ULTRA HIGH FREQUENCY DIELECTRIC HEATER

Filed Oct. 15, 1947

Fig. 1.

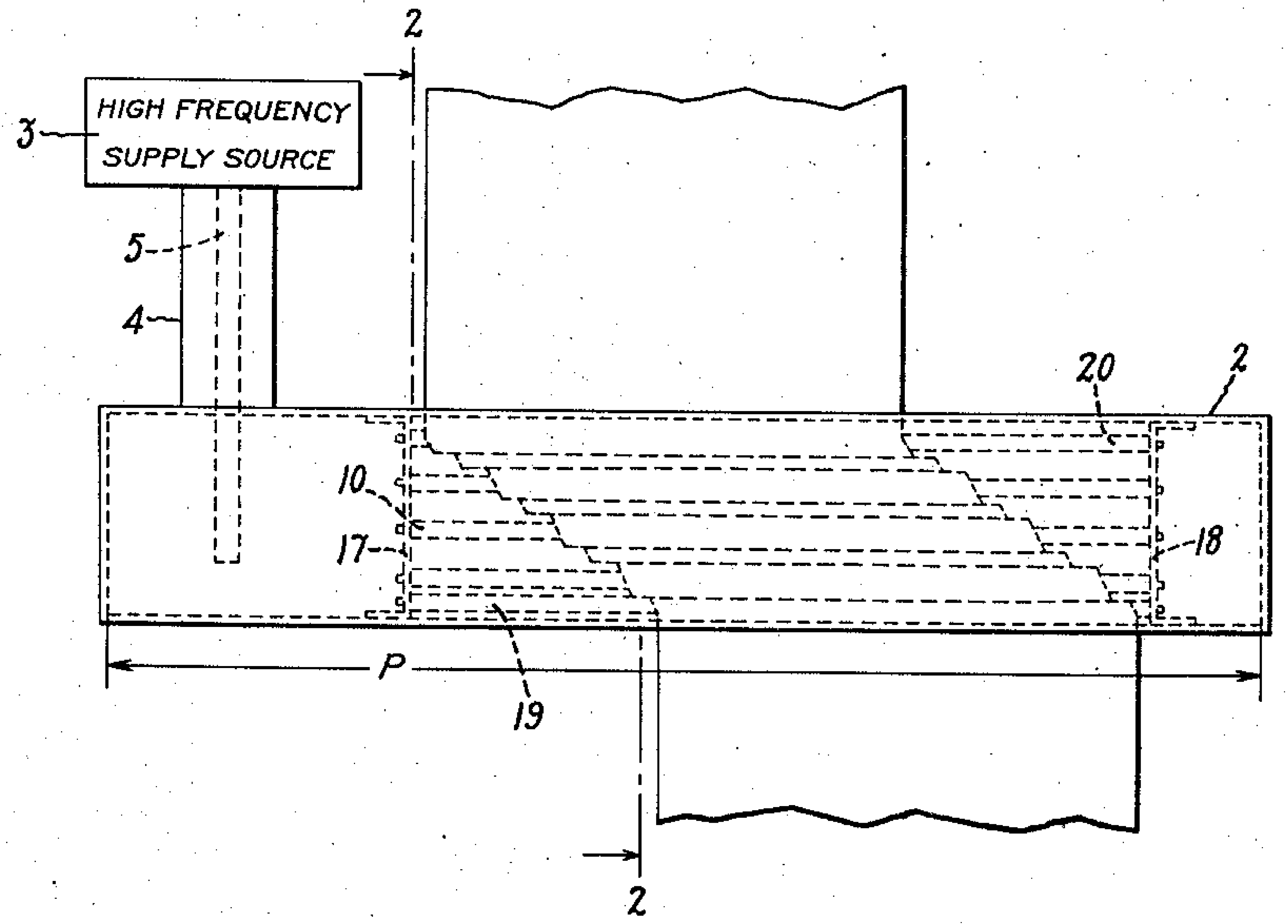


Fig. 2.

