United States Patent

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[33] **Japan**
[31] **44/78800**

[54] **CIRCULATOR HAVING HEAT DISSIPATING PLATE**
2 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** ..... **333/1.1,** 333/83 T
[51] **Int. Cl.** **H01p 1/32,** H01p 5/12
[50] **Field of Search** 333/1.1, 24.1–24.3

[56] **References Cited**
UNITED STATES PATENTS

3,225,318	12/1965	Heithaus	333/24.2
3,522,555	8/1970	Hashimoto et al.	333/1.1

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ABSTRACT: A nonreciprocal circuit element in which some portions of a heat dissipating plate or heat sink which are introduced into a magnetic shield case through apertures thereof are made in close contact with a case which houses microwave ferrite elements and a center conductor. The heat dissipating effect is remarkably improved.

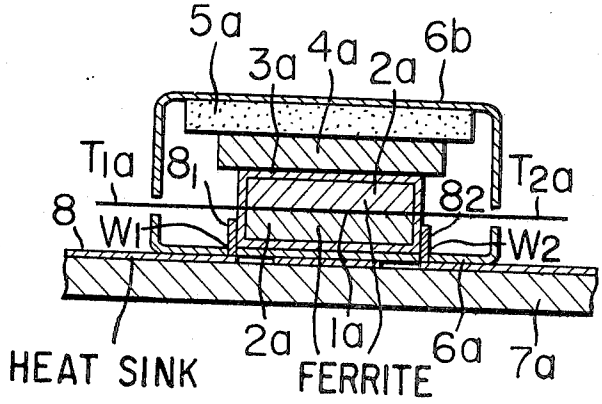


FIG. 1

PRIOR ART

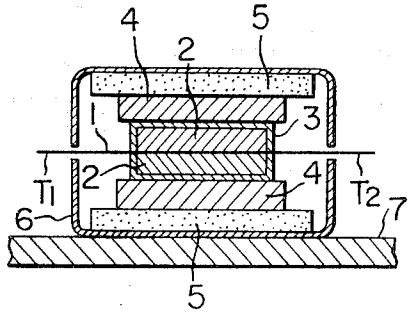


FIG. 2

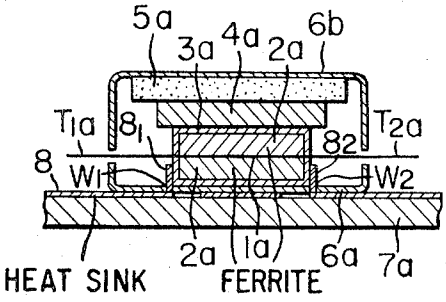
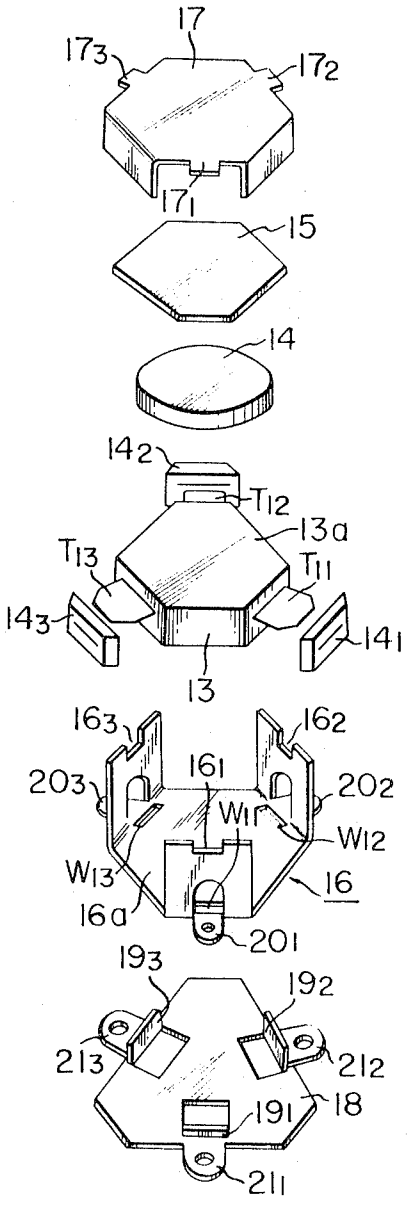


