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Gilliatt

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[54] **DIELECTRIC HEATING APPARATUS**

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[73] Assignee: **Raytheon Company**, Lexington, Mass.

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[21] Appl. No.: **375,404**

Related U.S. Application Data

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[52] **U.S. Cl.**..... **219/10.41**, 219/10.81, 425/41

[51] **Int. Cl.**..... **H05b 5/00**, H05b 9/00

[58] **Field of Search**..... 219/10.55, 10.81, 10.41; 425/41, 174.8

[56] **References Cited**

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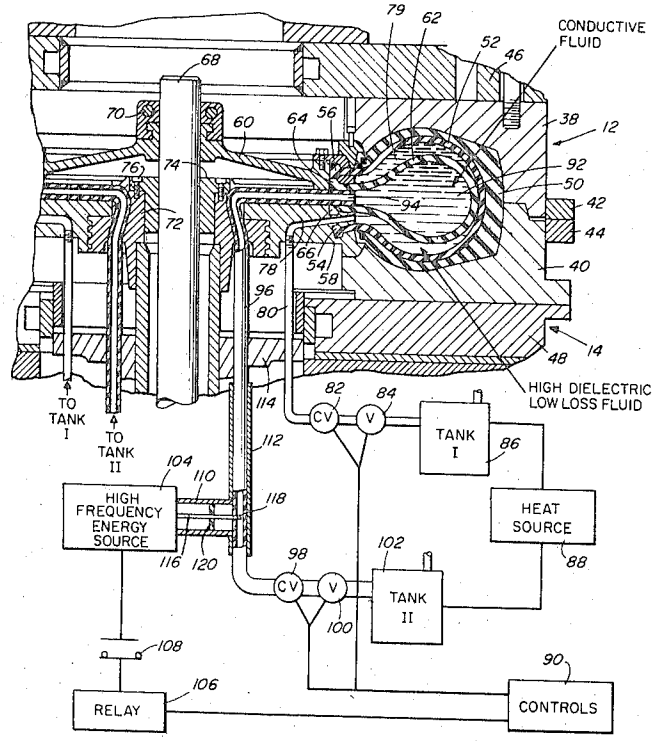
[57] **ABSTRACT**

A method of and apparatus for heating moldable articles, such as pneumatic rubber tires, is disclosed utilizing an inner expandable bladder having an electrically conductive fluid, such as mercury, salt water, or woods metal. A source of high frequency energy in the range of, illustratively, from 1 to 60 megahertz is coupled between the conductive fluid and the metallic tire vulcanizing apparatus to rapidly heat the inner casing wall surfaces to the desired curing temperatures. A second outer bladder conforming to the casing walls contains a high dielectric constant low thermal loss fluid, such as silicone oil. The inner bladder is contoured to provide a greater volume of such fluid adjacent to the thinner sidewalls and thereby expose the heated conductive fluid closer to the thicker tire tread region. The heating field strengths are thereby distributed substantially uniformly in all parts of a moldable article having a nonsymmetrical cross-sectional configuration and it is maintained in the desired shape during heating.

