is greatest at an edge of the body, the edge being at the outer periphery thereof.

Claim 26. Apparatus as in Claim 25 wherein the thickness is
5 less at the geometric center of the dielectric body than at an edge thereof.

Claim 27. Apparatus as in Claim 25 wherein the thickness is less at another edge than at the geometric center thereof.

Claim 28. Apparatus as in Claim 24 wherein the dielectric body
10 is comprised of a plurality of individual layers of dielectric material of different peripheral dimensions, stacked up, one upon another.

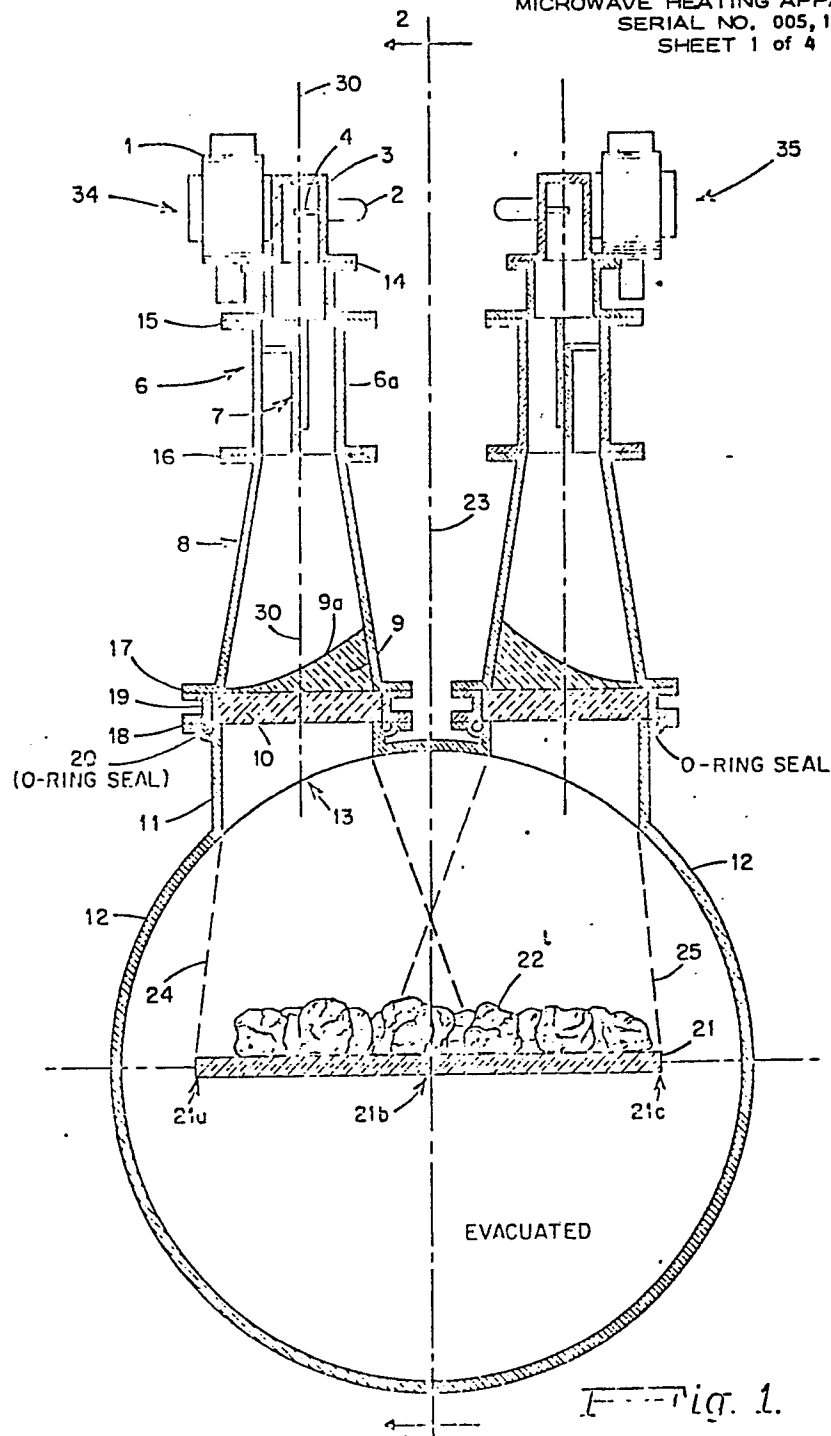
Claim 29. Apparatus as in Claim 24 wherein the thickness is
15 less at the geometric center of the dielectric body than at any place along the periphery thereof.

