Dec. 16, 1969 M. I. KAZIMI 3,483,614

METHOD FOR MAKING DIMPLED HONEYCOMB SANDWICH

Original Filed Dec. 14, 1962 2 Sheets-Sheet 1

Fig. 1.

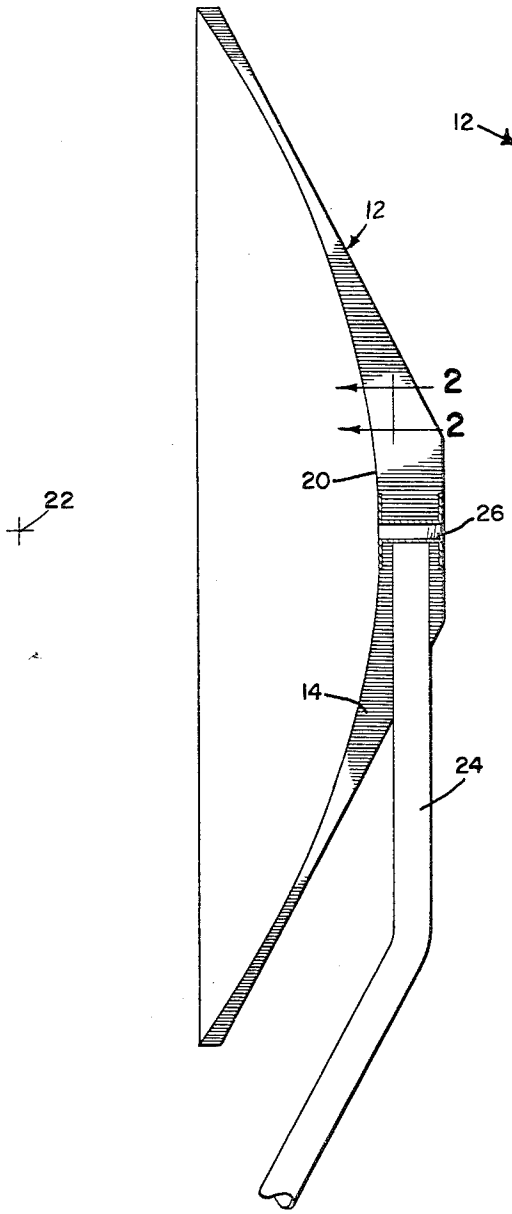


Fig. 2.

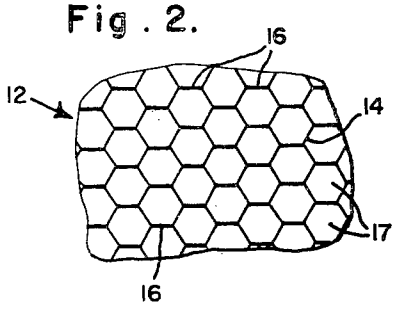
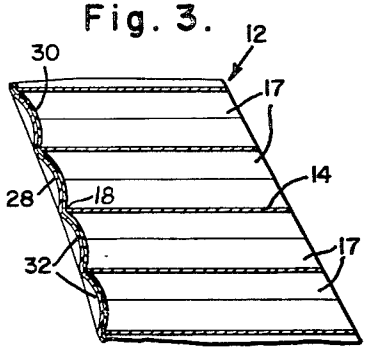


Fig. 3.



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Fig. 4.

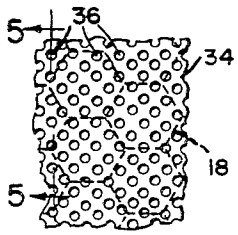


Fig. 5.

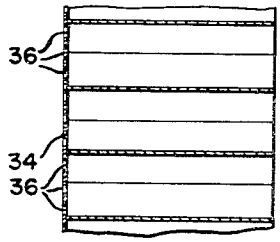


Fig. 6.

