United States Patent

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[54] **ARTIFICIAL SATELLITES**
4 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** 343/18; 244/1
[51] **Int. Cl.** H01q 15/14
[50] **Field of Search** ..... 244/1; 343/18 (B), 18 (E)

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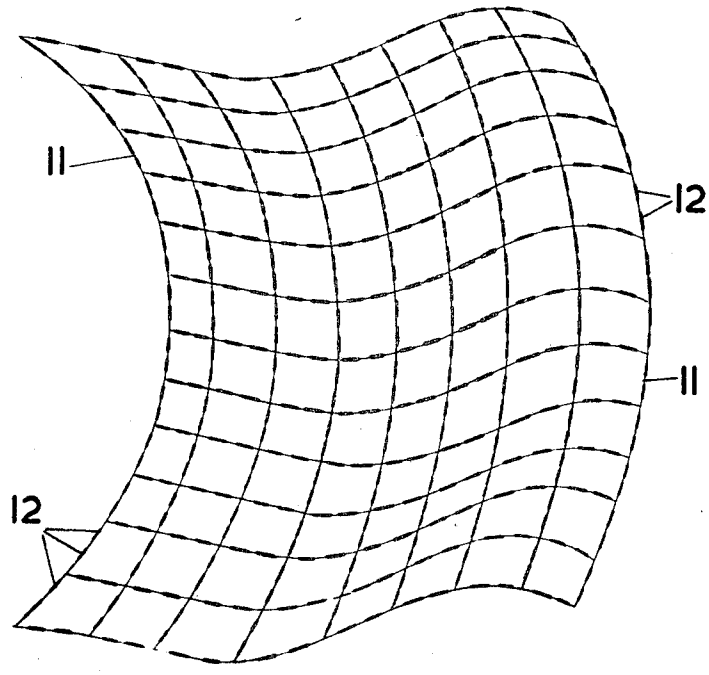
ABSTRACT: A very light, easily dispensed, efficient and durable passive radial communication satellite comprising a filamentary netlike structure of which alternate lengths of the filaments are metal coated to comprise dipoles, and in which those surfaces of the net filaments between the metal covered dipole regions are covered with a layer of metal which affords protection against damage to the net by long-wavelength ultraviolet radiation and reduces the rate of evaporation of the net material, said layer of metal being of small thickness compared to that forming the dipoles so that radio wave reflection therefrom is negligible.



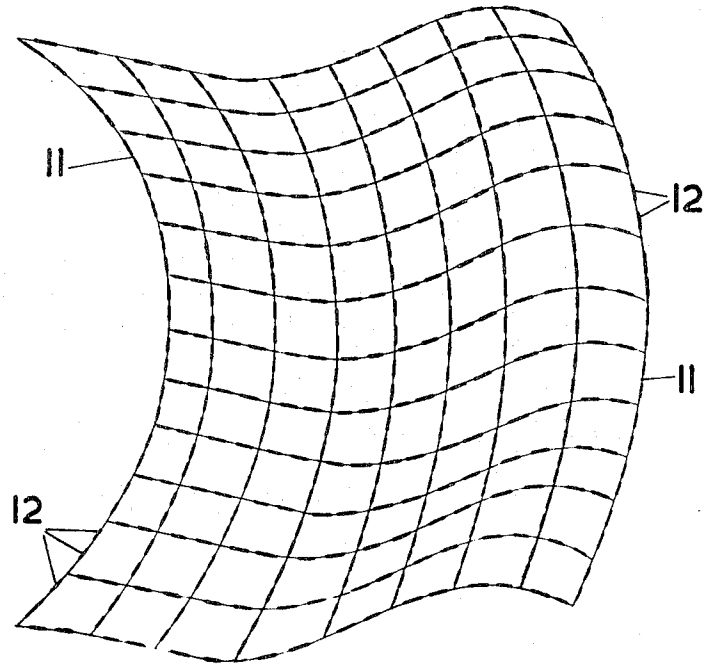


FIG. 1.

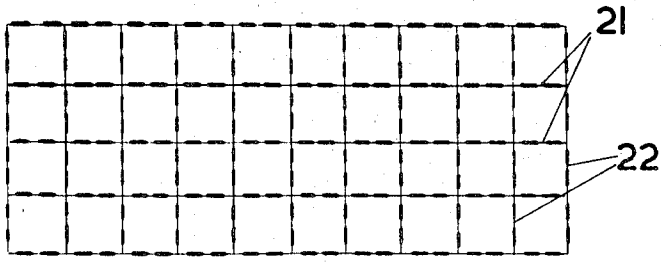


FIG. 2.

