

Laisi

[15] **3,654,580**

[45] **Apr. 4, 1972**

[54] RESISTOR STRUCTURE

[72] Inventor: **Risto Laisi**, Amherst, N.H.

[73] Assignee: **Sanders Associates, Inc.**, Nashua, N.H.

[22] Filed: Mar. 14, 1969

[21] Appl. No.: 807,172

[52] U.S. Cl.....338/61, 338/206, 338/307,
338/314, 338/322

[51] Int. Cl. H01c 3/02

[58] **Field of Search**.....338/61, 204, 307, 308, 314,
338/315, 206, 260, 322

[56] **References Cited**

UNITED STATES PATENTS

2,473,183	6/1949	Watson.....	338/322 X
2,836,693	5/1958	Yarbrough.....	338/322 X
3,111,570	11/1963	Strang et al.....	338/314 X
3,440,408	4/1969	Brittan.....	338/322 X
3,071,749	1/1963	Starr.....	338/314

FOREIGN PATENTS OR APPLICATIONS

245,693 7/1963 Australia338/314

Primary Examiner—Richard A. Farley

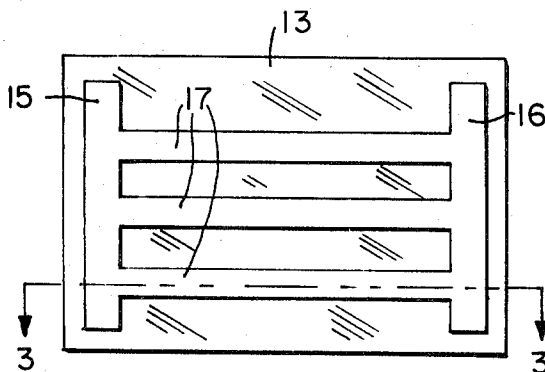
Assistant Examiner—R. Kinberg

Attorney—Louis Etlinger

[57] **ABSTRACT**

A laminated resistor structure for low ohmic valued, high frequency and high power applications and a method for fabricating such a resistor structure. In the disclosed method, part of the resistive layer is removed from the laminated structure to form a plural branch pattern having a pair of spaced apart portions and a plurality of spaced apart elongated strips extending between the portions. The resistive layer pattern forms a parallel electrical connection of the resistive strips to provide not only low ohmic value but also a relatively large area of the laminated structure for power dissipation. By forming the resistive strips with straight line geometries, the inductance is minimal, thereby providing a high frequency capability.

3 Claims, 6 Drawing Figures



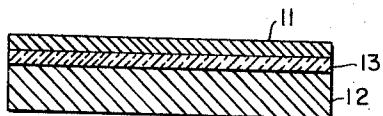


FIG. 1

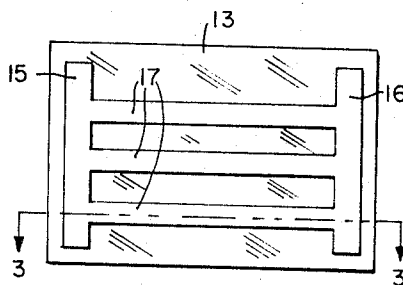


FIG. 2

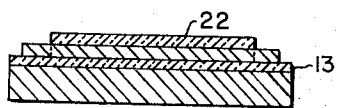


FIG. 3A

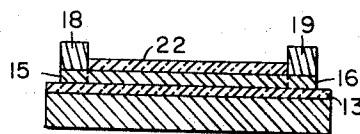


FIG. 3B

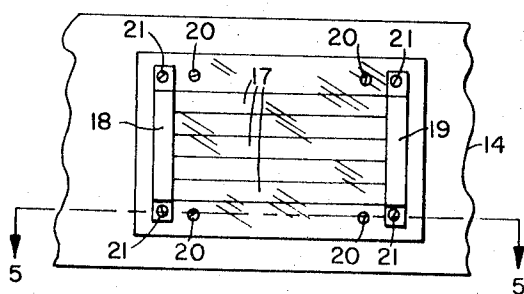


FIG. 4

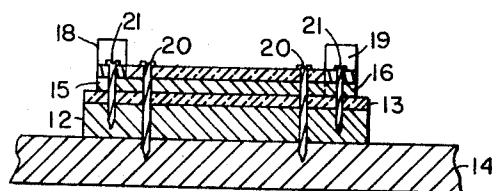


FIG. 5

INVENTOR

RISTO LAISI

BY *Robert R. Hubbard*

ATTORNEY

RESISTOR STRUCTURE

BACKGROUND OF THE INVENTION

This invention relates to new and improved electrical resistors and to a method for making such resistors. In particular, the resistors of the present invention have low ohmic value, low inductance, and a capability of dissipating considerable power. A typical application for resistors of this type includes the sensing of relatively large current such as occur, for example, in the deflection circuits of cathode ray tubes.

