

Jan. 15, 1952

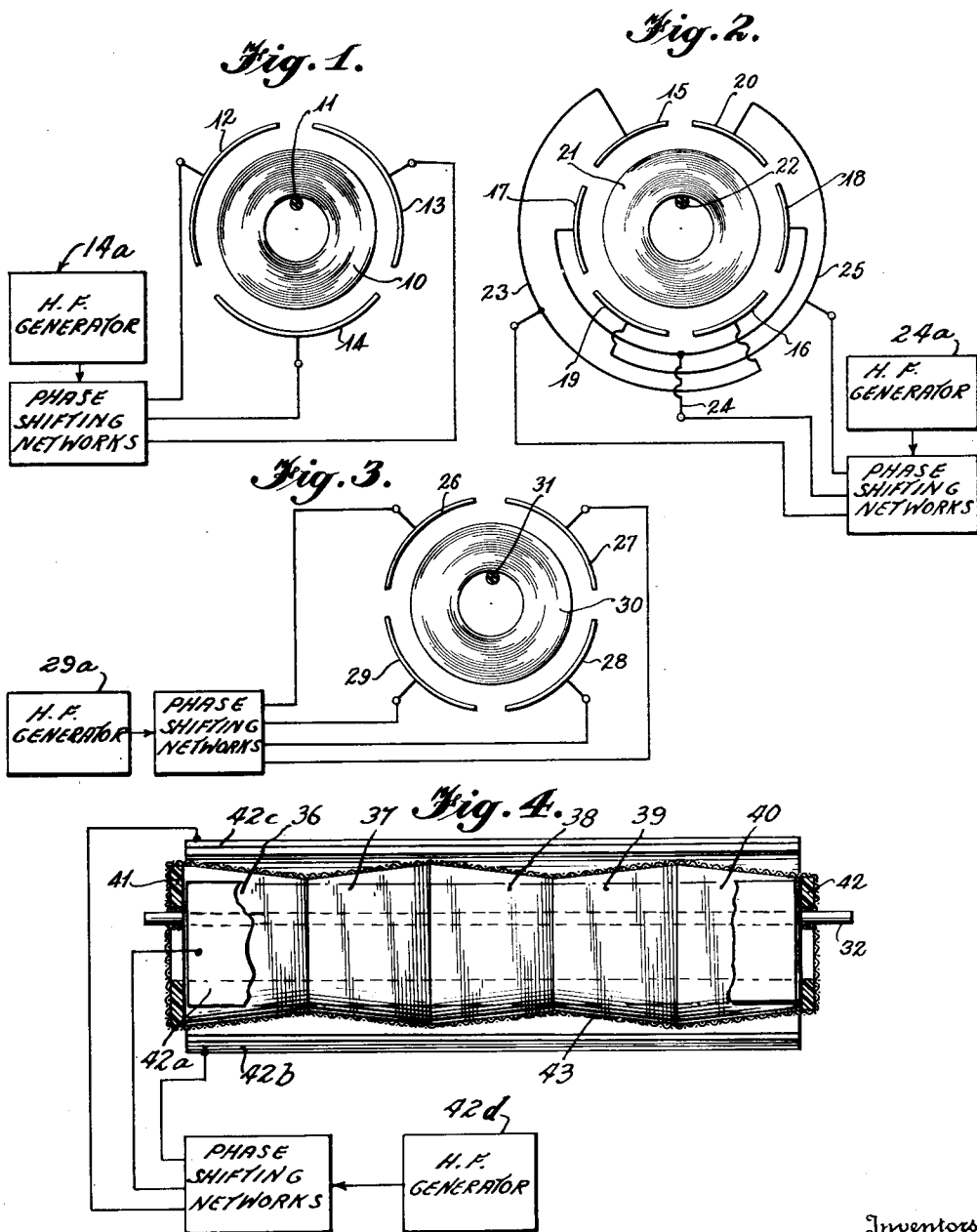
R. V. NES ET AL

2,582,806

DRYING OF HOLLOW YARN BODIES

Filed Jan. 23, 1948

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

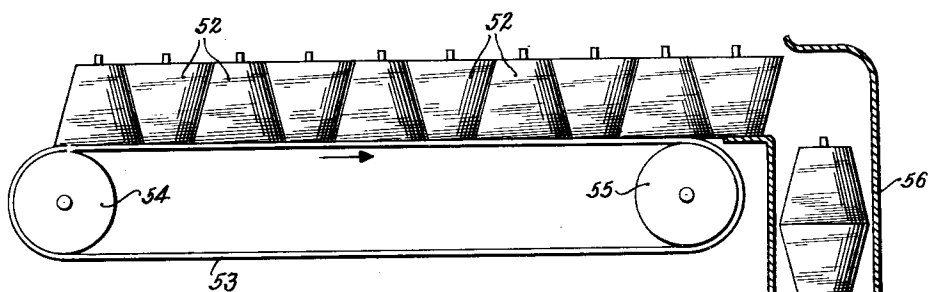


