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White

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[45] **June 12, 1973**

[54] **MULTI-CAVITY MICROWAVE APPLICATOR**

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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**

UNITED STATES PATENTS

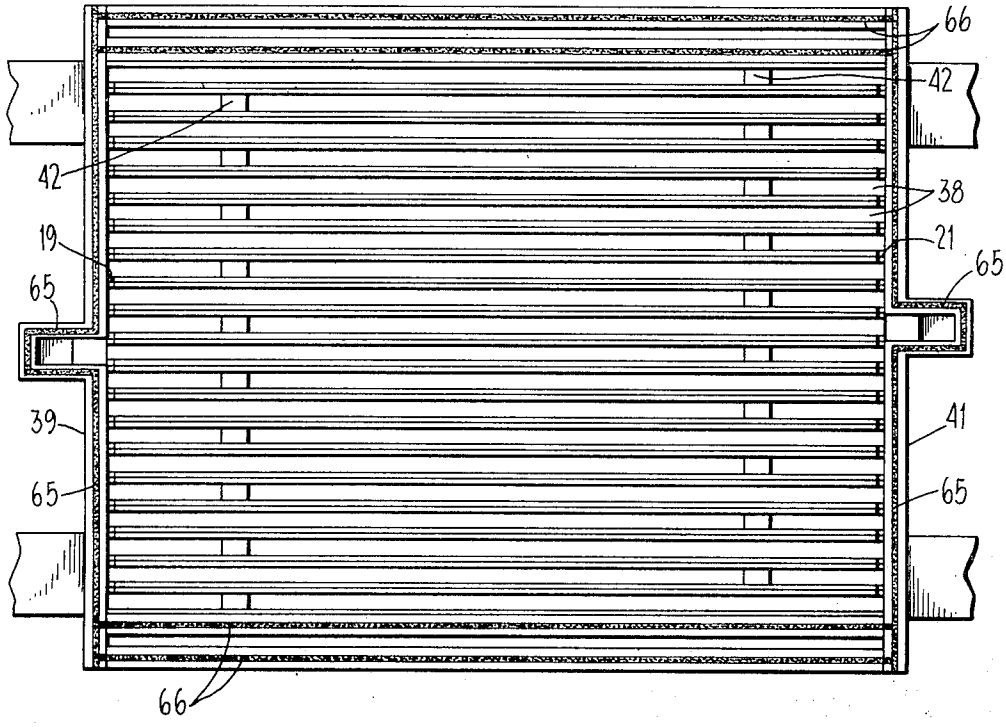
3,449,836	6/1969	Schreiber et al.	219/10.55 X
3,488,858	1/1970	Bilbrough	219/10.55 X
3,582,597	6/1971	Smith	219/10.55

Primary Examiner—C. L. Albritton
Assistant Examiner—Hugh D. Jaeger
Attorney—C. Michael Zimmerman

[57] **ABSTRACT**

A multi-cavity applicator is described for treating a moving web of material uniformly across its width with microwave energy. The applicator is made up of two separate sets of cavity resonators which are intermeshed with one another to provide a material treatment zone made up of alternating resonators of the two sets. The cavities of each set are energy coupled together and are individually dimensioned to support one of the classes of modes consisting of $TE^{\square}_{1,0,n}$; $TM^{\square}_{1,1n}$; $TE^{\circ}_{1,1,n}$ and $TM^{\circ}_{0,1,n}$ where n represents an integral number. Moreover, the resonators of each set in the treatment region are so positioned relative to the resonators of the other set that the points of highest electrical intensity in adjacent ones of such resonators are in space quadrature, i.e., the points of highest electrical intensity in the adjacent resonators are **90°** spacially out of phase.

