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J. L. BEALOR, JR.
METHOD OF MAKING AN ACOUSTIC WINDOW INCLUDING FILLING
HONEYCOMB CELLS INDIVIDUALLY

3,764,432

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2 Sheets-Sheet 1

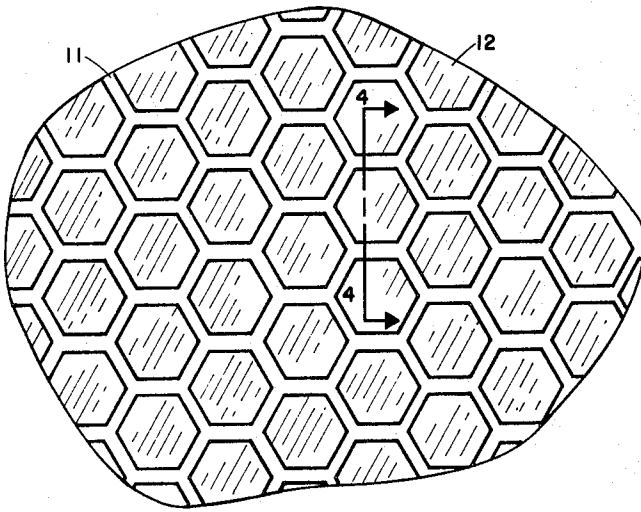


FIG. 1

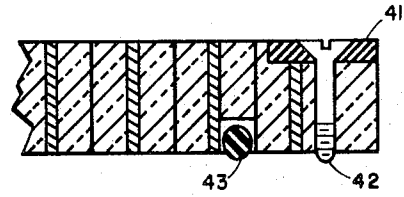