Fig. 7.

Fig. 6.

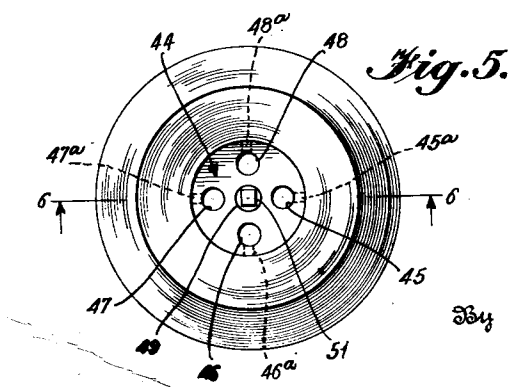
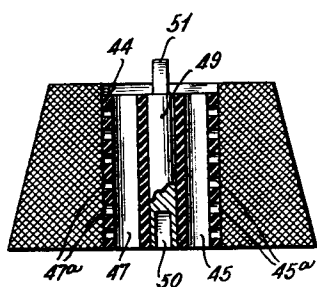
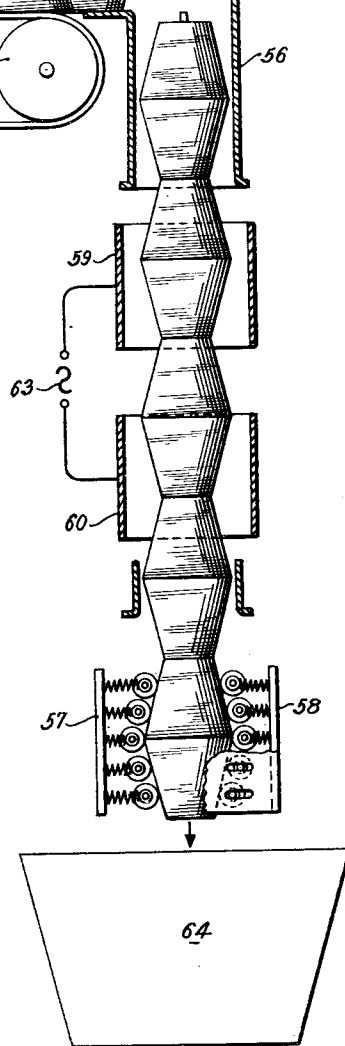


Fig. 5.



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Fig. 8.

