March 10, 1970 A. R. HINGORANY ET AL 3,500,276

ELECTRICAL FUSE AND HEATER UNITS

Filed Oct. 25, 1967 4 Sheets-Sheet 1

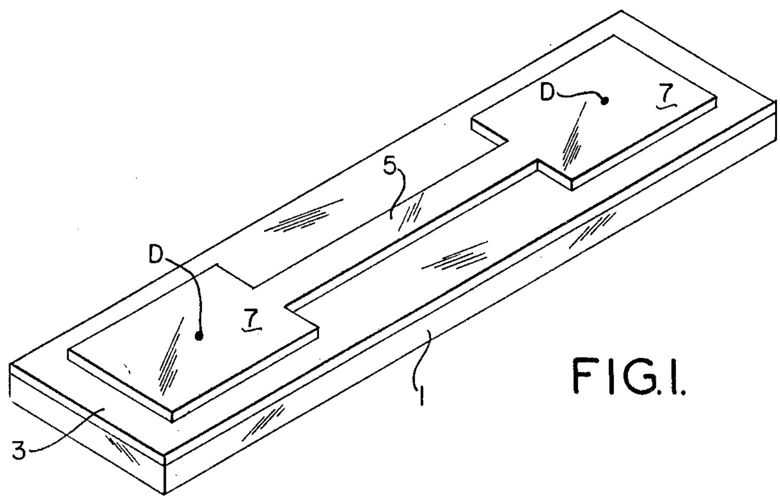
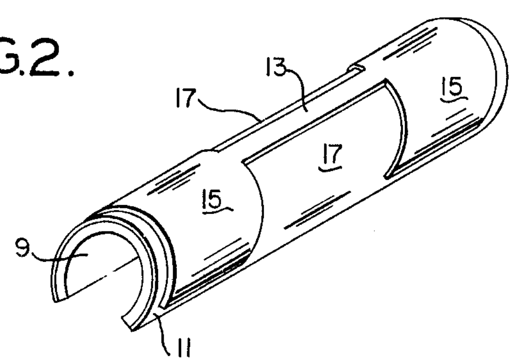


FIG.1.

FIG.2.



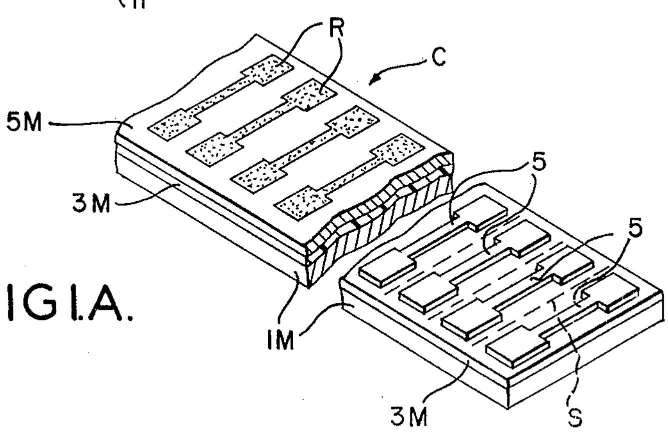


FIG.1.A.