12 Claims, 10 Drawing Figures



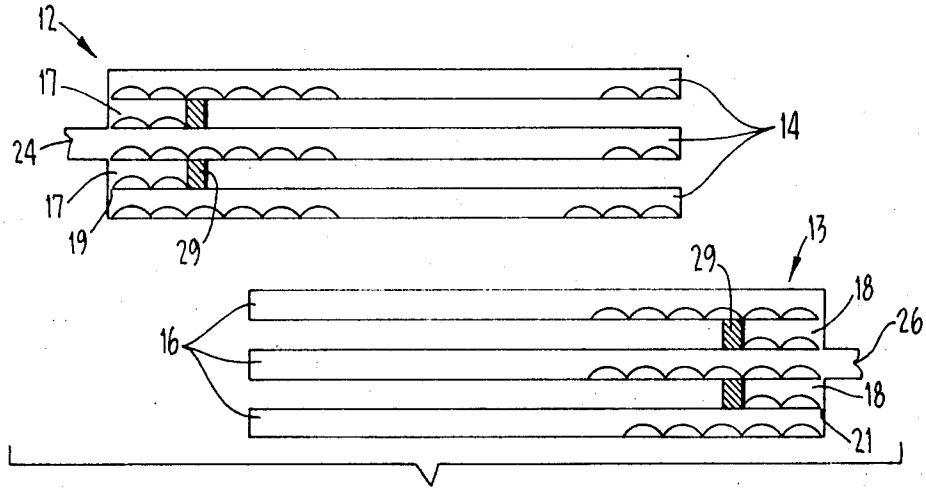


Fig_1

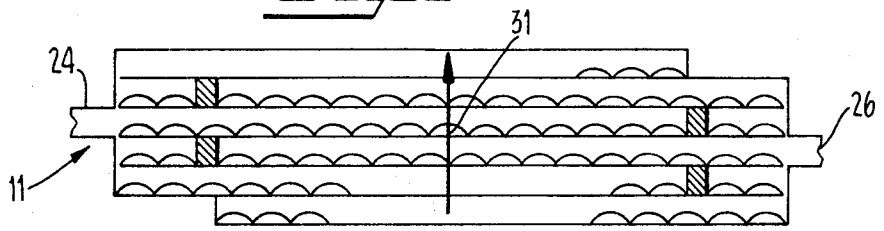
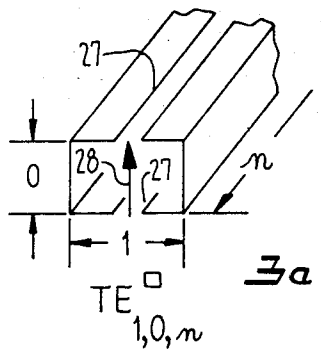
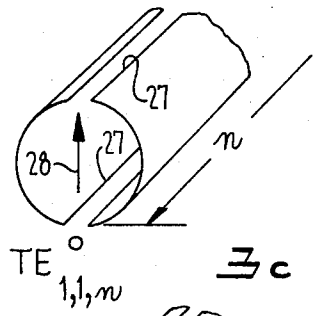