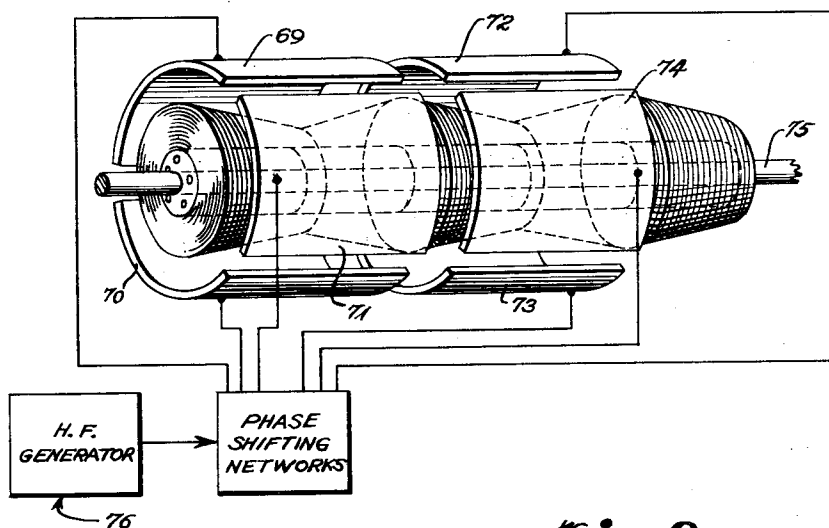
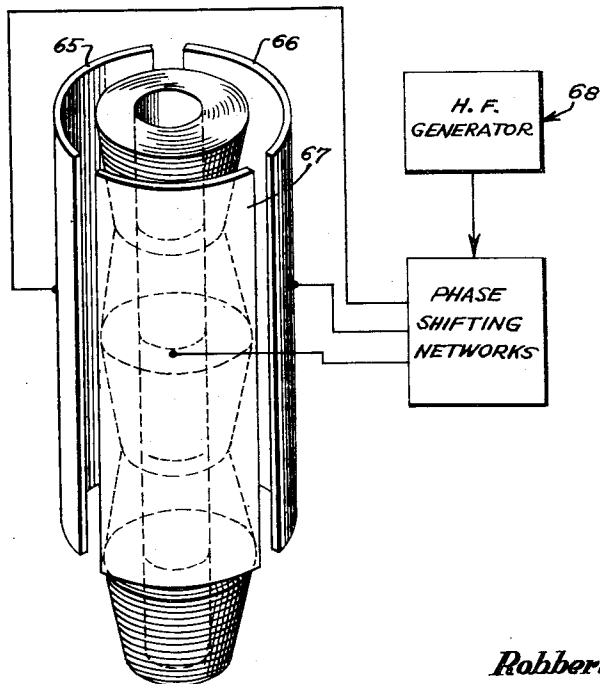


Fig. 9.



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DRYING OF HOLLOW YARN BODIES

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5 Claims. (Cl. 34—1)

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This invention relates to high frequency drying and more particularly to an improved method and apparatus for effecting the drying of hollow yarn bodies by subjecting them to the action of a high frequency electrostatic field operating, for example, above 10 megacycles.

In the drying of yarn bodies, by subjecting them to high frequency electrostatic fields, it has been found that all portions of the yarn body do not dry at the same rate. Since the operation is continued until all portions of the yarn body have no more than a predetermined moisture content, it would seem at first that differences in the rate of drying would not be important. Such, however, is not the case, for it has been found that lack of uniformity in drying deleteriously affects the physical and mechanical properties of the yarn to such an extent that dyeing affinity, shrinkage, strength and elongation are deleteriously affected in the yarn constituting some portions of the yarn body. This being the case, it is now realized that uniformity in the rate of drying throughout the yarn body is of paramount importance.

It has been found that at least a part of the foregoing difficulty results from the fact that, regardless of the relative positions of the yarn body and the capacitors during the drying period, the electrostatic field is not uniform throughout the yarn body. When this was discovered it was proposed to solve the problem of non-uniform drying by relatively rotating the yarn body and the capacitors during the drying period so that the average field strength would be nearly equal in all parts of the yarn body. This development was partially successful and has resulted in improvement in the quality of yarn bodies dried by high frequency methods. Unfortunately, however, the requirement that either the capacitors or the yarn body be physically moved during the drying period has brought with it the necessity for machinery which is so costly to install and maintain that most of the economic advantages of high frequency drying are lost.

Furthermore, it has been found that after the drying of yarn bodies by subjecting them to high frequency electrostatic fields, the surfaces of the dried yarn body are possessed of different physical properties from the inner layers of yarn, and that this problem is not solved or mitigated by relatively rotating the capacitors and the yarn body during the drying period.

It has been discovered as an important part of this invention that yarn bodies may be uniformly dried throughout their volume by electrostatic

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methods without recourse to physical movement of either the yarn bodies or the capacitors, and it is therefore an object of this invention to provide a method and apparatus for the high frequency drying of hollow yarn bodies at a uniform rate which is characterized by the maintenance of uniform physical and mechanical properties of the yarn throughout the yarn body.

It is contemplated according to the present invention to improve the handling of yarn bodies during drying in such a way that the number of bodies dried per unit of time is increased, the escape of the water vapor or steam is more easily effected and the physical properties of the surface layers of the yarn body are maintained at the same high standard as those of the remainder of the yarn body.

It is a further object of the present invention to control the drying at various radii of the yarn body in such a way as to avoid shrinkage difficulties while at the same time avoiding the necessity for electrical connections leading to the hollow interior of the yarn body.

