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3,246,262

HEAT SINK FOR A FERRITE MATERIAL EMPLOYING METAL OXIDES
AS THE DIELECTRIC MATERIAL

Filed May 22, 1963

2 Sheets-Sheet 1

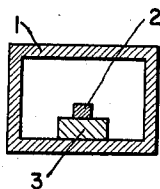


FIG. 1.

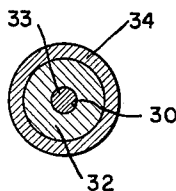


FIG. 3.

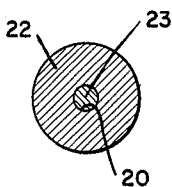


FIG. 2.

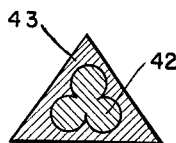


FIG. 4.

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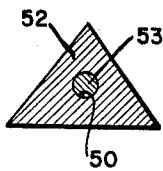


FIG. 5.

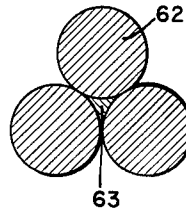


FIG. 6.

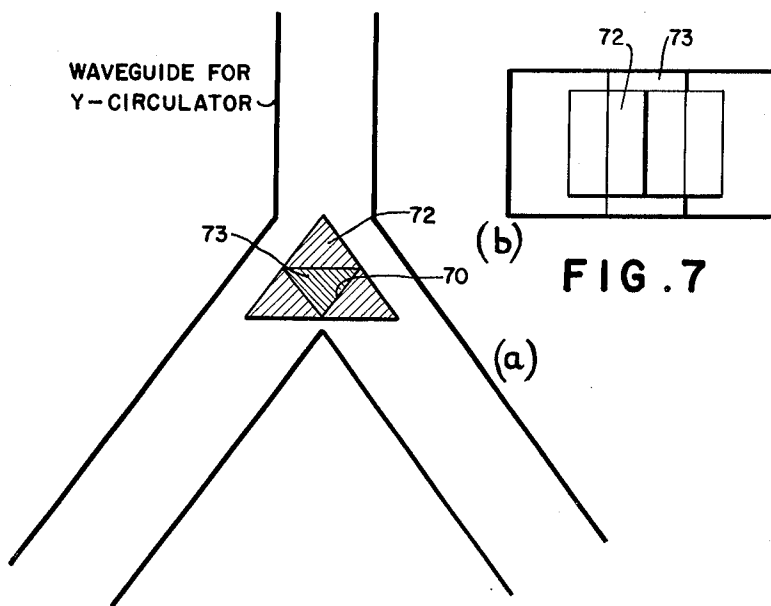


FIG. 7

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1

3,246,262

HEAT SINK FOR A FERRITE MATERIAL EMPLOYING METAL OXIDES AS THE DIELECTRIC MATERIAL

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8 Claims. (Cl. 333—1.1)

The present invention relates generally to ferrite devices and, more particularly, to a broadband arrangement for conducting heat away from a pre-magnetized microwave ferrite, wherein the ferrite is not in direct heat-conducting contact or relationship with the wall of a surrounding hollow conductor.

It has been found that considerable difficulties are encountered when heat is to be removed from ferrite elements or structural pieces in the microwave art if the power is greater than approximately one kilowatt. In known arrangements of this type, the heat is generally given off to the cooler surroundings by means of convection. In the case of large heat losses, however, this is possible only to a very limited extent. In order that the heat which is produced nevertheless be carried off, the shape and arrangement of the ferrite, in such microwave structures up to now, has been so selected that the heat which is produced is carried off by means of direct heat contact with the metallic conductor. This, however, means that at the same time the optimal electrical dimensioning of the ferrite structure must be sacrificed. In ferrite arrangements in which, due to special electrical characteristics, there may not be any direct contact with the metallic hollow conductor, it is therefore not possible, when the device is operating at high power, to drain the heat off the ferrite, i.e., it is difficult to remove the heat which is produced.