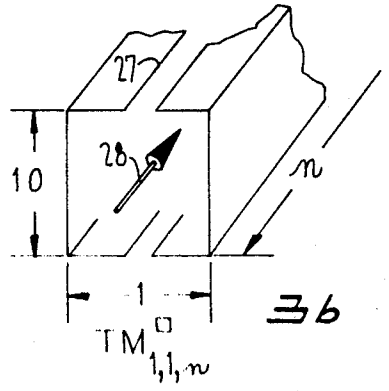
Fig_2



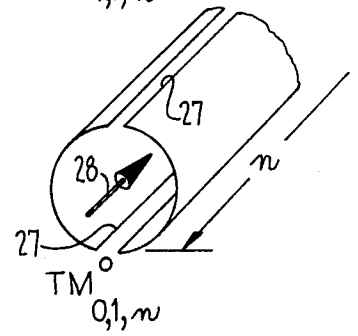
3a



3c



3b



3d

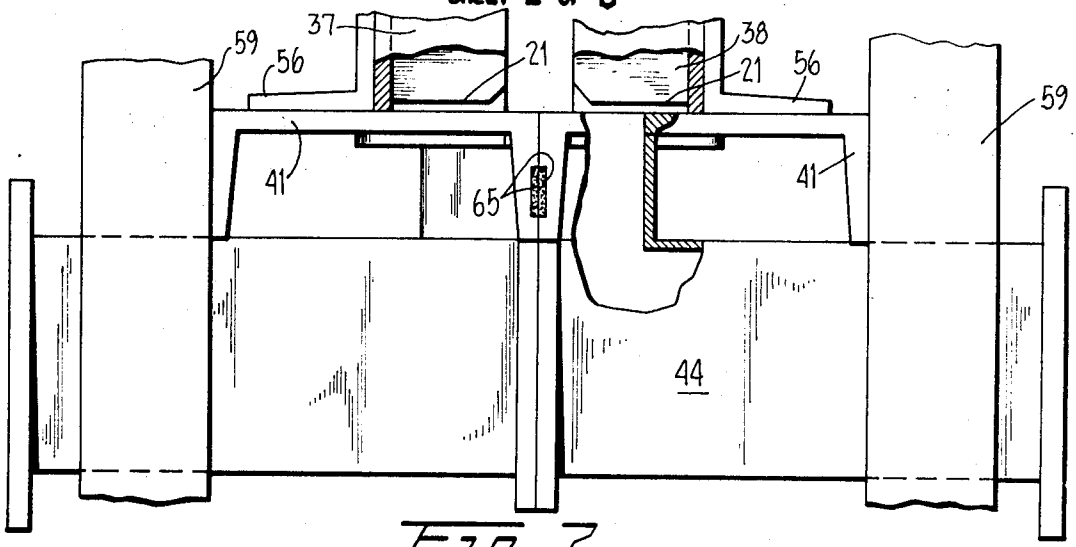

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Fig-2

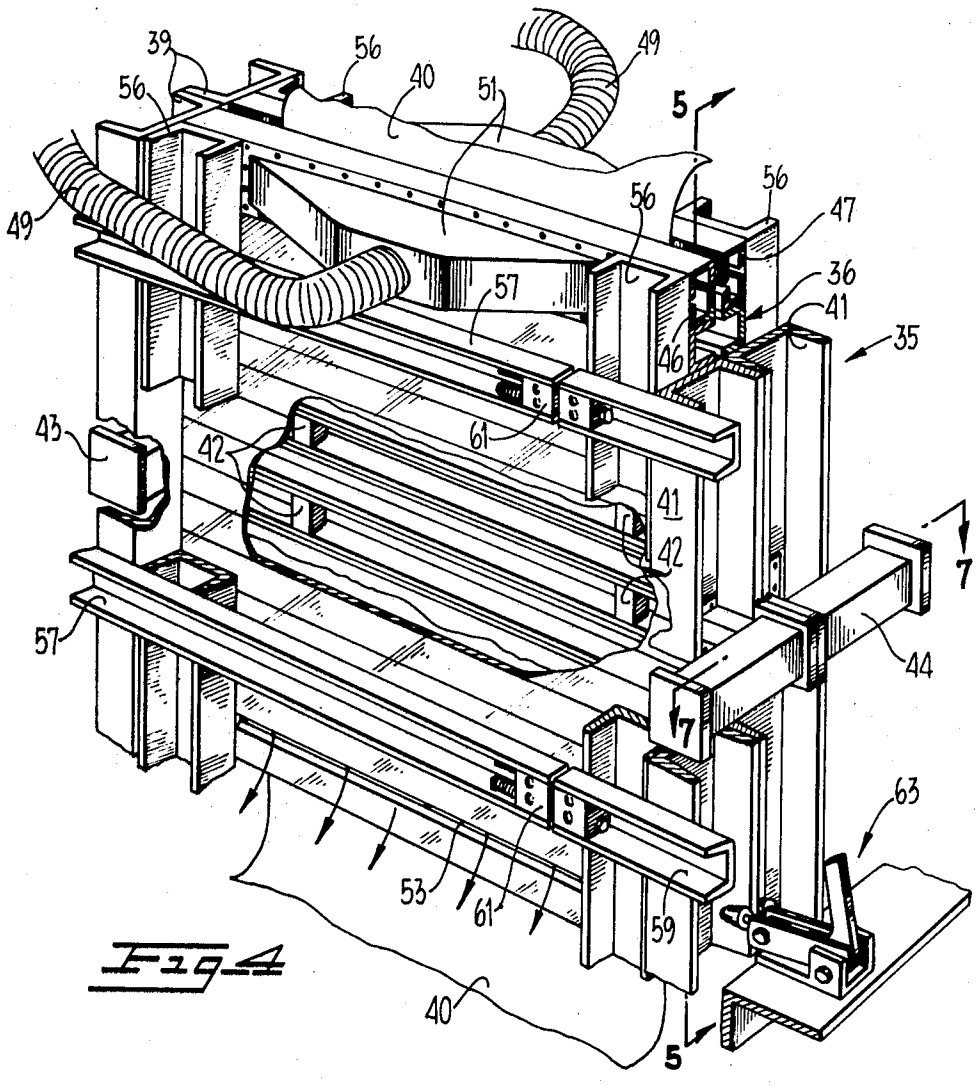

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Fig-4

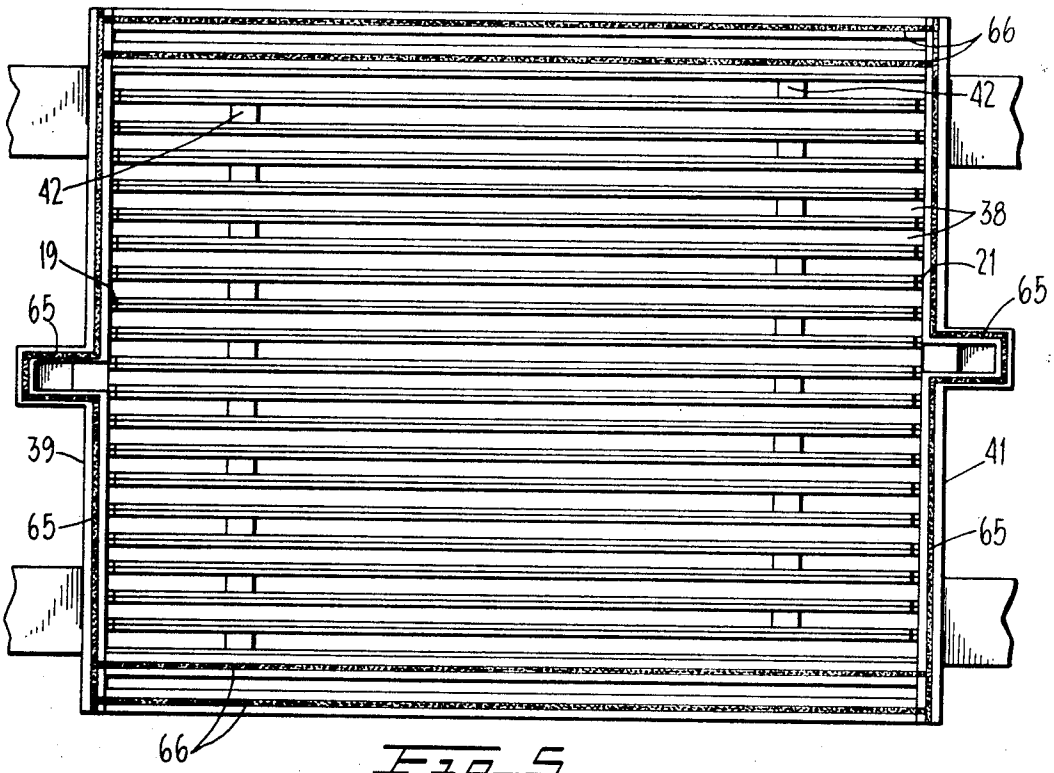

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Fig_5

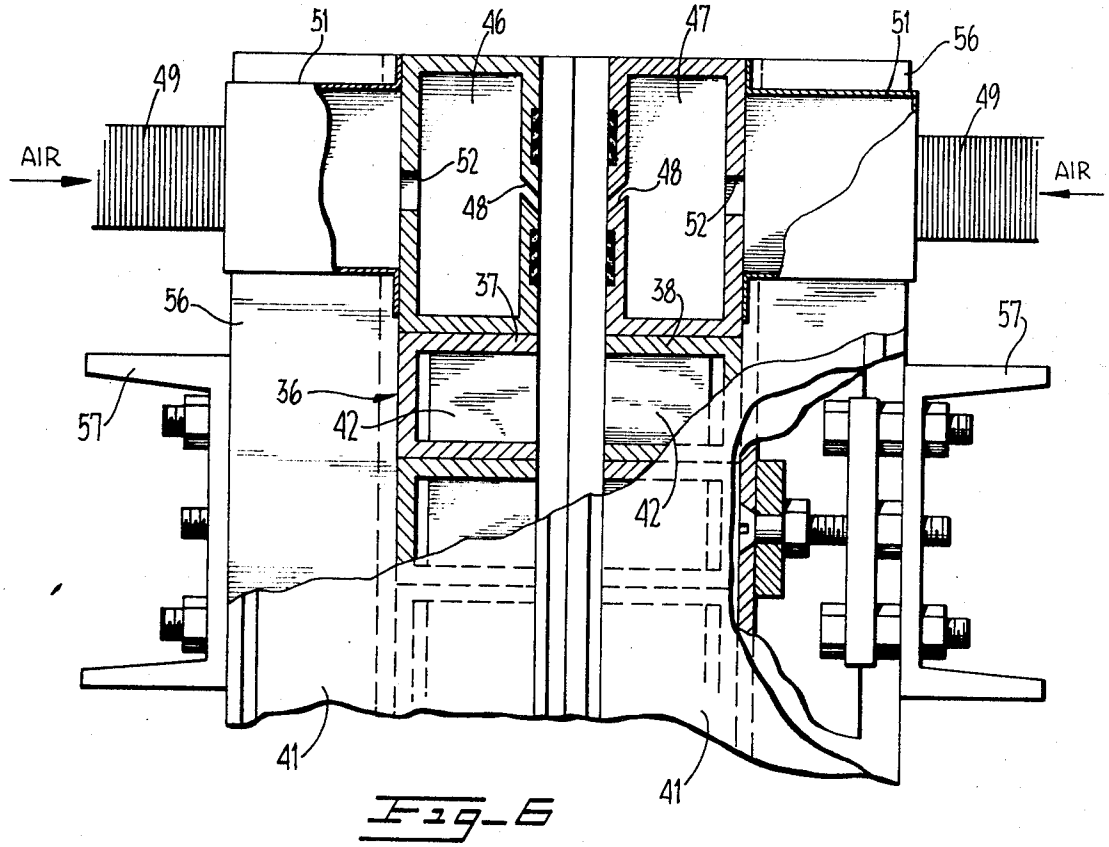

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Fig_6

MULTI-CAVITY MICROWAVE APPLICATOR

BACKGROUND OF THE INVENTION

The present invention relates to the treatment of sheet material with microwave or other electromagnetic energy and, more particularly, to a multi-cavity resonator applicator capable of treating a web of material uniformly across its width.

Because microwave radiation is capable of providing thermal energy within the interior of a dielectric material without such energy necessarily having to be conducted inwardly of the material from its surface, microwave energy is finding wide usage as a heating means. There is a large industrial field, though, which to date has not made substantial use of microwave energy. This is, the microwave heating art has not developed a microwave applicator that has received widespread industrial acceptance for the treatment of thin wide sheets of material, such as in the process for making or coating paper or plastic films, at present commercial widths and speeds. This kind of material is typically made or provided as a continuous sheet of the material wound into a convolute roll, and is referred to in the industry as "web" material, irrespective of whether or not it is a woven or fibrous material. As used wherein, "web" is meant to have the broader industrial interpretation and apply to sheet material of any composition which is normally manufactured and stored in convolute rolls.

Several approaches have been taken in the past in attempts to develop a commercially satisfactory microwave applicator for the treatment of web material. Some of such approaches have been based on the use of a "serpentine" traveling have structure which makes a multitude of passes across the path of a moving web of material desired to be treated. One major problem with this type of applicator is that it often has a quite low efficiency is converting the microwave energy to thermal energy within the material. Moreover, impractially large traveling wave structures are needed to convert sufficient microwave energy to thermal energy to obtain the desired heat treatment of certain industrially important materials. Another major problem with serpentine applicators is that non-uniform heating is often caused due to residual standing waves in such applicators. These and other factors have limited the use of serpentine traveling wave structures to a few special applications.