It is also an object of the present invention to provide a method and apparatus for the continuous or batch drying of large numbers of yarn bodies such as cakes, packages or the like.

Other objects and advantages of this invention will be apparent upon consideration of the following detailed description of several embodiments thereof in conjunction with the annexed drawings wherein:

Figure 1 is a schematic end view of a hollow yarn body disposed in a high frequency electrostatic drier constructed in accordance with the principles of the present invention;

Figure 2 is a view similar to Figure 1 but illustrating a modified circuit arrangement leading to the plates of the condensers which establish the electrostatic field;

Figure 3 is another view also similar to Figure 1 but illustrating a different disposition of the plates of the condensers which establish the electrostatic field;

Figure 4 is a view in side elevation of a plurality of cakes so disposed and covered as to protect their outer surfaces against undesirable non-uniform drying during subjection to high frequency electrostatic fields;

Figure 5 is a top plan view of a yarn cake having therein a core body constructed in accordance with the principles of the present invention;

Figure 6 is a vertical sectional view taken along the line 6—6 of Figure 5;

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Figure 7 is a schematic view of apparatus for the continuous or intermittent drying of hollow yarn bodies in accordance with the teachings of the present invention; and

Figure 8 is a perspective view of batch high frequency drying apparatus according to the present invention wherein a conductor is disposed centrally of the cakes to be dried.

Figure 9 is a perspective view of apparatus according to the present invention for drying a column of yarn bodies in a rotating electrostatic field.

Referring first to Figure 1 of the drawings, the numeral 10 designates a hollow yarn body which is physically supported in a horizontal position on a rod 11. Surrounding the yarn body are a plurality of arcuate plates 12, 13 and 14, these plates constituting capacitors for the establishment therebetween of high frequency electrostatic fields. If now the plate 12, the plate 13, and the plate 14 are connected to a source 14a of high frequency alternating currents, which differ in phase by 120° , it will be apparent that the field established between the several plates 12, 13 and 14 will rotate relative to the yarn body so that the average field distribution throughout all portions of the yarn body over the drying period will be constant. Thus the yarn body, even though held stationary, may be subjected to the action of an electrostatic field having a high average uniformity and this field will cause the uniform drying of the yarn body throughout.

If desired, the condenser plates may be connected in parallel groups rather than as single units. An example of this modification is shown in Figure 2, where three pairs of condenser plates are shown. Thus the plate 15 is connected in parallel with the plate 16, the plate 17 is connected in parallel with the plate 18, and the plate 19 is connected in parallel with the plate 20. The components of the parallel connected pairs are disposed physically 180° apart about a yarn body 21 which is supported on a rod 22. The pair 15 and 16 is connected through a lead 23 to a source 24a of high frequency alternating current. Similarly, the pair 17 and 18 is connected through a lead 24 and the pair 19 and 20 is connected through a lead 25. The leads 23, 24 and 25 are supplied with currents 120° out of phase so that again a rotating field is established which has a high uniformity (averaged over the drying period) throughout all parts of the yarn body.

It is not necessary that a three phase system be used or that the phase angle be 120° . For example, as shown in Figure 3, four plates 26, 27, 28 and 29 may be used, these plates being disposed about a yarn body 30 supported on a rod 31. In this case, the phase angle of the outputs of the high frequency source 29a is 90° . Accordingly, it is apparent that to determine the phase angle it is only necessary to find the quotient of 360° divided by the number of plates. Naturally, if the plates are arranged in parallel groups, as indicated in Figure 2, then the quotient will have to be 360° divided by the number of groups. Hence, the phase angle in Figure 2 is 120° while the phase angle in Figure 3 is 90° .

The speed of rotation of the electrostatic field is determined for the most part by the strength of the field, or otherwise stated, by the amount of energy supplied to the body to be treated per unit time. As this amount of energy increases, the speed of rotation of the field must be greater.

