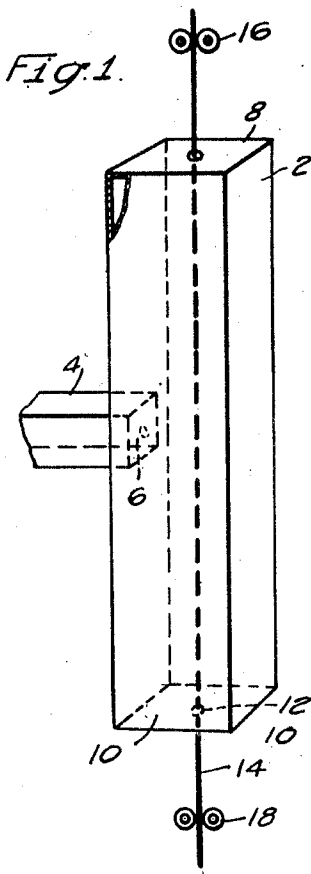
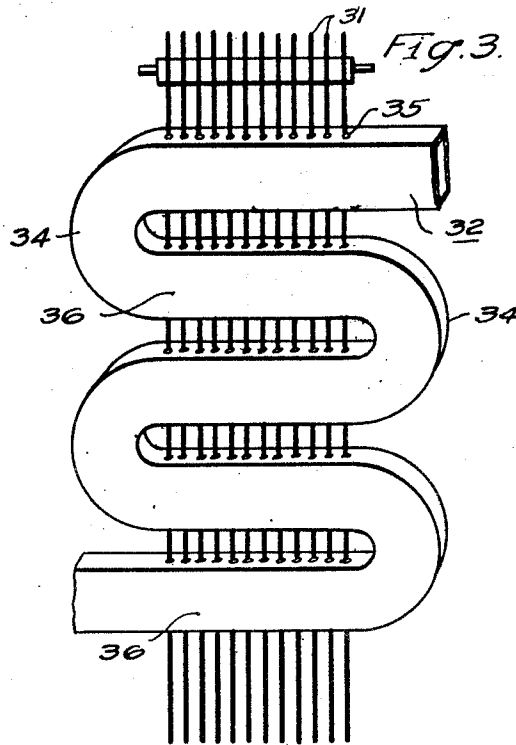
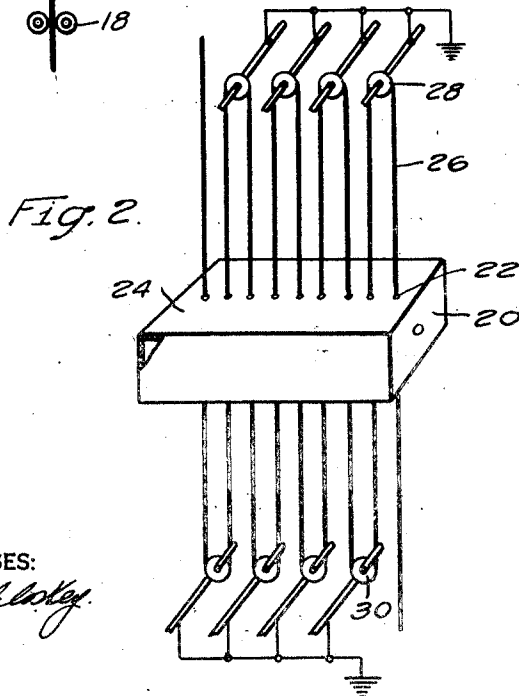


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MICROWAVE HEATING

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4 Claims. (Cl. 219-47)

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My invention relates to the heating of elongated electricity-insulating filamentary material by means of a high-frequency energy in the micro-wave region.

It is an object of my invention to treat elongated filamentary materials such as thread or narrow ribbons made of cotton, plastics, rubber, paper, or any other material or substance generally recognized as being insulating with respect to the conventional forms of electrical power commercially universally available at the present time. The treatment may be for the purposes of drying, curing, setting or any other purposes; and I accomplish this by means of an extremely simple and economical structure through which the elongated material may be passed continuously.

It is a further object of my invention to provide electrical apparatus for the purpose described which is energizable with alternating-current frequencies having wave lengths in the order of several centimeters, say 10, and less, although somewhat higher wave lengths are utilizable. Preferably the heating portion of the apparatus consists only of a hollow outer conductor which is at ground potential and the electrical energy is confined inside of the outer conductor. The conductor may be in the form of a resonant chamber or wave guide. Preferably, the filamentary material is passed through the conductor parallel to the electric field therein. This means, of course, that the conductor is preferably operated with a mode of energy transmission providing an intense electric field along substantially the full length of the portion of the material passing through it.

Features, objects, innovations and methods provided by my invention will be discernible from the following description which is to be taken in conjunction with the accompanying drawing, in which:

Figure 1 is a schematic view showing a rectangular cavity resonator for heating a thread of insulating material.

Fig. 2 is a schematic view of a similar apparatus for heating a thread or other filamentary material in steps, and

Fig. 3 is a modified form of apparatus for similarly heating a plurality of elongated insulating filaments by a single return bend wave guide.

Textiles such as rayon and nylon must be cured, dried and twisted. Rubber thread material, both synthetic and pure latex, must be cured. Such operations usually require heating

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and high production requires that such operations be carried out while the material is traveling at high speed. The apparatus herein described makes it possible to couple energy into the material at a rate suitable for high production requirements.