In view of the difficulties faced in attempts to design a traveling wave applicator suitable for a range of sheet materials, some workers in the art are now concentrating their efforts toward the development of resonant cavity applicators, i.e., one in which the material to be treated is subjected to standing wave patterns, rather than traveling waves. The problem with this type of applicator, though, is that it generally does not provide a uniform heating rate across the transverse width of a web since standing waves represent space and time variations in field strength and, hence, corresponding space and time variations in heating rate. While various approaches have been taken to increase the uniformity of the heating rate across a sheet of material provided in a cavity resonator, most of such approaches are along the line of designing the cavity to cyclically and sequentially support a plurality of randomly selected different standing wave patterns to smooth out the time-average electrical field strength throughout the cavity. U.S. Pat. Nos. 3,560,694 and 3,560,695 of

which I am named an inventor describe and claim improved applicators of this type. This multi-made approach has not been entirely satisfactory, however, primarily because although random selection of modes, like a shot gun pattern can give uniform heating it does not guarantee the desired uniformity. The result is that even in such arrangements, hot or cold spots (positions of inordinately high or low electric field strength) do develop at various times and places within the applicator, resulting in the formation of overheated or underheated streaks on the material as it passes through the applicator.

SUMMARY OF THE INVENTION

The present invention relates to a multi-cavity (as opposed to a multi-mode) applicator capable of treating a web material with electromagnetic energy uniformly across the transverse width of the web. Such applicator is made up of at least two separate sets of elongated cavity resonators which are all individually dimensioned to support a specific selected mode of electromagnetic energy in a resonant conditions. The two sets of reasonators are intermeshed with one another with elongated resonators of one alternating with elongated resonators of the other in side-by-side relationship, and coupling means are provided within each of the sets to exchange energy between the various resonators of such set.

The elongate resonators of each set alternate with the resonators of the other set in space quadrature. That is, the resonators of one set are offset in space from the resonators of the other set by a distance substantially equal to one quarter guide wavelength of the primary mode of energy supported in such resonators, in a direction transverse to the selected direction of travel of web material through the applicator. Because of this space quadrature relationship, the material to be treated is uniformly treated transversely of its travel direction as it passes through the applicator treatment region. More particularly, the positions of highest field strength in each set of resonators will be 90° spatially out of phase or, in other words, equally spaced between the positions of highest field strength in the other set of resonators, looking in the direction of travel of the material. Because the energy distribution in each of the resonators varies spatially in a generally 180° sinusoidal pattern, the 90° spatial offset will result in the total energy applied to the material during its passage through the applicator to be substantially uniform across the transverse width of such material. Moreover, because the resonators are provided in intermeshed sets, rather than merely as a pair of resonators, the rate at which thermal energy is imparted to the material is controlled so that the desired amount of energy can be imparted to the material without overheating. Also, the energy coupling of the resonators to each other within each set enables the resulting structure to accept energy over a relatively wide frequency band.

The primary mode which can be supported within each of the resonators is most easily selected by dimensioning such resonators relative to the frequency of the energy introduced therein so that such resonators will support any one of the class of modes consisting of TE $\square_{1,0,n}$; TM $\square_{1,1,n}$; TE°$_{1,1,n}$ and TM°$_{0,1,n}$ where n is an integral number and 1 is the numeral one. In each of the modes, the positions of high electrical field strength are not randomly positioned throughout the resonator, but

rather are located equal distances apart generally in the midplane of each resonator. Thus, by providing a material passageway through the resonators at the midplane, the material will not only be subjected to the desired space quadrature but also to a high intensity of the electrical fields.

The present invention includes other features and criteria which are important and advantageous, and which will become apparent from the more detailed description of a preferred embodiment which follows:

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the accompanying three sheets of drawings:

FIG. 1 is a schematic representation of two separated sets of cavity resonators making up the applicator of the invention, will sinusoidal representations of a desired primary mode of microwave energy excited in the same;

FIG. 2 is a schematic representation similar to FIG. 1 showing the cavity resonators intermeshed in a manner providing a treatment region having a 90° spatial relationship between the points of highest electric field intensity in adjacent resonators comprising the treatment region;

FIGS. 3*a*–3*d* are schematic views of cavity structures illustrating preferred classes of modes utilizable in the present invention;

FIG. 4 is a partially broken-away perspective view of a preferred embodiment of the invention;

FIG. 5 is a sectional view taken on a plane indicated by the lines 5—5 in FIG. 4, being also the internal view provided by one-half of the applicator when it is opened as discussed infra;

FIG. 6 is an enlarged and partial broken away end view of the preferred embodiment of FIG. 4; and

FIG. 7 is an enlarged, partial view taken on a plane indicated by the lines 7—7 in FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference is first made to FIGS. 1 through 3 for a general description of the structure and theory of the instant invention. A schematic representation of a multi-cavity applicator of the invention is generally referred to therein by the reference numeral 11. As can best be recognized by comparing FIGS. 1 and 2, the applicator 11 is made up of two separate sets 12 and 13 of cavity resonators. Each set 12 and 13 of resonators includes a plurality of spaced apart elongated cavity resonators 14 and 16, respectively which, when the two sets are intermeshed together, provide a treatment zone or region. The elongated cavity resonators of each set are coupled together by short, coupling resonators 17 and 18, respectively. More particularly, with respect to resonator set 12 for example, a coupling cavity resonator 17 is located between each pair of spaced-apart elongated resonators 16 with its side walls in common with the adjacent side walls of the pair of elongated resonators between which it is situated.