2 Claims, 2 Drawing Figures



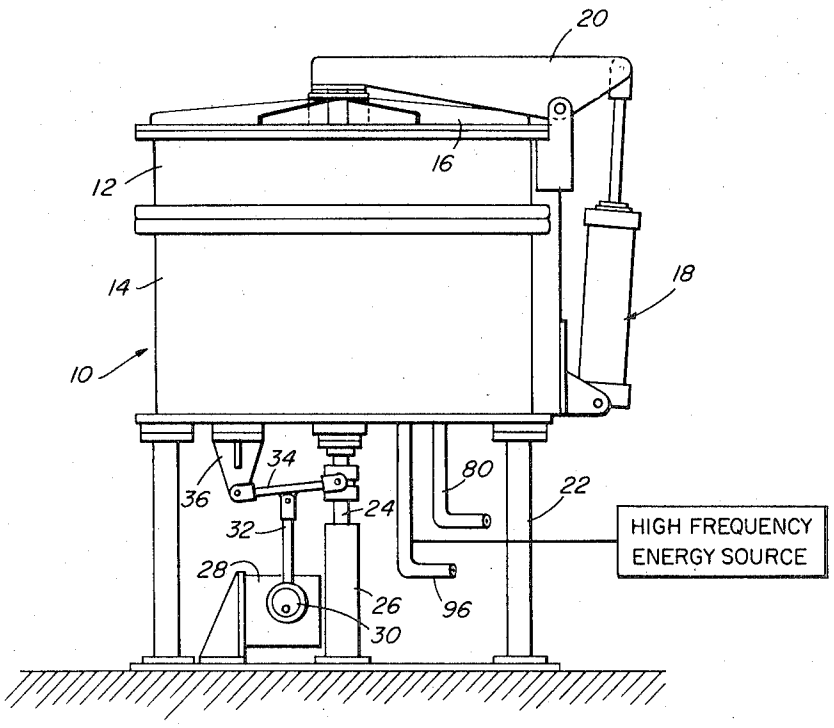

20
16
12
14
10
18
34
36
80
22
24
32
28
26
30
96
HIGH FREQUENCY
ENERGY SOURCE

FIG. 1

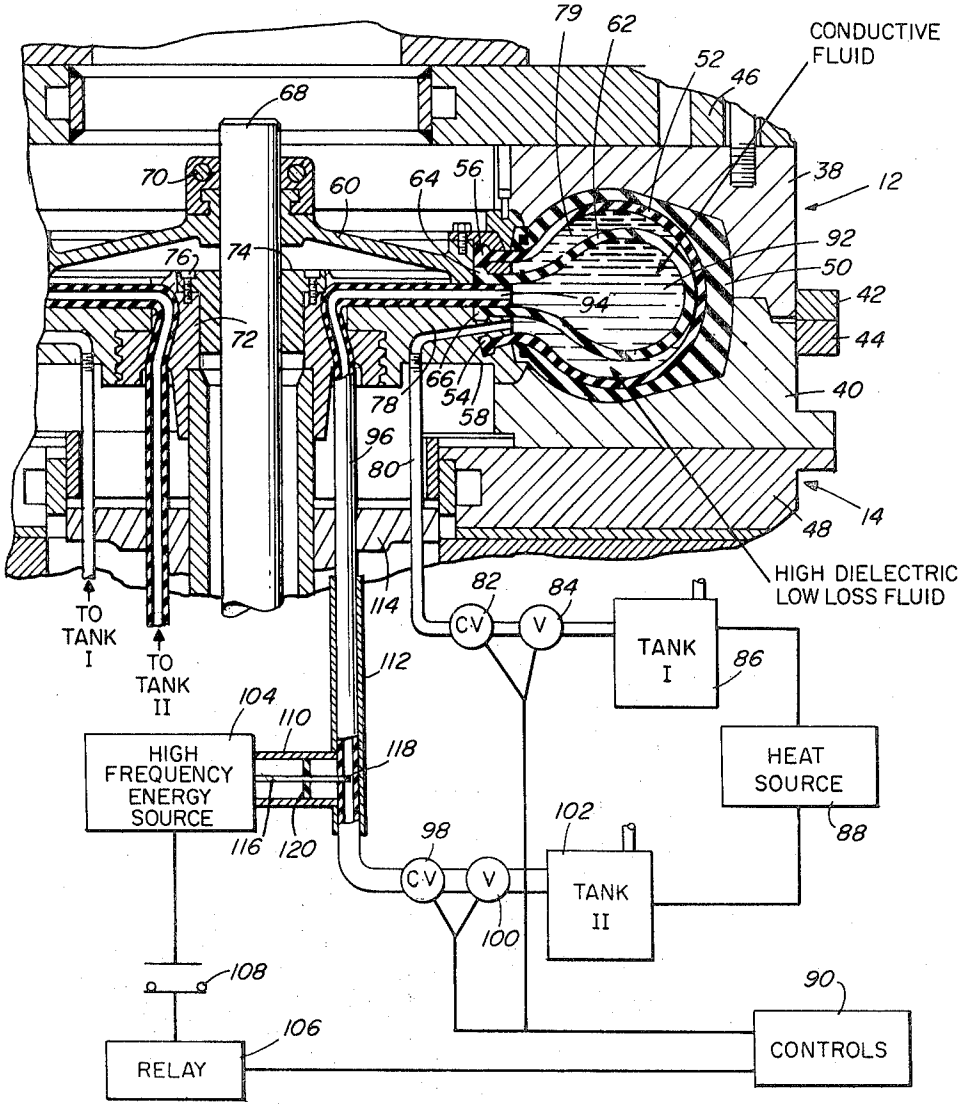

79
62
CONDUCTIVE FLUID
52
46
68
70
60
64
56
38
12
92
74
76
50
42
94
72
44
66
54
58
40
78
96
80
14
48
HIGH DIELECTRIC LOW LOSS FLUID
TO TANK I
TO TANK II
114
82
84
C.V
V
TANK I
86
112
104
110
HIGH FREQUENCY ENERGY SOURCE
118
HEAT SOURCE
88
116
120
98
102
C.V
V
TANK II
100
108
90
106
RELAY
CONTROLS

FIG. 2

DIELECTRIC HEATING APPARATUS

This is a division of application Ser. No. 277,463 filed Aug. 2, 1972 now U.S. Pat. No. 3,770,931, issued Nov. 6, 1973.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to the heating of moldable articles by high frequency electromagnetic energy.

