

[54] **ELECTRICAL COMPONENTS WITH
FLEXIBLE TERMINAL MEANS**

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338/262, 338/313

[51] Int. Cl.**H01c 1/14**

[58] Field of Search336/192; 338/262, 308, 322,
338/313, 332; 317/101 CC; 29/619, 627, 628

[56]

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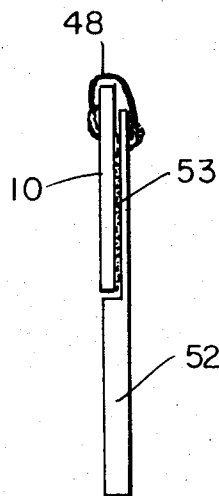
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[57]

ABSTRACT

Improved means of attaching electrical connectors to miniaturized electrical components are disclosed. Flexible leads separately attached to the front of an electrical component are attached at their opposite ends to more rigid electrical connectors on the reverse side of the electrical component. The electrical connectors and the electrical component are preferably bonded together for improved stability. The resulting electrical component is typically surrounded with at least one protective covering.

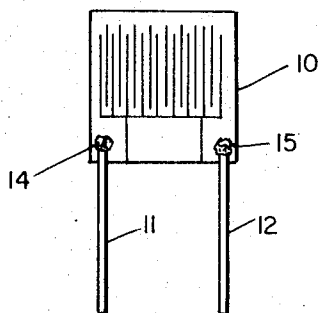
12 Claims, 13 Drawing Figures



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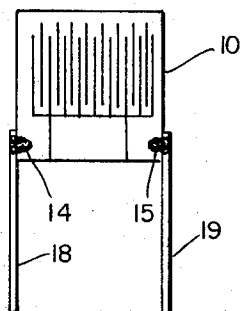
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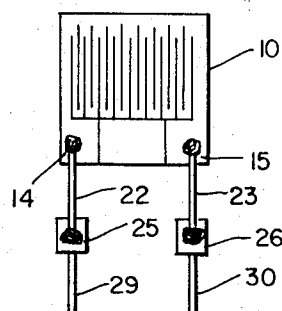
PRIOR ART