There also exists an arrangement in which a liquid coolant surrounds the ferrite body and is used for draining off the heat losses of the ferrite. The dielectric coolant is continuously circulated by a pump system. However, the expenses of such an arrangement are inherently very high.

With these defects of the prior art in mind, it is a main object of the present invention to provide a broadband arrangement which overcomes the above drawbacks without adversely affecting the electrical characteristics of the microwave arrangement.

Another object of the invention is to provide an arrangement for removing heat from ferrites which is simple and inexpensive.

These objects and others ancillary thereto are accomplished according to preferred embodiments of the present invention wherein an arrangement for draining the heat off a pre-magnetized microwave ferrite is provided. In this arrangement there is direct heat exchange contact with the wall of the hollow conductor. Between the ferrite and the hollow conductor a dielectric is arranged which itself is a good conductor of heat.

The interposition of a suitable dielectric between the ferrite and the hollow conductor has but little influence on the electrical characteristics of such a microwave structure, while there is a substantial improvement in the removal of the heat losses of the ferrite, i.e., the dielectric which itself is a good conductor of heat will substantially improve the way in which the heat losses are given off to the cooler surroundings of the hollow conductor.

The dielectric material can, for example, be the oxides of beryllium, aluminum or magnesium inasmuch as these materials, in addition to having a low dielectric loss in a

2

microwave region, are very good conductors of heat and have a thermal conductivity which is approximately in the same order of magnitude as the thermal conductivity of the corresponding metals. The dielectric materials at the same time serve for holding or positioning the ferrite part within the hollow conductor and maintain the ferrite element at a predetermined spaced distance from the wall of the hollow conductor.

In order that the dielectric material may conduct the heat which is produced to the cooler hollow conductor as quickly as possible, it is expedient that the dielectric material touch the ferrite on two opposite surfaces and itself be in contact with the wall of the hollow conductor over as large a contact surface as possible. It is also possible to surround the ferrite element on all sides with this dielectric material which itself is in engagement with the respective hollow conductor wall. According to a further feature of the present invention the ferrite can be equipped with at least one bore in which there is a core of the above-mentioned dielectric material, this core being connected to the hollow conductor of the arrangement.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a cross-sectional view through a first embodiment of the present invention with a rectangular wave guide.

FIGURE 2 is a cross-sectional view through a second embodiment wherein the elements are circular in cross section.

FIGURE 3 is a cross-sectional view of a modification of the embodiment of FIGURE 2.

FIGURE 4 is a cross-sectional view of a third embodiment for a Y-circulator.

FIGURE 5 is a cross-sectional view of a modification of the embodiment of FIGURE 4.

FIGURE 6 is a cross-sectional view of a fourth embodiment wherein a plurality of ferrite bodies are used.

FIGURE 7 is a cross-sectional view of a modification of the embodiment of FIGURE 6.

With more particular reference to the drawings, FIGURE 1 illustrates a rectangular hollow conductor 1 in which a ferrite 2 is arranged. In order to remove the heat produced in the ferrite and for simultaneously holding or mounting the ferrite, by sticking a piece of dielectric material 3 is provided which, for example, is made of beryllium oxide and is arranged between the ferrite and the hollow conductor.

As shown in FIGURE 2, in order to drain off the deleterious heat loss present in the ferrite and to bring this heat loss to the cooler surroundings, the ferrite body 22 may have a bore 20 in which a core made of the dielectric material 23 which is a good conductor of heat may be disposed. This material 23 is in good surface-to-surface contact with the wall of the hollow conductor.

Another form of the invention is shown in FIGURE 3. Arranged within the hollow conductor branching (not shown) is a pre-magnetized hollow ferrite 32 having a bore 30. The space between the ferrite and the hollow conductor wall is, in this embodiment, at least partially occupied by the dielectric material 34. The ferrite bore 30 contains dielectric material 33.

The present invention can be used to advantage in Y-circulators, which, in the microwave region, are made up of hollow conductors and possess a pre-magnetized ferrite. In order to obtain a large bandwidth for such a circulator, it has already been suggested to provide the ferrite with a cross section which is approximately the shape of a three-leaf clover. With this arrangement, too,

it is possible to use the above-described dielectric material for draining off the heat so that such Y-circulators can be used in connection with substantially greater power.