Referring to Fig. 1, a rectangular copper cavity resonator or envelope 2 can be energized in any suitable manner, and I schematically show a means for transferring energy to it as comprising a wave guide 4 coupled to the cavity resonator 2 by means of a perforated diaphragm 6. The ends 8 and 10 of the cavity resonator are provided with holes 12 at their centers through which an elongated filamentary material 14 is threaded and continuously moves. Pulleys 16 at the entrance end of the cavity resonator and pulleys 18 at the exit end keep the material 14 in suitable tension so that it does not flap around inside the cavity. The pulleys 18 may be metallic and grounded to remove any charge that the material might pick up. The apparatus herein described is especially suitable for heating circular threads. Accordingly, the holes 12 are shown as circular, but they can be otherwise formed to harmonize with the cross section of the material being heat-treated. The apparatus shown in Fig. 1 heat treats the thread 14 only a single time but for longer heat treatments, or for shorter apparatus, an arrangement such as shown in Fig. 2 may be used.

Referring to Fig. 2, a resonant cavity 20 has a plurality of spaced openings 22 in a side 24 of the cavity resonator and a similar group of openings in the opposite side thereof, with each opening in one of the sides being longitudinally aligned with an opening in the other side. Thread 26 is threaded through longitudinally aligned openings in the manner shown with portions coming out of the cavity resonator and being return-bent by means of pulleys 28 on one side of the cavity resonator and pulleys 30 on the other side. These pulleys may, if desired, be made of metal and grounded. As the thread enters and re-enters the cavity resonator a plurality of times, it is repeatedly heated in increments. Obviously, the portions of the thread outside the resonator can be short. If other intermediate treatments are desired, they can be longer and, if desired, more widely spaced.

Rather than using a cavity resonator, I also contemplate the use of a wave guide, as illustrated schematically in Fig. 3. In this embodiment, a plurality of separate threads 31 are passed rectilinearly through a tortuous wave

guide 32 having a plurality of return bends 34 interconnecting straight portions or sections 36. Opposite sides of the straight portions 36 are provided with a plurality of aligned spaced holes 35 through which the threads or other filamentary material is passed. As each portion of the material passes through a section 36 of the wave guide 32, it is heated so that, in the embodiment shown in Fig. 3, each filament is subjected to heating five times. However, it is obvious that the number of return bends is a matter of design or choice.

In all embodiments, the holes are preferably midway along the associated sides and the filamentary material passes through the cavity resonator or the wave guide, as the case may be, substantially parallel to the electric field vector.

While I have described my invention in connection with threads, it is obvious that fine ribbons can similarly be treated, in which case the holes in the conductors comprising the cavity resonators or wave guides can be shaped correspondingly. In the case of the cavity resonator, it is sometimes desirable to make the displacement between the entrance and exit of a thread portion about one-half a wave length, as disclosed and claimed in my concurrently filed application, Serial No. 701,305. However, my invention is not thus limited.

In all of the embodiments the actual structure in which the elongated filaments are heated consists only of an outer metallic shell of metal which does not require any metal parts inside of it.

While I have used the word "filamentary" or "filaments" for describing the elongated material to be heat treated, it is obvious that I use this term only in the lack of a more generic term for such material, but I do not desire to be limited, and the invention is obviously not limited to extremely fine threads which are hardly visible. It is also obvious that my invention is subject to wide application for other materials and is capable of being applied in many other ways.

I claim as my invention:

1. A high-frequency heating apparatus comprising a micro-wave conductor comprising a single metallic envelope comprising a return-bent wave guide having a plurality of sections extending in the same general direction between bends, each section having a pair of opposite sides, each of which is provided with a plurality of longitudinally spaced holes, and means for passing material through said sections in a plurality of paths each of which includes a hole in each of said opposite sides of a plurality of said sections, so that the material passes successively through said sections.

2. A high-frequency heating apparatus comprising a micro-wave conductor comprising a single metallic envelope comprising a return-bent wave guide having a plurality of sections extending in the same general direction between bends, each section having a pair of opposite sides, each of which is provided with a plurality of longi-

tudinally spaced holes with pairs of holes in each section in registry, so that elongated material may be passed through each pair of registered holes, means for guiding material longitudinally through said pairs of registered holes so that the material passes successively through said sections, and means for energizing said wave guide so as to provide an electric field substantially parallel to a plane including the lines between said pairs of registered holes.

3. High frequency heating apparatus for heating a dielectric filament, comprising a microwave energy-transfer hollow conductor having an inside space adapted to be electrically stressed by microwave energy therein, said conductor having a pair of sides each of which is provided with a plurality of holes, means for delivering microwave energy to said conductor for establishing an electric field therein, and guiding means for guiding a dielectric filament for continuous and successive passage through said conductor via said holes, in a direction substantially parallel to the direction of the electric field inside said conductor, said guiding means comprising a metallic member which is electrically grounded and in contact with said filament, said metallic member being external to said conductor at the material-exit side thereof.

4. A high frequency heating apparatus including a resonant microwave energy-transfer conductor having at least a first side and a second side, said first side being opposite in position relative to said second side, each of said sides being provided with an equal plurality of openings, each of said openings in said first side corresponding in position to one of said openings in the second side, such that a single elongated workpiece can be successively passed through said conductor between respectively corresponding openings in said first and second sides, with means for energizing said conductor so as to provide an electric field therein, and the direction of movement of said workpiece through said conductor being parallel to said electric field.

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