The foregoing description relative to Figures

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1, 2 and 3 has had reference to but a single cake or yarn body supported on the rods 11, 22 and 31 respectively. It has been found, however, as an important part of the present invention that a plurality of yarn bodies supported on a rod of insulating material may be dried simultaneously. In this regard attention is directed to Figure 4, wherein the cakes which are interiorly right cylindrical and exteriorly frusto conical in form, are arranged in end to end fashion on a supporting rod 32 corresponding in structure and function to the rods 11, 22 and 31 previously described. The small end of cake 36 abuts against the small end of cake 37, the large end of cake 37 abuts against the large end of cake 38, the small end of cake 38 abuts against the small end of cake 39, and the large end of cake 39 abuts against the large end of cake 40. This leaves exposed only the large end of cake 36 and the small end of cake 40, and these are covered with annular members made of a material possessed of a loss angle equal to or lower than that of the yarn. The large annular member, which bears reference numeral 41, is applied to the large end of cake 36 and the small annular member, which bears reference numeral 42, is applied to the small end of cake 40. The entire assembly of cakes 36, 37, 38, 39, and 40 is wrapped with a material 43 which has been found to protect the surface of the cakes during drying but is sufficiently open to permit the escape of the steam which is evolved. To this end the wrapping material 43 may be provided with perforations or other apertures. An ideal wrapper is one having dielectric properties which correspond as much as possible to those of the body to be treated. This is also true of the plates and annular members which bear against the end faces of the bodies to be treated. Thus, in the drying of rayon, it is apparent that one suitable material, of which the annular members 41 and 42 may be made, is cellulose paper. It must be noted, however, that when using a dry wrapper or dry plates which are in contact with the bodies to be treated, the wrapper or plate must not be permitted to become so hot as to have a detrimental influence on the bodies to be treated. To assure avoidance of this difficulty the wrapper and plates can be made of a material having a smaller loss angle than the material of the body to be treated.

The end plates 41 and 42 should be made of a material which will absorb moisture, and thus the thread layers at the ends of the cakes against which the annular members 41 and 42 bear will be affected by the electrostatic field in the same way as the portions in the center of the spinning cake.

While in Figure 4 plates 41 and 42 are shown bearing against the opposite ends of the stacked assembly of cakes, it is possible to use plates which are spaced from the end faces of the yarn body assembly. These plates may be provided with apertures or perforations, and in the case of the evolution of considerable steam during the drying operation, such steam may escape between the cake ends and the plates as well as through the plates themselves. Where spaced plates are used, it is advantageous in some cases to make them of a material which has a loss angle higher than that of the yarn. This, it can be seen, has the effect of maintaining the temperature at the cake end at the same value which prevails within the cake.

The three condenser plates which provide the

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electrostatic field which performs the drying operation in connection with Figure 4, are indicated by reference numerals 42a, 42b and 42c. It will be noted that the plates 42a, 42b and 42c extend for the full length of the group of cakes and are arranged relative to one another in the scheme disclosed in connection with Figure 1. The source of high frequency currents for the plates 42a, 42b and 42c is indicated schematically at 42d.

All of the high frequency generators are illustrated as block diagrams and include a block diagram labeled "Phase Shifting Networks." This type of illustration has been used in view of the fact that both high frequency generators per se and the phase-shifting devices associated therewith constitute, per se, no part of this invention. For information as to how these phase-shifting networks suitable for the purpose of the present invention may be designed, reference is made to Terman, "Radio Engineer's Handbook," McGraw-Hill, 1943.

In the continuous drying of a large number of cakes, an arrangement such as that shown in Figures 5, 6 and 7 may be used to advantage. In that case, each cake may be provided with a core body 44 of some insulating material such as a ceramic. This core body fits into the central hole in the cake and is itself provided with a plurality of axially extending holes or channels 45, 46, 47 and 48 which communicate with radial holes or ports 45a, 46a, 47a and 48a respectively. Thus, steam evolved during the drying operation can pass through the radial ports and into the axial passageways and from there to atmosphere. The ports 45a, 46a, 47a and 48a can be inclined in the direction of escape of the steam to further the flow of steam to the desired outlet.

Centrally located in the core body 44, there is provided a rod 49 of electrically conductive material. The rod 49 is provided with a socket 50 at one end and a projection 51 at the other. The mouth of the socket 50 lies flush with one end face of the cake when the core body 44 is in position, while the projection 51 extends above the core body enough to be received in the socket of another conducting rod located in the core body of the cake next above it in a vertical stack. Thus, by providing each of a large number of cakes with core bodies of the type shown in Figures 5 and 6 it is possible to connect them electrically in vertically stacked relationship.

