

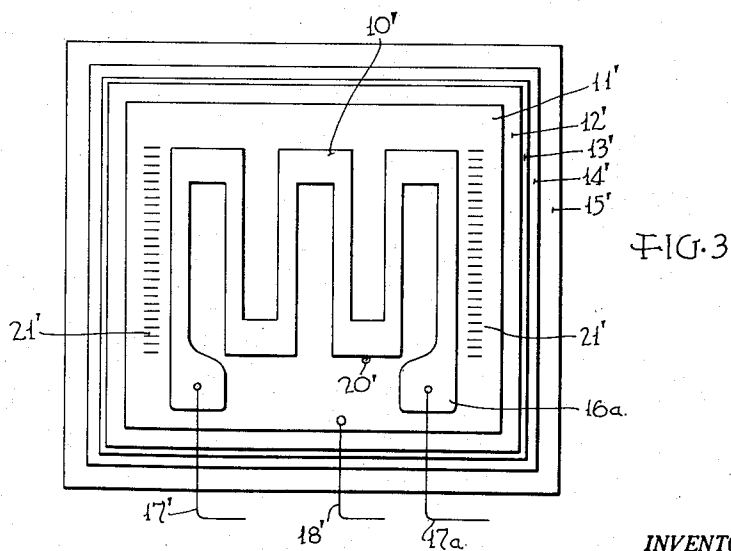
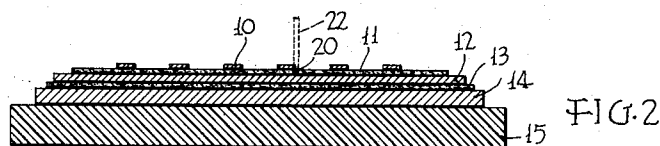
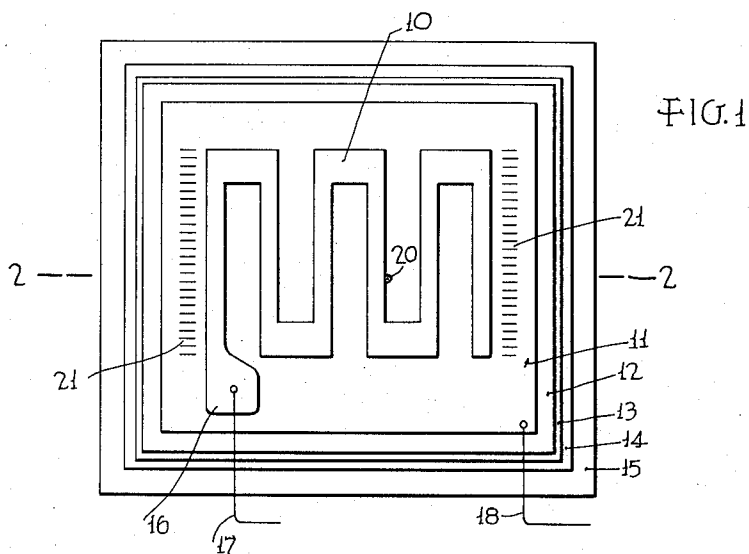
Jan. 1, 1963

J. E. STARR

3,071,749

ADJUSTABLE RESISTORS AND METHOD OF MAKING THE SAME

Filed May 17, 1960



INVENTOR.
James E. Starr

BY *Wm. R. Glisson*
ATTORNEY

1

3,071,749

ADJUSTABLE RESISTORS AND METHOD OF MAKING THE SAME

James E. Starr, Norristown, Pa., assignor to The Budd Company, Philadelphia, Pa., a corporation of Pennsylvania

Filed May 17, 1960, Ser. No. 29,711
13 Claims. (Cl. 338—314)

This invention relates to adjustable resistors and method of making the same and has for an object the provision of improvements in this art.

One of the specific objects of the invention is to provide an adjustable resistor which can readily have its resistance decreased as well as increased.

Another object is to provide a resistor which has a good heat sink to maintain a uniform temperature and resistance in use.

Another object is to provide a metal backing plate with a solder connection to a superposed insulated resistor to hold the resistor fast at the point of connection.

Another object is to provide a construction which is subject to quick and easy resistance selection.

Another object is to provide a simple and convenient method of adjusting the resistance of a resistor.

Another object is to provide a resistor which can have its resistance changed without affecting its external connections or the leads therefor.

The above and other objects and advantages of the invention and various features of novelty will be apparent from the accompanying description of an exemplary embodiment, reference being made to the accompanying drawings wherein:

FIG. 1 is a plan view of one form of resistor unit embodying the invention;

FIG. 2 is a cross-section of the resistor unit, the section being taken on the line 2—2 of FIG. 1; and

FIG. 3 is a plan view of another embodiment.

Resistors formed of metal foils or films have many advantages over wire or other types. Among these advantages is an extensive surface for bonding to a supporting body and for transferring heat to air or to an adjacent heat sink such as a supporting plate or body. Heat dissipation is improved by having a thin insulating layer support for the resistor; and a foil or film permits an insulating layer of minimum thickness to be used with the least danger of rupture and short-circuiting.