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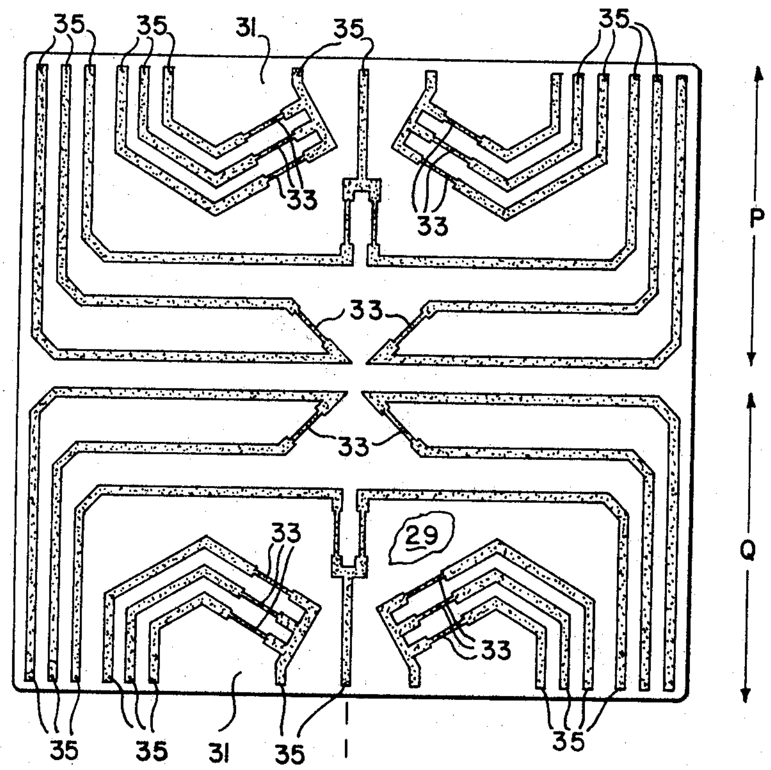
FIG. 3.



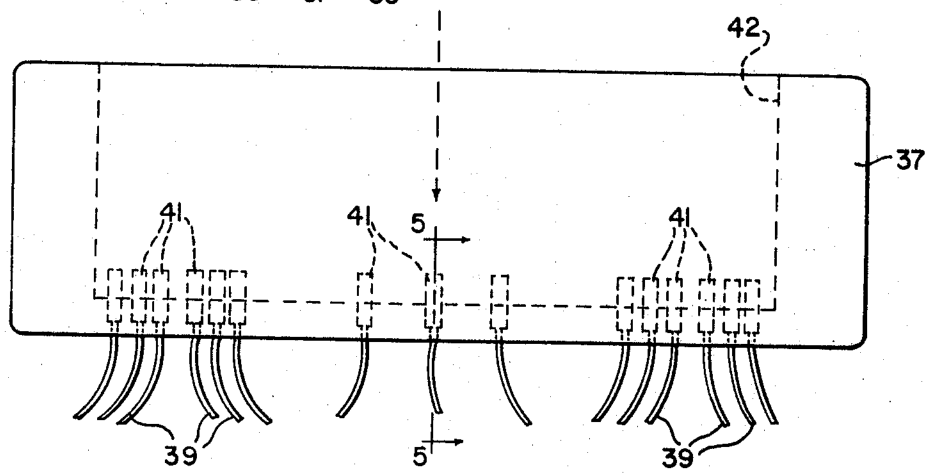


FIG. 4.

FIG 5

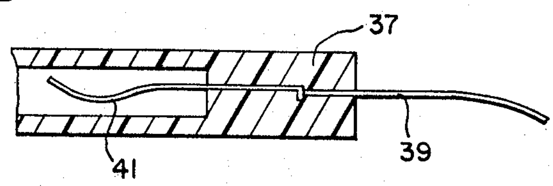


FIG.6.

