Aug. 30, 1960 O. HALPERN ET AL 2,951,247

ISOTROPIC ABSORBING LAYERS

Filed Feb. 19, 1946

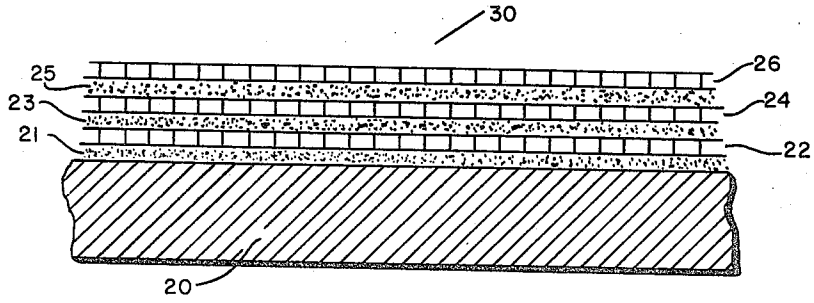


FIG. 1

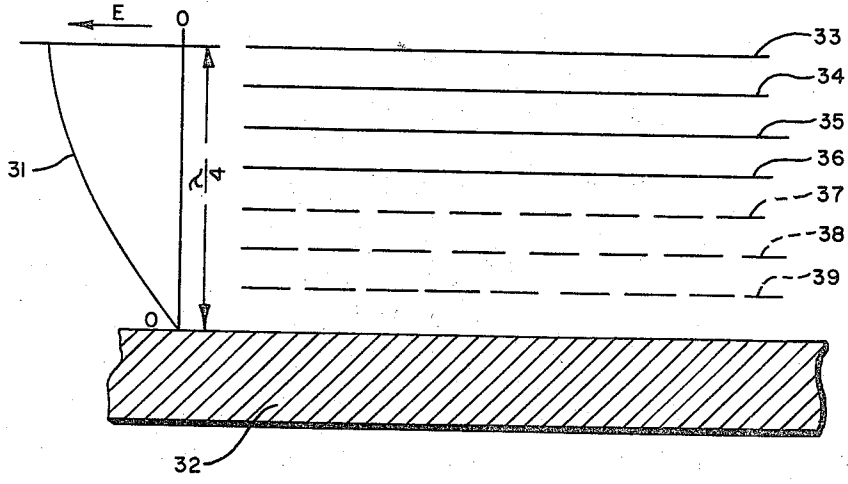


FIG. 2

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United States Patent Office 2,951,247
Patented Aug. 30, 1960

2,951,247

ISOTROPIC ABSORBING LAYERS

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Filed Feb. 19, 1946, Ser. No. 648,794

11 Claims. (Cl. 343—18)

This invention relates to a method and means for minimizing the reflection of radio microwave radiation incident upon surfaces and objects which normally reflect such microwaves. More specifically the invention is directed to an arrangement for producing isotropic layers of the type incorporating a suspension of electrically conducting particles in a non-conducting binder.

It is known in the art how to protect good reflectors, such as electrically conductive surfaces from incident radio microwaves of high frequency, one of these methods being designated as the resonant method. This method consists of affixing a high loss dielectric material layer to the metallic surface to be protected. In this case, the dielectric material must have a thickness which is an odd multiple of one-quarter of the wave length of the incident radiation, measured inside the material, and a high frequency loss of sufficient magnitude, which may be due either to surface treatment of the material or internal losses within it. One such material is achieved by providing a layer preferably comprising myriads of electrically conductive particles dispersed in an appropriate binder, the particles being quasi-insulated from each other. Electrically conductive particles thus arranged will impart to the whole layer a dielectric constant which will be greatly in excess of that of the binder alone.

