July 16, 1963 L. J. CRONIN 3,097,421

HIGH-FREQUENCY ENERGY ABSORBING MATERIAL

Filed Feb. 20, 1959

Fig. 1.

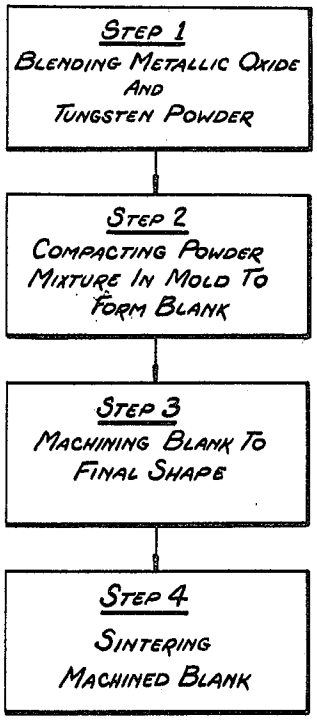


Fig. 2.

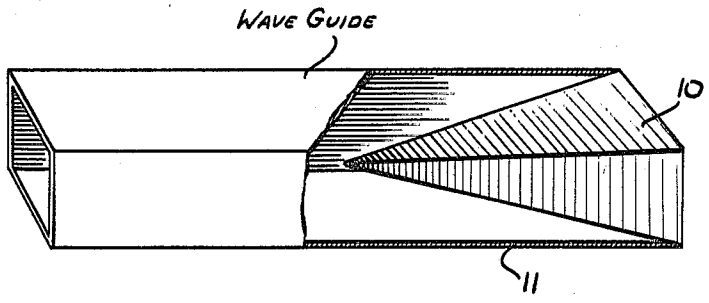
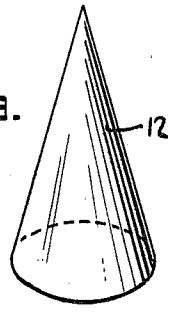


Fig. 3.



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HIGH-FREQUENCY ENERGY ABSORBING MATERIAL

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The present invention relates generally to lossy devices for absorbing high-frequency wave energy, and more particularly to terminations formed of dissipative material having improved characteristics, and to methods for fabricating such terminations.

It is common practice in high-frequency wave transmission elements, such as wave guides and coaxial devices, to employ inserts to lossy material so positioned as to absorb power propagated therethrough. Lossy terminations act to convert the electromagnetic wave energy into thermal energy, the resultant heat being carried off through the walls of the termination section. In order to minimize abrupt discontinuities in the incident wave energy, the lossy terminations are generally constructed in tapered or wedge form.

Existing materials for lossy terminations are usually constituted by resistive particles in a dielectric binder. One known technique for fabricating a lossy insert is to immerse a porous ceramic body in an organic solution, the body thereafter being fired to provide a carbon-impregnated lossy device. Lossy plugs may also be composed of a mixture of plastic and powdered metal molded as a unit, such as polystyrene and iron particles, or powdered metal and powdered carbon mixed and molded. Also used for this purpose are such trademarked products as "Aquadag" and "Polyiron."

Conventional terminations exhibit a number of serious drawbacks. The materials ordinarily used have poor and uneven heat conductivity, giving rise to hot spots and local overheating. They are mechanically fragile and easily fractured. Moreover, known lossy materials cannot be metalized and soldered. Mounting by brazing to a metal wall is not possible with convention terminations.

In view of the foregoing, it is the principal object of this invention to provide an improved lossy material and to methods for fabricating terminations of such materials.

Also an object of the invention is to provide a method of fabricating a lossy device wherein the resistivity thereof may be varied after it has been formed into a solid body.

More especially, it is an object of this invention to provide an improved high-frequency, energy-absorbing termination which is mechanically strong and which has thermal conductivity characteristics comparable to steel.

A significant advantage of the termination in accordance with the invention is that it can be metalized and soldered. Also the nature of the material is such that it can be readily machined to any desired shape and size.

A further object of the invention is to provide a superior termination which can be mass produced at relatively low cost.

Briefly stated, these objects are obtained by blending tungsten powder with a metallic oxide such as aluminum oxide to form a mixture which is pressed in a mold to form an oversized solid body. The pressed body is then machined to the desired shape. The machined blank is thereafter sintered to form a termination element which is mechanically stable and may be brazed to a mounting surface.

For a better understanding of the invention, as well as other objects and features thereof, reference is made to the

following detailed description to be read in connection with the accompanying drawings wherein:

FIG. 1 is a flow chart representing the method of making the dissipative device;

FIG. 2 is a perspective view of one form of termination element made of material in accordance with the invention; and

FIG. 3 is a perspective view of another form of termination element.

Referring now to the flow chart in FIG. 1, the technique for composing the lossy material according to the invention and for fabricating a termination therefrom first involves the blending of tungsten powder with a powdered metallic oxide, such as aluminum oxide, to form a powdered mixture (step 1). Other refractory metals such as molybdenum capable of withstanding relatively high temperatures may be used in place of tungsten, but tungsten is preferred. The powders are blended in approximately a 50 to 50 ratio, with an average particle size of about 4 microns.

