# United States Patent

**Bender et al.**

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[54] **RESISTORS AND STACKED PLURALITY THEREOF**


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[52] **U.S. Cl.** .....**338/317,** 338/318, 338/319

[51] **Int. Cl.** .....**H01c 1/02**

[58] **Field of Search**.....338/308, 312, 313, 315, 317, 338/319, 320



[56] **References Cited**

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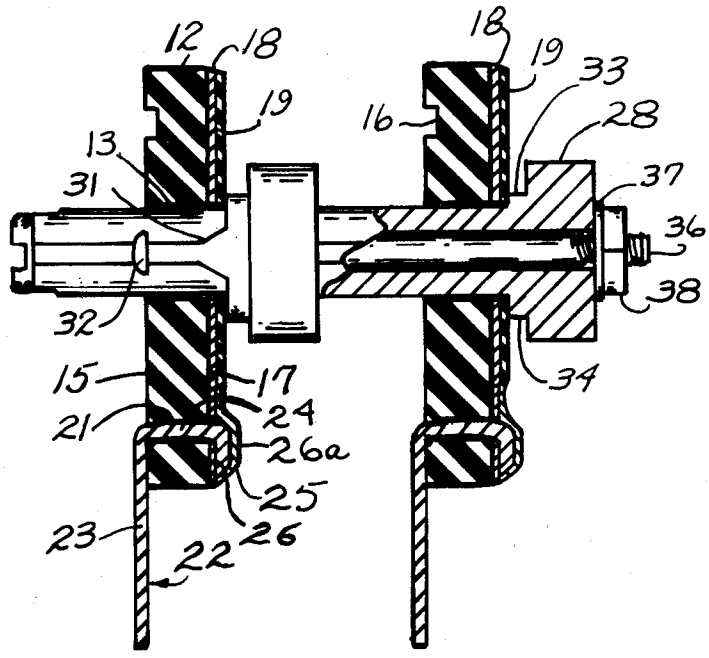
[57] **ABSTRACT**

An electrical assembly comprises a plurality of discrete resistors connected together in stacked relationship. Each of the discrete resistors comprises a dielectric substrate having an aperture extending therethrough and a film of resistance material secured thereon. A spacer supported in each of the apertures has means preventing rotation of the spacer relative to the dielectric substrate and interfits with an adjacent spacer to prevent relative rotation of the two spacers. Terminals extend through the dielectric substrate and are electrically connected to the film of resistance material such that forces applied to the end of a terminal are not transferred to the point of electrical connection between the terminal and the film of resistance material. Each of the spacers is provided with a hole extending therethrough such that a bolt passing through the holes maintains the discrete resistors in stacked relationship.