To obtain a high value of the dielectric constant, it is advisable to employe flake particles in dense concentration and so oriented in the binder that the plane of the large dimension of the flake is parallel to the plane of the aggregate. Conductors, such as aluminum, copper, iron, steel, Permalloy and graphite flakes and in addition ferromagnetic materials, have been utilized in the construction of such layers. The flakes average in thickness between 3×10^{-5} and 2×10^{-4} centimeters with the long dimension as high as 70 times the average thicknes. Metallic and ferromagnetic powders and threads may be used as well as flake particles. The concentration of the metal content of the mixture may vary between 20 and 80 percent, as example of practical concentration. Examples of binders used in the construction of such layers include waxes, rosins, polystyrene, synthetic rubber, and Vinylite. Xylene and toluene are examples of suitable volatile solvents. While absorbing layers as heretofore described, have formerly been produced, it has been discovered that such layers exhibit an anisotropy in the direction of the preferential alignment of the particles, that is, along the direction of the plane of the aggregate. While microwave radiation absorbent layers such as described have heretofore been constructed, such layers have proven unsatisfactory due to the polarization thereof which causes the layers to be anisotropic in the plane thereof.

An object of this invention is to provide a layer for absorbing electromagnetic energy, incident upon a reflecting surface of the type having elongated metallic particles in a non-conducting binder such that the absorption of the incident electromagnetic energy is substantially independent of the polarization of the radiation.

Another object of this invention is to provide an isotropic layer of material for absorbing incident radio microwave radiation.

Still another object of this invention is to provide a composite isotropic layer for absorbing incident radio microwave radiation in which the composite layer is composed of a number of individual layers having the direction of polarization of the alternate layers crossed at 90°.

Another object of this invention is to provide a resonant composite layer of material for absorbing incident radio microwave radiation in which the direction of polarization of a predetermined percentage of the outer layers of the composite layer is crossed at 90° to the direction of polarization of the remaining layers comprising the total composite layer.

Other objects and advantages of this invention, as well as its construction, operation, and arrangement, will be apparent from the following description and claims in connection with the accompanying drawings in which:

Fig. 1 is a schematic diagram of one form of a composite isotropic layer as contemplated by this invention.

Fig. 2 is a schematic diagram of the second composite isotropic layer constructed in accordance with the principles of this invention.

A layer of material as contemplated by this invention may be formed directly upon the surface to be protected from incident microwave radiation or upon a separate metallic electrically conductive surface which in turn is to be placed over the object to be protected. The composition or mixture of flakes, binder and solvent may be applied by spraying, rolling, or working with a flat smoothing tool. When the layer is applied in a fluid form, the composition quickly dries and becomes a fixed layer and coating as the solvent evaporates. It is known that with a composition prepared and applied in the above described manner, the flakes generally assume the preferred orientation, that is, parallel to the surface covered. Working the coating by a smoothing or stroking motion aids in obtaining a more uniform leafing of the flakes with the flat surfaces generally parallel to the plane of the layer. While the resulting layer may be obtained in a single coating, it has been found that a composite layer constructed of a plurality of thin coatings is generally more efficient. Multiple coatings tend to yield an effective dielectric constant which is higher than that obtained with a single coating application because of the better leafing of the flakes which is obtained when the coatings are thin and individually worked. Layers formed by spraying, knifing, or working in order to secure preferential orientation of the flake-like particles therein exhibit anisotropy in the direction of preferetnial alignment of the particles, that is along the direction of the knife strokes. Otherwise stated, the commercially obtainable flakes which are generally nonsymmetrical cause the layer to be polarized to a certain degree when the smoothing stroke is made in one direction to attain proper orientation of the flakes within the layer. It has been discovered that by altering the direction of spraying or the smoothing stroke 90° in the successively applied layers, a composite layer may be made which is isotropic in the plane thereof.

Referring to Fig. 1, there is shown a schematic diagram of an istotropic composite layer for absorbing incident radio microwave radiation constructed in accordance with the principles of this invention. As shown, an electrically conductive metallic plate **20** is covered by a composite layer **30**, formed of successively crossed coatings of electrically conductive particles dispersed in a non-conductive binder. The alternate layers **21**, **23** and **25** have the direction of polarization thereof crossed at ninety degrees to the direction of polarization of the remaining layers **22**, **24** and **26**.

A composite layer as heretofore described may be achieved by constructing pre-formed layers and stacking

such layers with the direction of the long dimension of the conducting particles disposed at ninety degrees to each other in adjacent layers. Likewise, a composite isotropic layer as contemplated by this invention may be formed by crossing at ninety degrees, the working motion alternately on every other coating, or every second or third coating.

