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[54] **MICROWAVE HEATING AND VAPOR CONDENSING APPARATUS**

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[52] **U.S. Cl.** **219/10.55**, 34/1

[51] **Int. Cl.** **H05b 9/06**

[58] **Field of Search** 219/10.55; 34/1

[56] **References Cited**

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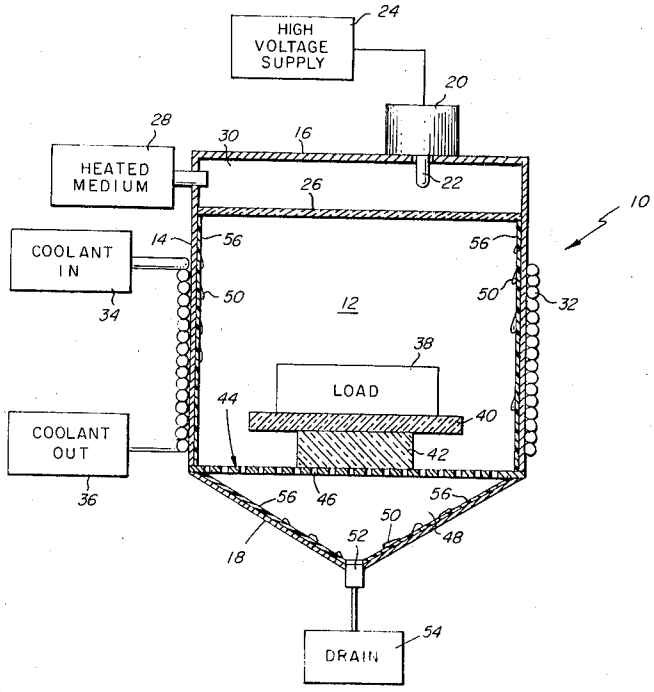
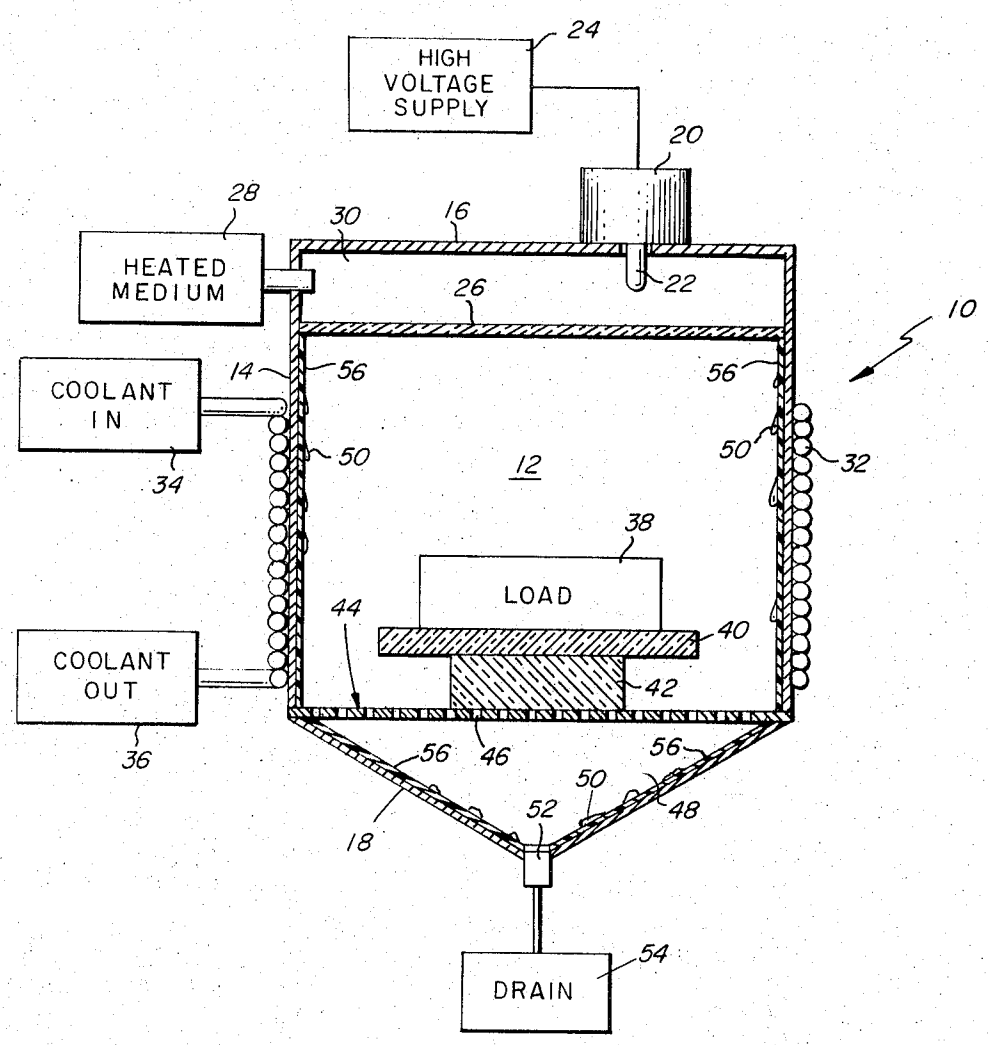
[57] **ABSTRACT**

