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Nystrom

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[54] **JAMMING ELECTRONIC WAVE-FORM INFORMATION DEVICES**

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[51] **Int. Cl.** **G01s 7/42**, G01s 9/02

[58] **Field of Search** ..... 343/18 B, 18 E; 340/5 D

[56] **References Cited**

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[57] **ABSTRACT**

Radar and other electronic devices which rely for information upon reflection of a primary wave-form signal are jammed by interposing in the path of the primary signal chaff of compacted vermiform, or expanded, graphite. The primary signal may be electromagnetic, as in the case of radar, or it may be sonic, as in the case of sonar.

10 Claims, No Drawings

JAMMING ELECTRONIC WAVE-FORM INFORMATION DEVICES

This invention relates to interference with electronic devices which are used to gain information by reflection of a primary wave-form signal that may be electromagnetic or sonic. Such devices and their uses are well known. For instance for military purposes they are used to locate enemy ships and their distance from a given point, or for communications.

The intentional interference with such devices to obstruct communication or the gaining of information by an enemy is called jamming. This has been accomplished by interposing in the path of the primary signal, a material which causes the creation of false signals, as by attenuation or reflection. To this end there is dispersed in the area to be jammed aluminum or other metal foil called chaff. Under some circumstances jamming in that way may not be satisfactory due, for instance, to rapid settling of the chaff coupled with the impracticability of maintaining sufficient chaff in the area to effect the desired object.

A primary important object of the invention is to provide an improved method of and chaff for jamming radar and related electronic detection or information gathering devices which afford longer effective time for jamming than is to be had with aluminum chaffs of similar dimensions, and which may be effective to control such factors, among others, as radar cross section, vertical and horizontal polarized radar, desired airfoil characteristics, chaff reflectivity, and others.

In accordance with this invention markedly improved jamming is achieved by the use as chaff of foil of compacted expanded natural flake graphite.

Expanded flake graphite, sometimes called vermiform graphite, and various ways of producing it have been known for many years, as by the treatment of natural flake graphite with oxidizing agents such as sulfuric acid, nitric acid, perchloric acid, etc., or by anodic oxidation. Numerous publications refer to such products and their production. The general technique is described, for example, by A. R. Uppelohde in his book "Graphite and Its Crystal Compounds" (Oxford, Clarendon Press, 1960).

In view of the extensive literature on the subject of expanded graphite no further elaboration is necessary. However, the following exemplary technique has been found to be satisfactory. One pint of fuming nitric acid is admixed with 150 g of a natural flake graphite and allowed to react at 60° C. for 30 minutes. At the end of this period of time, the excess nitric acid is removed by washing the graphite (which now has become the graphite intercalation compound known as graphite nitrate). The resulting material is then subjected to a 1600°F. heat treatment when it expands into vermiform graphite particles which have an average length of over 300 times their original thickness (the treated graphite flakes expand in the direction of the graphite crystal *c*-axis, which is also the direction of the thickness of the original flake). The vermiform graphite particles are collected, washed and compacted into foils by any of a number of fabrication techniques such as molding and rolling.

The density of the foils of the invention depends upon the pressures used in compacting the vermiform graphite. In producing foils for chaff the expanded, or vermiform, graphite is rolled to nominal thicknesses. If the rolling pressure is not known the density of the foil

can be determined from the weight of a known volume. In this way foils for use in the practice of the invention having densities ranging from 1.0 g per cc to 1.5 g per cc can be made by compacting the expanded graphite under pressures ranging from about 500 to about 3,000 p.s.i.

Such densities illustrate a major advantage of the foils of this invention in comparison with aluminum chaff, the density of which is about 2.7 g per cc. Application of Stokes Law of settling velocity shows that the settling rate of my new chaff in air is only one-third to one-half as fast as aluminum chaff.

The exact sizes and shapes of chaff will depend upon various factors such as the nature of the primary signal that is to be jammed, as well as the type of jamming that one is attempting to achieve, e.g., whether the primary signal is electromagnetic or sonic. Such factors as the desired fall rate, the rate of disappearance of the chaff cloud, and the frequency coverage will also affect the size and shape of chaff particles. The specific widths of graphite foil chaff will be determined also by such considerations as the desired airfoil characteristics (i.e., whether a long time of flight or a more rapid descent of the foils is desired), the convenience of handling the chaff, and the rate of dispersal.

The length of the radar jamming chaff should be that of the wave length of the primary signal that is to be jammed so that as the wave length of the signal is shortened, correspondingly shorter lengths of chaff become necessary. As an example, however, strips of graphite foil of a nominal thickness of one mil and 20 to 30 inches in length may be used to jam low frequency V. H. F. radar.

Furthermore, graphite foils can be prepared which taper in thickness from one edge to the other, being, for instance, 5 mils thick at one edge and tapering to only 1 mil thick at the other. This type of foil will tend to cause the chaff to descend on edge after release, as from an aircraft, which would make the foil effective against both horizontally and vertically polarized radars.

Additionally, there may be incorporated in the vermiform graphite various additives to influence the performance of the chaff with regard to such things as settling rate and reflectivity. Such additives may be introduced readily into the vermiform graphite particles prior to their fabrication into foils by a number of techniques such as dry blending an additive with the vermiform graphite particles or liquid spraying of the additive upon the particles. Also, the characteristics of these foils made from expanded graphite may be modified by various coating processes such as electroplating, vacuum deposition, and sputtering. In this way the foils may have the surface modified by the deposition of coating materials which alter their surface properties.

From what has been said it will be understood that the invention has to do with interference not only with radar but also with sonar and other types of electronic wave-form devices, including sonar, and whether or not the primary signal is a continuous wave or is made up of separate bursts of energy.

The invention is not concerned with the mode of dispersing chaff, which can be done in various ways.

According to the provisions of the patent statutes, I have explained the principle of my invention and have described what I now consider to represent its best em-

bodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. Chaff for jamming electronic wave-form information devices consisting essentially of expanded natural flake graphite compacted into foil the major dimension of which is substantially that of the wave length of the radar to be jammed.

2. Chaff for jamming electronic wave-form information devices consisting essentially of expanded natural flake graphite compacted into foil.

3. Chaff according to claim 2, the foil being about one mil thick.

4. Chaff according to claim 2, the foil having a density of about 1 to 1.5 gm/cc.

5. Chaff according to claim 2, the foil being tapered from edge to edge.

6. Chaff according to claim 5, the foil varying from a thickness of about 5 mils at one edge to one mil at the opposite edge.

7. Chaff according to claim 2, the expanded graphite including an additive to alter a surface characteristic of the foil.

8. Chaff according to claim 2, the foil being provided with a surface coating to increase its reflectivity.

9. In a method of jamming an electronic wave-form information device the step of interposing into the path of the wave jamming chaff consisting essentially of expanded natural flake graphite compacted into foil.

10. A method according to claim 9, the foil length being substantially that of the wave-length of the wave to be jammed.

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