CROSS REFERENCE EXAMINER

April 21, 1970 G. E. GARD 3,507,940

SHAPED CHARGE BLENDING METHOD AND PRODUCT

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FIG. 1A.

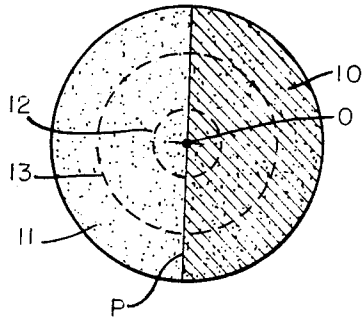


FIG. 1B.

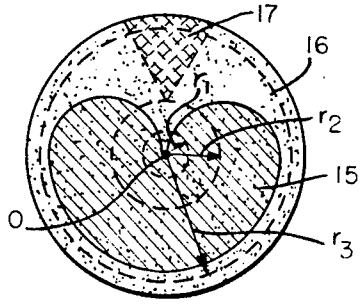


FIG. 1C.

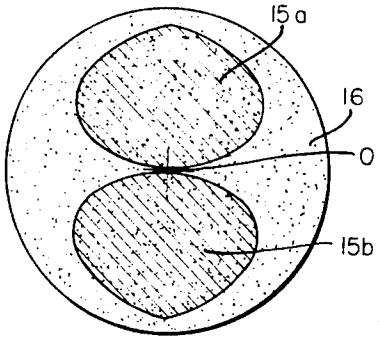
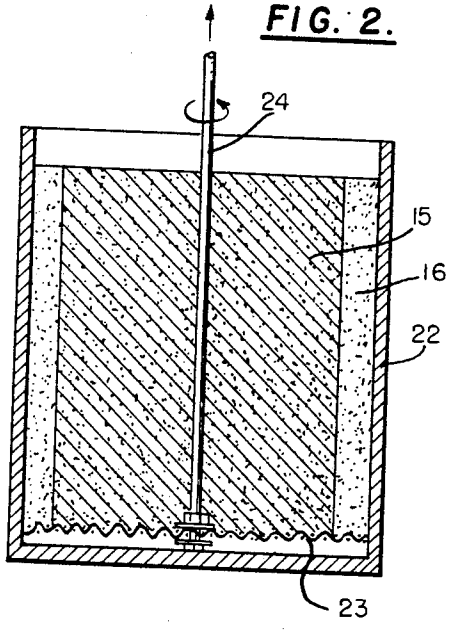


FIG. 2.



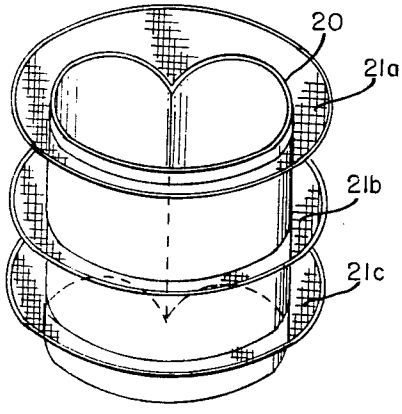


FIG. 3.