FIGURE 4 shows such a Y-circulator having a suitably cross-sectioned ferrite 42, which is surrounded on all sides by the dielectric material 43 so that the cross-sectional configuration of the arrangement is a triangle.

In lieu of the cross-sectional configuration of the ferrite shown in FIGURE 4, which is difficult in practice to produce, the arrangement can be made as shown in FIGURE 5. Here a ferrite body 52 which has a triangular cross section and a central longitudinal bore 50 is used. The core 53 of dielectric material of good conducting characteristics is inserted into bore 50.

FIGURE 6 shows a further embodiment of the present invention in which three cylindrical ferrite bodies 62 are positioned together in such a manner that they mutually touch each other. The hollow space which remains in the center between the three ferrite cylinders is, for purposes of draining off the deleterious heat losses, filled with a suitably configured dielectric material 63.

FIGURE 7 shows an embodiment of the invention in which the longitudinal bore 70 of the ferrite body 72, shown in FIGURE 5, has a triangular cross section. Again, the bore is filled with the dielectric core 73 which is in good surface-to-surface contact with the wall of the hollow conductor of the Y-circulator. If a good deal of heat has to be drained off, it is further possible to provide additional dielectric material between one or more of the surfaces of the ferrite and the wall of the hollow conductor.

If, as shown in FIGURE 7, the bore is so selected that its edges just touch the sides of the triangular configuration, there is obtained an arrangement which is particularly easy to make inasmuch as it comprises a ferrite prism and three similar dielectric prisms. It has been found that in the case of a Y-circulator according to FIGURE 7, there is obtained in addition to the good conduction of the heat losses, and also the retention of the usual electrical characteristics, a substantially greater bandwidth, about 40%, than was the case in heretofore known Y-circulators. The reason for this might be that, due to the central bore in the ferrite, the disturbing inherent resonances are shifted out of the operating region.

In order that the above-described ferrite arrangements be as independent of temperature fluctuations as possible, the invention can be carried further by building up the ferrite body of individual ferrite layers, between which there are arranged suitably configured discs made of the dielectric material which is a good conductor of heat.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. In a broadband arrangement for removing heat in a pre-magnetized microwave ferrite in a hollow conduc-

tor but which is not in direct and heat exchange contact with the wall of the conductor, the improvement comprising a dielectric material which is a good conductor of heat interposed between the ferrite and the hollow conductor, the dielectric material surrounding the ferrite on all sides, and the dielectric material being one selected from the group consisting of beryllium oxide, aluminum oxide, and magnesium oxide.

2. The improvement as defined in claim 1 wherein the ferrite has at least one opening defined therethrough which is filled with the dielectric material.

3. The improvement as defined in claim 2 wherein the ferrite is used for a Y-circulator and is triangular in cross section, said opening extending longitudinally through the ferrite and being triangular in cross section.

4. The improvement as defined in claim 2 wherein the cross sections of the dielectric material and the ferrite are circular.

5. The improvement as defined in claim 2 wherein the ferrite is clover shaped in cross section.

6. In a broadband arrangement for removing heat in a pre-magnetized microwave ferrite in a hollow conductor but which is not in direct and heat exchange contact with the wall of the conductor, the improvement comprising a dielectric material which is a good conductor of heat interposed between the ferrite and the hollow conductor, and a plurality of ferrites being used and defining an opening which is filled with the dielectric material.

7. The improvement as defined in claim 6 wherein the ferrites are circular in cross section.

8. In a broadband arrangement for removing heat in a pre-magnetized microwave ferrite in a hollow conductor but which is not in direct and heat-exchange contact with the wall of the conductor, the improvement comprising a dielectric material which is a good conductor of heat interposed between the ferrite and the hollow conductor, said ferrite being used for a Y-circulator and being triangular in cross section, said ferrite having at least one opening defined therethrough which extends longitudinally through the ferrite and is triangular in cross section and which is filled with the dielectric material.

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