The next step involves placing the powder blend in a pressure mold, which may be of cylindrical configuration, to form an oversize blank in the shape of a solid bar (step 2). For this purpose pressure in the order of 20,000 pounds per square inch may be used. Any known method of forming may be used, such as a dry press, a wet press, extrusion, slip cast, and hydrostatic pressing methods.

In the next step, the oversize blank of pressed powder is machined on a lathe or other metal working machine to its desired shape and dimension (step 3). This shape may be pyramidical, conical or any other form dictated by termination requirements.

Finally, the machined blank is fired at a high temperature in a furnace in an inert and non-oxidizing atmosphere to effect sintering (step 4). In practice a temperautre of 1700 to 200° C. is used for about 10 to 20 minutes to effect the desired sintering. The sintered body may readily be metalized and soldered, thereby facilitating mounting.

As shown in FIG. 2, the termination **10** formed of material in accordance with the invention may be in pyramidical form and brazed in place at the end of a rectangular wave guide **11**. The termination section may be formed with exterior cooling fins. As pointed out previously, the high thermal conductivity of the termination makes for efficient heat dissipation.

Other shapes are possible, such as the conical form **12** shown in FIG. 3. The power dissipating material may be used wherever attenuation or power-absorption is required in a wave transmission system.

A general advantage of this material is that its electrical resistivity can be varied over wide limits, say from 1 ohm per centimeter to 500 megohm-cm., by such processing variables as pressure, temperature, particle size and percentage of metal. The electrical loss will also vary with the electrical resistivity, but not necessarily in direct proportion thereto.

Further control of resistivity may be gained by the addition of a small percentage of a metal, such as titanium, which can be removed by evaporation. To illustrate this point, we shall consider as a specific example of usefulness a ⅛" diameter x ½" long rod. It was desired to obtain 20 ohms end-to-end resistance. However, due to excessive time in the sintering operation the resistance was found to be 1 ohm, which is too low. The resistance can be increased and the rod recovered by heating it in vacuum to say 1700° C. for 15 minutes. This heat treatment reduces the percentage of the metallic constituents by the evaporation of a portion of the titanium. It will be noted that the titanium is not evapo-

rated in the course of sintering, for this operation is carried out in an inert atmosphere, not in vacuum. In practice the amount of volatile metal added may be between .1% to 5% and is preferably 1%. The ultimate resistivity depends of course on the amount of volatile metal removed.

The sintered lossy material may be metalized by any one of several methods well known in the art of ceramic-metal seals. Such methods include the Telefunken process, the active metal process and the molybdenum-manganese method.

In addition, the lossy material can be metalized by a novel process not known or used in the ceramic-metal seal art. This novel method involves the application of a powdered refractory metal, such as molybdenum to the unfired or prefired (not fully sintered) pressed compact. For example, molybdenum powder, suspended in an organic binder may be painted or otherwise applied onto the surface of the machined blank derived from step 3 in FIG. 1. The assembly is then fired to normal temperatures of 1700° C. to 2000° C. in an atmosphere of hydrogen, as in step 4. During this firing the molybdenum powder sinters to itself and also to the lossy material, thereby forming a strong adherent metal layer. Conventional soldering techniques can now be used to braze the metalized lossy material to metal appendages.

The lossy device in accordance with the invention operates effectively in the 400 megacycle to 30,000 megacycle range and is also useful at frequencies higher and lower than this range. The device is operative in the VHF, UHF, SHF and EHF ranges. The term high frequency as used herein is intended to embrace all the specified ranges.

While there has been shown a preferred embodiment of the invention, it is to be understood that many changes may be made therein without departing from the essential spirit of the invention as set forth in the annexed claims.

What is claimed is:

1. A lossy device for absorbing electromagnetic wave energy in the high frequency region consisting essentially of a 50–50 mixture by weight of tungsten powder and aluminum oxide powder, the mixture being compacted, shaped and sintered to form a solid body of high thermal conductivity.

2. The method of forming a lossy body of high thermal conductivity for absorbing electromagnetic wave energy in a predetermined high frequency region, comprising the steps of compacting in a mold a blend consisting essentially of tungsten powder and aluminum oxide to which is added a small percentage of a volatile metal powder thereby to form a pressed blank, sintering the blank under temperature conditions at which said added metal is not evaporated thereby to form a solid body which includes said added metal, and heating the solid body at a temperature removing a portion of the added metal to an extent providing a desired resistivity, said tungsten powder and said aluminum oxide powder being in a ratio in said blend by weight resulting in electrical resistivity which is high relative to the resistivity of tungsten alone and at which absorption of energy in said region is effected.

3. The method of forming a lossy body of high thermal conductivity for absorbing electromagnetic wave energy in the high frequency region, comprising the steps of compacting in a mold a blend consisting essentially by weight of 49% tungsten powder and 50% aluminum oxide to which is added 1% of titanium powder thereby forming a pressed blank, sintering the blank under temperature conditions at which said titanium is not evaporated thereby to form a solid body which includes said titanium, and heating the solid body at a temperature removing a portion of the titanium to an extent providing an electrical resistivity greater than the resistivity of the solid body.

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