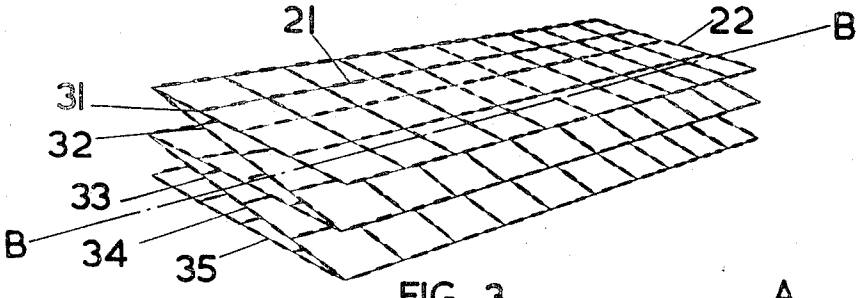


FIG. 3.

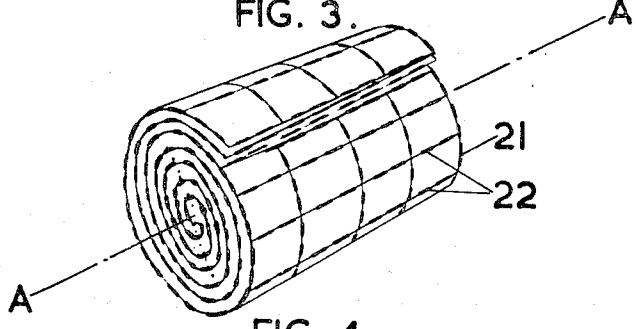


FIG. 4.

ARTIFICIAL SATELLITES

This invention relates to devices for use as passive radio communication artificial satellites.

Passive radio communication satellites have several advantages including simplicity, wide frequency capabilities, no multiple access problems and they are likely to have a longer useful orbit life than active communication satellites containing complex electronic equipment.

Passive radio communication satellites act simply to reflect radio signals and known prior proposals include a balloon of which the surface is treated so that more radiation is returned to ground than elsewhere. Other, directionally stabilized, radio reflecting satellite devices have also been proposed but these suffer from the disadvantage that they are necessarily of a complicated nature.

It is known that, excluding radio reflectors which are directionally stabilized, the metal object which reflects radio waves most intensely in relation to its size is a thin rod, or dipole, which has a length slightly less than one half radio wavelength. A single dipole reflects most strongly at right angles to its axis but a cloud of dipoles, in which each dipole is in random orientation relative to its neighbors reradiates with substantially the same intensity in all directions.

The present invention is concerned with the provision of a device for use as an improved passive radio communication satellite.

According to the present invention a device for use as a passive radio communication satellite comprises a filamentary netlike structure of which alternate lengths of the filaments are metal coated and comprise dipoles.

Preferably, the net structure comprises a low-density filamentary structure such as for example a polyamide or polyester fibre or glass fibre on which the dipoles are formed by coating alternate lengths of filaments with a layer of metal of sufficient thickness to act as a dipole.

It can be shown that radio waves only penetrate a small distance into the metal, for example for a wavelength of 6 cm. the penetration depth is in the order of 10^{-4} cm. for copper, and according to the invention a thin layer of metal of sufficient thickness to act as a dipole is deposited on the filamentary net structure such that the structure as a whole remains substantially of the same density as that of the filaments.

It can be shown by calculation that a random cloud of dipoles as would be constituted by the netlike structure according to the invention provides a weight reduction in the order of 1500:1 as compared to a sphere providing the same radio communication characteristics.

The netiike structure serves to limit dispersion of the dipoles under the effects of forces acting on them in orbit.

In general in accordance with the invention the dipoles are equispaced over the netlike structure and in total cover between 0.3 and 0.6 of the surface area of the structure although preferably they will cover between 0.5 and 0.6 of the surface area.

However, in a further arrangement according to the invention, and with a view to affording protection against damage to the net by long-wavelength ultravoilet radiation and in order to reduce the rate of evaporation of net material, those surfaces of the net filaments between the metal covered dipole regions are also covered with a layer of metal which is a small fraction of the thickness of the skin depth of the metal layer forming the dipoles so that radio wave reflection is negligible from those surfaces.

One example of a device according to the invention for use as a passive radio communication artificial satellite is illustrated by the accompanying diagrammatic drawings of which:

FIG. 1 shows the device as it might appear in orbit;

FIGS. 2, 3 and 4 illustrate a manner of construction and packaging of the device prior to use; and

FIG. 5 is an enlarged perspective view, partially in cross section, of one filament of the device.