FIG. 5

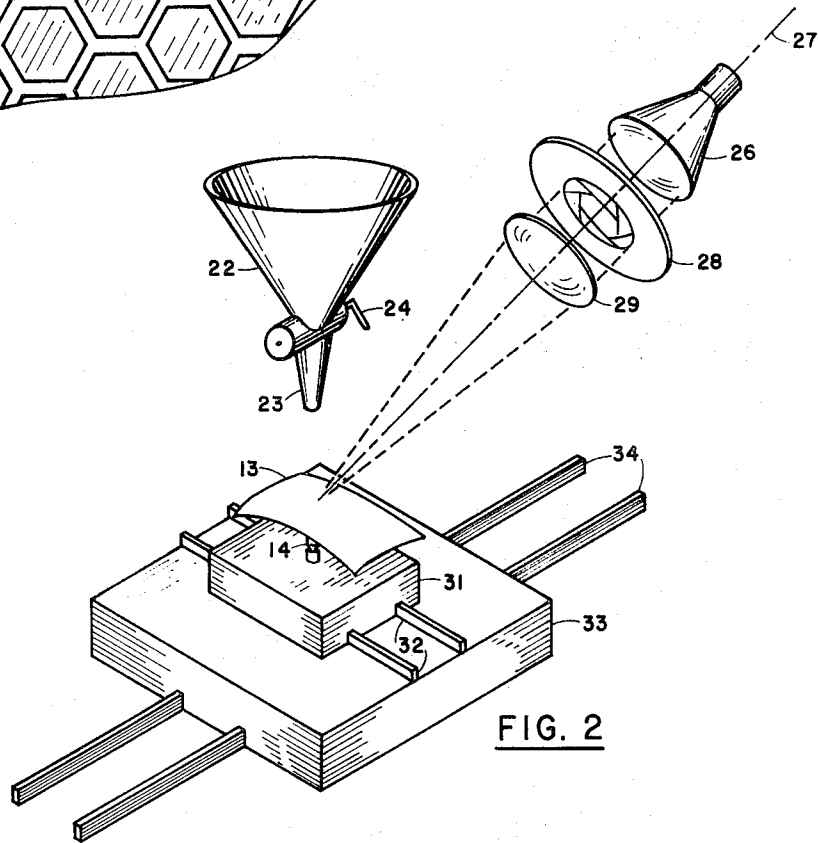


FIG. 2

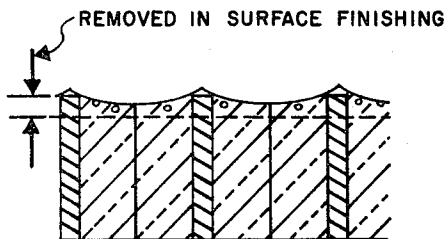


FIG. 4

JESSE L. BEALOR, JR.
INVENTOR

BY *William H. Sheer*
AGENT
Don R. Dwyer
ATTORNEY

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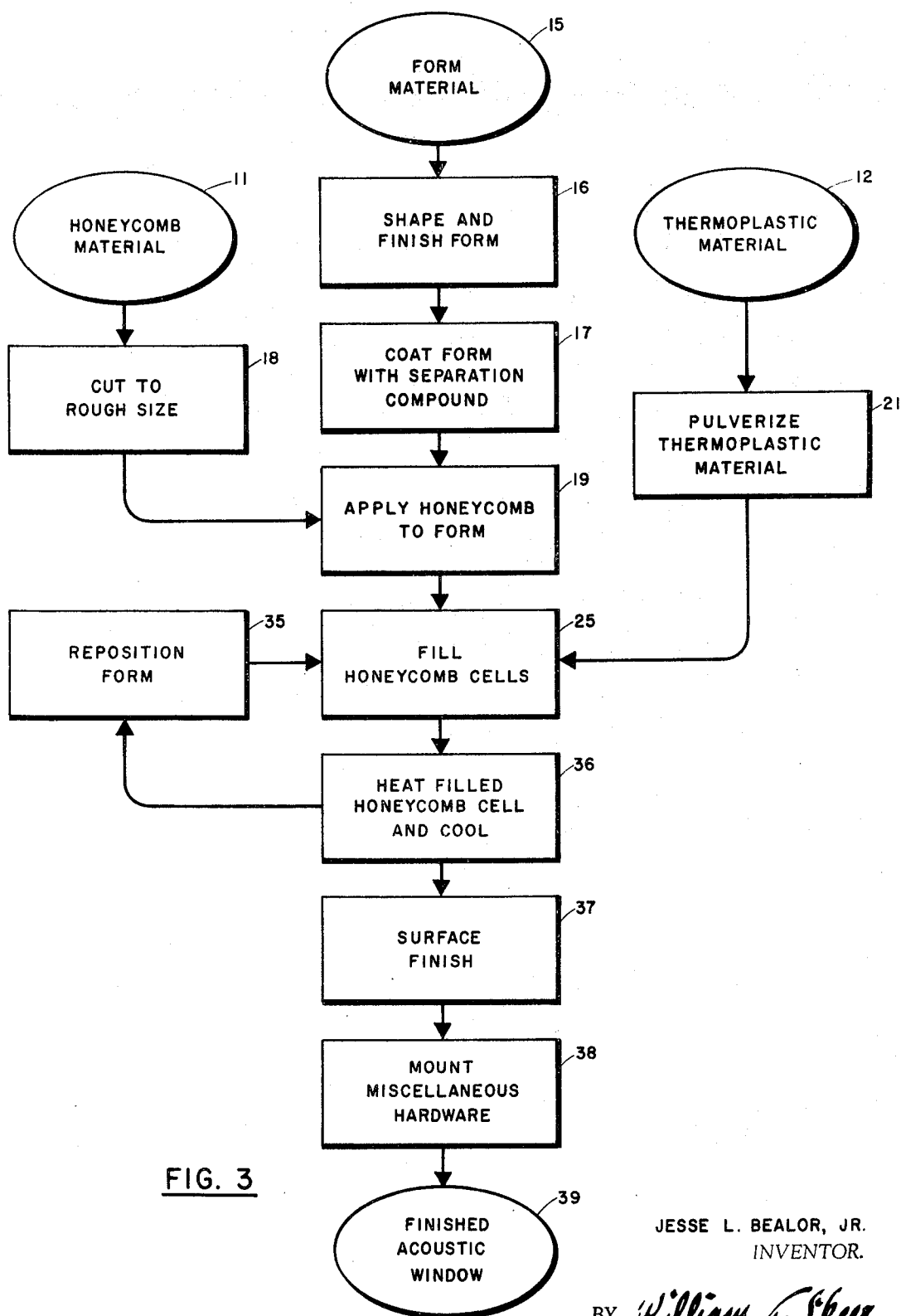


FIG. 3

JESSE L. BEALOR, JR.
INVENTOR.