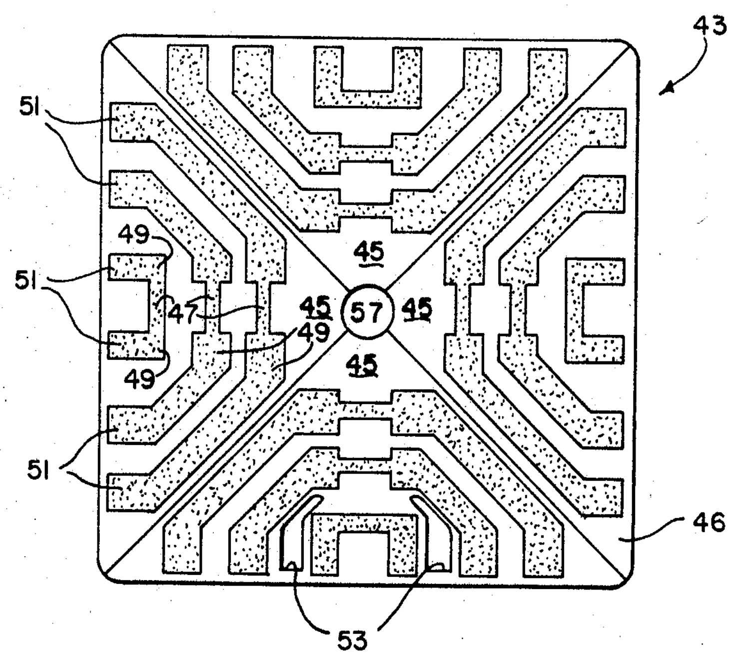
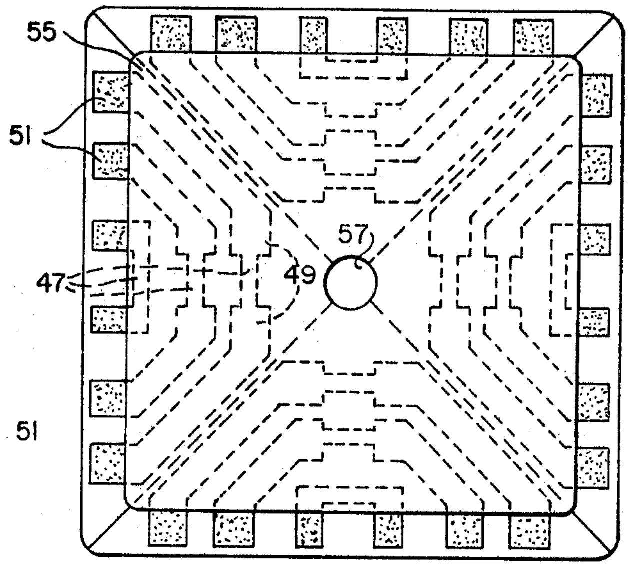


FIG. 7



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3,500,276
ELECTRICAL FUSE AND HEATER UNITS

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U.S. Cl. 337—183 2 Claims

ABSTRACT OF THE DISCLOSURE

A comparatively thick stiffening and in some cases deformable metal backing layer, which may also be thick enough to function as a substantial heat sink, has bonded thereto a comparatively thin etch-resistant electrically insulating polymer layer. Aluminum is used for the backing layer when corrosion is to be minimized. On the polymer layer is bonded a comparatively thin metal layer of conductive fuse-forming material or in the alternative conductive resistance-heating material. The prebonded layers and their bonded composite are preferably in strip or sheet form. The thin conductive layer may be adhered as a sheet or formed in situ as a sheet by plating on the insulating layer. The conductive layer in its position on the insulating layer is converted to form individual or groups of individual fuse or heater patterns as part of the composite. This is accomplished by printing etch-resistant patterns on the conductive layer by photographic, silk-screen or like printing. The conductive layer is then etched to remove all of its conductive material outside of the patterns, leaving the latter intact as fuse or heater elements. The backing and insulating layers of the composite are then segmented by shearing, cutting or the like along lines to form individual electrical units, each supporting one or more fuse or heater elements. The individual units may be formed into curved shapes or left flat for convenient use in making connections with line terminals or to form heater walls, as desired. The fuse units are shaped as polygons or the like and carry identical single fuse elements or groups of identical fuse elements carried on one or both sides and having terminals on different straight sides of the polygon. Thus by rotation the identical or grouped fuse elements may be substituted one for the other in a set of line terminal clips of a circuit served by the fuses.