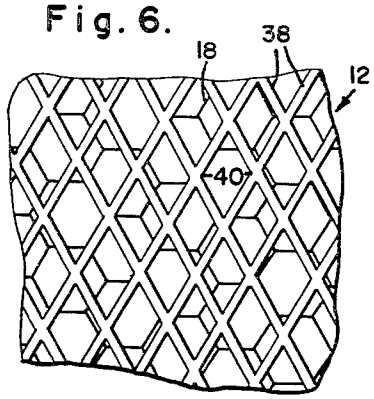
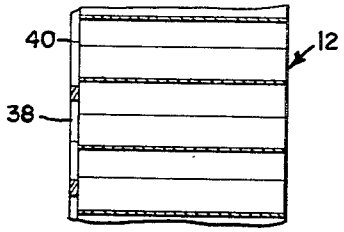


Fig. 7.



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METHOD FOR MAKING DIMPLED HONEYCOMB SANDWICH

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Original application Dec. 14, 1962, Ser. No. 244,728, now Patent No. 3,427,625. Divided and this application May 26, 1967, Ser. No. 668,261

Int. Cl. H01p *11/00;* H01q *13/00*

U.S. Cl. 29—600 1 Claim

ABSTRACT OF THE DISCLOSURE

A method for making a dimpled face on a honeycomb sandwich by creating a pressure differential across a face skin on a honeycomb core. The pressure differential is established by mechanical or pneumatic techniques.

This invention is a division of my copending application for patent Ser. No. 244,728, filed Dec. 14, 1962, now Patent No. 3,427,625.

This invention relates to a focusing reflector for radiated electromagnetic energy and more particularly to such reflector that discriminates against interfering electromagnetic energy of shorter wave length than the wave length of the radiated energy.

The preferred embodiment of the invention described herein and shown in the drawings comprises a core formed of cellular honeycomb constructed of plural bonded ribbons, the edges of which ribbons are shaped to define the contour of a concave surface such as a paraboloid. The honeycomb material has a cell size no greater than one quarter wave length of the energy being reflected so that the surface of the honeycomb material will be substantially opaque to such wave length and will reflect the same. Signals having shorter wave lengths will pass through the individual honeycomb cells and thus will not reflect to an antenna spaced relative to the concave surface.

Operation of paraboloid reflectors such as parabolic reflectors in an environment in which infra-red and shorter wave length radiation is present requires special precaution to prevent excessive heating of the reflector and to assure that the intensity of shorter wave length radiation does not exceed the intensity of the lower frequency intelligence containing signals. The foregoing considerations have become particularly important in relation to the placement of antennas in space vehicles, because the intensity of infra-red and shorter wave length radiation is greater in outer space since the radiation is not impeded by the ionosphere. Reflectors having the foregoing electrical characteristics must also have sufficient rigidity that the reflecting surface thereon maintains a desired shape. Additionally, an antenna of the type here under consideration should be lightweight, simple, and inexpensive to produce.

An object of this invention is to fulfil the foregoing desiderata.

Another object is to provide an antenna that has structural rigidity and has a reflective surface with electrical continuity and frequency selectivity so that higher interfering frequencies will not be reflected by the device.

Still another object is to provide a method for expeditiously forming an antenna with the last named characterics. The object includes providing a piece of honeycomb with a suitable contoured concave surface thereon and providing a thin sheet of conductive material, affixing the skin to the concave honeycomb surface, and creating a pressure differential across the thin sheet so that the thin sheet will be partially drawn down into the honeycomb cells. A myriad of small concavities or dimples will not have substantial effect on relatively longer wave length

signals but will have substantial effect on shorter wave length signals. The latter will be focused at a point very near to the surface of the skin and will there be dissipated, rather than being reflected to an antenna disposed in front of the concave surface to receive or transmit the longer wave length signal.

Alternate embodiments of the invention can be constructed in which a thin sheet of conductive material is affixed to the curved honeycomb core and is provided with a plurality of holes spaced from one another by an amount no greater than one quarter wave length of the signal being reflected. The thin layer can also be formed of conductive mesh attached to the edges of the honeycomb forming ribbons. These two modifications provide a path through the antenna for dissipation of thermal energy contained in infra-red and shorter interfering frequencies. Energy that passes through the openings in the conductive face will with high probability also pass through the honeycomb cells. Thus, the reflector is not heated to a temperature high enough to cause destruction thereof by the interfering short length waves.