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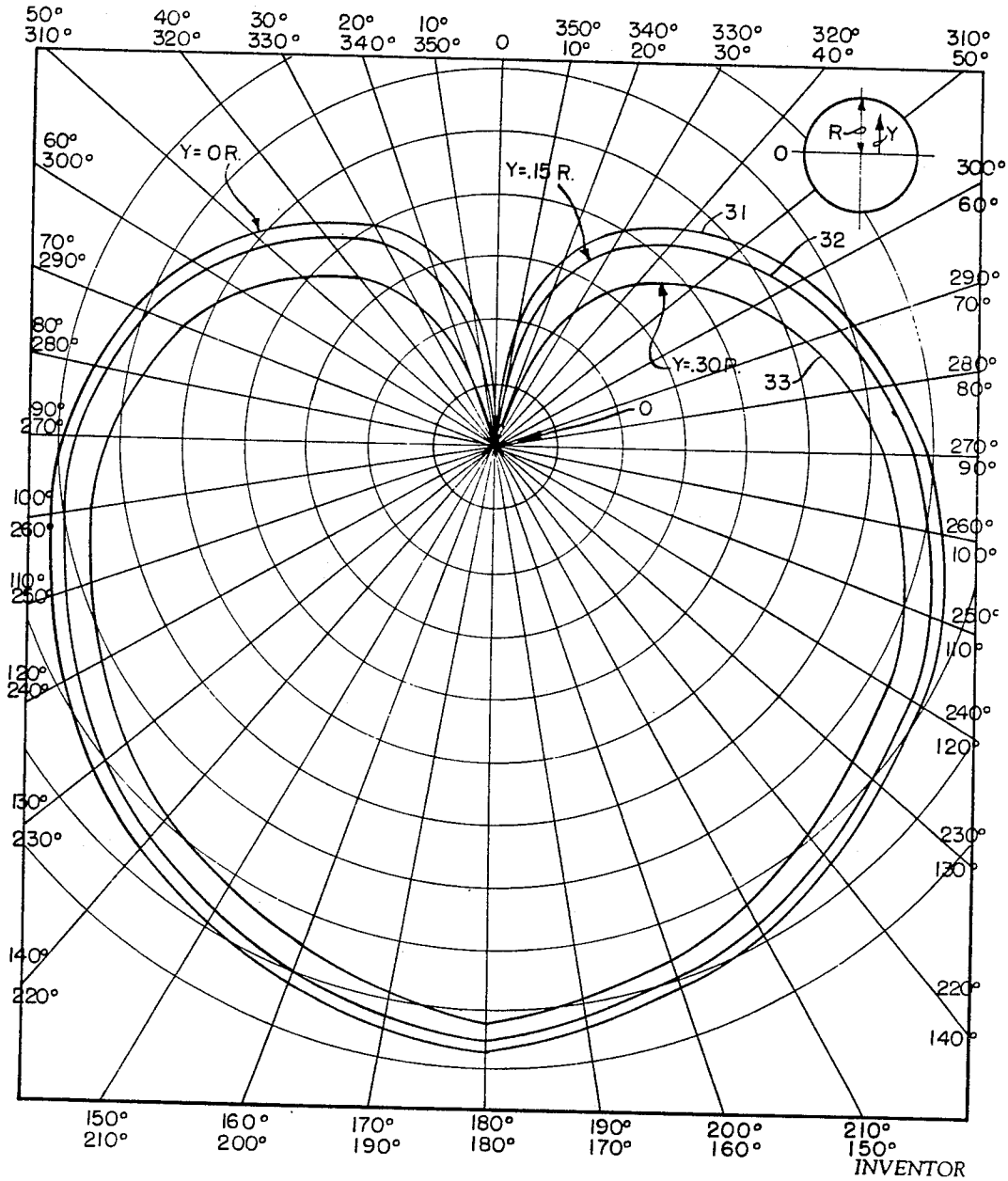
ATTORNEYS.

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SHAPED CHARGE BLENDING METHOD AND PRODUCT

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FIG. 4.



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FIG. 5.

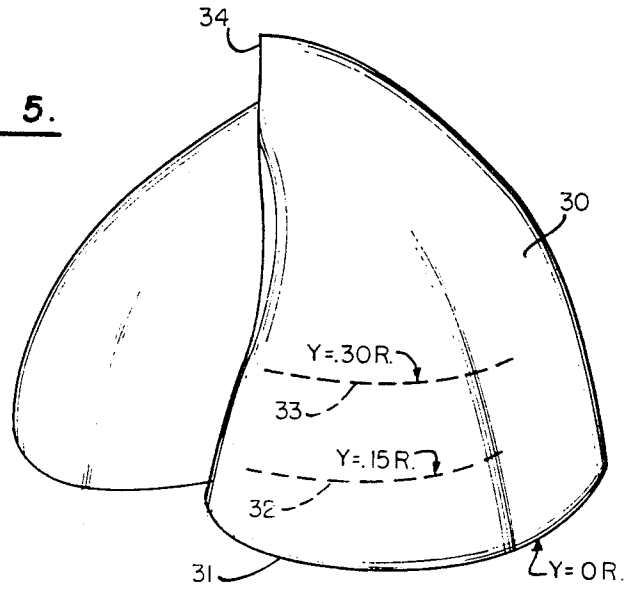
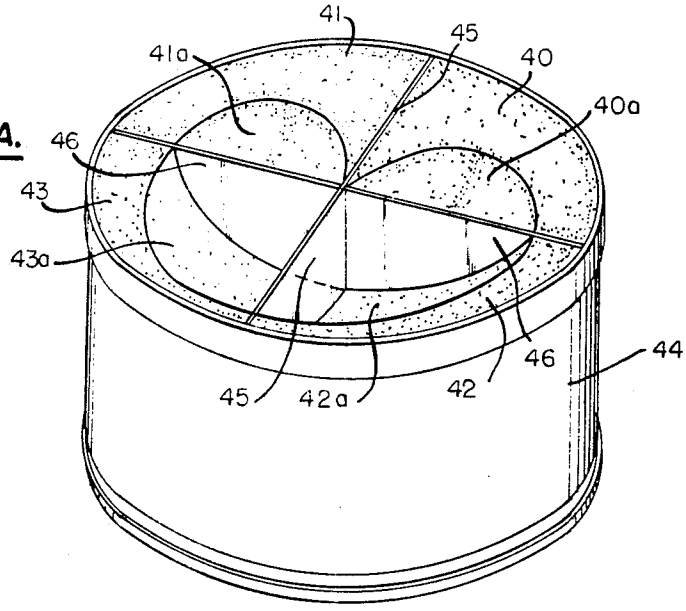


FIG. 6A.



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FIG. 6B.