Electrical resistors are known which have low ohmic value (on the order of a fraction of an ohm to a few ohms or so) and relatively low inductance. However, such known resistors have generally been incapable of dissipating considerable power (for example, 20 watts) in that the heat dissipated by the resistor element could not be rapidly transferred to a suitable heat sink. The lack of rapid heat transfer has been due to inadequate design of the resistor housing structure both as to geometry and as to rapid transfer of the heat dissipated by the resistor. Known resistors which are capable of dissipating high power have had either too high an ohmic value or too high an inductance for high frequency current sensing applications.

BRIEF SUMMARY OF THE INVENTION

An object of the invention is to provide a new and improved resistor structure which has low ohmic value, low inductance and a capability for high power dissipation.

Another object is to provide a new and improved method of fabricating resistors having low ohmic value, low inductance and a capability for high power dissipation.

Resistor structures embodying the invention are in the form of a sandwich type structure which includes a carrier body of relatively high thermal conductivity and a layer of resistive material disposed on one surface of the carrier body in a plural branch pattern. The pattern has a pair of spaced apart portions; a plurality of elongated strips or branches extends between the portions to provide a parallel electrical connection of the resistive strips. First and second electrical conductive members, for example, terminals are provided in electrical contact with different ones of the spaced apart portions.

In a preferred embodiment of the invention, the carrier body includes a layer of high thermal conductivity material and a layer of insulation overlying at least a portion of one surface of the metallic layer. The plural branch resistive pattern is then disposed on the insulating layer.

The parallel connection of the resistive strips and the spaced apart topology of the strips cooperate to provide both low ohmic value and high power dissipation. Preferably, the resistive strip geometry is that of a straight conductor in order to provide a low inductance.

In the method embodiment of the invention, a laminated structure having an insulating layer sandwiched between a metallic plate and a resistive foil is first produced. Then a part of the foil layer is removed to form a plural branch foil pattern having a pair of spaced apart portions and a plurality of spaced apart elongated strips extending between the portions.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings like reference characters denote like structural elements, and:

FIG. 1 is a cross sectional view of a laminated resistor structure at an early stage of fabrication;

FIG. 2 is a plan view of a resistor structure at a further stage of fabrication showing a plural branch resistive pattern embodying the invention;

FIGS. 3A and 3B are cross sectional views of the resistor structure at still further stages of fabrication, the cross section being taken along the line 3—3 in FIG. 2;

FIG. 4 is a plan view of a completed resistive structure embodying the invention; and

FIG. 5 is a cross section view taken along the line 5—5 of FIG. 4.

DESCRIPTION OF PREFERRED EMBODIMENTS

Although resistive structures embodying the invention can be fabricated by any suitable process, they are preferably fabricated in accordance with a method embodiment of the present invention which employs a laminating process. Laminating processes are well-known and reference is made to U.S. Pat. No. 3,374,129, issued to Gerald Boucher, for a brief description of one such laminating process. Referring first to FIG. 1, the starting materials consist of a resistive layer 11 and insulating layer 13 and metallic plate 12. In the first step, the starting materials are laminated to form a sandwich type structure in which the insulating layer 13 is sandwiched between the metallic plate 12 and the resistive layer 11. The insulating layer 13 and metallic plate 12 can be considered as a carrier body for the resistive layer 11.

The resistive layer 11 may be any suitable resistive alloy which has a relatively high resistivity and a relatively low thermal coefficient (i.e. the resistance does not change significantly with change in temperature). For example, the resistive layer 11 may suitably be a 1 mil thick foil of a copper and nickel alloy, such as Constantan. The metallic plate 12 may be any suitable high thermal conductive material, for example brass. The insulating layer 13 is preferably a sheet of epoxy glass. Epoxy glass is a transparent material and is so illustrated in the various views in the drawing. In order to enhance the rapid transfer of heat dissipated by the resistive layer 11 in response to current flow therethrough, the epoxy layer 13 is made relatively thin on the order of 0.004 inch. The brass plate 12 may suitably have a thickness on the order of 0.062 inch.

In the next step, the resistive foil 11 is formed into a plural branch topology in order to provide low ohmic value, low inductance and a high power dissipating capability. The plural branch topology is shown in the plan view of FIG. 2 to consist of a pair of spaced apart portions 15 and 16 with a plurality of elongated strips 17 in spaced apart parallel relation extending between portions 15 and 16. It is to be understood that the number of strips employed is a matter of design for a particular application and that only three strips have been shown for ease of illustration.