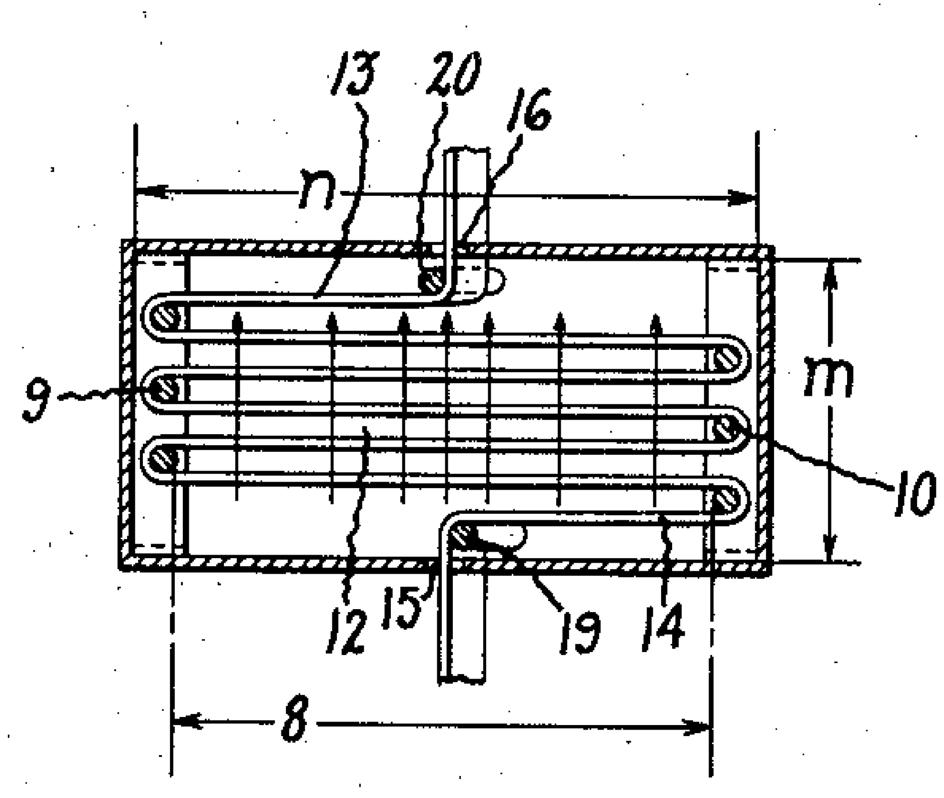
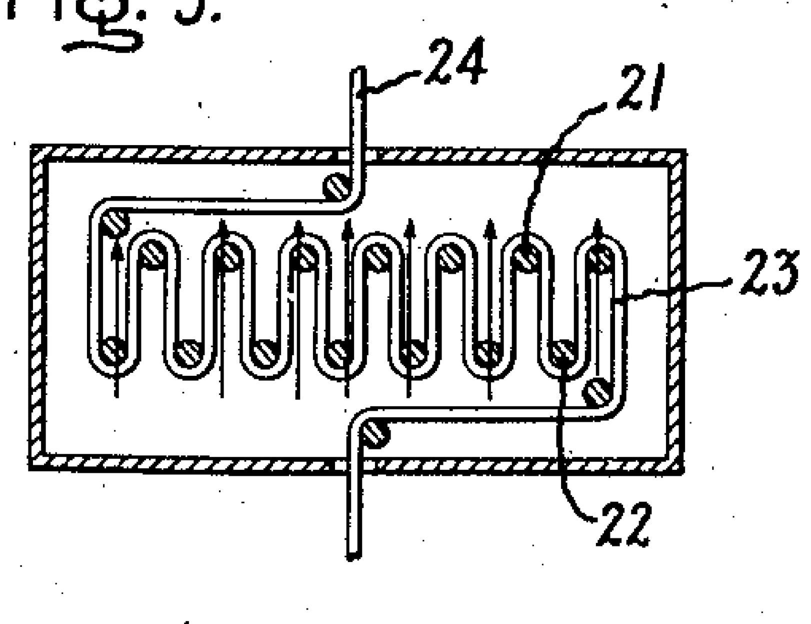


Fig. 3.



Inventors:
Henry Earl Revercomb,
Philip W. Morse,
by Claude A. Mott
Their Attorney.

Patented Oct. 4, 1949

2,483,933

UNITED STATES PATENT OFFICE

2,483,933

ULTRA HIGH FREQUENCY DIELECTRIC HEATER

Henry Earl Revercomb, North Syracuse, and Philip W. Morse, Clay, N. Y., assignors to General Electric Company, a corporation of New York

Application October 15, 1947, Serial No. 779,940

3 Claims. (Cl. 219—47)

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Our invention relates to ultra high frequency dielectric heaters, more particularly to such heaters employing a cavity or chamber of conducting material in which standing electromagnetic waves are produced, and has for its object a heater for continuously and uniformly heating thin sheets or cords of dielectric material.

