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(72) Timmerman, August T., BE
(73) EMERSON & CUMING MICROWAVE PRODUCTS, BE

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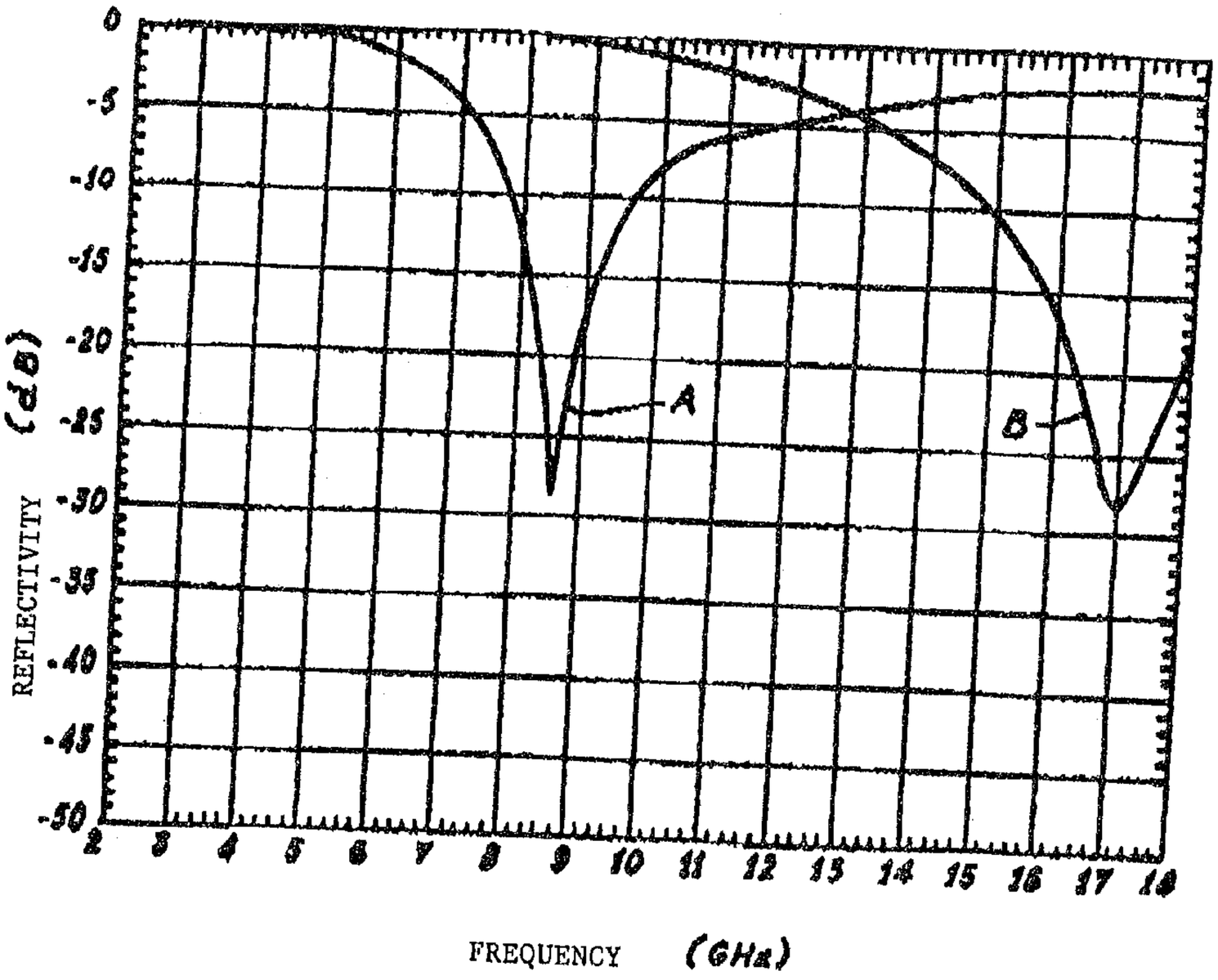
(54) **MATERIAU ABSORBEUR DE MICRO-ONDES**
(54) **MICROWAVE-ABSORBING MATERIAL**



(57) A microwave-absorbing material includes carborundum™ powder as the major microwave-absorbing pigment in combination with an elastomer carrier. Preferably the microwave-absorbing pigment further includes titanium dioxide, with a more preferable proportion of ten parts carborundum™ powder to one part titanium dioxide pigment. Advantageously carbon black may also be present as a minor proportion of the microwave-absorbing pigment.