2. Description of the Prior Art

Dielectric heating utilizing high frequency alternating fields has found wide acceptance in the treatment of inherently poor thermal conductors, such as paper, wood, leather and rubber articles. For the purposes of the present application the term "high frequency" is defined as electromagnetic energy in that portion of the spectrum having frequencies of under 60 megahertz. Numerous sources are known in the art including vacuum tubes and the energy is typically coupled to the article by conductive electrodes. In the utilization of such energy typically a nonsymmetrical and nonhomogenous mass is presented to the oscillating fields. The distribution of the electromagnetic energy within the product, therefore, becomes a function of the varied dielectric constants of the load as well as the power factor. This latter characteristic represents the amount of current which will flow through the mass and produce a heat loss. In the dielectric heating art the dielectric constant value and power factor are multiplied to obtain a measure of total loss. It is evident, therefore, that the physical properties of the materials as well as distribution of the oscillating fields is of primary consideration in dielectric heating applications.

One product which is an inherent poor thermal conductor is the pneumatic tire which is typically cured at elevated temperatures by steam or other means at temperatures of above 300°F. During the curing cycle the mold is heated and steam under pressure is generally applied within the tire casing walls by such means as a bladder of rubber or the like. The tire vulcanization process is time consuming and involves expensive and cumbersome apparatus. Such moldable article has a nonsymmetrical cross-sectional configuration with thin sidewalls and a thick tire tread region defining a substantially hollow interior. The variation in cross-sectional dimensions leads to problems with uniform heat distribution during the curing cycle. The search, therefore, for new and improved methods and apparatus for the heat treatment of moldable articles continues in industry.

SUMMARY OF THE INVENTION

In accordance with the present invention a method and apparatus for dielectrically heating moldable articles is provided with uniform distribution of the high frequency electromagnetic energy in all parts involving the use of expandable bladder members with two types of fluids. An inner expandable member contains an electrically conductive fluid and an electrode from the high frequency energy source is connected directly to the fluid. Surrounding the inner bladder member is a second outer expandable bladder member containing a high dielectric constant low loss fluid. The inner member is contoured to provide a greater volume of low loss fluid and thereby space the conductive fluid further away from the thinner sidewalls, for example, a pneumatic tire. The greater concentration of heat is, therefore, directed toward the thicker tire tread portions where the wall thickness is substantial. The fluids may also be heated to assist in curing times. The distribution of heating energy fields is maintained uniform throughout the curing cycle.

The invention is readily adaptable to existing tire vulcanizing mold apparatus using steam heat to raise the temperature of the mold cavity-defining members and platens. After curing the fluids are drained from the bladder members to reservoir means and the upper cavity member is pivoted away by hydraulic means to permit removal of the tire for cooling and post cure inflation. While rubber articles are described herein the invention is equally applicable to any moldable article of an inherently poor thermally conductive material including articles of any number of thermoplastic material.

BRIEF DESCRIPTION OF THE DRAWINGS

Details of the invention will be readily understood after consideration of the following description of the preferred embodiment and reference to the accompanying drawings, wherein:

FIG. 1 is an isometric view of the embodiment of the invention; and

FIG. 2 is a partial cross-sectional view of the embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The apparatus 10 embodying the invention comprises upper and lower mold annular cavity-defining members 12 and 14 supported by legs 22. A lid 16 controlled by a hydraulic mechanism 18 is provided with a connecting bracket 20 for pivotal movement thereof after the curing cycle has been completed. A shaft 24 disposed within a concentric tubular holder 26 is internally connected to the means for movement of the bladder members, to be hereinafter described, to provide for removal and insertion of such bladder members in the interior of the tire casing at the commencement and termination of the curing cycle. The shaft moves upwardly and is controlled by means of a gear box 28 having an eccentric sheave 30 coupled to a rod 32 with a lever arm assembly 34 pivotally secured to bracket 36 on the underside of the lower cavity member 14. A motor is also provided and is not illustrated for the sake of clarity.

Referring now to FIG. 2, upper and lower mold cavity-defining members 12 and 14 comprise top and bottom half sections 38 and 40 adapted to mate and define the shaping and tread vulcanizing walls which an annular moldable article, such as an uncured tire 50 having a substantially hollow interior, is disposed. A lip portion 42 and 44 provides mating surfaces for the joined mold members 12 and 14 during the curing cycle. Each of the half sections 38 and 40 have abutting top and bottom steam-heated platen members 46 and 48 secured thereto. Typically, in such apparatus, steam is continuously introduced into the platens to elevate the mold temperatures to approximately 310° to 350°F which is the normal curing temperature for passenger tires.