Fig. 1



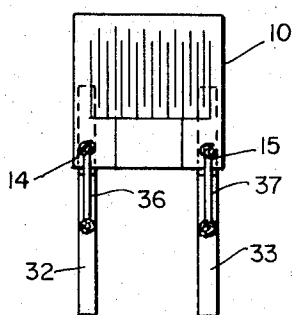
PRIOR ART

Fig. 2



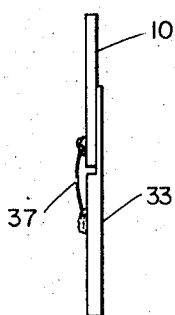
PRIOR ART

Fig. 3



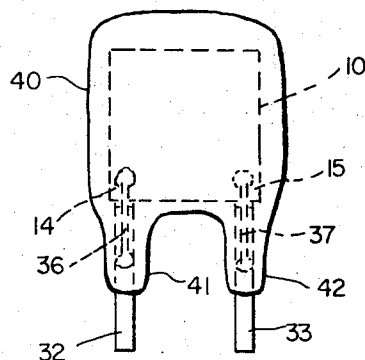
PRIOR ART

Fig. 4A



PRIOR ART

Fig. 4B



PRIOR ART

Fig. 4C

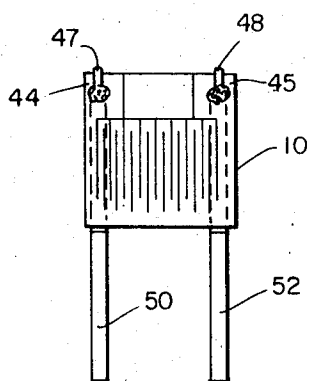


Fig. 5A

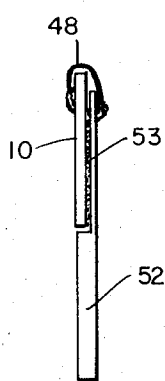


Fig. 5B

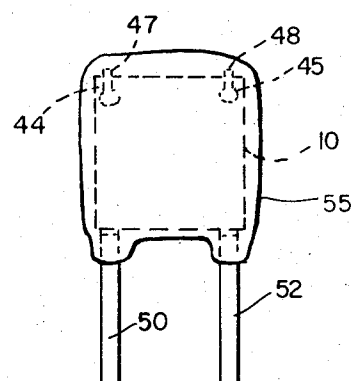


Fig. 5C

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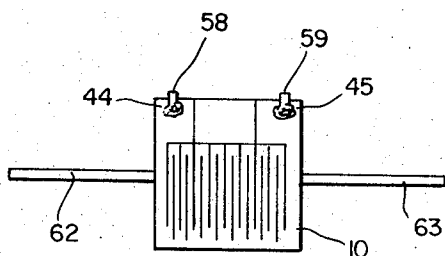


Fig. 6A

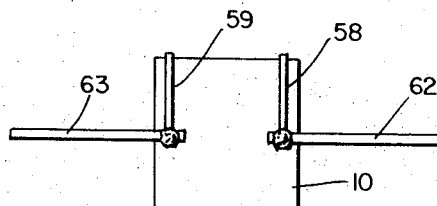


Fig. 6B

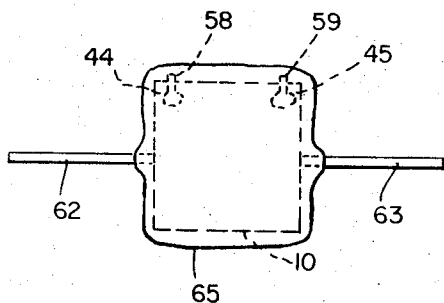


Fig. 6C

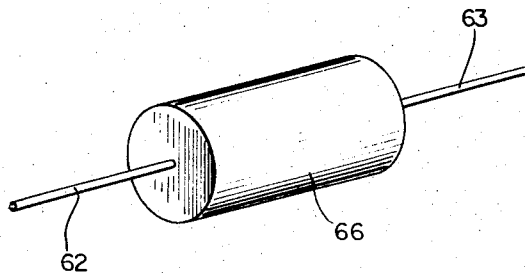
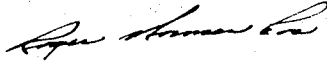


Fig. 6D

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ELECTRICAL COMPONENTS WITH FLEXIBLE TERMINAL MEANS

FIELD OF INVENTION

The present invention relates to miniaturized electrical components and the method of connecting somewhat rigid electrical connectors to such electrical components. More particularly, the present invention relates to an improved method of making electrical connections with a thin film resistor.

BACKGROUND OF THE INVENTION

In recent years there has been a tendency to construct precision electrical components in extremely small sizes. Precision resistors, for example, are now constructed by causing a predetermined pattern of thin metallic film to be supported on a thin substrate. Such resistors have distinct advantages over wire wound resistors with respect to reliability, economy, size and long term electrical and mechanical stability.

The reduction in the size of electrical components, however, has caused problems to arise in connection with the attachment of electrical leads to such components. For example, the size of a typical thin film resistor chip is in the order of $\frac{1}{4}$ inch by $\frac{1}{4}$ inch and the area for attaching each electrical lead is normally less than about $\frac{1}{16}$ inch square. Despite this small area for attachment, the electrical leads must be so firmly connected to the electrical component that normal stress will not cause the electrical connections to be broken. Thus, as the size of electrical components has decreased the problems associated with the attachment of electrical connections have tended to increase, thereby losing some of the advantages sought by the attempted miniaturization. Attachment problems have also caused a fairly high percentage of manufactured "finished" components to be rejected by quality control tests.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an improved thin film resistor.