BY *William T. Spurr*
AGENT
Max D. Doty
ATTORNEY

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METHOD OF MAKING AN ACOUSTIC WINDOW INCLUDING FILLING HONEYCOMB CELLS INDIVIDUALLY

Jesse L. Bealor, Jr., Panama City, Fla., assignor to the United States of America as represented by the Secretary of the Navy

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2 Claims

ABSTRACT OF THE DISCLOSURE

Disclosed is an improved acoustic window or lens comprising a metallic core element and a thermoplastic filler which is shaped to conform to complex curves. A method of manufacture is also disclosed, wherein voids in said core are filled with particles of thermoplastic and then heated to melt the particles into a fluid which hardens to fill the voids.

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

FILED OF THE INVENTION

This invention relates to an improved window of the type which provides a protective covering for radiant energy apparatus within the outer surface of a structure enclosing the apparatus and a method of manufacture therefor. More particularly, but not by way of limitation, the invention pertains to an improved acoustic window type lens to protect an acoustic transducer. By way of further description, the device of the invention pertains to an underwater acoustic window in the outer surface of a marine vehicle.

In modern naval architecture it is a primary consideration to provide a smooth streamlined surface for all marine vehicles, so as to minimize hydrodynamic drag. In many marine vehicles this consideration results in complex hull designs comprising convex and concave surfaces. When it becomes necessary to install sonar or other acoustic energy equipment in such hulls, a compromise in equipment location or hull design must frequently be made because of the unavailability of acoustic windows and lenses having the desired shape. Such compromises have resulted in bulbous protrusions on otherwise hydrodynamically clean hulls or, conversely, the location of such equipment as sonar transducers in locations which are not acoustically or electrically optimum because of the availability of a particular acoustic window. Many times, these compromises seriously limit the development of sonars and others electro-acoustic devices because of the cost and time required to fabricate a new window.

DESCRIPTION OF THE PRIOR ART

Heretofore, the prior art acoustic windows and lenses having complex curves were, for the most part, made by centrifugal casting processes. These processes require the making and mounting of a mated mold pair which can be accommodated on centrifugal casting apparatus. This is a costly and time-consuming process. Also, bubbles trapped in the mold, which are not discovered until the mold is opened, impair acoustic transparency.

Other methods comprise the drawing of thermally softened plastic sheets over prepared and heated forming surfaces. The acoustic windows and lenses made in this fashion are frequently weakened where the stock material is thinned in the drawing apparatus. Also, the acoustic transparency of acoustic windows and lenses made in this

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manner is not uniform due to the thinning resulting from the drawing operation.

Glass fibre and epoxy resin constructions are sometimes used as acoustic windows but their fabrication time is long, due to curing time, and the quality of transparency is quite variable. The difficulty in obtaining uniform quality from the glass fibre constructions is due to air being trapped between layers of the glass fibre material, resulting in opaque reflecting spots or zones in the window. Since these faults are hard to detect visually, a lengthy fabrication and testing procedure must be used to obtain satisfactory acoustic windows in small production or experimental quantities. Needless to say, such procedures are expensive and add to the already burdensome cost of developmental and evaluation tasks.

SUMMARY OF THE INVENTION

The device of the invention comprises a honeycomb preform made of lightweight metal strips, such as aluminum and alloys thereof, for example, with the voids thereof filled with an acoustically transparent plastic material. A process for fabricating the acoustic window of the invention is also disclosed as part of applicant's invention. The honeycomb preform has the longitudinal axes of the hexagonal voids thereof substantially aligned with the propagation axis of the acoustic or other compressional wave energy passing therethrough during the broadcast thereof. In this configuration, the honeycomb preform provides the strength for which it is well known without significantly obstructing the passage of energy. By following the steps of applicant's method, the device of the invention may be readily fabricated.

Accordingly, it is an object of this invention to provide an improved radiation transparent structure and a method of manufacture thereof.

Another object of the invention is to provide an improved acoustic window and a method of manufacture thereof.