The coupling cavities 17 and 18 act as means for transferring energy between the elongated resonators 14 and 16 of the respective sets. In this connection, it will be noted that the outward end walls of all the cavities of each set are in alignment with one another, and the common side walls between each coupling cavity 17 and 18 and its adjacent elongated cavities terminates a spaced distance from such aligned end walls. This results in coupling slots 19 and 21 being formed adjacent the end walls to provide electrical communication between all the cavities of each of the respective sets 12 and 13. Thus, dependent on the dimensions of the various cavities and the energy introduced therein, all of the resonators of each set of resonators can be fed with energy of the desired frequency via a single port 24 and 26, respectively.

The cavity resonators of each set are so dimensioned relative to the frequency of the energy to be introduced therein that from a practical standpoint, only certain desired classes of modes are supported. Such modes are chosen so as to place the points of high electric field intensity substantially all in one plane to facilitate treatment of web material by passing the same along such plane, and so as to provide the control necessary to obtain space quadrature. FIGS. 3*a*–3*d* schematically show four cavity sections designed to support four different classes of modes which are most desirable for use with the instant invention. As is shown, each of the four sections is provided with a pair of opposed slots 27 which represents the passageway through the cavity for a sheet of material to be treated. As can be seen from FIG. 3*a*, one of the desirable classes of modes is the TE $\square_{1,0,n}$ class. That is, the cavity should be rectangular and between about one quarter and one half guide wavelength long in the direction of flow of the material, and between one half and one guide wavelength long in the direction perpendicular to such material. The length of the cavity should be an integral number of the desired guide half wavelengths long. With this arrangement, the electric field vector of highest electric intensity, represented at 28, of substantially all of the modes which can be supported within the structure will be in the plane of the sheet of material to be treated.

FIG. 3b schematically represents another rectangular cavity resonator which will support desirable class of modes, those modes having the electric field vector 28 of highest electric intensity also within the plane of the material to be treated by extending generally parallel to the slots 27. FIGS. 3*c* and 3*d* represent the cylindrical analogs of FIGS. 3*a* and 3*b*, respectively, which cylindrical structures are equally applicable to the instant invention. In this connection, it will be appreciated by those skilled in the art that various tubular cavities having elliptical cross sections can be designed which are equivalent to either the rectangular or circular arrangement shown for supporting substantially the same modes.

The rectified sinusoidal indicia within the cavity resonators represents the absolute value of the spatial variations of the electric field intensity longitudinally of each of such resonators excited in the TE$\square_{1,0,n}$ mode where n is equal to fifteen for the elongated resonators, and to two for the short, coupling resonators. As depicted in FIG. 2, the sets of cavities are intermeshed together so that adjacent, elongated cavities are transversely or laterally offset from one another by the thickness of the end blocks 29 of the shorter cavities. As a particularly salient feature of this invention, this offset is equal to an odd number of quarter guide wavelengths long, e.g., one quarter guide wavelength as shown in the illustrated arrangement. This results in the fields of adjacent elongated cavity resonators being in space quadrature. This is, the points of highest electrical field intensity in the elongated cavity resonators on

one set are 90° spatially out of phase with the points of highest field intensity in the other. This relationship is represented in FIG. **2**, for example, by the showing of the points of highest electrical intensity (peaks in the sinusoidal curve) of each elongated resonator in one set coiciding with the points of zero electrical field intensity (zero points in the sinusoidal variations) of the elongated resonators of the other set, considering the same in the direction of material flow represented by arrow **31**. Because the variations in electric field intensity are substantially sinusoidal as shown, any point on a sheet of material passing in the direction of arrow **31** through an equal number of elongated cavities of each set will be subjected to the same electric field intensity as every other point passing through such equal numbers of offset cavities. This assures that the desired uniformity of treatment across the full width of material passing through the treatment region between the blocks **29** is obtained. It should be noted that the degree of uniformity required will depend on the material being treated and the tolerances of the operation. The required high degree of uniformity obtainable by treatment with an equal number of cavities of each set is essentially obtained with an applicator with one or two more cavities in one set than in the other, especially if the total number of treatment cavities is large, e.g., greater than twenty.

One other major advantage obtained with the space quadrature of the invention is that there is substantially no energy exchange between the elongated resonators of the respective sets even though they are in space communication by a material passageway extending in the direction of the arrow **31**. This is, when the energy is supported in the resonators in one of the classes of modes which has been previously described, the 90° spatial offset prevents substantially all coupling between the adjacent resonators through the slots provided to enable passage of the moving material from one cavity to the next. Thus, the electrical characteristics of the arrangement can be substantially ignored in dimensioning the material slots to accommodate a desired web of material.

It will be noted that the points of highest electrical field intensity within the coupling cavities and their associated elongated cavities are in phase with one another. This results in energy being exchanged between the cavities through the slots at such locations, which slots are extensions of the material slots. However, for this energy transmission at the sides of the treatment region and through the material slot to be sufficient to fully excite more than two or three adjacent cavities, the coupling region must be fairly long, some times as long as the treatment zone itself. However, both mechanical and energy considerations make it more desirable to minimized the length of such coupling cavities and, for this reason, it is preferred that the previously described additional coupling slots **19** and **21** be used so as to obtain adequate coupling with a minimum of cavity length.

While it should be relatively obvious that one reason for coupling the elongated resonators of each set together is that only one energy feeding point is then needed for each set, another major advantage may not be so obvious. More particularly, it has been found that when a plurality of resonators are coupled together, the collection of resonators as a set exhibits a plurality of spectrally closely-spaced modes, although the number of modes supportable within each resonator does not change. This range of spectrally closely-spaced supportable modes facilitates excitation of the applicator and minimizes the problems of keeping the microwave generator and the applicator turned to the same frequency.