In carrying out our invention in one form, we utilize a cavity or chamber of such size relative to the wave length of the high frequency source that a transverse electric field mode is produced in the chamber, together with a set of rollers on each side of the chamber for passing a strip or sheet material back and forth across the chamber in a direction either perpendicular, parallel, or at an oblique angle to the electric field whereby uniform heating by the electric field is obtained. Moreover, we mount the entrance roller and the exit roller at a slight angle with the axis of the cavity in such manner as gradually to move or shift the material lengthwise of the cavity for substantially a half wave length in order to give uniform heating by standing electromagnetic waves in the chamber.

For a more complete understanding of our invention reference should be had to the accompanying drawing, Fig. 1 of which is a plane view of an ultra high frequency heater embodying our invention, Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1 looking in the direction of the arrow, while Fig. 3 is a sectional view similar to Fig. 2 showing a modified form of our invention.

Referring to the drawing, we have shown our invention in one form as applied to the heating for drying purposes or otherwise of a thin strip or sheet 1 of dielectric material such as rubber, textile material, or cellulose material. It will be understood, however, that the sheet may comprise a large number of cords or threads positioned side by side and simulating a sheet.

As shown in the drawing, the heater comprises an elongated rectangular cavity or chamber 2 formed from thin walls of highly conducting material such as copper. High frequency power is supplied to one end of the cavity 2 from a suitable source 3 at a suitable ultra high frequency, such as 1000 megacycles, by suitable means shown as a co-axial supply line consisting of an outer tubular conductor 4 electrically connected to one end of the longer transverse side wall of the chamber and an inner conductor or probe 5 which extends into the chamber. The conductors 4 and 5 are electrically insulated

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from each other, and are perpendicular to the longer side wall of the chamber. The probe 5 is parallel with the electric field produced in the chamber.

We preferably construct the chamber 2 of such size with relation to the wave length of the high frequency supply source that a transverse electric field mode $H_{m,n,p}$ is produced in the chamber, i. e., an electric field whose components or vectors lie entirely in planes transverse to the chamber. In his mode the letters m, n, and p specify the number of half sinusoidal electric field variations in the three dimensions or walls of the chamber indicated by these letters on the drawing.

More specifically, we preferably use a transverse electric field mode $H_{o,1,p}$. This mode requires a short transverse dimension or side m which is less than one-half of the wave length in the chamber during the heating operation when the chamber contains the sheet 1 being heated, hereinafter referred to as a loaded chamber. Also, this mode requires a long transverse dimension or side n which is less than one wave length existing in the loaded chamber but somewhat more than one-half wave length. Preferably the distance 8 between the two parallel sets of parallel rollers 9 and 10 is made greater than one-half wave length. The length p of the chamber is at least several wave lengths. Standing electromagnetic waves are, therefore, produced in the chamber.

In view of the fact that the transverse electric field, as indicated by the arrows in Fig. 2, is confined to a distance of one-half wave length between the sets of rollers 9 and 10, the sets of rollers are positioned on opposite sides substantially outside of the electric field whereby heating of the rollers is minimized.

By suitable means, not shown, such as spools, on which the sheet 1 is wound, the sheet is passed continuously through the chamber at a uniform speed, and in the chamber passed back and forth over the rollers and between the sets of rollers 9 and 10 in a plurality of transverse substantially horizontal lengths 12, as seen in Fig. 2, extending substantially parallel with the longer side wall n. Five such lengths 12 are shown, together with a sixth length made up of two halves 13 and 14 at the entrance and exit points of the material, at which points oblique slots 15 and 16 are provided for the sheet in the walls of the chamber. The sets of rollers 9 and 10 are made of a suitable low loss dielectric material or a good electrically conducting material such as copper, preferably the latter. Each set is suitably supported on brackets mounted in the chamber adjacent the shorter side walls. As shown, the set 10 is mounted on brackets 17 and 18, similar brackets being provided for the set of rollers 9. Guide rollers 19 and 20 are provided adjacent the entrance and exit openings.