Now referring to Figure 7, a plurality of spinning cakes 52, each provided with a core body 44, may be arranged side by side on a conveyor belt 53 driven in the direction of the arrow of Figure 7 by pulleys 54 and 55. At the end of the upper course of the conveyor 53 the packages fall into a chute or vertical guideway 56 and become connected to one another through the operation of the projections and sockets of the rods 49. A series of conveyor elements 57 and 58, which are vertically arranged, control the rate of fall of the stacked thread bodies in the chute 56. During passage through the chute 56 the thread bodies are subjected to the action of a high frequency electrostatic field.

In Figure 7 cylindrical condenser plates 59 and 60 are shown, these plates being series connected to a high frequency current source 63. It will be noted from an examination of the electrical arrangement shown in Figure 7 that a rotating electrostatic field is not provided, but that an inner electrode is provided which may be said to function as a portion of a condenser to series

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connect the condensers 59 and 60 through the center of the yarn body. Since the inner condensers are comprised of the conductors 49, it is apparent that they are continuously replaced as the drying operation proceeds and that the necessity for external connections is entirely avoided. The ends of the cakes are protected by their end to end stacked relationship.

It is apparent that where the central core or rod is a conductor which participates electrically in the drying operation, the cake is more strongly effected by the field on the inside than on the outside, this being perfectly apparent from a comparison of the relative surface area of the inside of the cake with the outside thereof. Consequently, drying progresses more rapidly on the inside than on the outside. It can be seen therefore that by selecting the dimensions of the condenser, plate distances and strength of field in accordance with the requirements to be met, the drying of the cakes can be completely controlled so as to allow for free shrinkage and uniform properties after drying.

After subjection to the high frequency electrostatic field, the cakes are discharged by the conveyors 57 and 58 into a receiving hopper 64 located therebelow. In view of the fact that sockets and projections of the rod 49 quickly detachably lock the thread bodies together, no difficulty is encountered in connecting the bodies at the upper end of the chute 56, nor in disconnecting the bodies at the lower end thereof.

It will be noted that every other cake on the conveyor 53 is arranged in right-side-up position, while the intermediate cakes are upside-down, so that the cake ends butt together during passage through the electrostatic field much in the manner which was described in connection with Figure 4. Naturally, the core body 44 is arranged in the cakes with the projection 51 always upright.

In the vertical treatment, which is effected by the arrangement shown in Figure 7, the escape of steam is very conveniently effected through the channels 45, 46, 47 and 48 which may be caused to register by rendering the projection 51 and the complementary socket 50 of some non-round cross section as for example, square, as indicated in Figure 5.

The arrangement of Figure 7 may be operated as an intermittent batch system or as a truly continuous system, depending upon the length and intensity of the electrostatic field through which the cakes are passed. If a batch system is employed, the conveyors 53, 57 and 58 are operated periodically in timed relationship. If a truly continuous operation is contemplated, these conveyors are continuously operated at a relatively low rate of speed. It is apparent that one of the advantages of the vertical arrangement of Figure 7 is that the weight of the cakes tends to maintain the cake ends in butting relationship during their travel through the electrostatic field. Furthermore, as the cakes become drier they are further down the stack than the wet cakes, with the result that when the danger of damage to the cake ends is greatest, the pressure can never get sufficiently great to damage the cakes due to the fact that the central cores 44 will allow only a certain amount of axial compression of each cake.

It will be understood that the core body shown in Figures 5 and 6 is only intended to demonstrate the basic principle of the construction. Consequently, it goes without saying that some

provisions have to be made to compensate for shrinkage while the body is being treated in the high frequency field. This may be effected by placing the body to be treated loosely upon the core body supported from a horizontal extension of the core body, or by rendering some part, such as the outer layer of the core body, compressible.

It is within the scope of this invention to apply the rotating field of Figures 1 to 3, inclusive, to the continuous handling apparatus of Figure 7. Such an arrangement is shown in Figure 9 wherein the parts corresponding to the conveyor 53, the chute 56 and the conveyors 57 and 58 are omitted for convenience of illustration. Likewise omitted are the cores within the cakes which, however, are of the form shown in Figures 5 and 6 except that the central rod corresponding to the rod 49 is not of electrically conductive material.

In Figure 9, three condenser plates 65, 66 and 67 are shown connected to a high frequency generator 68 provided with suitable phase-shifting networks. The delivery of the cakes to the drying apparatus, the passage of the cakes through that apparatus and the removal of the cakes from it, correspond to the descriptions in connection with Figure 7.