**15 Claims, 3 Drawing Figures**



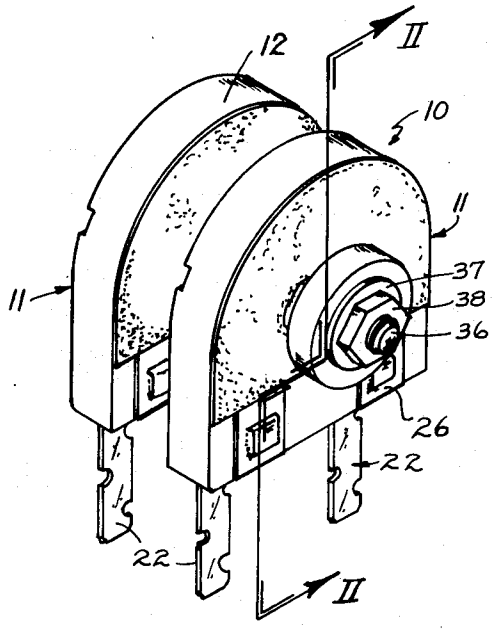



FIGURE-1

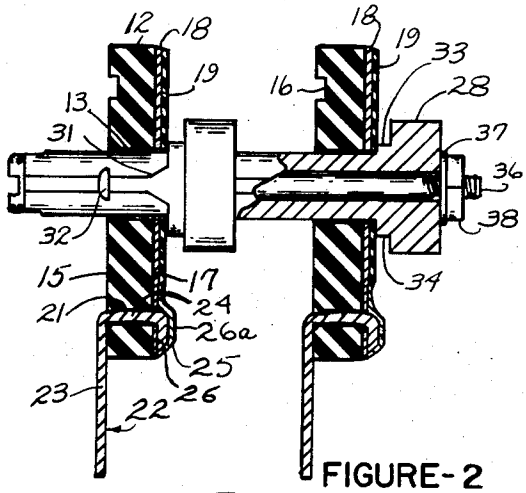
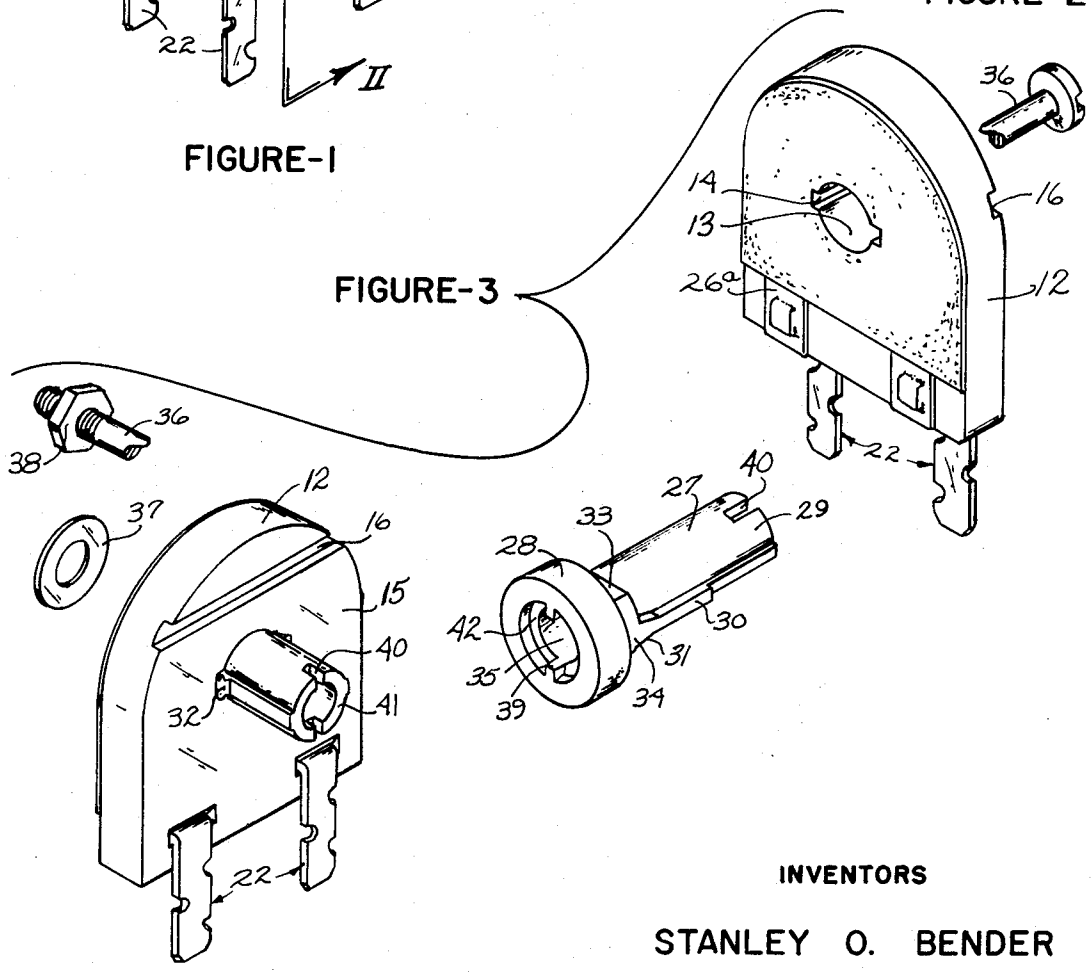



FIGURE-2

FIGURE-3

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# RESISTORS AND STACKED PLURALITY THEREOF

The present invention relates to resistors and more particularly to a plurality of resistors held together in stacked relationship.