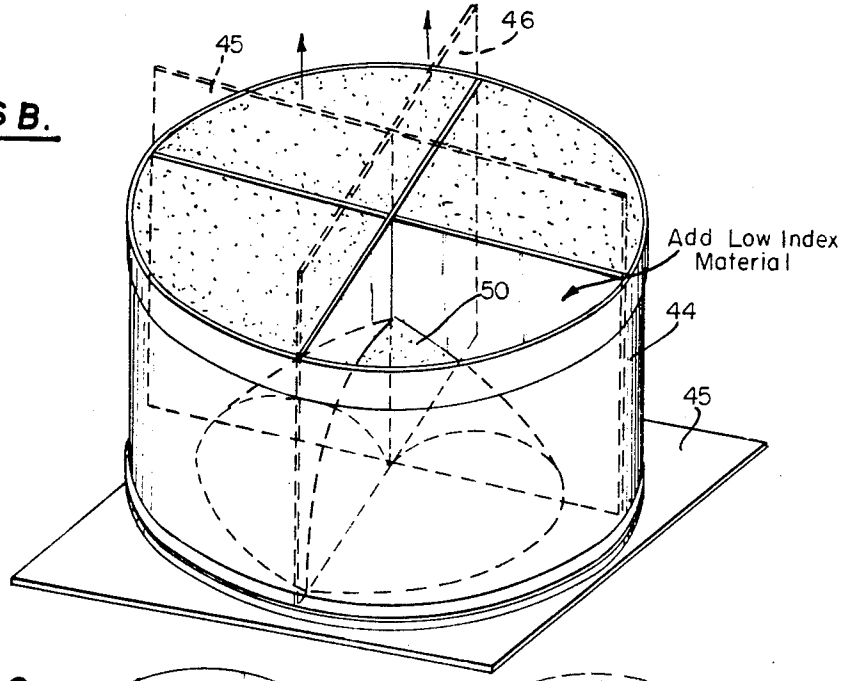
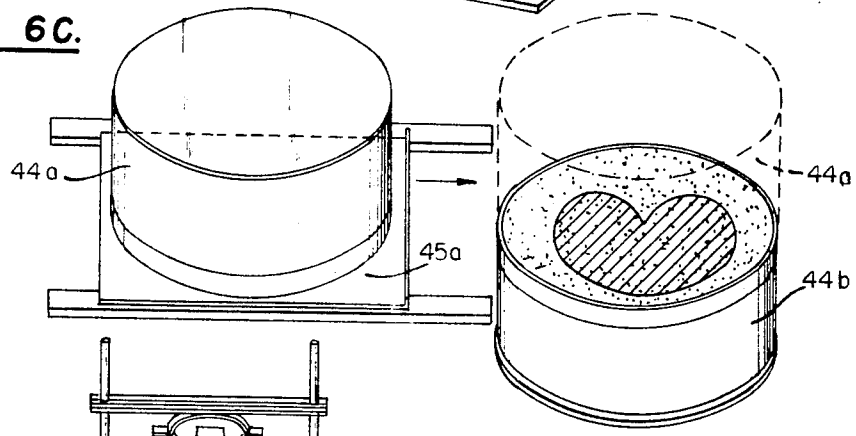


FIG. 6C.



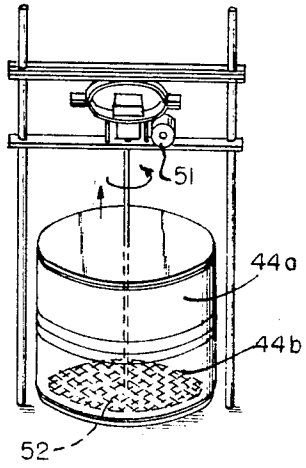


FIG. 6D.

INVENTOR

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ATTORNEYS

United States Patent Office 3,507,940 Patented Apr. 21, 1970

3,507,940

SHAPED CHARGE BLENDING METHOD AND PRODUCT

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Filed Mar. 14, 1967, Ser. No. 623,020
Int. Cl. H01q 15/08
U.S. Cl. 264—71 17 Claims

ABSTRACT OF THE DISCLOSURE

A charge of particulate first dielectric material, having a predetermined shape in two or three dimensions, is disposed adjacent to a particulate charge of second dielectric material. The composite charge is stirred in circles to evolve a mixture of the two materials which exhibits a dielectric constant gradient in two or three dimensions. The stirred mixture is then fused into a monolithic mass.

BACKGROUND OF THE INVENTION

The present invention relates to a novel method of blending natural or artificial dielectric materials, having different dielectric constants, to produce a composite mixture exhibiting a dielectric gradient in desired directions. Such a composite mixture can be used to fabricate dielectric microwave lenses e.g. a Luneberg lens, a Maxwell lens, an Eaton lens, or the like wherein the dielectric constant, and hence the refractive index of the lens, varies as a function of the lens coordinates.