Heretofore fuses have been variously complexly constructed, as for example with metallic terminal cups joined by a fragile fuse wire surrounded by a protective glass sleeve carried by the cups. Circuitry without fuses or heaters has been constructed on what are called circuit boards made by printed and etched circuitry applied directly to insulating boards or ceramic platens. In some cases an individual board of this type carrier an individual fuse element (see U.S. Patent 2,941,059). However, the insulating board form was subject to warping, abrasion and spontaneous disintegration, and the ceramic form was quite fragile. Neither of them could be bent to desired fuse or heater shapes. Moreover, none of these incorporating any fuse or heater elements provided any effective heat sink, as in many cases is desirable. In the case of heater constructions it has heretofore been costly and clumsy to get them into close efficient heat-exchange relationship with heating panels, composite thermostatic sheets and the like which are served by the heaters.

Advantages of the invention are reduction in volume and weight of the units and therefore reduction in costs of raw materials. The method of their manufacture favors rapid quantity production and therefore low labor costs. More accurate circuit values may be obtained along with

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a high degree of design flexibility. Fuses may be designed for reliable applications to locations having higher temperatures and/or corrosive ambient conditions. Heaters may be more closely organized with heating panels, thermostatic composites or the like which they serve. Expended fuses or damaged heaters are more apparent visually. The units are very compatible with electrical systems employing conventional printed circuit boards. Other objects and features will be in part apparent and in part pointed out hereinafter.

Referring to the accompanying drawings:

FIG. 1 illustrates one form of a fuse made according to the invention;

FIG. 1A on a reduced scale illustrates how a unit such as shown in FIG. 1 is made;

FIG. 2 illustrates a bent variation of the FIG. 1 form;

FIG. 3 is a plan view of a multiple twin fuse unit made according to the invention, a small portion of certain layers being broken away;

FIG. 4 is a plan view of a line terminal block for accepting the unit of FIG. 3, as shown by the broken dart;

FIG. 5 is an enlarged cross section taken on line **5—5** of FIG. 4 and illustrates one of the line terminal clips in the terminal block;

FIG. 6 is a plan view of a quadrated form of a multiple fuse unit;

FIG. 7 is a view like FIG. 6 illustrating a modification of the quadrated form of unit.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings. The drawings are not to a proportional scale, the thicknesses of various layers having been exaggerated for clarity.

Referring to FIG. 1, numeral **1** indicates a metal backing lever which forms a sufficiently stiff support for normal handling of the finished fuse in placing it in, and removing it from, circuitry. However, under sufficient force applied during manufacture it is bendable during manufacture as illustrated in FIG. 2. It may be single-ply or multiply. Any appropriate metal may be employed such as, for example, steel, copper, or aluminum if atmospheric corrosion is to be resisted. In cases requiring it the back layer is made thick enough to constitute a good heat sink. Appropriate thicknesses for the backing layer are in the range of twenty to fifty mils, with about twenty-five mils preferred. The greater thicknesses are appropriate in those cases in which the backing layer is to function as a heat sink.

Attached to one face of the metal back is an etch-resistant insulating layer **3** composed of a polymer. The polymer material may be Teflon-coated Kapton. Teflon is a fluorocarbon and Kapton is a polyimide, both being trade names of the E. I. du Pont de Nemours & Co. The Teflon forms a good bond under heat and pressure. Mylar may be also used but requires attachment by one of the usual adhesives for such purposes. Mylar is also a Du Pont trade name. Kapton may also be used without the Teflon and attached by means of a similar adhesive. An appropriate range of thicknesses for the insulating layer **3** is two to six mils with about two mils preferred.

On the polymer layer **3** is a flat fuse element consisting of a calibrated link part **5** having terminal portions **7**. The metal composing the fuse element is any of those well known for the purpose, including zinc, copper, alloys such as those composed of bismuth, lead and tin, etc. The fuse element is what is left after a layer of conductive material attached to the top of the polymer layer **3** has been etched away, as will appear. Appropriate thicknesses are in the range of two to twelve mils with three mils preferred. The shape of the fuse may be varied as desired, for example to include a shunt portion.