Claim 30. Apparatus as in Claim 29 wherein the dielectric body is comprised of a plurality of individual layers of dielectric material, stacked up, one upon another, the direction of the stack being substantially parallel to the direction of the
20 microwave energy intercepted by the lens and at least some of the layers are ring shaped.

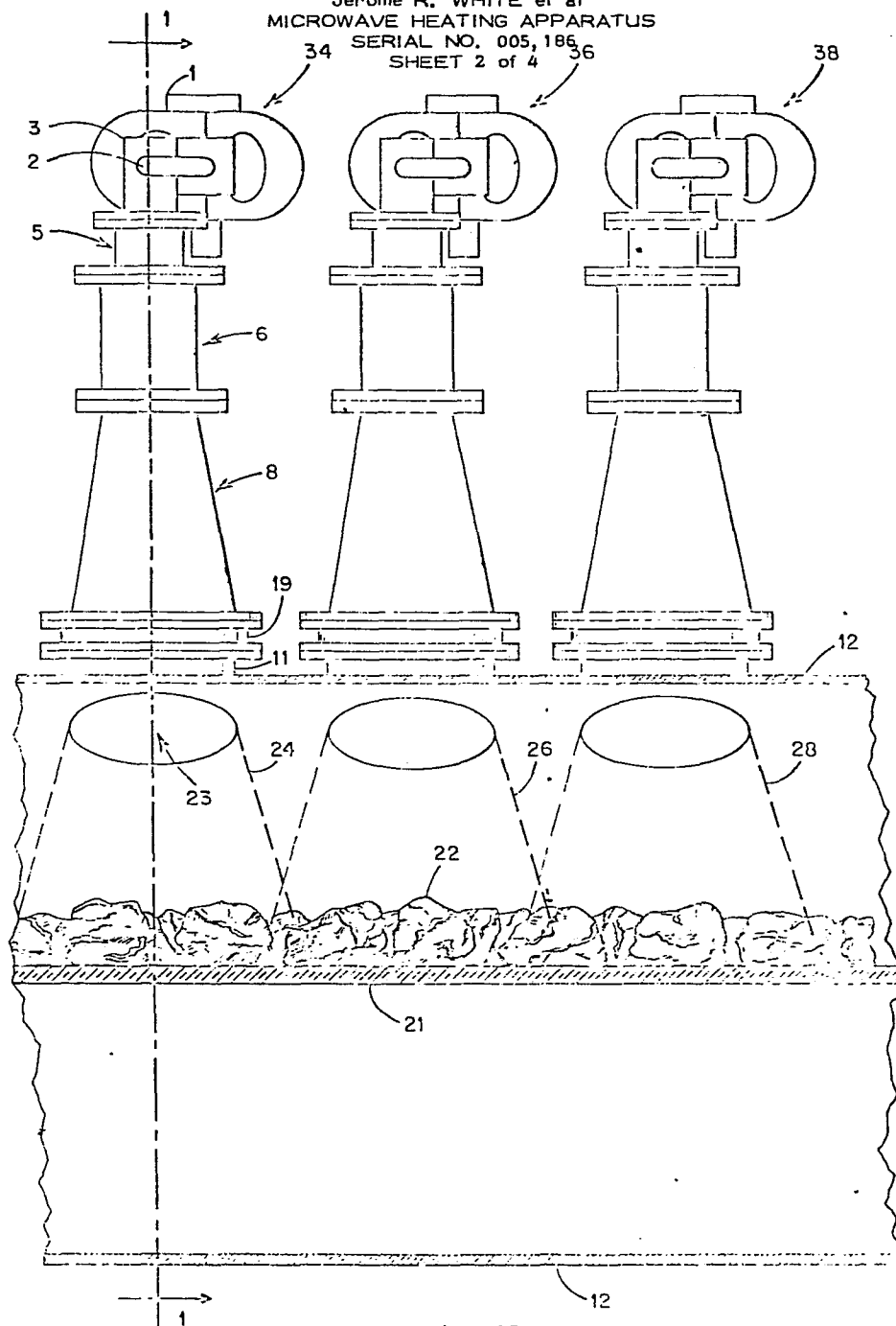
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Jerome R. WHITE et al
MICROWAVE HEATING APPARATUS
SERIAL NO. 005,186
SHEET 1 of 4