Another advantage of the foil type resistor is the ease in which the resistance value can be varied by thinning or narrowing the elements of the pattern. Either chemical etching or mechanical reduction of the width or thickness to increase the resistance are easily accomplished. The reduction in thickness which may be practically attained with a foil resistor without impairing the performance of the resistor is about 30%.

Heretofore after a foil resistor was made, as by the photographic pattern printing and etching process, it could only have its initial resistance increased; it was impossible to decrease its resistance. The present invention makes it possible to decrease the resistance to any desired extent and then, if desired, to increase the selected resistance to attain a final resistance value of high accuracy.

With the herein described resistance unit and method it is possible to achieve great economy and convenience by making resistor units of certain ranges and readily bringing them to specific precision resistance values for use or sale. Thereby with a very small stock range it is possible to supply an unlimited range of unit resistance values.

As shown in the drawings, a resistor foil pattern or grid 10 is formed, as by a photographic printing and

2

chemical etching process, and adhesively bonded to a thin insulating layer 11, as of suitable plastic. The plastic layer may follow the foil from its solid free sheet shape through its forming processes or may have the formed foil pattern transferred to it after formation or at some time during its formation. An insulating layer of good dielectric properties and shape stability throughout its range of use is very desirable and epoxy or glass fabric have been found suitable. The insulation is one which can be scraped off locally or punched through easily for making a solder connection as will be described hereinafter.

The insulating layer 11 is secured, as by adhesive bonding, to a metal sheet 12 of good electrical and heat conductivity, such as copper, aluminum or the like. For some uses, as where the metal sheet is thick enough to be an adequate heat sink for the heat created in the use of the resistor unit, the one metal sheet may be sufficient; but herein it is shown to be relatively thin and to be secured, with an intervening insulating layer 13, to a heavier metal sheet or plate 14 which provides a heat sink of much greater capacity. If the resistor unit is in service mounted on a metal base then this base will form the heat sink.

When desirable, the unit may be mounted and secured, as by adhesive, on an insulating carrier sheet, plate or substrate 15.

The resistor grid 10, at one end is provided with a lead tab 16 and in service a lead 17 is connected, as by soldering, to this tab. This lead may be connected in the field; or, since the connection requires a delicate operation, a short lead of material heavier than the foil may be connected at the time of manufacture.

To the metal sheet 12 there is secured, as by solder, a lead 18. This connection is less delicate than the other but, if desired, may be made at the time of manufacture and covered by insulation except at a protruding end.

To make a resistor unit of any selected resistance possible with the initial grid or pattern a spot is selected for a predetermined resistance value along the elements of the grid and the underlying insulation scraped away and a solder connection 20 made between the grid element and the metal sheet 12. Scale markers 21 may be formed from the original foil sheet along with the grid to indicate values along the pattern.

The sheet 12 is relatively so thick and so highly conductive that it, in effect, forms a direct electrical connection from its lead 18 to any point over its area at which the connection 20 is made.

If a pointed soldering tool is used it may serve both to rupture the insulation and to make the solder connection instead of having to scrape away the insulation as a separate operation. A pointed soldering tool 22 is indicated in broken lines in FIG. 2.

In some cases it may be desirable to connect a lead, such as 18, directly to the surface of the resistor. If so, it is still desirable to make the solder joint through the insulation from the resistor to the metal plate. This provides a firm anchorage at this point. Alternatively a connection may be made to the metal plate by more direct means such as mounting the plate on a conductor or mounting a conductor on the plate.

A great variety of resistor units may be made by the present invention. One other example is shown in FIG. 3 where leads 17' and 18' are provided as before but where the grid has a lead tab 16a and a lead 17a at its other end and the connection 20' divides the total resistance of the grid into selected relative values as before, the solder joint 20' is useful as an anchorage for the foil to a substantial body even if the lead 18' is connected directly to the foil instead of to the metal plate.

After the solder connection 20 or 20' has been made

to establish the minimum resistance, selected to be slightly lower than the desired final resistance value, the resistance is increased up to the exact desired value by decreasing the cross section of the active portion of the pattern, carefully measuring the resistance by instruments as the adjustment proceeds. As stated above, the cross section can be reduced in various ways. One simple way is to rub the top surface evenly with a light abrasive like pumice or rouge with the finger tip or a small rubbing tool. Skilled workers become very adept at this operation even with resistors of very small size.

It is thus seen that the invention provides an improved adjustable high-precision resistor and an improved method of forming it.

While one embodiment of the invention has been described for purposes of illustration it is to be understood that there may be various embodiments and modifications within the scope of the invention.

What is claimed is:

1. A printed circuit resistor unit comprising in combination, a foil resistor pattern, a thin plastic insulating layer supporting and bonded to one side of said resistor pattern, a continuous metal sheet bonded to the other side of said insulating layer, said metal sheet being of a material of good electrical and heat conductive material to constitute a common potential area and heat sink, an electrical conductor lead connected to said resistor pattern, and a solder connection between said resistor pattern and said metal sheet through said thin plastic insulating layer at a calibrated point spaced from the lead connected on the pattern electrically connecting said metal sheet to said electrical conductor lead with a portion of said resistor pattern in series therebetween.