In FIG. 1A is illustrated a rapid method by which fuses made according to the invention may be constructed. This figure shows a sheet in strip form of starting backing material **1M** from which backings such as **1** are made. To this strip is bonded in the manner above described a sheet in strip form 3M which provides the starting material to form insulation such as **3**. To the strip **3M** is bonded, by plating or in strip form, fuse material **5M** which provides the starting material from which fuse elements such as **5**, **7** are obtained. It is to be understood that the term bonded layer for layer **5M** includes a plated-on layer and a strip form of layer. The composite C is formed under heat and pressure, as required, by pressure rolling or in a platen type of press. The layered assembly **1M**, **3M**, **5M** may be referred to in general as a starting composite.

The composite is converted to form fuse elements such as **5**, **7** by printing etch-resist patterns on the conductive layer **5M** by photographic, silk screen or other appropriate printing process. In the photographic process, by the development of the print formed in a photosensitive film on layer **5M**, such a print is converted into insoluble etch-resist material. Unprinted portions being soluble are washed away. In the silk-screen process the print is applied directly in etch-resistant form. Photoresist patterns thus applied are illustrated in FIG. 1A by stippled areas R outlined on the layer **5M** of composite C. Then by etching the layer **5M** its portions not outlined are dissolved away leaving for example fuse elements **5**, **7** such as shown in the lower right in FIG. 1A. Then by shearing or cutting along dotted lines such as indicated at S individual fuse elements **1**, **3**, **5**, **7** are produced such as shown in FIG. 1.

The dots D on the tab **7** in FIG. 1 indicate where circuitry may be attached by anyone of conventional means such as welding, soldering or any other appropriate means. It may be mentioned that when the layer **1** is made thick enough to act also as a heat sink to prevent overheating and change of calibration of the link portion **5**, that this also prevents destruction of any soldered connections at D.

In FIG. 2 there is shown on a reduced scale a unit such as **1**, **3**, **5**, **7** such as shown in FIG. 1 but bent during manufacture to a partially tubular form. This again has a stiff metal backing in the form of a tube **9** on the outer surface of which is a curved layer **11** of the insulating polymer. Axially disposed on the tube is the calibrated conductive link portion **13** terminated by curved end tabs **15**. The tabs may be inserted in the usual way into and removed from the usual line terminal spring clips to replace conventional cylindrical type glass housed fuses. Two areas of the fuse shown at **17** are nonconductive and form convenient places for manipulation by the fingers or pliers.

In FIG. 3 a form of the invention is illustrated in which a square, metal backing plate **29** shown at a broken-away portion carries the insulating polymer layer **31** upon which is the etched printed circuitry obtained as above described. In this case the circuitry constitutes two separate but identical banks P, Q of circuit arrangements having ten fuses each, numbered **33**. From each fuse are two leads extending to thirteen marginal terminal portions **35**. Various groups of the fuses have common grounds as shown.

At numeral **37** is shown a line terminal block for thirteen circuit lines **39** having thirteen springy line terminal clips **41**, as illustrated in FIGS. 4 and 5. The clips **41** are located on the bottom of a socket **42** in the terminal block **37**. The side of one half of the composite fuse block as shown in FIG. 3 is inserted into the terminal block **37** as shown in FIG. 4. The terminals **35** engage the line terminal clips **41** respectively, which places the lower half of the fuse block into circuit. At this time the upper half of the block extends above the terminal block **37** and acts as a dead standby. If and when one of the fuses **33** blows, the user may extract the fuse block from the terminal block **37**, turn it over and insert the inverted upper half into block **37**. This restores all of the circuits. If desired a layer such as **31** with circuitry **33** and **35** thereon may be carried on the other side of the backing plate **29** to supply additional replacement circuits.

While it might appear that it would be wasteful to remove good unblown fuses from circuitry just because one, or less than all, has blown, this is not the case because of the economical construction, both in materials used and the manufacturing cost.