Referring first to FIG. 1 the device comprises a net-type structure 11 made of nylon fibers of 10 microns diameter. Alternate lengths of the net 11 are coated with a sufficient thickness of aluminum to form dipoles 12 ..... 12, while the lengths between the dipoles are covered with a layer of metal which is a small fraction of the thickness of the skin depth of the metal layer forming the dipoles. The spacing of the dipoles from each other is such that between 0.5 and 0.6 of the surface area of the net filaments is covered by the metal forming the dipoles. The device will take up some random shape when in orbit as shown.

Referring now to FIGS. 2, 3 and 4 the device comprises several similar sections one of which is shown at FIG. 2 having 'warp' filaments 21 and 'weft' filaments 22. As shown at FIG. 3 several sections 31.....35 are joined at their adjacent edges and folded concertina fashion. The joints may be made by a weaving process, stitching or by use of adhesive. The folded sections are then rolled along the fold line as shown at FIG. 4 to form a package for carriage by a rocket or other launching device.

As shown in FIG. 5, alternate lengths of a fine filament 51, such as a nylon filament, are covered with a thin metal coating 52 and a substantially thicker metal coating 53 of sufficient thickness to form dipoles, the metal coating 52 being a small fraction of the thickness of the coating 53. The same metal may be used throughout, or a thin coating of a metal having good adherence to the filament 51 may be first applied to the entire filament net, followed by the application of another metal to alternate lengths to form the dipoles. The metal coatings may be applied. by any convenient metal deposition technique. Examples are vacuum deposition of any suitable metal, chemical deposition of silver, and glass filaments covered by metal attached to the glass in the molten state.

The use of nylon as the filament is preferred as it is readily processed by known textile techniques, it has a very high strength to density ratio and its physical characteristics make it suitable for use in a space environment.

The device can be extended in space after release from the launching device by several methods. Spin imparted to the rolled up package about the roll axis (A–A of FIG. 4) will unroll the net and further spin about an axis parallel to the fold line (B–B FIG. 3) will cause the net to unfold. In an alternative arrangement the effects of solar radiation pressure can be used to unfold the net. Thus, in one arrangement not illustrated, members of similar reflectivity but different area or vice versa are attached to different regions of the net, the effect of solar radiation causing separation of those members and hence extension of the net.

A further alternative arrangement not illustrated for extending the net makes use of the gradient in the gravitational field due to the earth. Thus if two masses are attached to separate portions of the net, then because of their different distance from the center of the earth, the masses would have different orbital periods and would tend to move apart. For example, at an altitude of 23,000 miles a difference of 1 metre in height above the earth would result in a change of 3 milliseconds for one orbit of about 24 hours, and as the speed of the net at that altitude is approximately 3 km./sec. it follows that the two masses will drift apart at a rate of about 9 metres per day.

Weak links may be provided in the net to prevent the net being torn to pieces.

In the example described with reference to the drawings it will be noted that the nylon fibers used are of 10 microns diameter. From the point of view of radio communication the diameter should be as small as possible but it is unlikely that a diameter of less than 6 microns would be practicable because of strength efficiencies. Similarly, it is undesirable to use fibers of greater than 30 microns diameter because of reducing radio communication characteristics with increasing diameter.

I claim:

1. A passive radio communication satellite comprising a filamentary netlike structure of which alternate lengths of the filaments are metal coated to comprise dipoles, and in which

those surfaces of the net filaments between the metal covered dipole regions are covered with a layer of metal which affords protection against damage to the net by long-wavelength ultraviolet radiation and reduces the rate of evaporation of the net material, said layer of metal being of small thickness compared to that forming the dipoles so that radio wave reflection therefrom is negligible.

2. A passive radio communication satellite as claimed in claim 1 in which the net structure comprises a low-density filamentary structure of material selected from the group consisting of polyamide, polyester and glass fibre on which the dipoles are formed by coating alternate lengths of filaments with a layer of metal of sufficient thickness to act as a dipole.

3. A passive radio communication satellite as claimed in claim 1 in which the dipoles are equispaced over the netlike structure and in total cover between 0.3 and 0.6 of the surface are of the structure.

4. A passive radio communication satellite as claimed in claim 3 in which the net structure comprises a low-density filamentary structure of material selected from the group consisting of polyamide, polyester and glass fibre on which the dipoles are formed by coating alternate lengths of filaments with a layer of metal of sufficient thickness to act as a dipole.