2. A printed circuit resistor unit as set forth in claim 1, which further includes a heavier metal body bonded to and insulated from said metal sheet to act as a heat sink of greater capacity.

3. A resistor unit comprising in combination, a metal sheet of negligible resistance, of good heat conductivity and of sufficient thickness to constitute a good heat sink, an insulation layer bonded to said metal sheet, a resistor pattern bonded to the other side of said layer of insulating material, said layer being very thin and easily pierced, a solder connection between the pattern and sheet, a conductor lead connected to said metal sheet, and at least one conductor lead connected to one end of said pattern, the unit being adapted to have said solder connection made between said pattern and said metal sheet through said insulating layer at a selected point along the pattern electrically connecting said metal sheet and an electrical conductor lead on said pattern with a portion of said resistor pattern in series therebetween.

4. A resistor unit comprising in combination, a metal sheet, an insulation layer bonded to said metal sheet, a resistor pattern bonded to the other side of said insulating layer, said pattern being freely accessible on one side, spaced leads connected to said pattern, and a solder connection between said sheet and pattern through said insulating layer at a point between the leads connected to said pattern, whereby a connection to said sheet and one of said leads defines a precision resistance path.

5. The method of making a resistor unit which comprises, bonding a flat foil resistor pattern having at least one lead connection affixed thereto to one side of a metal heat sink sheet with a thin sheet of insulation therebetween, connecting a lead to said metal sheet, and making an electrical solder connection between said resistor pattern and said metal sheet through said insulation at a measured point spaced from the pattern lead to connect a portion of said resistor pattern between said pattern lead and said lead on said metal sheet.

6. The method as set forth in claim 5, which further includes the step of reducing a portion of the cross section of the pattern between the pattern lead and electrical connection to make a fine adjustment in the re-

sistance value by increasing it after the lead and electrical connections have been made to establish an initial minimum resistance in said pattern.

7. The method as set forth in claim 5, which further includes the step of connecting two spaced leads to said pattern before the electrical connection is made and making the electrical connection at a selected point between said leads.

8. The method as set forth in claim 6, which further includes the step of reducing the cross section of the pattern between one of said leads and said electrical connection after the electrical connection has been made.

9. The method of making a resistor unit which comprises, forming on an insulating sheet a resistor pattern from a foil sheet by the photographic printing and chemical etching or milling process, bonding the foil pattern and insulation to a metal conducting and heat sink sheet, making lead connections to said metal sheet and pattern, and making an electrical solder connection from said pattern to said metal sheet through said insulation at a point spaced from a lead connected to the pattern.

10. The method as set forth in claim 9 which further includes the step of reducing a portion of the cross section and increasing the resistance of the useful length of the foil pattern by thinning it by abrasion on the top surface.

11. The method of making precision printed circuit resistors which comprises the steps of: making a printed circuit type grid pattern on a thin calibrated insulation layer mounted on an electrically conductive sheet, said pattern having a resistance value greater than the desired precision value, connecting a lead to said pattern, connecting another lead to said sheet, making a solder connection through said thin insulation to electrically connect a point on said pattern with said sheet to define a predetermined calibrated length of said grid pattern between said leads, and reducing a portion of said calibrated length by abrasive action while carefully measuring the resistance until a predetermined precision value is reached.

12. The method of making a precision temperature compensating printed circuit resistor which comprises: forming a bonded laminate of a heat sink metal sheet, a thin insulation layer, and a flat foil pattern resistance grid; making at least two lead connections to said pattern spaced apart to define a predetermined portion of said pattern resistance grid; removing a portion of said resistance while simultaneously measuring the resistance value until a desired precision value is obtained; and making solder connections from said pattern resistance grid through said insulation layer to said metal sheet at points along said grid outside said predetermined portion of said pattern resistance grid.

13. The method of making precision printed circuit resistors comprising the steps of: making a flat thin printed circuit metal grid resistor on one side of an insulating sheet, said insulation sheet having a metallic conductive sheet bonded to the other side of said insulating sheet, connecting leads to said conductive sheet and said printed circuit, making a solder connection between a point on said resistor and said insulating sheet by piercing the insulation, measuring the resistance of the path between any pair of said leads, and increasing said measured resistance by abrasive action removal of a portion of said grid resistor.

References Cited in the file of this patent

UNITED STATES PATENTS

1,930,932	Freyman	Oct. 17, 1933
1,962,438	Flanzer et al.	June 12, 1934
1,970,051	McWeeny	Aug. 14, 1934
2,474,988	Sargrove	July 5, 1949
2,482,316	Bocking	Sept. 20, 1949
2,518,941	Satchwell et al.	Aug. 15, 1950
2,939,807	Needham	June 7, 1960