These and other objects will be more apparent after referring to the following specification and attached drawings in which:

FIG. 1 is a cross-sectional elevation view of a honeycomb core forming a parabolic reflector surface;

FIG. 2 is an enlarged view of a portion of the honeycomb core taken substantially along line 2—2 of FIG. 1;

FIG. 3 is an enlarged cross-sectional elevational view showing another embodiment of the present invention;

FIG. 4 is an enlarged view of a portion of the antenna illustrating still another embodiment of the invention;

FIG. 5 is a cross section view taken substantially along line 5—5 of FIG. 4;

FIG. 6 is a plan view of yet another embodiment of the present invention; and

FIG. 7 is a cross section side view of the embodiment of FIG. 6.

Referring more particularly to the drawings, reference numeral 12 denotes generally a honeycomb core formed by a plurality of flat ribbons 14 bonded at recurring intervals as at 16 to form a plurality of cells 17. The type honeycomb shown in FIG. 2 is hexagonal honeycomb but is should be understood that any suitable shape cell structure can be provided within the scope of the present invention. Core 12 is preferably formed with cells wherein the maximum dimension between opposite surfaces of ribbon 14 is within the range of one thirty-second inch to one-quarter inch. Such range assures that the structure will have the requisite rigidity and have the proper cell size for the desired radio frequency selectivity. The upper edges 18 of ribbons 14 are shaped to form a contour that defines a concave surface 20; the surface is preferably a paraboloid to obtain optimum focusing but may take other concave shapes as well. A reference point 22 in FIG. 1 indicates the position of the focus of the paraboloid of curve surface 20. A transmitting or receiving antenna is placed at focus 22 in accordance with well-known procedures.

Core 12 is supported upon a mast 24 that is attached to the reflector remote from surface 20 of the core. A suitable antenna feed (not shown) can be mounted in a passage 26 formed axially with the major axis of the paraboloid surface.

In the embodiment depicted in FIG. 2, ribbons 14 are formed of a conductive material such as aluminum and are welded or brazed by suitable material at their bond points 16. The weld points at bond 16 electrically interconnect all areas of surface 20. Thus, the reflector, if constructed of one thirty-second inch honeycomb, will be substantially opaque for frequencies up to about 10^{11} cycles per second (3×10^{3} m. wave length) and will re-

flect to focus 22 all signals having frequencies below that frequency. If one-quarter inch honeycomb is used, the paraboloid surface will appear substantially opaque to frequencies up to about 10^{10} cycles per second ($2\frac{1}{2} \times 10^{-2}$ m.). Energy having wave lengths shorter than those referred to above will pass through cells 17 because the maximum dimension between opposing ribbons of a given cell exceeds one-quarter wave length. Because all ribbons 14 are electrically bonded at 16, electrical continuity will exist over the entire paraboloid surface, and the entire surface will contribute to reflection of energy having relatively longer wave lengths.

Referring now to FIG. 3, core 12 is shown in greatly enlarged scale to emphasize an alternate embodiment of the invention. The edges 18 of the core 12 are formed with a suitable concave shape, such as a paraboloid as in FIG. 1. To edges 18 is affixed a conductive layer 28 by means of an adhesive layer 30. In the present embodiment it is not necessary for ribbons 14 or bond points 16 between adjacent ribbons to be electrically conductive, because conductive sheet 28 provides electrical interconnection between all areas of surface 20.

After a conductive sheet 28 is affixed to core 12, concavities or dimples 32 are formed. I prefer to form the concavities by evacuating the air from each cell 17 so that atmospheric pressure acts on the top of sheet 28 to cause partial attenuation or distortion thereof into the cells. In one reflector made according to my invention sheet 28 was formed with a layer of 3 mil aluminum (.003 inch); a pressure differential across sheet 28 of approximately 2–3 atmospheres suitably formed concavities 32. Any permanently extensile material can be used to form the concavities. The pressure differential formed by evacuating cells 17 must be sufficient to exceed the elastic limit of thin sheet of permanently extensile material but insufficient to rupture the thin sheet.