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MICROWAVE-ABSORBING MATERIAL

The present invention relates to a material capable of absorbing microwave radiation.

It is known to provide materials which are capable of absorbing microwave radiation, for application in various fields. For example, such materials are advantageous for lining the nacelles surrounding a microwave antenna such as an airborne radar antenna, or for attaching to the exterior of the structure such as the masts or superstructure of vessels such as ships in order to reduce reflections and echoes experienced by a nearby antenna.

Traditional microwave absorbers include iron titanium dioxide and carbon black, and it is also possible to incorporate these materials in a rubber-based absorber.

The prior art microwave absorbers have the disadvantage of deteriorating upon exposure to the elements, for example when used on the external surfaces of ships. In particular the iron content of these absorbers is subject to oxidation.

It is an aim of the present invention to provide microwave-absorbing material having better weathering capabilities than the prior art materials.

The present invention provides a microwave-absorbing sheet material comprising a carrier comprising an elastomer selected from the group consisting of natural rubber, silicone rubber, nitrile rubber and polyurethane, in which carrier a microwave-absorbing pigment is incorporated, said microwave-

absorbing pigment comprising pulverulent silicon carbide.

Accordingly, the present invention provides a microwave-absorbing material comprising a carrier with silicon carbide, preferably pulverulent carborundum™, as a microwave-absorbing pigment therein.

In order that the present invention may more readily be understood the following description is given, merely by way of example, with reference to the accompanying drawing and to the following Examples of tested compositions falling within the scope of the present invention. The sole Figure shown on the accompanying drawing is a plot of the reflectivity against frequency obtained with the products described in Examples 1 and 2.

Generally, the novelty of the microwave absorber in accordance with the present invention resides in the use of pulverulent carborundum™, possibly in combination with other pigments to render the carrier material absorptive of microwave radiation.

The variation of the peak attenuation frequency can be achieved by changing the amount and the proportions of the various microwave-absorbing pigments in the composition and by changing the thickness of a layer of the material. For example, increasing the proportion of carrier material, all other factors being equal, has the effect of reducing the peak attenuation frequency.

EXAMPLE 1

A microwave-absorbing material was made from silicone rubber, carborundum™ (SiC) powder, titanium dioxide (TiO_2) and carbon black in the ratios:-

Silicone rubber	52.8 vol. %
Cross-linking agent	2.2 vol. %
TiO_2	4.1 vol. %
SiC	40.9 vol. %

The pigments (SiC and TiO_2 and the cross-linking agent) were added to the silicone rubber liquid pre-polymer and mixed thoroughly, after which the blend was calendered to give a sheet having a thickness of 2.09 mm. The density of the sheet was 2.04 g/cm^3. The results of reflectivity in decibels of the 2.09 mm sheet tested at various frequencies in GHz are plotted at A on the accompanying Figure 1. As can be seen, the mixture provides a peak attenuation frequency of 8.6 GHz.

EXAMPLE 2

The process of Example 1 was repeated but this time with the following constituents (all the pigments having been added to the silicone rubber liquid pre-polymer before mixing commenced):-

Silicone	57.2 vol. %
Cross-linking agent	2.3 vol. %
Carbon black	0.4 vol. %
TiO_2	4.0 vol. %
SiC	36.1 vol. %

The sheet thickness was 1.18 mm and the density was found to be 1.93 g/cm^3.

The frequency response is plotted at B on the accompanying Figure and from this it can be seen that there is a peak attenuation at a frequency of 17 GHz.

In addition to the chemical cross-linking agent listed in the table of constituents in Examples 1 and 2, a catalyst will also be present in small quantities to enhance cross-linking.

Generally we prefer that the volume percentage of carborundum^{TM} be of the order of ten times the volume percentage of titanium dioxide, and where carbon black is present this is preferably up to one tenth of the volume percentage of titianium dioxide.

By testing of various different formulations and sheet thicknesses other than those given above, we have found that it is possible to achieve peak attenuation frequencies of from 3 to 17 GHz and we do not expect that these are the limits of the available frequency spectrum.