It has been discovered that if the surface of an individual layer of flake-like particles in a binder as heretofore described, be smoothed by working the surface thereof with a working motion which is constantly performed in a single direction, the flake-particles tend to orient themselves parallel to the plane of the aggregate and with the long axes of the flakes parallel to the direction of the working motion. This is true whether the individual layer be formed by rolling, spraying, or smoothing with a flat tool, so long as the direction of spraying or working is maintained constant. If a composite layer is composed of a sufficient number of successively crossed layers (layers having the direction of polarization at ninety degrees to the adjacent layer), a penetrating wave of radiation will experience equal effects for all polarizations.

In Fig. 2 there is shown an isotropic composite layer formed of individual coatings of flake-like electrically conductive particles dispersed in a non conductive binder as hereafter explained. Fig. 2 also shows the distribution curve of the electric field intensity for a quarter-wave resonant layer. As shown, by curve **31**, the intensity of the electric field is approximately zero at the surface of the conductive metallic plate **32** and is maximum at the outer surface **33** of the composite layer. Assuming the energy absorption of an individual layer to be a function of the average field intensity in that layer, it is clear that the coatings (individual layers) nearest the outer surface of the composite layer will absorb most of the energy. Therefore, in producing composite layers of individual cross-polarized coatings (layers) isotropy in the plane of the composite layer may be obtained either by having a large number of successively cross-polarized layers to the composite layer, or by providing a predetermined number of outer layers all polarized in a common direction, with the remaining inner layers polarized at right angles thereto. That is, if from ten (10) to thirty (30) percent of the layers or coatings nearest the outer surface of the composite layer are polarized in a given direction, and the remaining seventy (70) to ninety (90) percent are polarized at ninety (90) degrees thereto, the composite layer will be isotropic. As shown in Fig. 2, outer layers **33**, **34**, **35** and **36** are all polarized in a common direction, while inner layers **37**, **38** and **39** are polarized in a common direction at ninety degrees from the direction of polarization of the outer layers.

While the above method of construction of a composite isotropic layer may be used in connection with either pre-formed layers or composite layers achieved by spraying or rolling of layers directly upon adjacent layers, it is particularly useful where the component layers are pre-formed and stacked to complete the resultant layer. The stacking schedule, that is the number of outside sheets that need to be crossed relative to the underlying sheets may be determined by mathematical theory known to those skilled in the art, an approximate optimum is twenty-five (25) percent of the total.

The flake-like electrically conductive particles which are dispersed quasi-insulated in a non-conductive binder may be either electrically conductive or ferromagnetic particles. In the construction of a composite layer consisting of individual layers as heretofore described, the thickness of the composite layer must be an odd-multiple of the quarter wave length of the incident radiation for which the composite layer is designed to be resonant. Where ferromagnetic particles are used, however, the composite layer need not, in theory, have the thickness thereof limited to an odd multiple of a quarter-wavelength of the incident radiation, although the layer may be so constructed.

While alternate embodiments of this invention have been disclosed and described, it is to be understood that various modifications and changes may be made in this invention without departing from the spirit and scope thereof as set forth in the appended claims.

What is claimed is:

1. A composite isotropic layer for minimizing reflection of incident radio microwave radiation comprising a plurality of individual layers each having myriads of non-symmetrical electrically conductive particles dispersed such that they are substantially insulated one from another in a non-conducting binder, the direction of alignment of conductive particles of a predetermined number of such layers being oriented at ninety degrees to the direction of alignment of conductive particles of the remainder of said layers, the thickness of said composite layer being equal to an odd-multiple of a quarter wavelength of the incident radiation for which the composite layer is designed to be resonant, measured inside the composite layer.

2. A composite isotropic layer for minimizing reflection of incident radio microwave radiation from surfaces which normally reflect such radiation comprising a plurality of individual layers each having myriads of non-symmetrical flake-like electrically conductive particles dispersed such that they are substantially insulated one from another in a non-conductive binder, the direction of alignment of conductive particles of a predetermined number of the outer layers of said composite layer being oriented at ninety degrees to the direction of alignment of conductive particles of the remainder of said layers, the thickness of said composite layer being equal to an odd multiple of a quarter wavelength of the incident radiation, measured inside the composite layer.