Various techniques have been described heretofore for mixing two or more dielectric materials, for the purposes described. In my prior Patent No. 3,088,713, issued May 7, 1963, for "Blending Method," I describe a technique utilizing a pair of conveyors for transporting two different materials toward a common mixing location, one of said materials comprising, for example, plain polystyrene beads, and the other material comprising aluminum-silver loaded polystyrene beads. The amounts of these two different materials transported along their respective conveyors is controlled by a pair of gates disposed respectively adjacent and parallel to its associated conveyor. A composite mixture is produced which can then be fused into a monolithic mass. Variations in this technique, particularly relating to the form of gating apparatus employed, and/or to the steps of utilizing the monolithic mass produced, are described in Horst U.S. Patent No. 3,149,650, issued Sept. 22, 1964, for "Admittance Meter and Dielectric Control System"; in Horst U.S. Patent No. 3,216,464, issued Nov. 9, 1965, for "Method and Apparatus for Fabricating One-Dimensionally Graded Devices"; in Horst U.S. Patent No. 3,255,453, issued June 7, 1966, for "Non-Uniform Dielectric Toroidal Lenses; in Horst U.S. Patent No. 3,256,373, issued June 14, 1966, for "Method of Forming a Cylindrical Dielectric Lens"; and in Horst U.S. Patent No. 3,274,668, issued Sept. 27, 1966, for "Method of Making Three-Dimensional Dielectric Lens."

Techniques of the types described above sometimes contemplate that the final monolith be subdivided into modules which are thereafter assembled to produce a new structure having a desired gradient in three dimensions, e.g. as described in said Horst Patent No. 3,274,668. It is also possible to position-program variably contoured gates to directly achieve a dielectric gradient in three dimensions e.g. as described in Horst U.S. application Ser. No. 234,135, filed Oct. 30, 1962 for "Three-Dimensional Dielectric Lens and Method and Apparatus for Forming the Same." While all of these prior blending techniques produce lenses which exhibit quasi-optical properties far

superior to those previously obtainable by so-called step construction techniques, employing a large plurality of individually ungraded modules, some disadvantages have been noted.

The use of conveyors, gates, and collection receptacles tends to limit the size of the monolith, due to practical limitations in the physical size of available equipment. It has also been found that, during processing, some of the material being transported may inadvertently find its way underneath the conveyors, raising the conveyors above a desired datum level and reducing the effective size of the gate openings at one or more points. This makes dielectric gradient errors possible unless extreme care is taken to avoid such accumulation. When relatively large lenses (e.g. 44" diameter lenses) are made by assembling wedges sliced from the monolith, e.g. as described in Horst U.S. Patent No. 3,274,668, any systematic phase error, resulting from a density gradient in the monolith, tends to accumulate and degrades the radiation pattern obtainable over 360°, making the best patterns obtainable only over lesser viewing angles.

The present invention, recognizing these problems, is concerned with a new blending technique which can achieve a desired two-dimensional or three-dimensional dielectric gradient in a monolithic mass of any size, large or small, and which achieves such a gradient more perfectly throughout the entire mass than has been the case heretofore.

SUMMARY OF THE INVENTION

Rather than employing conveyors and gates, the present invention directly forms a composite charge of two different, preferably particulate, materials in a mold. The composite charge includes a charge of first material which is placed in said mold in a predetermined 2-dimensional or 3-dimensional shape; and this shape charge is then associated with a charge of second material placed adjacent thereto. The shaping of the particulate charges is preselected to assure that, when the composite charge is stirred in circles, successively different relative amounts of the two materials are blended with one another on successive incremental circles extending outwardly from the axis of stirring. As a result, such stirring of the two materials produces a dielectric, or other desired parameter, gradient across the mixture. This gradient is then effectively "frozen" into the mixture by fusing the mixed materials into a monolithic mass, e.g. by a steam molding technique. Any desired gradient can be achieved by giving appropriate attention to the shape of the charges employed and/or to the path of stirring employed.

When the shaped charges consist of materials having different dielectric constants, a dielectric gradient is produced by the aforementioned stirring, and the final mass can be used as a dielectric lens or to fabricate such lenses. The present invention lends itself, however, to variably mixing other materials so as to produce different percentages of two or more materials at different places throughout a composite body; and therefore, in its broader aspects, the techniques of the present invention are not limited to lens formation.

It is accordingly an object of the present invention to provide a method of blending two or more materials to produce a composite mixture having a desired variation in a preselected parameter in two or three dimensions.

Another object of the present invention resides in the provision of a mixing technique capable of fabricating a monolithic structure having a dielectric gradient therein, which gradient can be achieved with greater accuracy throughout the monolith than has been possible heretofore.

A further object of the present invention resides in the provision of a blending technique adapted to fabricate

relatively large dielectric lenses which avoid phase errors that have sometimes occurred in such large sizes heretofore.