Another object of the present invention is to provide improved means for attaching electrical connectors to an electrical component, such as a thin film resistor chip.

A further object of the present invention is to provide a thin film resistor with electrical leads bonded to such resistor in a manner which will substantially prevent separation of the electrical connection between the leads and resistor under the application of normal handling stress.

Still a further object of the present invention is to reduce the finished size of electrical components which have electrical leads attached.

In accordance with the present invention, improved means of attaching electrical leads to an electrical component are presented. In particular, electrical connectors are positioned at the back of an electrical component and connected to flexible leads which are bonded at their opposite ends to the front of the electrical component. The electrical connectors are permanently affixed to the back of the electrical component by suitable bonding means.

According to a preferred embodiment of the invention, the resulting electrical component is encased in a rubbery or plastic material after the electrical connections have been made. If desired, the encased electrical component can then be covered with a still further rubbery or plastic material or be enclosed in a suitable protective container.

BRIEF DESCRIPTION OF THE DRAWINGS

Other and further objects, advantages and features of the invention will be apparent to those skilled in the art from the following detailed description thereof, taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates in highly schematic form a prior art embodiment in which electrical connectors are attached directly to an electrical component;

FIG. 2 illustrates in highly schematic form a prior art embodiment in which electrical connectors are attached directly to an electrical component at two opposing sides of the electrical component;

FIG. 3 illustrates in highly schematic form a prior art embodiment in which electrical connection between electrical connectors and an electrical component is accomplished by means of flexible leads;

FIG. 4A illustrates in highly schematic form the front view of a prior art embodiment in which electrical connection between electrical connectors and an electrical component is accomplished by means of flexible leads; FIG. 4B is a side view of the embodiment illustrated in FIG. 4A; and FIG. 4C is a view of the embodiment shown in FIGS. 4A and 4B encased in a protective coating;

FIG. 5A is a highly schematic drawing which illustrates the front view of an embodiment in accordance with the present invention wherein an electrical component is attached to electrical connectors at the back of the electrical component and electrical connection between the electrical connectors and electrical component is made by means of flexible electrical leads extending from the front of the electrical component to the back of the electrical component; FIG. 5B is a side view of the embodiment shown in FIG. 5A; and FIG. 5C is a view of the embodiment illustrated in FIGS. 5A and 5B encased inside a plastic or rubberized protective coating; and

FIGS. 6A through 6D illustrate in highly schematic form another schematic embodiment of the present invention in which the electrical connectors extend at right angles to the flexible leads, and wherein FIG. 6A is a front view; FIG. 6B is a back view; FIG. 6C is a view of the apparatus shown in FIGS. 6A and 6B encased in a rubber or plastic protective coating; and FIG. 6D illustrates the apparatus of FIG. 6C encased in a still further plastic or rubber protective coating.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The construction of miniaturized electrical equipment is illustrated by the development of high precision resistors, which are constructed by supporting a thin film of a selected metal alloy upon a substrate having known physical properties. The metallic film is caused to have a predetermined pattern, such that electric current flows along a conducting path of very great length

and extremely small width, this pattern preferably including a great number of parallel narrow linear path portions in a planar array. The combination of thin film upon the substrate is termed a "chip" because of its shape and size.

The substrate for thin film resistors can be made of any suitable material such as a ceramic material or glass and can be of the order of $\frac{1}{4}$ inch $\times$ $\frac{1}{4}$ inch with a thickness of about 0.04 inch. The bulk metal film applied to the substrate can be made from a suitable resistive alloy such as one of the Nichrome alloys, wherein nickel and chromium are the principal metals. This film can be of the order of 0.0001 inch thick. Typically, the metallic film applied to the substrate is photoetched to a pattern which establishes a narrow conductive path of much greater total length than the dimensions of the face of the substrate. This photoetching operation can be carried out after the film has been bonded to the substrate or it can be carried out when the metallic film is on a thin support such as a plastic layer before the plastic layer is bonded to the substrate.