The prior art includes many types of electrical assemblies comprising a plurality of stacked individual resistors. Examples of such devices are as disclosed in Weiscopf U.S. Pat. No. 1,993,496. The prior art devices, however, have proved unsatisfactory in that in attempting to obtain high power requirements the size of the resistors have become unwieldly. With the present emphasis on space requirements, it is necessary to obtain a high power resistor without sacrificing size. Accordingly, it would be desirable to fabricate a high power resistor using a minimum of space.

In connecting the terminals of the discrete resistors to the external electric circuits, forces applied to the terminals have resulted in partial destruction of the electrical connection between the terminals and the resistors. Accordingly, it would be desirable to fabricate termination means eliminating the possibility of damages due to forces applied to the terminals.

During operation of the electrical assembly, temperature changes will occur producing changes in the size of the materials used in the assembly due to their corresponding coefficients of expansion. The prior art devices utilizing wire-wound bobbin resistors encountered problems due to the different coefficients of expansion of the core and the wire wound thereon. A change in the stress on the wire would change the cross-sectional area of the wire thus changing the resistance of the wire. Accordingly, it would be desirable to provide a plurality of stacked high power resistors wherein problems associated with matching the coefficients of expansion of a resistance wire and a core upon which the wire is wound are eliminated.

Accordingly, it is an object of the present invention to provide a new and improved plurality of stacked high power resistors. Another object of the present invention is to provide a plurality of high power resistors occupying a minimum of space. A further object of the present invention is to provide a termination for a discrete resistor wherein forces applied to one end of a terminal are not transferred to the other end of the terminal. Yet another object of the present invention is to provide a plurality of high power resistors wherein the means connecting the resistors together is independent of changes in holding power due to temperature change. An additional object of the present invention is to provide a plurality of stacked high power resistors eliminating problems associated with matching coefficients of expansion of a resistance wire and a core upon which the wire is wound. Still another object of the present invention is to provide a plurality of high power resistors with maximized heat dissipation characteristics. Further objects and advantages of the present invention will become apparent as the following description proceeds and the features of novelty characterizing the invention will be pointed out with particularly in the claims annexed to and forming a part of this specification.

Briefly, the present invention relates to a resistor and an electrical assembly comprising a plurality of stacked resistors. Each of the resistors comprises a high heat resistant substrate of dielectric material having an aperture extending therethrough with a film of resistance material secured thereon. A spacer is supported in the aperture with holding means holding the spacer in said aperture and securing means securing the spacer against rotation relative to the substrate. Termination means in the form of a pair of terminals extend through a pair of terminal apertures in the substrate. Electrically conductive material engages one end of each terminal and electrically connects the terminals to the resistance film such that forces applied to the other ends of the terminals are not transmitted to the electrically conductive material. The spacers are provided with a hole extending therethrough such that a bolt passing through the holes maintains the resistors in stacked relationship.



For a better understanding of the present invention, reference may be had to the accompanying drawings wherein the same reference numerals have been applied to like parts and wherein

FIG. 1 is an isometric view of an electrical assembly built in accord with the present invention.

FIG. 2 is a sectional view taken along lines II—II of FIG. 1.

FIG. 3 is an exploded view of the electrical assembly shown in FIG. 1.

Referring now to the drawings and more particularly to FIG. 1, there is disclosed an electrical assembly generally indicated as **10** comprising a plurality of stacked individual resistors **11**. As best shown in FIG. 3, each of the individual resistors **11** comprises a high heat resistant substrate **12** of suitable dielectric material, such as alumina, having an aperture **13** extending therethrough. A channel **14** extends from the aperture **13** into the substrate **12**. The substrate **12** has a bottom surface **15** provided with a notch **16** for registration during automatic feeding of the substrate and a top surface **17** having a film of resistance material **18** secured thereon. The film of resistance material **18** can be suitably covered with an insulating covering as shown at **19**.