Another object of this invention is the provision of an improved method of metal reinforced plastic fabrication and an article of manufacture produced thereby.

Another object of this invention is the provision of an acoustically transparent section of the hull of a marine vessel and a process of construction thereof.

Yet another object of this invention is the provision of a honeycomb reinforced acoustic lens and a method of manufacture thereof.

Still another object of the invention is to provide an acoustically transparent section of the hull of a marine vessel employing honeycomb preform as a component part thereof.

A further object of the invention is the provision of an improved sonar housing element and a process for the manufacture thereof.

A still further object of the invention is to provide a method of manufacture for constructing an improved acoustic window employing a metallic, honeycomb preform as an internal mechanical strengthening therefor.

Another object of the invention is the provision of an improved sonar apparatus covering employing a metallic, honeycomb preform and a thermoplastic filler in the voids thereof and bonded thereto and a method for the manufacture thereof.

Other objects and many of the attendant advantages will be readily appreciated as the subject invention becomes better understood by reference to the following detailed description, when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a section of the acoustic window of the invention;

FIG. 2 is a partially diagrammatic showing of the apparatus used to manufacture the device of the invention;

FIG. 3 is a process diagram of the steps of the manufacturing method of the invention;

FIG. 4 is a section of a partially complete acoustic window according to the invention taken along line 4—4 of FIG. 1; and

FIG. 5 is a sectional view of a marginal portion of an acoustic lens according to the invention showing the miscellaneous hardware used to mount the window.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a section of the acoustic or lens of the invention is shown in plan view. A honeycomb preform 11 is shaped to fit a particular aperture and conform to a predetermined curve. The interstices of honeycomb preform 11, that is the hexagonal voids passing therethrough, are filled with a plastic material 12 which is acoustically transparent. In the developmental uses, low density polyethylene has proven satisfactory, but, obviously, other materials might be used if desired.

Honeycomb preform 11 is a commonly available stock material developed for the aerospace industries as a core for structural laminates. Such a material possesses great strength in resisting compressional forces applied along the longitudinal axis of the honeycomb cells. At the same time the light gage of metal used in its construction, approaching the thickness of foil, permits the honeycomb preform to be bent to conform to nonplanar shapes in directions substantially transverse to the longitudinal cell axis. This great compressional strength is a particular advantage in withstanding hydrostatic pressures associated with deep submergence.

In shaping honeycomb preform 11 into the desired configuration, some distortion of the hexagonal cells occurs. However, the small size of the cells permits this cellular distortion to be distributed over a great many cells in such a manner that the individual distortion remains small enough, for all practical purposes, to be negligible. Furthermore, the distortion generally is in the same direction as the divergence of the acoustic energy beam.

The plastic material 12, which fills the hexagonal voids in honeycomb preform 11, is, of course, acoustically transparent. Besides permitting the passage of compressional wave energy, plastic material 12 gives a rigidity to the honeycomb preform 11 which holds it into its shaped configuration. The marginal portions of filled and encapsulated honeycomb preform 11 are terminated in suitable mounting structure, to be described presently.

The precise nature of the mounting hardware will, quite naturally, depend upon the particular application for which the acoustic window is designed. For purposes of explanation, this may be a groove fitting a rubber gasket and a line of spaced holes extending around the marginal portions of the lens. This arrangement is only exemplary of the possibilities, as the device of the invention may be mounted in any conventional fashion. To this end, the device of the invention may replace less satisfactory prior art arrangements and, therefore, may use the mounting arrangement that was employed in the older system. The device of the invention permits a minimum expenditure of expensive drydock labor in conversion, a highly desirable feature of using the device of the invention.

METHOD OF MANUFACTURE

The method of manufacture will now be described with reference to the remaining figures. Referring to FIG. 2 a form 13 is shown mounted on a universal support 14. Form 13 may be pivoted about on support 14 to bring any portion thereof into a horizontal position.

As may be seen from FIG. 3, the construction of form 13 is the first step in the manufacture of the acoustic

window of the invention. Block 15 indicates the material from which form 13 is constructed which, for example, may be plaster of paris. As shown by block 16, the form material is shaped and finished into the desired shape.