Microwave apparatus together with an intergral vapor condensation collection system is disclosed for any heating and/or drying application. The oven enclosure walls include means for the circulation of a fluid medium to condense substantially all vapors released by the treated material. The condensed fluids are collected in the lower section of the apparatus by gravity and are either recirculated or removed. The microwave energy generator means is suitably isolated by energy permeable means, as well as, a warm air circulation system to minimize attenuation of the energy by the condensed vapors. Perforated partition means are provided in the collector region to substantially inhibit the escape of microwave energy from the oven enclosure.

2 Claims, 1 Drawing Figure




HIGH VOLTAGE SUPPLY
24
20
28
30
16
HEATED MEDIUM
22
26
10
COOLANT IN
14
56
56
50
50
32
34
12
38
LOAD
44
40
COOLANT OUT
42
36
56
46
56
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52
48
18
DRAIN
54

MICROWAVE HEATING AND VAPOR CONDENSING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to microwave heating and, in particular, to the removal of moisture released within confined areas during the application of the microwave energy.

2. Description of the Prior Art

Processing with microwave heating has become widely accepted for a large number of domestic and industrial products due to the rapid heating times provided by electromagnetic energy generated from such sources as the magnetron. Heating with microwaves provides the so-called "dielectric heating" phenomenon descriptive of the high frequency oscillatory movements of the molecules within the material by combined interaction with the electric and magnetic fields associated with absorbed electromagnetic energy. A rapid rise in material temperatures cause heating by essentially molecular friction. The electromagnetic energy is typically radiated within an enclosure defining a confined area within which the article is disposed or transported by means of a conveyor. The energy conventionally operates in the region of the electromagnetic energy spectrum having frequencies of 915 ± 13 MHz and 2,450 ± 50 MHz in the industrial, scientific and medical band assigned for such heating apparatus by the Federal Communications Commission. The microwave energy is radiated within an enclosure which is dimensioned to support a plurality of modes at the assigned operating frequency. The energy is distributed in multimode energy patterns by such means as paddle-type mode stirrers and the like. For the purposes of the present description, the term "microwave" is defined as electromagnetic energy in the region of the spectrum having wavelengths in the order of 1 meter to 1 millimeter and frequencies in the order of 300 MHz to 300 GHz.

All materials have differing values of dielectric constant and loss tangent characteristics which control the rate of absorption of energy and, therefore, the rate of heating becomes a varying factor. In certain processing operations frozen products as well as products having a considerable amount of moisture are treated which results in the release of a considerable amount of trapped vapors. To render the processing with microwave more efficient the rapid removal of the moisture is desired to prevent any attenuation of the energy radiated within the confined area. In certain processes the released vapors resulting from the drying or heating operation may be corrosive or toxic and in prior art heating techniques rather costly methods and/or equipment are used to neutralize and/or dispose of such vapors.

An example of a prior art processing technique is the deposition of a platinum catalyst on such materials as ceramic cores which requires the carrying of the platinum material in a solution of hydrochloric acid. The acid solution is driven off as a vapor before the high temperature firing is undertaken. Prior art apparatus employed in such techniques involves long gas-fired ovens, lined with special low-corrosion high-temperature metals and the corrosive vapors are conducted away by means of water curtains or condensed to effectively "scrub" such vapors. In the more effective utilization of microwave energy the removal of vapors during the heating and/or drying operations becomes of importance and, particularly, in processing of products which result in the release of corrosive or toxic vapors.

SUMMARY OF THE INVENTION

In accordance with the teachings of the invention means are provided for the efficient removal of substantially all of the released vapors from products being processed with microwave energy. Condensation on the fluid impervious walls defining the oven enclosure is encouraged by the provision of suitable heat transfer media in close proximity to the walls. Such means include cooling coils coupled to the walls together with forced circulation of any liquid coolant having sufficient flow and thermal absorbing capacity to condense substantially all of the vapors released by the material being dried or heated on the oven interior walls. The condensation is conducted by gravity to the lower section of the microwave heating apparatus where it is collected and can be either reused or disposed of by appropriate means.