Terminal apertures **21** extend through the substrate **12** with terminals **22** being secured therein. During assembly the terminals **22** are positioned in the terminal apertures **21** with a first terminal portion **23** disposed adjacent the bottom surface **15** of the substrate **12** and a second terminal portion **24** disposed in the terminal apertures **21**. A third terminal portion **25** is bent over and disposed adjacent the top surface **17** of the substrate **12**. The terminals **22** can be formed with a notch between the second terminal portion **24** and the third terminal portion **25** to facilitate bending the third terminal portion **25** over onto the top surface **17** after insertion of the terminals **22** in the terminal apertures **21**. In the preferred embodiment, the terminals **22** have a thickness of 0.025 inches and the terminal apertures **21** have a length of 0.200 inches and a thickness of 0.033 inches. When the third terminal portion **25** is bent over onto the top surface **17**, the second terminal portion **24** deforms slightly into a bow-shaped configuration firmly engaging the walls of the terminal apertures **21**. Thus any forces applied to the first terminal portion **23** are absorbed by the substrate **12** through the second terminal portion **24** and not transmitted to the third terminal portion **25**. A suitable electrically conductive material **26** electrically connects the third terminal portion **25** to the film of resistance material **18**.

As shown in FIG. 2, the conductive material 26 is secured to the top surface 17 of the substrate 12. In the preferred embodiment, this is accomplished by screening a conductive paint, i.e., a composition containing at least one of the noble metals dispersed in finely divided form in a vitreous matrix, onto the top surface 17 in electrical connection with the film of resistance material 18 and firing to fuse the vitreous matrix. The third terminal portion 25 is bent over on top the conductive material 26. In order to insure a good electrical connection between the terminals 22 and the conductive material 26, a conductive metal deposit 26a is adhered to each of the terminals 22 and surrounding conductive material 26. This is accomplished by suitable means such as by dipping the substrate 12 into molten metal, e.g., solder. It should be appreciated that the thickness of the film of resistance material 18, insulating covering 19, conductive material 26, and metal deposits 26a are greatly exaggerated in relation to the size of the substrate 12 for purposes of explanation.

A spacer 27 is supported in the aperture 13 having a head end 28 abutting the top surface 17 and a tail end 29 projecting outwardly from the bottom surface 15. As best shown in FIG. 3 securing means in the form of a rib 30 interfits with the channel 14 to prevent relative rotation between the spacer 27 and the substrate 12. In order to eliminate any angular play of the spacer 27, the rib 30 can be tapered slightly as indicated at 31. Holding means in the form of a projection 32 abuts the bottom surface 15 and cooperates with the head end 28 abutting the top surface 17 to maintain the spacer 27 in assembled relationship with the substrate 12. If desired, a separate spacer section could be secured to the tail end 29 to maintain the spacer 27 secured to the substrate 12. Such a construction is desirable where the tail end 29 needs to be of a larger diameter than the diameter of the aperture 13 as, for example, where the resistor 11 is used to replace a single wire-wound bobbin resistor in a stack of bobbin resistors having mating ends larger than the diameter of the aperture 13. The preferred embodiment discloses a metallic spacer 27 which could either be die cast or turned with a portion of the rib 30 being staked radially outwardly to form the projection 32. In order to provide for mechanized assembly of one of the resistors 11 and a spacer 27, the spacer 27 is provided with a flat portion 33 at the head end 28 to enable proper orientation during assembly. As best shown in FIG. 2, the head end 28 of the spacer 27 is provided with a reduced diameter portion 34 to provide sufficient electrical clearance between the film of resistance material 18 and the head end 28. In addition to providing sufficient electrical clearance, the space between the film of resistance material 18 and the head end 28 provides for heat dissipation.

The spacer 27 is provided with a hole 35 extending therethrough in concentric relationship to the aperture 13. Suitable connector means in the form of a fastener such as a bolt 36 passes through the holes 35 of any preselected number of spacers 27 to maintain the selected plurality of individual discrete resistors 11 in stacked relationship. When both the spacer 27 and bolt 36 are formed of metals or other materials having similar coefficients of expansion, problems associated with changes in holding power due to temperature changes are eliminated. A suitable washer 37 and nut 38 are provided to maintain the bolt 36 in assembled relationship. In order to prevent relative rotation between the individual discrete resistors 11, restraining means in the form of a tongue 39, is provided in the head end 28 and interfits with a groove 40 in the tail end 29. As best shown in FIG. 3 an end wall 41 of the tail end 29 rests on an annular shoulder 42 of the head end 28 of an adjacent spacer 27 to firmly seat the tail end 29 in the head end 28.