Jerome R. WHITE et al
 MICROWAVE HEATING APPARATUS
 SERIAL NO. 005,186
 SHEET 2 of 4



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MICROWAVE HEATING APPARATUS
SERIAL NO. 005,186
SHEET 3 of 4

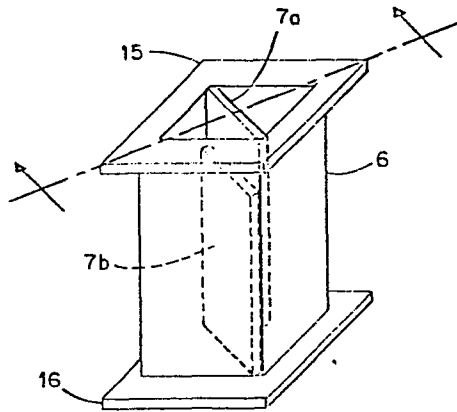


Fig. 3.

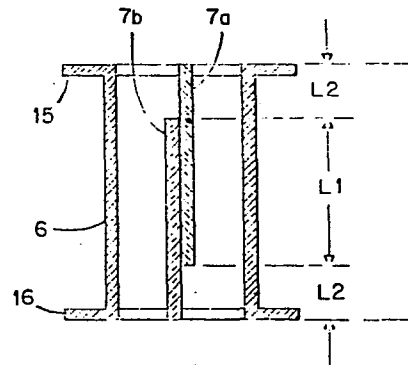


Fig. 4.

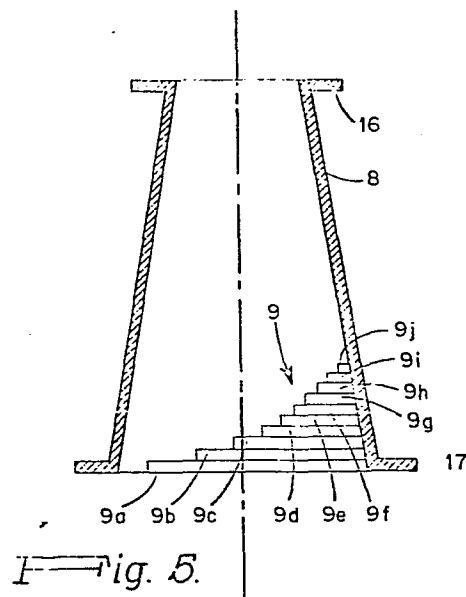


Fig. 5.

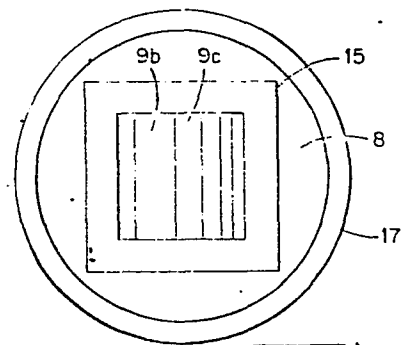


Fig. 6.

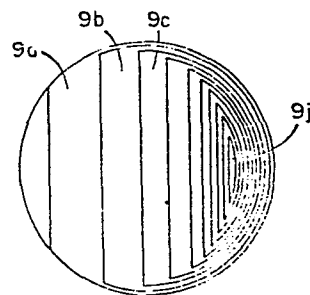


Fig. 7.