FIG. 1 illustrates one of the procedures adopted by the prior art for attaching relatively rigid electrical connectors to a resistor chip 10. Rigid electrical connectors 11 and 12 are shown bonded to contact pads 14 and 15, respectively, by some suitable means. Because of the rigidity of electrical connectors 11 and 12, the resistor of FIG. 1, even when encased in rubber or plastic, tends to be sensitive to handling and under stress the rigid electrical connectors frequently become separated from chip 10 thereby destroying electrical contact with the resistor.

A prior art modification of the resistors shown in FIG. 1 is illustrated in FIG. 2. In an effort to prevent breaking, rigid electrical connectors or wires 18 and 19 are attached to the side of the resistor chip by cement and then electrically bonded to contact pads 14 and 15. This mode of attaching rigid electrical connectors 18 and 19 to chip 10 fails, however, to overcome the problem of breaking under stress and tends to increase the size and cost of making resistors.

In another effort to eliminate breakage problems, flexible leads, such as flexible leads 22 and 23 in FIG. 3, have been utilized by the prior art. These flexible leads are bonded to contact pads 14 and 15 of chip 10 and also to the rigid electrical connectors. In FIG. 3 flexible leads 22 and 23 are bonded to contact pads 25 and 26, respectively. Rigid electrical connectors 29 and 30, respectively, are also attached to contact pads 25 and 26. The overall arrangement shown in FIG. 3 is not as rigid as that illustrated in FIGS. 1 and 2 and consequently the apparatus in FIG. 3 can be subjected to more stress without breaking the electrical contact at any point. Support problems arise, however, in the physical separation of contact pads 14, 15, 25 and 26. The arrangement also necessitates a greatly enlarged case or a protective coating in order to seal the resistor in such a manner that only the end portions of rigid electrical connectors 29 and 30 are exposed.

FIGS. 4A and 4B illustrate the front and side view, respectively, of a somewhat improved prior art resistor which utilizes flexible leads to connect chip 10 to rigid electrical connectors. As illustrated in FIGS. 4A and 4B, rigid electrical connectors 32 and 33 extend up to and in back of chip 10. Flexible leads 36 and 37 are

bonded directly to contact pads 14 and 15 and also to rigid electrical connectors 32 and 33, respectively. Although this arrangement is an improvement over other prior art procedures, it still did not overcome the problems which continued to plague this particular art. Breakage occurs with resistors constructed as in FIGS. 4A and 4B even when the electrical resistors are encased in a protective coating as shown in FIG. 4C. It is also hard to calibrate resistors prepared in accordance with FIGS. 4A and 4B. Moreover, because of the necessity of covering all of resistor chip 10 and flexible leads 36 and 37 with a protective coating, the size of the encased portion of the resistor has to be substantially greater than that of chip 10. As seen in FIG. 4C, when the resistor is encased in a rubber or plastic protective coating 40 elongated "pant legs" 41 and 42 are required, extending down rigid electrical connectors 32 and 33, respectively, in order to completely cover the flexible leads and particularly the point of their attachment to the rigid electrical connectors. If pant legs 41 and 42 are too thin, too short, or irregularly shaped, a weak spot occurs in protective coating 40. As a result, when this type of procedure is employed for connecting flexible leads to rigid electrical connectors, an excess of protective coating material must be employed which increases the overall size and weight of the final resistor.