It will be appreciated that many different structural configurations can be designed and made employing the principles of the invention. FIGS. **4** through **7**, however, illustrate a preferred embodiment **35** of such an applicator which is relatively simple in construction and has additional advantageous features. With reference to such figures, it will be seen that the resonators of the invention are provided by a plurality of parallel and closed ended tubular structures **36** arranged in a rectangular array. Each of the tubular structures **36** is made from an electrical conducting material and adjoins it adjacent tubular structures in electrical contact therewith. Moreover, as is best illustrated in FIG. **6**, each of the tubular structures **36** is composed of a pair of rectangular channels **37** and **38** which have their open sides facing one another in spaced and opposed relationship. The result is, in effect, that the applicator is made up of two facing halves. The spacing between the valves provides a passageway through the applicator for a web of material, represented at **40** in FIG. **4**, which is to be treated. As can be seen from FIGS. **5** and **6**, the opposite ends of the channels making up the applicator halves are closed by the base wall of rectangular ends channels **39** and **41**, respectively. Such end channels extend inwardly of the applicator beyond the resonator channels with which each is associated to also provide side closures for the material passageway.

The structure of the two halves of the applicator is identical in most respects and the following description will apply to both halves unless otherwise noted, even though only one of the halves may be referred to at any given place. In this connection, the manner in which tubular structures **36** provide the two sets of cavity resonators of the invention can best be appreciated with reference to FIG. **5** which illustrates the interior construction of the half of the applicator made up by the channels **38**. Each of such channels **38** is divided into a short, coupling cavity of one set of the resonators and an elongated cavity of the other set of resonators. That is, each channel includes a metallic shorting block **42** positioned therein at a location closer to one of the end wall channels **39** and **41** than the other, to thereby divide the channel within which it is situated into short and long resonators. The blocks **42** alternate in adjacent ones of the channels from a position closer to the wall **39** and a position closer to the wall **41** in order to provide the required alternating arrangement of short and elongated cavities of each set. Moreover, the side walls of the channels, except for the outside side walls of the two end channels, terminate short of the end walls **39** and **41** to provide the coupling slots **19** and **21** as described previously. Microwave energy is fed into each of the resonator sets via waveguide junctions **43** and **44**.

Means are provided for directing the flow of air or another desired gas though the material web passageway of the applicator for the removal therefrom of vapor evolved from the sheet of material being treated. For this purpose, rectangular plenums **46** and **47** are mounted adjacent the material passageway at the exit end of the applicator region. Each of the plenums **46**

and 47 extends for the full width of the applicator and is provided with a nozzle slot 48 which also extends for such width to cause flow of gas into the material passageway transversely across the path of any material passing therethrough. As is shown in FIG. 6, the nozzle slots 48 are inclined toward the center of the applicator to direct the flow of the gas in the direction opposite that to which a web of material is passed through the passageway. This counter flow of gas and treated sheets has been found to provide the best results since more vapor tends to be evolved toward the exit end of the applicator than the entrance end, and optimum vapor entrainment is obtained by having relatively dry gas at the exit end.

The end of the applicator 35 opposite that to which the gas is introduced is adapted to exhaust such gas from the material passageway. More particularly, an elongated slot 53 is provided transversely of both sides of the applicator adjacent such end. It will be appreciated that if it is desired that the exhausted gas with its entrained vapor not be introduced into the surroundings, a suitable exhausting system can be communicated with the slots 53 to capture the exhausting gas. Moreover, in some instances the slots 53 are not necessary if venting into the ambient atmosphere is satisfactory. The gas is introduced into the plenums from a conventional source via hoses 49 which communicate with distribution chambers 51 on the backside of each of the plenums 46 and 47. An inlet slot 52 extends through each of the plenums 46 and 47 and communicates the same with its respective distribution chamber 51 fully across the width of such plenum chamber. Most desirably, the gas or air which is introduced via the above structure into the material passageway is heated so as to be capable of entraining a greater amount of vapor. It will also be appreciated that depending upon the temperature of the gas and the volumetric flow rate of the same through the passageway, it can be used to provide conventional heating of the material along with the microwave heating provided by the applicator 35.

The channels 37 and 38 of each of the applicator are respectively secured together and maintained in a rectangular array by a pair of channel members 56 which are secured to the bases of the resonator channels and extend longitudinally of the applicator adjacent the opposed ends of such resonator channels. Each of the resulting structural halves of the applicator is mounted within a frame which supports the same while allowing thermal expansion. In this connection, the channels 39 and 41 defining the coplanar end walls of the resonator channels extend rearwardly of such channels as shown in FIG. 4 beyond the support channels 56. Spaced cross channels 57 extends transversely of the arrangement and are connected between the end wall channels 39 and 41 of each half to laterally secure them together. Each of such channels 57 is divided into two parts 58 and 59 which are joined via a spring loaded arrangement 61 which permits the resonator channels to expand thermally in a longitudinal direction without stress or buckling. The support channels 56 extending along the back of the bases of the resonator channels 37 are suitably connected by means not shown to the channels 57 in a manner enabling adjustment of the spacing between the channels 37 and the channels 38.