It will be observed that in Fig. 2 the cross lengths 12 of the sheet pass each a number of times, depending upon the number of passes, through the transverse electric field indicated by the arrows, which electric field is a maximum value at the middle and a minimum value at each side.

For the purpose of producing uniform heating in the sheet at all points crosswise of the sheet, the entrance roller 19 and the exit roller 20 are arranged each in non-parallel relation with the length of the chamber in such manner that the sheet is passed obliquely through the chamber and thereby caused to shift lengthwise of the chamber. As shown in Fig. 2, the roller 19 is positioned at a small angle with the side walls and longitudinal axis of the chamber, its remote end being nearer the right hand side wall, and the roller 20 being parallel with the roller 19. As a result of these angular positions of the rollers 19 and 20, the lengths 12 of the strip extend obliquely crosswise of the chamber and the sheet takes a net oblique path in passing through the chamber as indicated by the dotted lines in Fig. 1. In other words, assuming that the strip is moving downward as viewed in the drawing, the lower exit end of the sheet, while parallel with the upper entrance end, is displaced toward the right hand longitudinally of the chamber. This displacement laterally of the strip in passing through the chamber is regulated by the angular relation of the rollers 19 and 20 with the side walls of the chamber. Preferably, this angular relation is such as to give a total displacement or shift of the sheet lengthwise of the chamber of substantially one-half of the length of the standing electromagnetic waves in the chamber. This assures that the strip at all crosswise points passes through the same values of field produced by the standing waves whereby it is heated uniformly.

In the modified form of our invention shown in Fig. 3, the two parallel sets of rollers 21 and 22 extend each horizontally across the chamber so that the lengths 23 of the strip 24 are vertical, as seen in the drawing, and parallel with the electric field indicated by the arrows. The rollers in this case must be made of a low loss dielectric material, such as polystyrene, low loss glass, etc.

This arrangement of Fig. 3 is especially effective in the heating of sheets or strips of thin dielectric material, such as very thin cellophane. The arrangement of the lengths of the sheet in parallel relation with the field components provides for an increased generation of heat in thin material as compared with the arrangement of Figs. 1 and 2, wherein the lengths are perpendicular to the field components. In a typical apparatus very thin cellophane was heated to a smoking temperature in about two seconds.

As applied to our invention we define ultra high frequency as a frequency of one megacycle or higher.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An ultra high frequency heater comprising walls made of an electrically conducting material forming an elongated chamber, a high frequency

supply source connected to said chamber for producing a transverse electric field mode in said chamber, two sets of rollers mounted in said chamber in spaced apart relation with each other transversely of said electric field a distance at least substantially one-half of the wave length in said chamber whereby heating of said rollers is minimized, and two opposite walls of said chamber being provided each with an opening through which a sheet of material to be heated may be passed over said rollers back and forth between said sets of rollers in a plurality of lengths extending transversely of said chamber.

2. An ultra high frequency heater comprising walls made of an electrically conducting material forming an elongated chamber, a high frequency supply source connected to said chamber for producing transverse standing electromagnetic waves in said chamber, two sets of rollers mounted in said chamber in spaced relation with each other transversely of said chamber, two opposite walls of said chamber being provided each with an opening through which a sheet of material to be heated is passed over said rollers back and forth between said sets of rollers in a plurality of lengths extending transversely of said chamber, and means for guiding the sheet obliquely to said sets of rollers so as to cause the sheet to shift lengthwise of said chamber an amount at least substantially one-half of the wave length in said chamber thereby to effect uniform heating of the sheet.

3. An ultra high frequency heater comprising walls made of an electrically conducting material forming an elongated chamber, a high frequency supply source connected to said chamber for producing transverse standing electromagnetic waves in said chamber, two sets of rollers mounted in said chamber in spaced relation with each other transversely of said chamber, two opposite walls of said chamber each being provided with an opening through which a sheet of material to be heated is passed over said rollers back and forth between said sets of rollers in a plurality of lengths extending transversely of said chamber, and a guide roller in said chamber adjacent each of said openings extending at an acute angle with the longitudinal axis of said chamber for guiding the sheet obliquely to and from said sets of rollers so as to cause the sheet to shift along the longitudinal axis of said chamber an amount at least substantially one-half of the wave length in said chamber thereby to effect uniform heating of the sheet.

HENRY EARL REVERCOMB.
PHILIP W. MORSE.

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