This may be done by conventional modelmaking and surface shaping techniques. In many instances, the section of hull or other surface which is to be replaced by the window may be used as a master molding surface to help fashion form 13. When the form is prepared, it is coated with a suitable separation compound to assist in removing the finished acoustic window therefrom, as indicated at block 17. A variety of well-known substances are commercially available for this purpose and selection as between them is within the skill of the proficient worker in such processes, depending on the plastic material used.

The honeycomb preform 11 is rough-cut to the size of the desired acoustic window, with attention to a marginal surplus to permit the installation of the accessory hardware, as previously noted. This cutting step is shown as block 18. Honeycomb preform 18, thus cut, is placed on form 13, as indicated in block 19. One surface of preform 11 is brought into contact with form 13 in such a manner that each void therein forms an open topped container having form 13 as a bottom co-extensive with all the voids. No special attachment means to secure honeycomb preform 11 to form 13 is required. In some instances it may be practical to manually secure honeycomb 11 to form 13 until the first few cells are filled, at which time plastic material 12 provides the necessary uniting structure. In other cases, conventional means, such as wiring the two together, may be employed.

Honeycomb preform 11, as its name suggests, is comprised of hexagonal cells. It should be understood, however, that other cellular cross section shapes may be employed, if desired. Nevertheless, the material shown is commonly available and is satisfactory in this application.

The individual cells of honeycomb preform 11 are filled with small solid particles of plastic material 12. These particles of plastic material 12 may be obtained by grinding other otherwise pulverizing solid stock, as indicated by block 21. This pulverization step may, of course, be preformed at any time to the time the material is used, in some instances by the supplier of the plastic material.

Referring to FIG. 2, the pulverized thermoplastic material is placed in a suitable hopper 22. From hopper 22 the thermoplastic granules are gravity fed through spout 23 to be deposited in the cells of honeycomb preform 11. A cut-off valve 24 controls this operation, illustrated in FIG. 3 at block 25.

When each cell is filled, the filling charge of thermoplastic material 12 is melted in situ by the action of a suitable heat source, such as infrared lamp 26. Other sources of infrared, or other radiant heat, may be used in place of infrared lamp 26, if desired. Radio frequency heating may be employed, for example, in place of the heating arrangement shown. One advantage of using an optical arrangement, such as shown, is that the heating may be directed along an optical axis 27 to localize the area heated, thereby permitting the honeycomb preform 11 to be conveniently handled as it is positioned for subsequent fillings. The intensity of the heat is controlled by suitable episcotister means, or other suitable light control means, such as iris diaphragm 28, and focusing means, such as lens 29.

The artisan performing the manufacturing steps watches the heating and melting of thermoplastic material 12, adding more as required, until the cell is full and bubble free. He then removes the heat and permits thermoplastic material 12 to cool and harden, as shown by block 36, FIG. 2.

When the heated material hardens, the artisan repositions form 13 to place another cell of honeycomb preform 11 under spout 23. The filling and heating steps are

repeated. As shown in FIG. 2, this operation involves moving carriage 31, on which universal support 14 is mounted, on rails 32 which are mounted on a carriage 33. Next, carriage 33, carrying carriage 31 and universal support 14 and form 13 therewith, is moved on rails 34. Rails 32 and 34 guide the form 13 in transverse directions to permit any portion of form 13 to be placed under spout 23, and universal support 14 permits the leveling of form 13, so that the melted thermoplastic material remains in its cell. This repositioning, shown as block 36 in FIG. 2, is more quickly accomplished than it is explained. The steps of filling, heating and cooling, and repositioning, shown by blocks 25, 36, and 35, respectively, are repeated until the cells of honeycomb preform 13 (as viewed in FIG. 2) are all filled.

When the cells are all filled and solidified, the upper surface of the filled honeycomb preform is finished, as by surface grinding, shown as block 37 in FIG. 3, to obtain a smooth finish and to remove miniscus curves in each cell, as shown by FIG. 4. The grinding is continued until the acoustic window's two surfaces are parallel—that is, the window has a uniform thickness. This configuration causes no change in divergence of the compressional waves during the transmission thereof and is the usual configuration. However, prisms, spherical surfaces, cylindrical surfaces, and a variety of aspheric or otherwise contoured surfaces may be introduced in this surfacing operation, if desired.