A preferred embodiment of the present invention is illustrated by FIGS. 5A to 5C. As seen in FIGS. 5A and 5B one end of flexible leads 47 and 48 is bonded to contact pads 44 and 45, respectively, on chip 10. The other ends of the flexible leads extend over back of chip 10 and are bonded to rigid electrical connectors 50 and 52, respectively, which are affixed to chip 10 by cement 53. Both junctions of the flexible leads may, if desired, be welded junctions, with reinforcing epoxy mounds. The resulting resistor is not only compact but substantially eliminates all breakage problems. Moreover, the resistor can be readily calibrated. An additional advantage is that the size of the final resistor encased in a protective coating 55 (see FIG. 5C) is kept at a minimum. In contrast to the elongated pant legs in FIG. 4C, no more than a normal amount of protective coating is required to completely encase both chip 10 and rigid electrical connectors 50 and 52 in FIG. 5C. For clarity, flexible leads 47 and 48 have been shown as forming a loop over the top of chip 10. In actual practice flexible leads 47 and 48 are bent over the top of chip 10. Since these leads are generally made from a thin ribbon of material, the flexible leads remain flush with the surfaces of chip 10. Thus, when the completed resistor is encased in a protective coating 55 a very strong unit construction is obtained. The construction is such that movement or stress applied to rigid electrical connectors 50 and 52 will not cause any breakage or otherwise destroy the resistor unless the rigid electrical connectors are completely ripped off the back of chip 10 against the resistance of protective coating 55 and cement 53. Until the rigid electrical connectors become unattached from the back of chip 10 no strain is placed on the flexible lead connections. This can be contrasted with the prior art embodiment illustrated in FIG. 4A where even if the rigid electrical connectors are cemented to the back of chip 10 the electrical connection through the flexible leads can be broken prior

to any separation of the rigid electrical connectors and chip 10.

Another preferred embodiment of the invention is illustrated in FIGS. 6A to 6D. As seen in FIGS. 6A and 6B, flexible leads 58 and 59 are bonded to contact pads 44 and 45, respectively, and are also bonded to rigid electrical connectors 62 and 63, respectively, on the reverse side of chip 10. As in the previous preferred embodiment, the rigid electrical connectors are cemented to the back of chip 10. However, unlike the embodiment illustrated in FIGS. 5A through 5C, the rigid electrical connectors are mounted substantially perpendicular to the flexible leads. A protective coating 65 (see FIG. 6C) is preferably used to encase the resistor in a manner similar to that illustrated in FIG. 5C. If desired, a still further protective coating, of the same or a different material, can be applied over protective coating 65. FIG. 6D illustrates the resistor of FIG. 6C further encased in a cylinder of suitable material, such as hard rubber, Bakelite, or epoxy resin.

Any conventional method of applying the protective coating or coatings to the electrical components made by the present invention can be employed. Suitable methods include dipping, painting, transfer molding, use of a fluidized bed, injection molding, etc.

The use of two or more different protective coatings applied at different stages helps prevent any fracturing resulting from differences in coefficients of thermal expansion. Moreover, the protective coatings can be specially chosen in order to obtain the most advantageous combination of properties. For example, the inner protective coating can be selected from a relatively soft silicone rubber whereas the final protective coating can be made from a relatively inflexible rubber or plastic material which has desirable insulating and sealing properties, such as hard rubber, polyesters, and epoxy resins. Other suitable protective coatings include polyurethanes. Even when multiple protective coatings are applied to the electrical components prepared in accordance with the present invention, the electrical components have a remarkable degree of compactness. For example, precision resistors have been prepared which require less than about an eighth of the board space occupied by conventional wire wound resistors.

It will be understood that, if desired, multiple chips rather than single chips can be incorporated into the same protective coating. It will also be understood that there can be more than two electrical connections present if so desired.

In order to minimize the size of electrical components reference has been made in this specification to the bonding of electrical connectors to the nonconducting surface on the back of an electrical component. It will be understood that if a somewhat elongated electrical component had one or more nonconductive surfaces adjacent to one or more conductive surfaces on the same side, that the present invention could be adapted for such a modification by bonding the electrical connectors to either side of the electrical component.