FIG. 3



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FIG. 4A

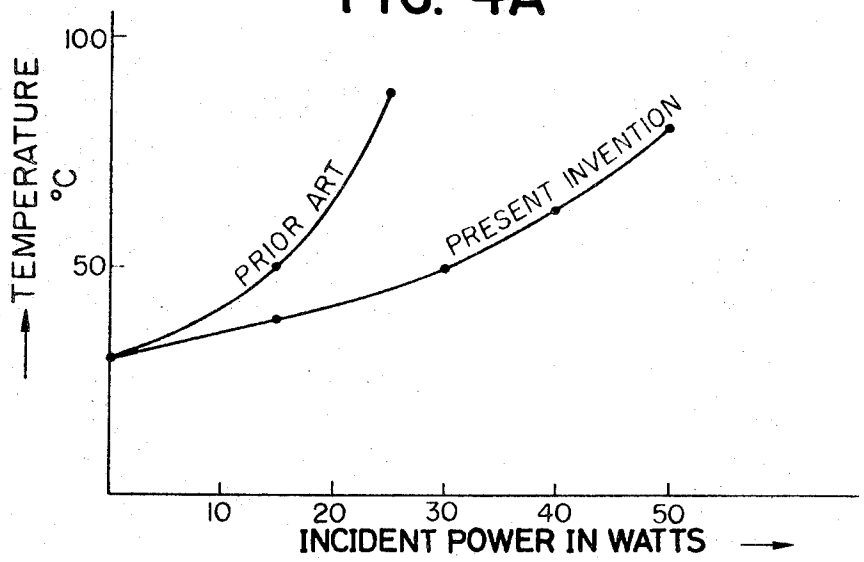
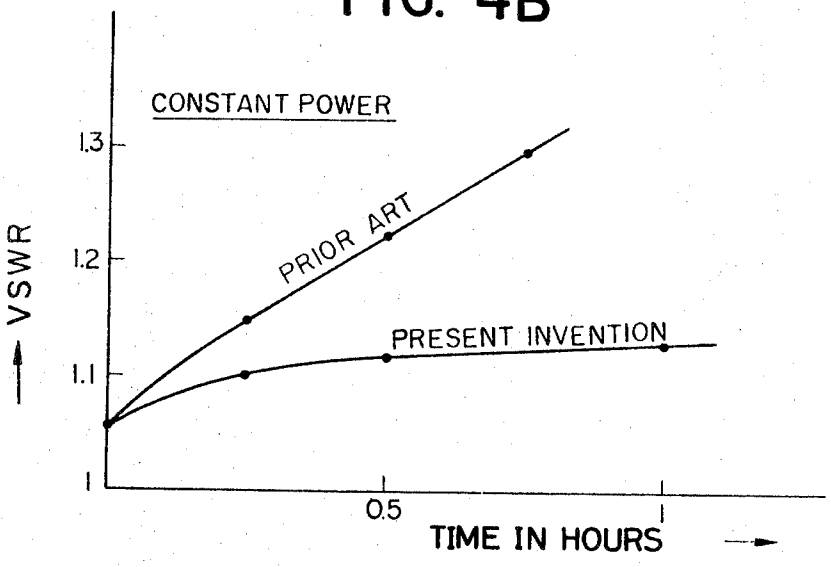


FIG. 4B



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CIRCULATOR HAVING HEAT DISSIPATING PLATE

BACKGROUND OF THE INVENTION

The present invention relates to an improvement of a nonreciprocal circuit element for a circulator system and more particularly an improvement of a heat dissipating member or heat sink of a nonreciprocal circuit element.

A typical nonreciprocal circuit element has a construction as shown in FIG. 1. A center conductor 1 having terminals T_1, T_2 and so on is interposed between a pair of microwave ferrites 2 which in turn is covered by a case 3 made of, for example, copper. The case 3 is interposed between magnets 4. All of the components described above are held in position in a magnetic shield case 6 with pressure plates 5 made of, for example, silicon rubber. The magnetic shield case 6 is mounted upon a mounting plate 7. In operation of the nonreciprocal circuit element having the construction described above at high average power level, a considerable quantity of heat is generated in the center conductor 1, microwave ferrites 2, so that the voltage standing wave ratios At the terminals T_1, T_2 and so on are deteriorated and the primary purpose of such element cannot be achieved. In the conventional circuit element, the handling power has been limited to a low value by the generation of the heat in the element. Accordingly, one of the objects of the present invention is to eliminate the defects of the conventional nonreciprocal circuit element as described above.

Another object of the present invention is to provide a nonreciprocal circuit element which has a large power handling capability, is economical and exhibits a remarkable heat dissipating effect only by adding a few improvements to the conventional circuit element.

SUMMARY OF THE INVENTION

According to the present invention, some portions of a heat dissipating plate or heat sink which are introduced into a magnetic shield case through apertures thereof are made in close contact with a case which houses microwave ferrite elements and a center conductor interposed. Since the heat dissipating plate or heat sink is directly firmly fixed to a mounting plate, the efficiency of heat dissipation is much improved.

In the one embodiment of the present invention, the bottom of the magnetic shield case is made in close contact with the surface of the heat dissipating plate or heat sink, thereby facilitating the heat dissipation.

According to the present invention, the heat dissipation is further enhanced by directly contacting one surface of the case housing therein the microwave ferrite elements and the center conductor with the magnetic shield case without interposing any part such as a magnet therebetween.