The surface finishing also removes the trapped bubbles which were unable to break the surface tension of the thermoplastic material 12 when it was melted. The amount of material removed is exaggerated in FIG. 4 for purposes of illustration but is, in fact, quite small.

After surface finishing, the acoustic window or lens is removed from the block form and miscellaneous hardware is mounted thereon, as shown by block 38, FIG. 3. The miscellaneous hardware may include the mounting hardware discussed previously and shown in FIG. 5.

Referring to FIG. 5, it may be seen that the outer surface of the acoustic lens has been relieved to receive a marginal reinforcement 41 therefor. Marginal reinforcement 41 may, for example, comprise a metallic band extending about the periphery of the acoustic window. If desired, other materials, such as high strength plastics, may be used to provide marginal strength. At suitable intervals, marginal reinforcement 41 is drilled to receive threaded fasteners 42, which extend therethrough and beyond the acoustic window. Reinforcement 41 may be adhesively held to the window or held by fasteners 42 which secure the window to a suitable mounting surface. The inner surface of the acoustic window has been grooved to receive gasket 43. Although gasket 43 is illustrated as a simple O-ring type, it should be realized that more complex sealing arrangements may be used, if conditions so justify.

The foregoing description taken together with the appended claims constitute a disclosure such as to enable a person skilled in the metal working and fabrication arts to practice the invention. Further, the structure and the method herein described meets the objects of invention and generally constitute meritorious advances in the art unobvious to such a skilled worker not having the benefit of the teachings contained herein.

Obviously, other embodiments and modifications of the subject invention will readily come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing description and the drawings. It is, therefore, to be understood that this invention is not to be limited thereto and that said modifications and embodiments are intended to be included within the scope of the appended claims.

What is claimed is:

1. A method of manufacturing an acoustic lens, comprising in combination the steps of:

shaping and finishing a block form in such manner

as to make it have the surface configuration, size, and shape of the acoustic lens desired to be manufactured;

coating the configured surface of said block form with a predetermined separation compound;

mounting a honeycomb preform, having a pair of oppositely disposed sides and a plurality of voids extending therethrough, on said block form in such manner that one of the sides thereof is in contact with the coated configured surface of said block form and one end of each of said plurality of voids is closed thereby;

positioning said block form and the honeycomb preform mounted thereon in such manner that a selected one of said plurality of voids has such disposition that it may be individually filled with an acoustically clear, dry, granular, low-density, polyethylene thermoplastic;

filling said selected one void of said honeycomb preform with the aforesaid acoustically clear, dry, granular, low-density, polyethylene thermoplastic, without interfering with those portions of the aforesaid honeycomb preform and the voids therein that are in proximity therewith;

concentrating infrared heat on the aforesaid acoustically clear, dry, granular, low-density, polyethylene thermoplastic disposed in said one void of the honeycomb preform for effecting the melting thereof in such manner as to cause it to completely fill and acquire the inside form of said one void without disturbing any filled and unfilled honeycomb preform voids in contiguous disposition therewith;

cooling said melted acoustically clear polyethylene thermoplastic until it solidifies;

repositioning said block form and the honeycomb preform mounted thereon for timely implementing the aforesaid filling, heating and melting, and cooling steps, sequentially and in that order, and successively so doing with respect to other predetermined honeycomb preform voids in contiguous disposition with or spatially disposed from said one void;

grinding those surfaces of said honeycomb preform and the solidified acoustically clear polyethylene thermoplastic contained in the voids thereof which are opposite those surfaces thereof which are in contact with the aforesaid coated block form in such manner as to effect a predetermined continuous smooth surface of predetermined contour configuration thereat; and

separating said acoustically clear polyethylene thermoplastic filled honeycomb preform from said coated block form.

2. The method of manufacturing an acoustic lens of claim 1, further comprising the step of reinforcing the outer periphery of said acoustically clear polyethylene thermoplastic filled honeycomb preform in such manner as to cause the acoustic lens effected thereby to be framed and maintained within the aforesaid size and shape.

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ROBERT F. WHITE, Primary Examiner

W. E. HOAG, Assistant Examiner

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