Still another object resides in the provision of a novel product produced by the method of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1A is a plan view of a shaped charge configuration in accordance with one aspect of the invention;

FIGURE 1B is a plan view of a different shaped charge configuration in accordance with a preferred embodiment of the present invention;

FIGURE 1C is a plan view of another shaped charge configuration in accordance with the present invention;

FIGURE 2 is an elevational cross-sectional view of a stirring apparatus;

FIGURE 3 is a perspective view of a form used to fabricate a shaped charge of the type shown in FIGURE 1B;

FIGURE 4 is a graphical representation of a three-dimensional charge formation contour in accordance with the present invention;

FIGURE 5 is a perspective view of a shaped charge of the type graphically depicted in FIGURE 4;

FIGURE 6A is a perspective view of a forming apparatus which can be employed to achieve a shaped charge of the type shown in FIGURES 4 and 5; and

FIGURES 6B, 6C, and 6D, illustrate the manner in which the structure of FIGURE 6A can be manipulated in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In forming a shaped charge of the type contemplated by the present invention, a first particulate material is placed in a container, e.g. a cylindrical container, in such manner that a boundary wall of said first charge is spaced from a side wall of the container. Another charge of a second particulate material, with which the first material is to be mixed, is then disposed in the space between said boundary wall of the first charge and the side wall of the container so that said second charge supports the first charge in place. The composite charges are then stirred in said container along a plurality of similar closed paths, e.g. circles, at least some of which paths intersect both of the first and second charges. During such stirring along paths intersecting the two charges, both of the materials will be blended along each of the stirring paths; and the relative percentages of the two materials which are blended along any one path are dependent upon the configuration of the boundaries between the two charges or, more particularly, upon the relative amounts of the two materials which lie along the stirring path.

FIGURE 1A illustrates the plan view of a shaped charge adapted to produce a 50–50 mix of two materials. A cylindrical container may be provided with a diametral partition extending along the axis of said container; and the two halves of the container can then be filled with two matrials **10** and **11** having parameter values which differ from one another. When the partition P is removed, the two materials **10** and **11** can be stirred along a plurality of incremental circles about the central axis O of the container. Two such circles have been indicated at **12** and **13**; and it will be seen that each stirring path **12** and **13** intersects the two materials **10** and **11** in equal amounts. As a result, stirring of a shaped charge configuration shown in FIGURE 1A will blend the two materials **10** and **11** together in such manner that the final mix exhibits a parameter value equal to the average of the two parameter values for the initial charges **10** and **11**. This final mix can be fused into a monolithic mass, e.g. by a steam molding technique of the type described in the aforementioned prior Horst patents.

With shaped charges of the types shown in FIGURE 1A, no parameter gradient is achieved; and the final mixture exhibits uniform parameter characteristics in all directions. If it is desired to achieve a gradient, however, e.g. a Luneberg gradient in a dielectric mass, the shaping of the charges must be appropriately selected to assure that, after stirring, a desired variation in dielectric constant is achieved in radial directions. A plan view of a shaped charge, suitable for producing such a Luneberg gradient, is illustrated in FIGURE 1B. Reference is made to the aforementioned Gard and Horst patents for a discussion of the Luneberg gradient, and also for a discussion of the types of natural and artificial dielectric materials, and their respective dielectric constants, which can be blended to achieve a graded dielectric mass suitable for use as a Luneberg lens.

In FIGURE 1B, a shaped inner charge **15** of relatively higher dielectric constant material is surrounded by a further charge **16** of lower dielectric constant material. Charge **16** may comprise, for example, plain polystyrene beads; whereas charge **15** may comprise aluminum-silver loaded polystyrene beads. Charge **15** exhibits, in plan, a heart or cardioid configuration and has two distinct lobes which meet at the center O of the cylindrical container. The heart shaped boundary wall of inner charge **15** is maintained, prior to stirring, by the engaging complementary boundary wall of outer charge **16**. When the charge configuration shown in FIGURE 1B is stirred on circles about the center O, different amounts of the two materials **15** and **16** are mixed with one another along each such circle; and the shape of charge **15** in relation to the complementary shape of charge **16** assures that the relative proportions of the materials mixed on each incremental circle produces a final blend having a variation in a dielectric constant consistent with a Luneberg gradation.

More particularly, as one stirs in a circle immediately adjacent to the center O, substantially high dielectric constant material **15** only is stirred. At a circle of radius r_1, the stirring blends a relatively large percentage of material **15** with a relatively small percentage of lower dielectric constant material **16**. At a larger circle of radius r_2, the stirring again blends the two materials **15** and **16**, but the proportion of material **16** to that of material **15** increases. The proportions continue to change on successively larger stirring circles until, e.g. at a circle of radius r_3, the stirring mixes low dielectric constant material **16** only. By utilizing the Luneberg equation to determine the dielectric constant which should appear at each radius, the precise shape of the charge **15**, in relation to its surrounding charge **16**, can be very accurately determined.