In the circuit element in accordance with the present invention, the case housing therein the microwave ferrite elements and the center conductor is directly physically connected to the heat dissipating plate or heat sink so that the circuit element of simple construction has an excellent heat dissipating effect. Furthermore, when the circuit element in accordance with the present invention is directly mounted upon the mounting plate, the latter also serves as a heat sink so that the overall efficiency of heat dissipation is further improved. The circuit element in accordance with the present invention is simple in construction and easily assembled and EMBODIMENTS best suited for mass production.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal sectional view of one conventional nonreciprocal circuit element illustrated for the purpose of comparison of that in accordance with the present invention;

FIG. 2 is a longitudinal sectional view illustrating a first embodiment of the present invention;

FIG. 3 is a perspective exploded view illustrating a second embodiment of the present invention; and

FIGS. 4A and B are graphs depicting the characteristics for explanation of the effect of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 2, illustrating the first embodiment of the present invention, a center conductor 1*a* provided with terminals T_{1a} and T_{2a} is interposed between microwave ferrite elements 2*a* which in turn are covered by a case 3*a* made of copper. Upon the top of case 3*a* a magnet 4*a* is placed and the bottom of the case 3*a* is positioned in direct contact with a magnetic shield case 6*a* made of steel. A pressure plate 5*a* made of silicon rubber is disposed upon the magnet 4*a* and a magnetic shield case 6*b* making a pair with the shield case 6*a* is disposed upon the pressure plate 5*a*. The shield case 6*a* is provided with a plurality of apertures W_1, W_2 and so on through which are inserted tongues 8_1, 8_2 and so on of a heat dissipating plate or heat sink 8 made of a thermal conductive material such as copper, aluminum, etc. The tongues 8_1, 8_2 and so on are made in close contact with or soldered to the sidewalls of the case 3*a*. The heat dissipating plate or heat sink 8 is firmly fixed to a mounting plate 7*a* by, for example, soldering.

Next the second embodiment of the present invention will be described with reference to FIG. 3. A case 13 houses microwave ferrite elements (not shown) and a center conductor having terminals T_{11}, T_{12} and T_{13} at which insulating spacers 14_1, 14_2 and 14_3 are fitted. The case 13 is then disposed upon the bottom plate 16*a* of a steel magnetic shield case 16 through a silicon compound (not shown) in order to facilitate the thermal transfer therebetween. A magnet 14 is bonded to the upper surface 13*a* of the case 13 with a suitable adhesive (not shown), and a steel cap 17 is fitted over the magnet 14 through a pressure place 15 made of, for example, silicon rubber. The tongues 17_1, 17_2 and 17_3 integrally extending from the cap 17 are fitted into the notches 16_1, 16_2 and 16_3 formed in the shield case 16 and securely bonded thereto by use of a suitable adhesive (not shown). The case 16 is provided with apertures W_{11}, W_{12} and W_{13} into which are inserted the tongues 19_1, 19_2 and 19_3 of a heat dissipating place or heat sink 18 made of copper, aluminum, etc. These tongues 19_1, 19_2 and 19_3 are made in close contact with or soldered to the sidewall of the case 13. Between the heat dissipating plate or heat sink 18 and the case 16 a silicon compound film is interposed in order to facilitate the thermal transfer therebetween. The mounting tongues 20_1, 20_2 and 20_3 of the case are securely fixed to a mounting plate (not shown) together with the mounting tongues 21_1, 21_2 and 21_3 of the heat dissipating plate or heat sink 18 by soldering or by use of screws, etc.

The heat generated in the circuit elements having the constructions as described herein above can be dissipated in a very satisfactory manner as shown by the characteristic curves in FIG. 4. FIG. 4A illustrates the relationship between the power and the temperature rise and it is clearly seen that the circuit element in accordance with the present invention has a power handling capability of about twice as much as that of the conventional element having the same size. FIG. 4B illustrates the relationship between the time and the variation in voltage standing wave ratio and it is seen that the variation of the circuit element in accordance with the present invention is very small.

I claim:

1. A nonreciprocal circuit element for a circulator system comprising

a pair of opposed microwave ferrite elements;

conductor means passing between said ferrite elements in abutting relation;

said conductor means having at least three terminals extending therefrom;

a hollow body case surrounding and enclosing said ferrite elements, said case having a top surface and a bottom surface;

a magnet element mounted on said top surface of said case, and a pressure plate mounted on top of said magnet element;

a magnetic shield case provided in two matching parts, the upper part positioned above said conductor means and

enclosing one of said ferrite elements, the upper part of said body case, the magnet element and the pressure plate; and the lower part positioned below said conductor means and enclosing the other of said ferrite elements and the lower part of said body case;

said lower part including a flat portion parallel with and abutting the bottom surface of said body case, said flat surface including apertures therein adjacent edges of said bottom surface;

a support on which said magnetic shield case is positioned; and

a heat dissipating plate located between the lower part of said magnetic shield case and said support in abutting relation therewith, said heat dissipating plate including

projecting tongue elements extending through said apertures in abutting contact with said body case.

2. A nonreciprocal circuit element according to claim 1 in which said body case, said magnetic shield case and said heat dissipating plate each have six sides to be hexagonal in shape, three equal spaced terminals are provided extending from nonadjacent sides of said body case said apertures in the lower part of said magnetic shield case includes three equally spaced apertures each located adjacent a flat side of said body case that is adjacent to the flat side in which a terminal is located, and said tongue elements includes three upwardly projecting tongues respectively corresponding in placement to said apertures and extending therethrough.

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