Within the casing of the uncured or green tire 50 bladder members 52 and 62 are disposed. Bladder member 52 which is referred to herein as the outer bladder member conforms to the tire casing walls. The

ends of outer bladder 52 are provided with enlarged feet 54 and 56 to form an annular bead disposed within anchoring channels in lower fixed clamping ring 58 and upper movable clamping ring 60. This arrangement provides a fluid-tight structure when a fluid is pumped within the bladder 52 during operation. A similar arrangement provides enlarged feet 64 and 66 for securing the inner bladder member 62 to the clamping rings 58 and 60. A piston rod member 68 is joined to the vertically displaced shaft 24 and is secured by a clamp 70 to the upper clamping ring 60. The rod extends within a hub 72 having cylindrical cap 74 joined by bolts 76 to the lower clamping ring member 58. Upward movement of the rod 68 results in the drained bladders assuming a shape which will permit ready removal and insertion of the tire casing.

Clamping ring member 58 defines inner passageways 78 at a number of points around the annulus of the tire-casing to permit the introduction of a fluid 79 within the outer bladder member 52. Line 80 threadably engages the passageways and is connected by a check valve 82 and regulator valve 84 to a reservoir tank 86 containing fluid I. The fluids in the practice of the invention are desirably heated by any suitable source designated by the numeral 88 and all the electrical controls for the operation of the apparatus are designated by the box 90. Fluid I is of a high dielectric constant low thermal loss characteristic, such as silicone oil, and is utilized for spacing of the heat source, to be hereinafter described, with relation to the nonuniform walls of the tire being cured.

An electrically conductive fluid 92 is introduced within the inner bladder member 62 by passageways 94 which are electrically insulated from the clamping ring 58 by a nonconductive line 96 forming a conduit for the introduction of the fluid II. Line 96 incorporating a check valve 98 and regulator valve 100 is coupled to tank 102 which is also connected to the controls 90. An illustrative fluid having the desired electrically conductive characteristics comprises mercury, salt water or woods metal. The latter material "woods metal" describes a low temperature alloy containing bismuth, antimony and tin of the type often employed in automatic sprinkler heads.

A suitable high frequency electromagnetic energy source 104 having an operating frequency of around 40 megahertz is controlled by a relay 106 having contacts 108 coupled to electrical controls 90. Coaxial electrode 110 is connected to a metallic sleeve 112 surrounding the insulated line 96 which is connected to the ring 114 of the grounded tire molding apparatus. Center electrode 116 has inner end 118 disposed directly in the conductive fluid 92 to complete the circuit for the raising of the temperature of the conductive fluid to the temperature required to heat the inner casing walls. A diaphragm 120 is coaxially disposed as indicated to prevent backup of the electrically conductive fluid 92 to the high frequency source.

At the beginning of the curing cycle with the upper mold member 12 raised the uncured tire casing is placed in the cavity around the bladders members 52 and 62. Upon the closing of the apparatus and filling bladder 52 containing the low loss material having a high dielectric constant assumes the shape conforming to the inner casing walls. The inner bladder 62, however, is contoured so as to be closer to bladder 52 at the point adjacent to the thick tread of the tire casing 50. A greater volume of the heating conductive fluid 92 is thereby concentrated adjacent to the thicker tread region. The thinner sidewall portions are protected from excessive heating by the intervening fluid 79 to provide a more uniform heat distribution arrangement responsive to a nonsymmetrical article. After the curing, the lines with both fluids are drained and the upper mold member 12 is again raised and pivoted to permit removal of the treated product for cooling and postcure inflation.

Since numerous modifications in the preferred embodiment disclosed herein as well as alternative materials, such as those of the thermoplastic composition will become apparent to those skilled in the art, a broad interpretation of the invention as defined in the appended claims is intended.

I claim:

1. In a method of heating a moldable annular article with nonuniform walls and substantially hollow interior characterized by a heating cycle wherein the exterior walls are heated to a predetermined temperature in a cavity mold; the steps of:

inserting within said interior an outer expandable fluid-tight bladder means conforming to the coutour and adapted to maintain pressure against, as well as dielectrically heat, the inner wall surfaces of the article and an inner bladder means disposed within said outer bladder means;

filling said outer expandable bladder means with a fluid having a high dielectric constant low thermal loss characteristic and the inner bladder means with an electrically conductive fluid; and

connecting said electrically conductive fluid to a high frequency electromagnetic energy source having a range of from 1 to 60 megahertz.

2. The method according to claim 1, and the further step of thermally heating both of said fluids within said inner and outer expandable bladder means to a flowing temperature.

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