Other moisture removal means include the flow of air or other fluids within the cavity walls or other absorbing media to encourage the condensation of the liberated vapors. The condensation on the walls of the enclosure takes place in the region where the microwave electric fields are minimal and, therefore, there is little or no coupling or loss of energy to the condensate formed on the enclosure walls. Where the process involves the liberation of toxic or corrosive vapors a thin layer of a corrosion-resistant plastic material such as that available under the trademark TEFLON will protect the metal walls without hindering microwave energy distribution. To substantially prevent the attenuation of the microwave energy in the input region a microwave permeable panel is provided and warm air circulated adjacent to the panel to inhibit condensation. In the collection region in the lower portion of the apparatus, means in the form of a perforated partition will permit the passage of condensation without the coupling or escape of the microwave energy from the apparatus. Numerous alterations, modifications and variations of the embodiment to be described will be apparent to those skilled in the art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the single FIGURE shown, the invention will now be described in detail. The apparatus **10** comprises a microwave oven enclosure delineating the confined area **12** defined by fluid impervious conductive sidewalls **14,** top wall **16** and tapered bottom wall **18.** A door which may be provided in one of the sidewalls **14** has purposely been omitted in order to aid in the understanding of the invention. The enclosure is radiated by a microwave energy from a source **20,** such as a magnetron, with a probe-type antenna **22** extending through the top wall **16.** A high voltage supply **24** provides for the energization of the magnetron. The described energy source is directly coupled to the apparatus and, if desired, the source may be mounted at a remote location with a waveguide transmission line coupled directly to the top wall **16.** This energy coupling structure has not been illustrated since it will be obvious to one skilled in the art. The input energy section **30** is isolated from the remaining enclosure area by means of a microwave permeable panel **26** that is also

impervious to fluids. A heated medium from source **28** may be circulated within the isolated region **30** to thereby inhibit condensation formation on the panel which would affect microwave energy passage.

The sidewalls **14** are provided with convoluted coils **32** containing a forced circulating coolant fluid medium provided from a source **34,** and egress means **36.** The flow rate is controlled to provide the most efficient condensation of vapors released within the enclosure **12.**

The product to be processed, indicated generally as load **38,** is supported by a dielectric plate member **40** which is in turn supported on a pedestal **42** of a dielectric material to provide for the radiation of the load **38** uniformly on all sides. In addition a partition member **44** having a plurality of perforations **46** is disposed in the bottom portion of the enclosure and supports the pedestal **42.** The perforations **46** are disposed in an array to substantially prevent the escape of any microwave energy through the condensate collection region **48.**

Condensation droplets **50** formed along the inner portions of sidewalls **14** are permitted to pass through the partition member **44** perforations **46** into the collection region **48** defined by tapered walls **18** by means of gravity and are directed to the outlet passage **52.** A drain or pump means **54** provide for the removal of the condensate or reuse if desired.

Where corrosive or toxic vapors are involved sidewalls **14,** as well as bottom wall **18,** may be provided with a thin layer of any suitable corrosion-resistant material **56.** The provision of this layer provides for the protection of the metallic sidewalls and will not hinder the distribution of the microwave energy within the enclosure.

There is thus disclosed a unique microwave apparatus which provides an integral vapor condensing and collector system for substantially all microwave heating and drying applications. The invention is particularly useful where the liberated vapors are of a corrosive or toxic nature. The described apparatus will eliminate the need for prior art systems providing flow of a hot or warm fluid media to maintain the released vapors at the appropriate temperature for transport from the microwave apparatus to an exterior location. The effective cooling of the oven enclosure walls encourages substantial condensation and the means for the conduction of released vapors as a fluid to an exterior location. Other condensation and removal systems may be incorporated such as the circulation of heat transfer media in the enclosure walls or the provision of other absorbing and conversion means for the transporting of the heating vapors to an exterior location. It is intended that the foregoing description of the illustrative embodiment be considered broadly and not in a limiting sense.

I claim:

1. Microwave heating apparatus comprising:
a source of electromagnetic energy;
an enclosure defined by fluid impervious top, bottom and sidewall members;
means for coupling said energy to said enclosure;
means for disposing a load within said enclosure;
means for circulation of a heat transfer fluid medium over a substantial portion of said sidewalls to condense vapors on the interior walls of said enclosure; and
means for collecting and removing said condensation from said enclosure.

2. Apparatus according to claim **1** wherein said energy coupling means are substantially isolated from said enclosure by a panel member impervious to fluids and permeable to said energy disposed between said top and bottom wall members to form an input energy region.

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