In FIG. 6 is shown in plan view a square multiple fuse block made in the manner which will be readily understood from the above descriptions. In this case the independent fused circuitries are quadrupled and placed in quadrature, as shown. Thus the FIG. 6 block numbered **43** has four quadrants **45** each of which carries three etched patterns forming three fuses **47** with their leads **49** extending to marginal tab portions **51**. If the current and voltage in any two adjacent circuits are such as might cause leakage of current and/or heat between them across the insulator layer **46**, then block **43** may be punched out as illustrated at numerals **53**. The form of the multiple fuse blocks shown in FIG. 6 may be used in connection with a suitable terminal block to make four fuse replacements in a circuit.

In FIG. 7 is shown a form of the invention like that shown in FIG. 6, except that in this case holes such as **53** are omitted. In this form a second polymer insulating layer **55** is bonded on the upper surfaces of the polymer layer **46** and the fused circuits. This prevents electrical leakage or excessive communication of heat between any two circuits on the entire board.

In both the FIG. 6 and FIG. 7 forms the back surfaces may have circuitry repeated thereon, as above described in the case of FIG. 3. Also, in both of these FIGS. 6 and 7 forms of the invention are shown a hole **57** through the device by means of which it may be anchored by a suitable bolt or the like when in position in a terminal block. This prevents vibration or the like from ejecting the device from the terminal block.

It is further to be understood that a polymer layer may be applied to cover fuse or heater circuitry so that a unit would have a metal base, a polymer insulator thereon, a heater or fuse pattern on this polymer, and a protective polymer layer covering the heater or fuse pattern.

Highly accurate circuit values may be obtained, especially when a photographic process is used, because then the original art work for the required patterns may be made quite large. Any errors in such work are minimized by the photo-reduction to the actual pattern size preceding etching. Thus the accuracy in the ultimate scale to which the fuses are made has been found to be on the order of about ten times that of the master drawing accuracy.

The advantage of the metallic backing, when made thick enough to provide a heat sink, minimizes the deviation from the calibration of a fuse when operating under excessively high temperature. Heavy duty fuses will sometimes burn out under temporarily hot conditions when the current in the circuitry does not call for it. By the use of a thick enough metal backing as part of the fuse, heat may be abstracted from the printed circuitry to forestall this trouble. Fuses, and more particularly those for light duty and high accuracy of calibration and operating under conditions of ordinary temperatures, should in general be constructed with a backing layer such as **1** which will not supply much heat sink effect but only rigidity. Otherwise the heat sink effect may destroy the accuracy of calibration.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An electrical fuse unit comprising electrically insulating sheet material arranged substantially coextensive with and bonded to a stiff layer of metal sheet material, and a plurality of groups of electrically conductive fuse elements of selected thickness bonded to said insulating sheet material in spaced, electrically insulating relation to each other, each of said fuse elements having a pair of terminal portions of selected width electrically interconnected by an intermediate fuse portion of relatively smaller width fusible in response to the passage of selected electrical current therethrough, said groups of fuse elements being arranged adjacent respective identical edges of said insulating sheet material, said terminal portions of said fuse elements in each group being located in spaced relation to each other along an edge of said insulating sheet material commonly adjacent thereto for forming a plurality of fuse circuits extending between spaced locations along said commonly adjacent edge of said insulating sheet material.

2. An electrical fuse unit comprising a layer of electrically insulating sheet material having a plurality of substantially identical sheet edges, a stiff backing layer of metal sheet material arranged substantially coextensive with and bonded to one sheet surface of said insulating layer, and a plurality of groups of electrically conductive fuse elements of selected thickness bonded to an opposite sheet surface of said insulating layer in spaced, electrically-insulating relation to each other, each of said fuse elements having a pair of terminal portions of selected width electrically interconnected by an intermediate fuse portion of relatively smaller width fusible in response to the passage of selected electrical current therethrough, said groups of fuse elements being arranged adjacent respective identical edges of said insulating layer, said terminal portions of said fuse elements in each group being located in spaced relation to each other along said insulating layer edge commonly adjacent thereto for forming a plurality of fuse circuits extending over said insulating layer between spaced locations along said commonly adjacent edge of said insulating layer.

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H. B. GILSON, Primary Examiner

U.S. Cl. X.R.

337—187, 293, 416