Likewise, we have been able to achieve with many results a peak attenuation (negative relfectivity) of 20 decibels, and with certain compositions such as those preferred compositions in Examples 1 and 2 we have been able to demonstrate attenuation levels of the order of 27 to 28 decibles.

Generally our results show that the volume percentage of the four main constituents can be in the following ranges:-

Rubber	62-44 vol. %
SiC	35-50 vol. %
TiO_2	3-5 vol. %
Carbon Black	0-1 vol. %

Although Examples 1 and 2 both use silicone rubber of the addition type, any other polymer, preferably elastomeric, may be chosen, and in particular we find that nitrile rubber and polyurethane are particularly convenient for providing cross-linked rubber sheets with resonant microwave absorption characteristics.

The invention also extends to other carrier materials such as a liquid which sets on exposure to air or on heating and acts as a paint.

With the general compositions in the ranges shown above, the electromagnetic properties of the materials are as follows:-

real part of dielectric permittivity	:	= 19 to 27
real part of magnetic permeability	:	= 1
imaginary part of dielectric permittivity	:	* = -4 to -6.5
imaginary part of magnetic permeability	:	* = 0

The elastomeric absorbing sheets made in accordance with Examples 1 and 2 have been tested under simulated adverse climatic conditions (for example sprayed with water and frozen to -40^{o}C, and at temperatures of +40^{o}C and a relative humidity of 90%) and been found to have the same frequency responses and to be capable of withstanding the effects of climatic aging.

Preferably the range of mesh sizes for the carborundum™ powder used as the pigment in accordance with the present invention is from 45μm to 6μm, more preferably from 30μm to 9μm.

Where the microwave-absorbing material in accordance with the present invention is in sheet form, the

preferred range of thicknesses for the sheet is from 1 to 5 mm, and the most preferred range is from 1.35 to 2 mm.

The invention also provides a microwave-absorbing material bonded to the structure of a vessel for eliminating microwave reflections from a nearby antenna, the material having a narrow band resonant frequency of absorption with the median frequency of said narrow band substantially equal to the frequency of microwave transmission by the antenna.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A microwave-absorbing sheet material comprising a carrier comprising an elastomer selected from the group consisting of natural rubber, silicone rubber, nitrile rubber and polyurethane, in which carrier a microwave-absorbing pigment is incorporated, said microwave-absorbing pigment comprising pulverulent silicon carbide.

2. A microwave-absorbing material according to claim 1 wherein said microwave-absorbing pigment further comprises titanium dioxide, and wherein the volume percentage of said silicon carbide is up to ten times that of the titanium dioxide.

3. A microwave-absorbing material according to claim 1 wherein said microwave-absorbing pigment further comprises carbon black.

4. A microwave-absorbing material according to claim 2 wherein said microwave-absorbing pigment further comprises carbon black.

5. A microwave-absorbing material according to claim 1 comprising from about 62 to 44 vol. % of a carrier, from about 35 to 50 vol. % silicon carbide, from about 3 to 5 vol. % titanium dioxide, and from about 0 to 1 vol. % carbon black.

6. A microwave-absorbing material according to claim 5 wherein said carrier is silicone rubber in an amount of about 52.8 vol. %, said silicon carbide is used in an amount of about 40.9 vol. %, said titanium dioxide is used in an amount of about 4.1 vol. %, and further comprising a cross-linking agent used in an amount of about 2.2 vol. %.

7. A microwave absorbing material according to claim 5 wherein said carrier is silicone rubber in an amount of about 57.2 vol. %, said silicon carbide is used in an amount of about 36.1 vol. %, said titanium dioxide is used in an amount of about 4.0 vol. %, said carbon black is used in an amount of about 0.4 vol. %, and further comprising a cross-linking agent used in an amount of about 2.3 vol. %.

8. A microwave-absorbing material according to claim 1 wherein the mesh size of the silicon carbide is from about 45 μm to 6 μm.

9. A microwave-absorbing material according to claim 1 wherein said material is in the form of a sheet of calendered material, having a thickness of from about 1 to 5 mm.

10. A microwave-absorbing material according to claim 1 further comprising a carrier comprising a liquid capable of setting on exposure to air or heat.