The particular cardioid shape for charge **15**, shown in FIGURE 1B, is not the only charge shape adapted to achieve a Luneberg gradient. FIGURE 1C illustrates another shape wherein charge **15** comprises two separate lobes **15***a* and **15***b* meeting one another at the center O of the composite charge, and surrounded, as before, by charge **16** of lower dielectric constant material. The lobate shape of FIGURE 1C, can, indeed, be further modified to exhibit more than two lobes; but it is preferred to limit the shape to two lobes to facilitate accurate charge formation.

The particular charge configurations shown in FIGURES 1B and 1C achieve a Luneberg gradation in a two-dimensional, or cylindrical, lens. Other gradations appropriate for other types of lenses, may be readily effected by plotting the relative amounts of material which should be blended on each incremental circle, as determined by the equation for the desired gradient, and then assembling the charges in the shapes so plotted. Moreover, the shaped charge concepts of the invention can be utilized to achieve desired electrical properties other than dielectric gradients. For example, as illustrated in FIGURE 1B, a wedge shaped charge **17** of relatively high-loss particulate material, preferably having the same

index of refraction as the relatively low-index material **16**, can be inserted into the charge container prior to stirring. When stirred, the particles of wedge **17** will be distributed in varying amounts along the exterior of the composite charge, whereby, after fusion, the resultant monolithic mass is adapted for use as a lens which has desired side lobe suppression. This technique, utilizing an insert charge of high-loss material, can be used in the fabrication of either two-dimensionally or three-dimensionally graded lenses.

FIGURES 2 and 3 depict a former which can be utilized to form, and stir, the charge shown in FIGURE 1B. The apparatus comprises a hollow sheet metal form **20** having a configuration corresponding to that of charge **15**, said form **20** being mounted in a circular basket support consisting of superposed screen sections **21***a*, **21***b*, and **21***c*. Each support section **21***a*, **21***b*, and **21***c* is sized to conform to the interior of a cylindrical mold **22** (FIGURE 2). Sheet metal form **20** is open at both its top and bottom. After the overall former is inserted into mold **22**, relatively high dielectric constant material is filled into form **20** to produce shaped charge **15**; and relatively low dielectric constant material is deposited through screen sections **21***a*, etc. to surround interior charge **15** with complementary charge **16** of lower dielectric constant material. The former structure shown in FIGURE 3 may then be carefully pulled upward, out of mold **22**, to leave the charge configuration **15**, **16** shown in FIGURE 1B.

The resultant composite charge can then be blended in circles by means of a stirring apparatus comprising a circular wire mesh screen **23** disposed adjacent the bottom of said mold **22** and mounted for rotation on a shaft **24** extending upwardly through the composite charge **15**, **16** along the center O of said composite charge. Shaft **24** is rotated relatively slowly and, simultaneously, is pulled upwardly to effect a stirring in circles about the center O of the charge. The stirring should occur at a sufficiently low rate to avoid any centrifugal displacement of particles within the body of the mix. In a **10**" diameter lens, stirring preferably occurs at a rate of about 3 r.p.m. In an 18" lens, stirring preferably occurs at a rate of about 1½ r.p.m. In a 44" lens, stirring preferably occurs at a rate of approximately ½ r.p.m. During its rotation, wire mesh screen **23** is lifted at a rate of approximately ⅛" to ¼" per revolution. It has been found that with a stirring arrangement of the type shown in FIGURE 2, there is some tendency for disturbances to occur in the central part of the mix due to central support rod **24**. Therefore, it is preferable to mount stirring screen **23** on a hollow support drum rather than a central rod, with the support drum being disposed in surrounding relation to shaped charge **15** and located entirely in the relatively low dielectric constant material **16**. Disturbances due to a central rod are thus avoided, and any disturbances due to the stirring screen support apparatus occur only in the relatively low dielectric constant material where they are not significant.

Following the stirring step shown in FIGURE 2, it is desirous to slowly pull a further screen, having a mesh of smaller size than that of stirring screen **23**, through the mix. This further screen functions to randomize the individual particles in the composite mix, without disturbing the relative proportions, so as to improve the isotropy of the mix prior to fusion. The composite mix can then be fused e.g. by a steam molding technique.

The arrangements and techniques thus far described have been concerned with the fabrication of a two-dimensionally graded mass of material. The same techniques can be used in the fabrication of a three-dimensionally graded mass.

FIGURE 4 illustrates, in a polar diagram, portions of the contour of a three-dimensional charge formation **30** (FIGURE 5) of relatively high dielectric constant material which can be disposed within a surrounding mass of lower dielectric constant material to effect a three-dimensional dielectric constant gradient by a stirring technique of the type described. The curves **31**, **32** and **33** (FIGURE 4) show the shape of charge **30** at three arbitrary planes, designated by like number in FIGURE 5. As indicated in the upper right corner of FIGURE 4, the three curves **31**, **32** and **33** show the contour of charge **30** at different levels Y above the central plane of a sphere having a radius R. Curve **31** is a cardioid which corresponds in shape to the charge shape for a two-dimensional lens of the types previously described. Curve **32** shows how the cardioid shape is modified at an elevation level Y which is .15R about the central plane. Curve **33** shows how the cardioid shape is further modified at a level .30R above the central plane. Successive further curves are generally similar in shape to those shown in FIGURE 4, but are of successively smaller internal area until, at the outermost point **34** of charge **30**, the shape degenerates to a line disposed along the 180° line of FIGURE 4.