Each concavity 32 acts as a parabolic reflector for wave lengths that are short relative to the distance between opposite points on the perimeter of each concavity. Because the perimeter is determined by the ribbon edges 18, the frequency characteristics of the present embodiment are similar to those of the embodiment first described above.

The embodiments shown in FIGS. 1–3 have ribbons 14 parallel with the principal axis of the paraboloid of surface 20. Parallelism is not required; it is more important that the dimension between cell walls along surface 20 be chosen relative to the wave length of reflected energy and the interfering energy present to secure proper electrical characteristics. The openings or depressions presented to the electro-magnetic radiation are thereby permitted to serve the intended function.

An alternate method for forming depressions 32 in sheet 28 is to affix the skin to core 12 with adhesive layer 30, and then to move a relatively hard rubber roller over the surface. If the rubber of the roller is of sufficient hardness to attenuate thin conductive sheet 28, the desired dimples or concavities 32 will be formed.

A skin 34 can be attached to ribbon edges 18 which has a plurality of randomly positioned holes 36 therethrough (FIGS. 4 and 5). Holes 36 have a diameter no greater than the quarter wave lengths of the reflected signal, and are sufficiently numerous to pass shorter wave length energy. Although removal of at least 80% of skin 34 by formation of holes 36 therein affords adequate conveyance of shorter wave length energy through the skin, up to 90% can be removed without excessively weakening the structure. Unwanted energy having a quarter wave length less than the diameter of holes 36 will pass through the holes to cells 17, and will not interfere with the energy that is to be reflected by skin 34.

A conductive layer can be formed on the concave surface 20 of honeycomb core 12 by a conductive mesh 38

(FIG. 6). The mesh has plural individual conductors 38 that can be formed by expanded or stamped metals or by intersecting wires. The conductors are both electrically and mechanically bonded to one another at their intersecting points 40, so that electrical interconnection is attained between all areas of the surface. Mechanical bonding of mesh 38 to ribbon ends 18 of core 12 provides structural rigidity to the electrically continuous surface, so that waves reflected therefrom are focused at point 22. The openings between the conductors of mesh 38 are formed no larger than one-quarter wave length of the energy to be reflected by the device. Energy of shorter wave lengths passes through the mesh and the honeycomb core and is not reflected to an antenna. Because mesh 38 forms the conductive surface area, honeycomb core 12 in the embodiment of FIGS. 6 and 7 need not be conductive material.

It is to be noted in connection with the embodiment of FIGS. 1–2 and 4–7 that the cell forming side surfaces of ribbons 14 provide reflecting surfaces for energy entering cells 17. Such energy is reflected back and forth between opposite cell walls until it is expelled from the rear open end of cells 17. Consequently, the shorter wave length energy that enters the cell will not interfere with the signal reflected to or from an antenna by surface 20.

Thus, I have provided a paraboloid reflector that is rigid, inexpensive to produce and frequency selective. In addition, the structure has extremely light weight. The novel method for manufacturing reflector can be used to form reflectors of different shapes; and of different frequency discriminating characteristics.

While several embodiments of my invention have been shown and described, it will be apparent that other adaptations and modifications may be made without departing from the true spirit and scope of the invention.

What is claimed is:

1. A method for forming a parabolic-shaped reflector for reflecting energy of a predetermined wave length, comprising the steps of providing a piece of cellular core material generally defining a parabolic-shaped concave surface, said honeycomb having cell dimensions no greater than one-quarter of the length of said predetermined wave length, providing a thin sheet of permanently extensile material of a size sufficient to overlay said parabolic-shaped surface, applying a layer of adhesive to one face of said extensile material, bonding the extensile material to said parabolic-shaped surface, and thereafter creating a negative pressure differential through said honeycomb core and across said extensile material of a magnitude sufficient to exceed the elastic limit of said material, but insufficient to rupture said material, so that said material is distorted into the ends of the cells of said core to form a plurality of similar concave depressions whereby when said reflector is employed for reflectively focusing radio frequency energy, signals having shorter wave lengths than said predetermined wave length will not be reflected by the reflector.

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U.S. Cl. X.R.

29—421, 455; 156—197; 161—69; 343—840