The plural branch foil topology is formed according to any suitable technique for forming patterns on a metallic surface. One such technique is described in some detail in the above-identified Boucher patent. Briefly, the technique there described is as follows. A photosensitive coating is first applied to the free (upper) surface of the foil 11. A film mask of the plural branch pattern is then aligned with the coated foil surface and exposed to produce on the photosensitive coating an image of the plural branch pattern. After the image has been developed, the unrequired portions of the photosensitive material are removed, as by rinsing. Those portions of the foil surface not coated by the developed pattern of photosensitive material are then etched away in a suitable etching bath. The developed pattern of photosensitive material is then removed such that the foil layer 11 now consists only of the plural branch pattern of spaced apart portions 15 and 16 and strips 17 as shown in the plan view of FIG. 2.

In the next step, a protective insulating layer 22, which may also be epoxy, is laminated to the patterned foil surface 11 to form the sandwich structure shown in FIG. 3A. The protective layer 22 covers enough of the foil containing surface of the structure to protect the resistive strips 17. However, the layer 21 does not cover all of the spaced apart portions 15 and 16.

Referring now to FIG. 3B, the plural branch foil pattern is adapted to receive electrical current by attaching (as by soldering) a pair of electrically conductive members illustrated as terminals 18 and 19 to the spaced apart portions 15 and 16, respectively. The resistor structure so formed is shown in the plan view of FIG. 4 and the sectional view of FIG. 5 as attached to a heat sink means, illustrated as a relatively thick plate 14 of suitable material, such as metal. To this end,

screws 20 are shown to extend through the laminated resistor structure and into the heat sink plate 14. Also shown in FIGS. 4 and 5 are insulated screws 21 which extend through terminals 18 and 19 to facilitate the connection of electrical leads thereto. It is to be understood that the heat sink 14 may take other suitable forms. For example, the heat sink 14 could employ a cooling fluid, such as water or oil.

A desired low ohmic value is achieved by virtue of the parallel electrical connection of the strips 17 and by selecting appropriate lengths and widths for the resistive strips. Although it is unnecessary to provide equal lengths and widths (i.e., equal resistance values) for the strips 17, it is convenient to do so since the circuit equation for the ohmic value calculation is simplified. As illustrated, the resistive strips have a straight line geometry such that the inductance of each strip is essentially that of a straight line conductor. In addition, the elongated strips are arranged parallel to one another such that there is magnetic field cancellation between adjacent strips in the plane of the strips such that the total inductance of the resistor structure is further reduced.

The topological arrangement of parallel spaced apart resistive strips 17 results in a division of the total power dissipation among the several strips. As compared to an equivalent valued resistor of a single solid sheet of resistive material, the total area of the carrier body (insulating layer 13 and metallic plate 12) which is effective to transfer heat is increased by an amount equal to the spaces between the strips 17. In addition, the thinness of the epoxy layer 13 and the high thermal conductivity of the brass plate 12 enable a rapid transfer of the heat dissipated by the resistive strips 17 to the heat sink 14.

There has been described a low ohmic value, low inductance and high power resistive structure embodying the invention and a method, also embodying the invention, for

fabricating such resistive structures. One resistor structure actually constructed in accordance with the invention, has an ohmic value of $0.2 \text{ ohm} \pm 5 \text{ percent}$, a power dissipation of 20 watts and a frequency response in excess of 20 megacycles. This resistor employed six strips of length 1.3 inches and width 0.035 inch. It is to be understood that other resistor structures of different ohmic value, power capability and frequency response can also be constructed in accordance with the invention.

What is claimed is:

1. The combination comprising:

a layer of resistive material disposed on a carrier body in a plural branch pattern having a pair of spaced apart portions and a plurality of separate branch strips spaced apart from one another and extending between the portions so as to form separate resistive elements electrically connected across one another;

first and second electrically conductive members in electrical contact with different ones of the spaced apart portions; and

said carrier body including a high thermal conductivity metallic plate and a relatively thin layer of insulating material, the insulating layer being disposed between the metallic plate and the resistive layer in a sandwich type structure.

2. The invention as set forth in claim 1 wherein the elongated strips have straight line geometries and are disposed parallel to one another.

3. The invention as set forth in claim 2 wherein a further layer insulating material overlies the resistive foil pattern in a protective relationship.

* * * * *

35

40

45

50

55

60

65

70

75