11. A microwave-absorbing material according to claim 1,

wherein said material has a narrow band resonant frequency of absorption with the median frequency of said narrow band substantially equal to the frequency of microwave transmission by an antenna.

SMART & BIGGAR
OTTAWA, CANADA

PATENT AGENTS

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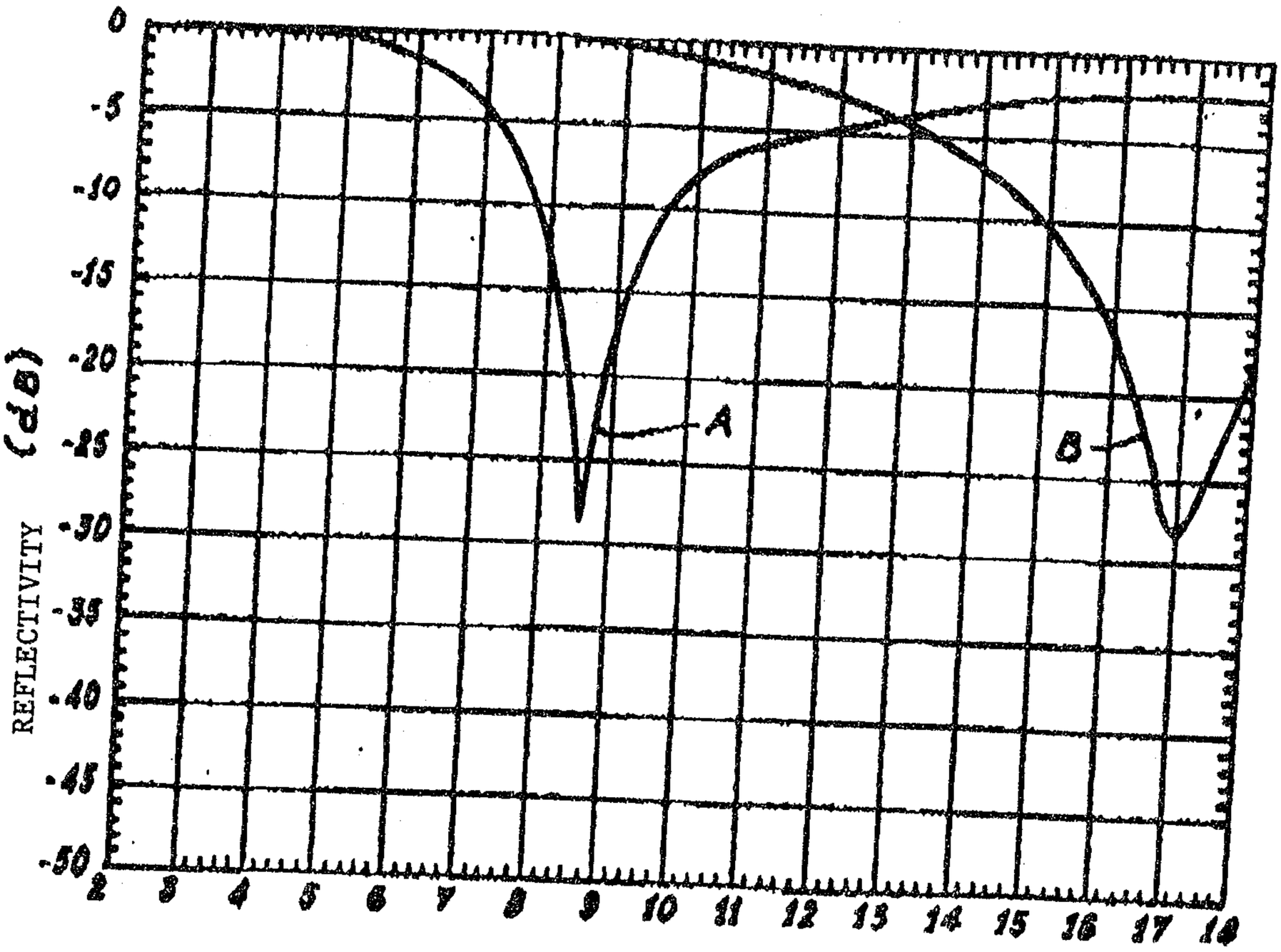
FIGURE 1



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