3. A composite isotropic layer for minimizing reflection of incident radio microwave radiation from surfaces which normally reflect such radiation, comprising a plurality of individual layers of non-symmetrical flake-like electrically conductive particles dispersed in a non-conductive binder, the direction of alignment of conductive particles of the alternate layers of said composite layer being oriented at ninety degrees to the direction of alignment of conductive particles of the individual layers adjacent thereto, the thickness of said composite layer being equal to an odd multiple of a quarter-wavelength of the incident radiation, measured inside the composite layer.

4. A composite isotropic layer for minimizing reflection of incident radio microwave radiation comprising a plurality of individual layers each having myriads of electrically conductive particles dispersed in a non-conductive binder, the direction of the long axes of such particles in a predetermined number of such layers being disposed at ninety degrees to the direction of the long axes of such particles in the remainder of said layers, the thickness of said composite layer being equal to an odd-multiple of a quarter-wavelength of said incident radiation, measured inside the composite layer.

5. A composite isotropic layer for minimizing reflection of radio microwave radiation from surfaces which normally reflect such radiation comprising a plurality of individual layers each having myriads of flake-like electrically conductive particles dispersed in a non-conductive binder, the direction of the long axes of said flakes in a predetermined number of the outer layers of said composite layer being oriented at ninety degrees to the direction of the long axes of said flakes in the remainder of said layers, the thicknes of said composite layer being equal to an odd multiple of a quarter-wavelength of the incident radiation, measured inside the composite layer.

6. A composite isotropic layer for minimizing reflec-

tion of incident radio microwave radiation from surfaces which normally reflect such radiation comprising a plurality of individual layers of flake-like electrically conductive particles dispersed in a non-conducting binder, the direction of the long axes of said particles in alternate layers of said composite layer being oriented at ninety degrees to the direction of the long axes of said particles in the individual layers adjacent thereto, the thickness of said composite layer being equal to an odd multiple of a quarter-wavelength of the incident radiation, measured inside the composite layer.

7. A composite isotropic layer for minimizing reflection of incident radio microwave radiation from surfaces which normally reflect such radiation comprising a plurality of individual layers each having myriads of non-symmetrical electrically conductive ferromagnetic particles dispersed in a non-conductvie binder, the direction of alignment of said particles of a predetermined number of said layers being oriented at ninety degrees to the direction of alignment of said particles of the remainder of said layers.

8. A composite isotropic layer for minimizing reflection of radio microwave radiation from surfaces which normally reflect such radiation comprising a plurality of individual layers of non-symmetrical flake-like electrically conductive ferromagnetic particles dispersed in a non-conductive binder, the direction of alignment of said particles of the alternate layers of said composite layer being oriented at ninety degrees to the direction of alignment of said particles of the individual layers adjacent thereto.

9. A composite isotropic layer for minimizing reflection of radio microwave radiation comprising a plurality of individual layers each having myriads of non-symmetrical flake-like electrically conductive ferromagnetic particles dispersed in a non-conductive binder, the direction of the long axes of such particles in a predetermined number of said layers being disposed at ninety degrees to the direction of the long axes of said particles in the remainder of said layers.

10. A composite isotropic layer for minimizing reflection of radio microwave radiation comprising a plurality of individual layers each having myriads of non-symmetrical flake-like electrically conductive ferromagnetic particles dispersed in a suitable binder, the direction of the long axes of said flakes in a predetermined number of the outer layers of said composite layer being oriented at ninety degrees to the direction of the long axes of said flakes in the remainder of said layers.

11. A composite isotropic layer for minimizing reflection of incident radio microwave radiation from surfaces which normally reflect such radiation comprising a plurality of individual layers of non-symmetrical flake-like electrically conductive ferromagnetic particles dispersed in a non-conductive binder, the direction of the long axes of said particles in alternate layers of said composite layer being oriented at ninety degrees to the direction of the long axes of said particles in the layers adjacent thereto.

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