While there has been illustrated and described what is at present considered to be a preferred embodiment of the present invention, it will be appreciated that numerous changes and modifications are likely to occur to those skilled in the art, and it is intended in the appended claims to cover all those changes and modifications which fall within the true spirit and scope of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A resistor comprising a high heat resistant substrate of dielectric material comprising a top surface and a bottom surface, a film of resistance material secured on said top surface, said substrate having an aperture extending therethrough from said top surface to said bottom surface, a spacer supported in said aperture and extending outwardly from one of said top and bottom surfaces, the spacer being provided with a head end and a tail end, one of the head and tail ends of the spacer being matable to the other of the head and tail ends of another spacer, means for holding said spacer in said aperture, securing means for securing said spacer against rotation relative to said substrate, and termination means electrically connected to said film of resistance material for electrically connecting said film of resistance material to an electrical circuit.

2. The resistor of claim 1 wherein said head end abuts one of said top and bottom surfaces, said tail end comprises a tubular portion, one of said spacer and said substrate having a channel, and said securing means comprises a rib extending from the other of said spacer and said substrate and interfitting with said channel.

3. The resistor of claim 2 wherein said holding means comprises a projection secured to said tail end abutting the other of said top and bottom surfaces.

4. The resistor of claim 1 wherein one of said head and tail ends has a groove therein and the other of said head and tail ends has a tongue thereon for non-rotatably coupling the head end of one spacer to the tail end of another spacer.

5. An electrical assembly comprising a plurality of resistor elements, each of said resistor elements comprising a high heat resistant substrate of dielectric material having an aperture extending therethrough and a film of resistance material secured thereon, a spacer supported in each of said apertures, each of said spacers having a head end and a tail end, said resistor elements being stacked with the head end of one spacer abutting the tail end of another spacer, connector means for maintaining said resistor elements in stacked relationship, and restraining means for restraining said resistor elements against rotation relative to one another.

6. The electrical assembly of claim 5 wherein said spacers are provided with a hole extending therethrough and said connector means comprises a fastener passing through the holes.

7. The electrical assembly of claim 5 wherein holding means holds said spacers in said apertures and securing means secures said spacers against rotation relative to said substrates.

8. The electrical assembly of claim 7 wherein each of said resistor elements has a channel extending into the substrate from the aperture and each of the spacers has a rib interfitting with said channel.

9. The electrical assembly of claim 7 wherein said restraining means comprises a groove in one of said head and tail ends of one spacer and a tongue on the other of said head and tail ends of an adjacent spacer interfitting with said groove.

10. The electrical assembly of claim 9 wherein one of said head and tail ends has an end wall abutting an annular shoulder in the other of said head and tail ends of an adjacent spacer.

11. In a resistor, the combination of a base of dielectric material having first and second surfaces, a resistance path on one of the surfaces, a spacer assembly to the base and disposed adjacent to one of the surfaces, first restraining means for preventing relative rotation between the spacer and the base, second restraining means on the spacer for preventing relative rotation between the spacer and another resistor when two resistors are coupled together, and termination means for electrically connecting the resistance path to an electrical circuit.

12. The resistor of claim 11, wherein the second restraining means comprises a first mating end disposed adjacent to said one of the surfaces and a second mating end disposed adjacent to the other of the surfaces, the first mating end of one spacer being adapted to interfit with the second mating end of another spacer for restraining relative rotation therebetween.

13. The resistor of claim 11, wherein the base is provided with a noncircular aperture, and a portion of the spacer having a cross section corresponding to the noncircular aperture is disposed in the aperture for restraining relative rotation between the base and the spacer.

14. A resistor comprising a substrate of dielectric material having a top surface and a bottom surface, a resistance path on one of the surfaces, the substrate having an aperture extending therethrough from the top surface to the bottom surface, the aperture in the substrate being adapted to receive a spacer, the spacer being provided with a head end and tail end, the substrate being provided with means for restraining relative rotation between the spacer and the substrate, one of the head and tail ends of the spacer being matable to the other of the head and tail ends of another spacer for restraining relative rotation between a pair of resistors in stacked relationship, and termination means for electrically connecting the resistance path to an electrical circuit.

15. The resistor of claim 14, wherein the substrate is provided with a noncircular aperture, and a portion of the spacer having a cross section corresponding to the noncircular aperture is disposed in the aperture for restraining relative rotation between the base and the spacer.

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