0014121

Jerome R. WHITE et al
MICROWAVE HEATING APPARATUS
SERIAL NO. 005,186
SHEET 4 of 4

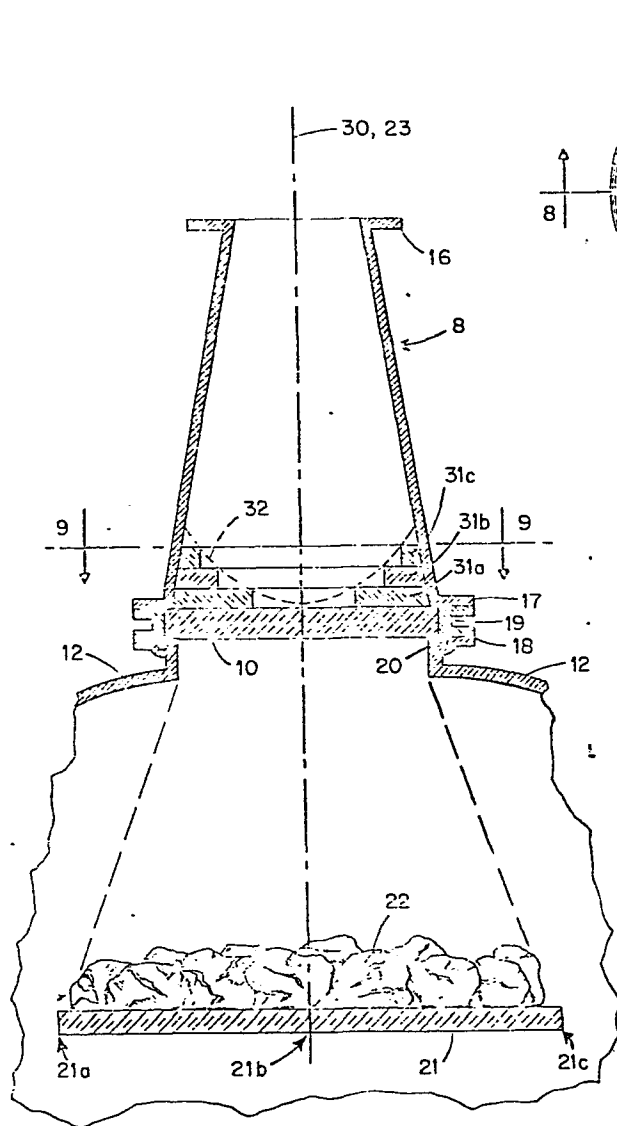


Fig. 8.

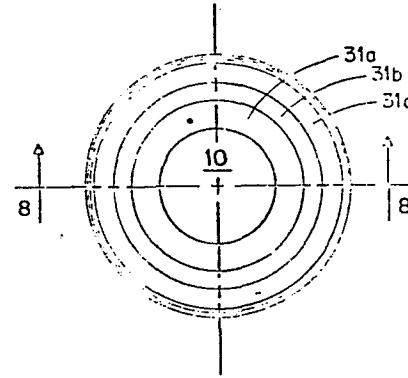


Fig. 9.

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European Patent
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EUROPEAN SEARCH REPORT

Application number

EP 80 40 0045

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>FR - A - 2 275 961 (ANVAR)</u> * Page 1, line 33 - page 2, line 2; page 2, line 32 - page 3, line 1; page 5, lines 18-23; figure 1 * -- <u>US - A - 2 480 682 (RAYTHEON)</u> * Column 2, line 53 - column 4, line 36 * -- <u>US - A - 2 801 412 (MAYBURY et al.)</u> * Column 3, lines 34-51 * -- <u>DE - C - 832 026 (SIEMENS)</u> * Page 2, lines 50-62 * -- <u>US - A - 2 599 864 (ROBERTSON-SHERSBY-HARVIE)</u> * Column 2, lines 16-50 * -- A <u>US - A - 2 603 741 (SEIFRID et al.)</u> * Column 3, lines 49-70; figure 1 * -- A <u>FR - A - 2 284 945 (PHILIP MORRIS)</u> * Page 4, lines 29-36; figure 1 * ----	1,2,5, 6,8, 11-15 1,2,4, 7-9, 17-19 7,17, 21,22, 24,28, 30 7,17, 21,22, 24-26, 29,30 21-23, 25-27 1,14 1,14	H 05 B 6/78 6/80 TECHNICAL FIELDS SEARCHED (Int.Cl. 3) H 05 B 6/78 6/80 6/74 6/72 6/64 H 01 Q 19/08 H 01 P 1/17 CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons &: member of the same patent family, corresponding document
☒ The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		24-04-1980	RAUSCH