It is also possible according to the present invention to provide a rotating field in conjunction with a conductive central core and such an arrangement is illustrated in Figure 8. In Figure 8 there are shown six plates 69, 70, 71, 72, 73 and 74. The plates are arranged in an annular path around the outside of the cakes and the interior of the cakes is provided with a centrally located conductive rod indicated at 75. The plate 69, the rod 75 and the plate 72 constitute a pair of condensers in series and two other such pairs are provided respectively by the plates 70—73 and 71—74, each in co-action with the rod 75. The principal difference between the arrangement shown in Figure 8 and that shown in Figure 4 is that instead of having three condensers 120 degrees out of phase, three pairs of series connected condensers 120 degrees out of phase are provided. In Figure 8 the generator with its phase-shifting networks is generally indicated by the numeral 76. The spacing means for holding the central rod 75 in coaxial position can be in exact correspondence to the arrangement shown in Figures 5 and 6 except that a continuous conductive rod may be substituted for the intermittent rods 49 shown in Figure 6.

Throughout the specification, little has been said with respect to the temperatures to which the bodies are subjected during drying. The reason for this is that the temperatures depend upon the properties of the component threads of the cakes. In view of the fact that the bodies are treated for only a short time, temperatures higher than those assumed to be maximum in the prior art may be used. Naturally, the temperatures in spinning cakes or spools remain low as long as they are wet, because the heat supplied to the spinning cakes is employed in evaporating the moisture content. Enough energy may be supplied to the spinning cakes so that the drying takes place at a temperature of about 100° C. without detrimental consequences. It may be desirable, however, after a part of the moisture has been removed, to continue drying at lower temperatures. Optionally, this may be done in a second field following the first.

It is understood that the invention is not lim-

ited to the embodiments described above by way of example and set forth in the drawings, but that they may be varied in numerous ways without departure from the scope of the invention. Furthermore, while reference has been made throughout the specification to spinning cakes or yarn cakes of the type which are produced by the pot-spinning process, it is apparent that the invention is equally applicable to other types of yarn bodies such as arbor-wound packages of cylindrical shape, etc.

What is claimed is:

1. Apparatus for drying hollow yarn bodies which comprises a plurality of condenser plate assemblies the plates of which are so spaced relative to one another as to substantially surround the exterior of a hollow yarn body to be dried, and means for supplying said assemblies with high frequency currents separated in phase by a number of degrees corresponding to the quotient of 360 divided by the number of assemblies.

2. Apparatus for drying hollow yarn bodies which comprises three pairs of condenser plates, the components of each pair being connected in parallel, said plates being so positioned relative to one another as to substantially surround the exterior of a hollow yarn body to be dried and the components of each pair lying 180° apart, and means supplying each of said pairs with high frequency currents separated in phase by 120°.

3. Apparatus for batch drying a plurality of hollow yarn bodies which comprises a group of condenser plates, the components of the group being circumferentially spaced to surround a group of hollow yarn bodies arranged in end to end abutting relationship, a conductor spaced from the plates so as to lie within the hollow interior of the yarn body, and means supplying a high frequency current to each plate of the group, the high frequency currents supplied to the several plates differing in phase by the quotient of 360° divided by the number of series plates, whereby a rotating electrostatic field is provided to effect uniform drying of the elongate hollow yarn body.

4. An electrically nonconductive core for hollow yarn bodies having an axial gas port and radial gas ports connecting the inner layers of the yarn body with the axial gas port, an electrical conductor passing through said core, the electrical conductor comprising a portion at each end for connecting it to the conductor of another core to permit yarn bodies to be stacked for subjection to high frequency drying with the conductors of the several cores functioning as a part of the capacitor.

5. A core for hollow yarn bodies comprising a ceramic insert adapted to be received in the hollow interior of a yarn body, said ceramic having a plurality of axially extending gas ports therethrough with radially extending gas ports connecting the axially extending gas ports with the inner layers of the yarn body, a centrally located electrical conductor passing axially through said ceramic core, said conductor being provided with a projection at one end and a complementary socket at the other adapted for interconnection in a predetermined angular position so that a plurality of yarn bodies may be stacked in connected relationship with the conductors of the several cores electrically connected, and with the axially extending gas ports in registry by virtue of the alignment afforded

by the angular adjustment of the yarn bodies to effect the connection of the conductors.

ROBBERT v. NES.
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