The two halves of the applicator defined by the opposed channels 37 and 38 are separably secured together with respect to one another so that access can be had to the interior of the applicator for cleaning and other purposes. More particularly, the adjoining side walls of the end channel members 39 and 41 are selectively secured in place by an over-center releasable locking lever arrangement illustrated at 63 in FIG. 4. Though such a locking arrangement is illustrated securing together the lower ends of the adjoining side walls of the end wall channels 41, such a locking arrangement preferably is provided adjacent all four corners of the applicator. To enable the selective separation of the two halves, each of the feed waveguides 43 and 44 is separable along the plane defined by the abutting surfaces of the end wall channels 39 and 41. Moreover, suitable absorbing material, such as that marketed under the trademark "ECCOSORB" by Emerson & Cuming of Canton, Massachusetts, is situated along the adjoining surfaces of the two applicator halves to prevent microwave leakage. FIG. 5 illustrates longitudinal strips 65 of such absorbing material along the side walls of the end channels 39 and 41 for this purpose, as well as on the flanges of the waveguides 43 and 44 which are to meet with corresponding flanges of the other half of the applicator. Strips 66 of such absorbing material are provided transversely across the material passageway at the entrance and exit ends of the applicator so as to reduce microwave leakeage from the applicator through such passageway.

From the above, it will be seen that the two separate sets of resonators are simply provided in this embodiment of the invention by the appropriate positioning of the shorting blocks 42 within the rectangular channels making up each of the resonators. The material passageway through the applicator is simply provided by spacing the channels of each half of the applicator a suitable distance apart. Moreover, the construction enables ready access to the applicator interior for cleaning, adjustments, etc. However, although the invention has been described in connection with this preferred embodiment thereof, it will be appreciated by those skilled in the art that various changes and modification can be made without departing from its spirit. It is therefore intended that the coverage afforded the applicant be limited only the claims and their equivalents.

I claim:

1. A multi-cavity applicator for uniformly treating a web of material with electromagnetic energy comprising at least two separate sets of elongated cavity resonators which are individually dimensioned to support selected modes of said energy in a resonant condition, means associated with each of said sets for exchanging said energy between the resonators of said set, said sets of resonators being intermeshed with one another with elongated resonators of one of said sets alternating in space quadrature with elongated resonators of the other of said sets in side-by-side relationship to provide a space quadrature applicator region for a web of material, and a web material passageway extending through said applicator region at a treatment zone thereof having a high electrical field intensity.

2. The multi-cavity applicator of claim 1 wherein each of said cavity resonators is dimensioned to support said electromagnetic energy in one of the classes of modes consisting of $TE_{1,0,n}$; $TM_{1,1,n}$; $TE_{1,1,n}$ and $TM_{0,1,n}$ where n represents an integral number.

3. The multi-cavity applicator of claim 1 wherein means are provided for directing the flow of gas

through said web material passageway for the removal from said applicator region vapor evolved from material being treated.

4. The multi-cavity applicator of claim 3 wherein said means for directing the flow of gas through said passageway directs said flow in a direction therethrough opposite to that in which a web of material being treated passes therethrough.

5. The multi-cavity applicator of claim 1 wherein a separate energy feed port is associated with each of said sets of elongated cavity resonators for individually feeding electromagnetic energy from an external source to each of said sets.

6. The multi-cavity applicator of claim 5 wherein said means associated with each of said sets for exchanging said energy between said elongated resonators of each set includes a coupling cavity resonator between each adjacent pair of elongated resonators of each set.

7. The multi-cavity applicator of claim 6 wherein each of said coupling resonators between each adjacent pair of elongated resonators of each set has side walls in common with said elongated resonators, and said means associated with each of said sets for exchanging said energy between said elongated resonators further includes a coupling slot projecting through each of said common side walls.

8. The multi-cavity applicator of claim 7 wherein one end wall of each elongated and coupling resonator of each set is in alignment with the corresponding end wall of every other elongated and coupling resonator of said set, and said common side walls between elongated and coupling resonators terminate a spaced distance from said aligned end walls to provide said coupling slots.

9. The multi-cavity applicator of claim 7 wherein said individual resonators are provided by a plurality of parallel, closely adjacent and closed ended tubular structures arranged in a rectangular array, each of said structures including electrical shorting means positioned therein at a location closer to one end wall thereof than to the other to thereby divide the same into an elongated cavity resonator of one of said sets and a shorter, coupling cavity of the other of said sets, said shorting means alternating in adjacent ones of said tubular structures from a position closer to one of said end walls and a position closer to the other end wall to thereby define the elongated cavity resonator of each set in alternate ones of said tubular structures and the coupling cavities thereof in the other of said tubular structures.

10. The multi-cavity applicator of claim 9 wherein the corresponding end walls of said tubular structures are coplanar with one another and said shorting means in each is approximately one quarter guide wavelength long to provide said space quadrature between said sets of cavity resonators.

11. The multi-cavity applicator of claim 9 wherein each of said tubular structures is defined by a pair of generally equi-dimensioned rectangular channels having their open sides facing one another in spaced relationship to provide therebetween said material passageway through said applicator.

12. The multi-cavity applicator of claim 11 wherein adjacent channels defining one half of said adjacent tubular structures are secured together and are selectively separable from their opposed channels defining the other half of said tubular structures to enable access to the interior of said applicator.

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