The shape of the several curves, such as those shown in FIGURE 4, can be plotted from the Luneberg equation given in the aforementioned Horst patents, by determining the dielectric constants which are needed to achieve a Luneberg gradation at every point in the mass. This computation is, of course, much simplified by programming a computer to solve the Luneberg equation in reference to the amounts of the two constituent materials which must be mixed at each point to achieve the desired dielectric constant at each point. By similar computation, the three dimensional contour of any charge needed to satisfy any other desired equation, or to achieve any other desired gradient, can be determined.

In essence, the charge shape shown in FIGURES 4 and 5 is a three-dimensional heart having two lobes which meet one another adjacent the central axis O of the overall mass. Throughout the charge, along the central axis O, the material is of relatively high index; and stirring about this axis will stir only high index material. As the stirring proceeds, at each level, on successive circles about the central axis O, successively smaller amounts of high index material, and successively larger amounts of lower index material, will be mixed with one another. Moreover, as the stirring proceeds at different levels above the base of the mix (Y=OR), the amount of low index material stirred becomes more and more predominant until, at points beyond the tip **34** of charge **30**, there is a stirring of relatively low index material only. When the shaped charge **30** is disposed within a cylindrical mold, and stirred in the manner described, a three dimensional gradient is achieved throughout a hemisphere embedded within a cylindrical mass; and all points outside of this hemisphere are of relatively low index. The superposition of two masses of the types shown in FIGURE 5, with their base planes in engagemnet, will produce a full spherical gradient within a cylindrical mass. In either case, the resultant mass, after fusion, can be used directly as a lens; or, if desired, portions of the surrounding relatively low index material can be removed from the final mass to expose the inner, three-dimensionally graded, lens.

A three-dimensional lens, fabricated by the shaped charge blending method of the present invention, can be produced by the technique shown in FIGURES 6A through 6D inclusive. Once the contour of the charge **30** is determined, this contour can be accurately reproduced by hollowing out a former of the type generally shown in FIGURE 6A. The former is divided into four separate sections **40**, **41**, **42** and **43** each of which has an interior shaped surface **40***a*–**43***a* corresponding to a quadrant of shaped charge **30**. Each section **40**–**43** of the former is molded of urethane foam material, and the outer side of each former section comprises a quadrant of a cylinder which closely fits into a cylindrical mold **44**, open at both its top and bottom. The four quadrants

40–43 of the former are separated by mutually orthogonal sheet metal divider plates 45 and 46.

After the former, with its dividers, has been assembled within cylindrical mold 44 in the manner shown in FIGURE 6A, the hollowed-out quadrants of the former are filled with relatively high index material. A planar retaining cover 45 (FIGURE 6B) is then placed over the upper surface of the mold, and the entire assembly is inverted as shown in FIGURE 6B. Then, working with one quadrant at a time, the former sections 40–43 are removed to expose a portion of shaped charge 30, such as that illustrated in FIGURE 6B at 50, and the exposed quadrant is filled with relatively low index material. During each of these four filling steps, mold 44 is preferably tipped at an angle to its normal vertical axis to preserve the shape of the exposed portion 50 during the filling step. After the four quadrants of the mold have been filled in succession with relatively low index material, the sheet metal dividers 45 and 46 are pulled out of the filled mold 44, in the manner depicted in FIGURE 6B, leaving the shaped charge 30 of relatively high index material embedded in a surrounding mass of relatively low index material. The resultant mass of material, within mold 44, is then stirred in circles in the manner previously described, is further subjected to the randomizing effect of an isotropy basket as described, and is then fused into a cylindrical mass having a desired hemispherical gradient therein.

Alternatively, after filling and prior to stirring and fusion, one open-ended mold section 44*a* can be placed on top of another open-ended mold section 44*b*, whereafter a divider plane structure 45*a* is removed from therebetween as shown in FIGURE 6C. The superposed mold sections 44*a* and 44*b* are then stirred by an apparatus, such as 51, arranged to slowly rotate a circular mesh surface 52 in circles while said mesh 52 is gradually lifted through the composite mix in the two molds 44*a* and 44*b*. The stirring and lifting speeds correspond to those previously described in reference to FIGURE 2. The stirring screen or basket is preferably vibrated as it experiences its rotary and upward motion, to effect the desired mixing with greatest accuracy. The overall mix may then be subjected to the randomizing step discussed earlier, whereafter the final mix is fused into a single cylindrical mass having a spherical gradient therein. The spherically graded central portion of the mass can then, if desired, be turned out of the surrounding matrix material by any desired machining process.