From the foregoing, it will be seen that this invention is well adapted to obtain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the system. Electrical components of the present invention

have the advantage of being reliable, economical to construct, capable of being made in extremely small sizes, and have excellent long term electrical and mechanical stability. The absence of sensitivity to handling is of particular importance. The electrical contact which is made in accordance with the attachment procedure of the present invention cannot be broken by any ordinary manipulation of the electrical connectors during the interconnection of an electrical component. Thus, a problem which has plagued the art is eliminated without any significant increase in either cost or size.

Obviously, many other modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof.

What is claimed is:

1. The combination of an electrical component, flexible leads and relatively rigid electrical connectors wherein each relatively rigid electrical connector is bonded to the back of the electrical component and separately extends beyond only one edge of said electrical component, and the flexible leads are separately connected to the front of the electrical component and to the electrical connectors on the back of the electrical component the flexible leads extending over an edge of said electrical component thereby making an electrical connection between the relatively rigid electrical connectors and the electrical component.

2. The combination as set forth in claim 1 wherein the electrical component, flexible leads and at least part of the relatively rigid electrical connectors are protected by at least one covering.

3. The combination as set forth in claim 1 wherein the electrical component is a precision resistor having a thin metallic film supported on a substrate on the front of the electrical component and the flexible leads connect the thin metallic film with the relatively rigid electrical connectors.

4. Electrical apparatus comprising:

an electrical component having an electrically conductive surface and a substantially non-conducting surface which forms at least a portion of the back of the electrically conductive surface;

at least two relatively rigid electrical connectors bonded to the substantially non-conducting surface of the electrical component, each relatively rigid electrical connector separately extending beyond only one edge of said substantially non-conducting surface; and

at least two flexible leads separately connected to the electrically conductive surface of the electrical component and to the electrical connectors on the substantially non-conducting surface the leads extending over an edge of said electrical component, such that one flexible lead is connected to one electrical connector.

5. Electrical apparatus as in claim 4 protected by at least one covering.

6. Electrical apparatus as in claim 4 wherein the electrical component is a thin film resistor.

7. Electrical apparatus comprising:

an electrical component consisting essentially of a thin film resistor mounted on a substantially non-conducting surface which forms the back of the thin film resistor;

at least two relatively rigid electrical connectors bonded to the substantially non-conducting surface of the electrical component, each relatively rigid electrical connector separately extending beyond only one edge of said substantially non-conducting surface; and

at least two flexible leads separately connected to the thin film resistor and to the relatively rigid electrical connectors, the leads extending over an edge of said electrical component such that each flexible lead is separately connected to an electrical connector on the substantially non-conducting surface.

8. The apparatus of claim 7 wherein two relatively rigid electrical connectors are present and said relatively rigid electrical connectors extend in different directions from the electrical component.

9. Electrical apparatus protected by at least one covering comprising:

an electrical component consisting essentially of a thin film resistor mounted on a substantially non-conducting surface which forms the back of the thin film resistor;

at least two relatively rigid electrical connectors bonded to the substantially non-conducting surface of the electrical component, each relatively rigid electrical connector separately extending beyond only one edge of said substantially non-conducting surface; and

at least two flexible leads separately connected to the

thin film resistor and to the relatively rigid electrical connectors, the leads extending over an edge of said electrical component such that each flexible lead is separately connected to an electrical connector on the substantially non-conducting surface.

10. The process for attaching electrical leads to an electrical component having as opposing surfaces an electrically conductive surface and a substantially non-conducting surface which comprises:

bonding at least two relatively rigid electrical connectors to the substantially non-conducting surface such that each electrical connector separately extends beyond only one edge of said non-conducting surface, and

separately connecting a flexible lead to the electrically conducting surface and to each relatively rigid electrical connector on the substantially non-conducting surface the connection made by extending the leads over an edge of said electrical component.

11. A process as in claim 10 which includes the step of applying a protective covering to the electrical component, each flexible lead and at least part of each relatively rigid electrical connector.

12. The process as in claim 10 wherein the electrical leads are separately connected to a thin film resistor which constitutes the electrically conducting surface of the electrical component.

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