In its broader aspects, a lens of any desired gradient may be achieved by selecting the proper charge shape. Stirring need not be accomplished in circles; and other stirring paths e.g. elliptical paths, can be utilized depending upon the shape of the charge, so long as a proper coordination is assured between the stirring paths and charge shape to provide the desired gradient. The techniques of the present invention are, moreover, not limited to lens formation, and can be used whenever it is desired to variably mix two or more materials to produce different relative percentages of the two materials at different places throughout a larger body. Thus, color gradations or patterns can be achieved by mixing granular particles of appropriate pigmentation. Other desired gradients or patterns in electrical, physical, or visual characteristics can be achieved in either two or three dimensions by the techniques described.

While I have thus described preferred embodiments of the present invention, many variations will be suggested to those skilled in the art; and it must therefore be understood that the foregoing description is meant to be illustrative only and not limitative of my invention. All such variations and modifications as are in accord with the principles described are meant to fall within the scope of the appended claims.

Having thus described my invention, I claim:

1. The method of fabricating a mass of material having a parameter gradient therein which comprises the steps of placing a shaped charge of a first dry particulate material, having a first value of said parameter, in a container with a boundary wall of said shaped first charge being spaced from a side wall of said container, placing another charge of a second dry particulate material, having a second value of said parameter different from said first value, in the space between said boundary wall of said first charge and the side wall of said container, said second charge having a boundary wall complementary in shape to said boundary wall of said first charge and engaging said boundary wall of said first charge to support said first charge within said container thereby to maintain the shape of said first charge in said container, and stirring said first and second charges about an axis in planes extending transverse to said axis, the stirring in each plane occurring along a plurality of similar closed paths extending about and successively outward from said axis with at least some of said paths intersecting both of said first and second charges to blend said two materials incrementally along each of said similar paths in relative concentrations dependent upon the amount by which said path intersects said first and second charges.

2. The method of claim 1 wherein said first and second materials comprise dielectric materials respectively having different dielectric constants.

3. The method of claim 1 wherein said first charge has a cardioid shape in cross section, the exterior of said first charge being surrounded by said second charge.

4. The method of claim 1 wherein said plurality of similar closed paths comprise a plurality of concentric circles.

5. The method of claim 1 including the step of fusing said blended materials into a monolithic mass in said container following said stirring step.

6. The method of claim 5 including the step of passing a mesh screen through said blended materials following said stirring step and before said fusing step to randomize the positions of the particles in said blended materials.

7. The method of claim 1 wherein said first charge has different cross-sectional shapes in different parallel planes passing through said first charge, whereby the exterior of said first charge is shaped in three dimensions.

8. The method of claim 1 wherein said container is cylindrical, said complementary charge boundary walls being contiguous with one another at least in part at the central axis of said cylindrical container, said stirring step being effected in circles concentric with the central axis of said container.

9. The method of claim 1 wherein said container has a circular cross-section, said first charge being surrounded, in a plane traverse to the axis of said container circular cross-section, by said second charge, said first and second charges each comprising a dielectric material, the dielectric constant of said first charge being greater than the dielectric constant of said second charge.

10. The method of claim 9 wherein said first charge is shaped to provide, in cross-section, at least two distinct lobes meeting one another at a position adjacent the axis of said container circular cross-section.

11. The method of treating a mass of material comprising the steps of placing dry particulate material in a container, stirring the material in said container by rotating a mesh screen surface within said container while simultaneously moving said screen surface through the material in said container along the axis of rotation of said screen surface, and thereafter randomizing the particles of said stirred materials by moving a further mesh screen surface, having a smaller mesh size than that of said first mentioned screen surface, through the material in said container.

12. The method of claim 11 including the step of vibrating said first-mentioned mesh screen surface while it is being rotated and moved through said material.

13. The method of claim 11 including the step of fusing said material, while still in said container, into a monolithic mass following said stirring and randomizing steps.

14. The method of claim 10 wherein said stirring axis is substantially colinear with the axis of said container circular cross-section.

15. The method of fabricating a body of dielectric material having a dielectric gradient therein, comprising forming a shaped mass of a first substantially dry particulate dielectric material, said shaped mass being formed to exhibit a plurality of lobes meeting at a junction, embedding said shaped mass in a second substantially dry particulate dielectric material having a dielectric constant different from that of said first material, and blending said first and second materials together by stirring said particulate materials in planes extending transverse to the junction of the lobes in said shaped first mass and at a stirring speed sufficiently slow to avoid centrifugal displacement of said particulate materials, said blending being effected in each such plane along a plurality of incremented circles extending outwardly from and concentric with a stirring axis positioned adjacent the junction of said lobes.

16. The method of claim 15 wherein said shaped mass is formed to exhibit a cardioid cross-section.

17. The method of claim 15 wherein said shaped mass is formed to exhibit a plurality of differently sized lobes located respectively in superposed planes transverse to said stirring axis.

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U.S. Cl. X.R.

264—122, 45, 46, 73; 259—114, 4, 180; 343—911; 18—30