

[54] **RESISTOR TRIMMING TECHNIQUE**

[75] Inventors: **Lino Sella, Banchette; Claudio Dalmasso**, Ivrea, both of Italy

[73] Assignee: **Ing. C. Olivetti & C., S.p.A.**, Torino, Italy

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[51] Int. Cl. **H01c 9/00**

[58] Field of Search 338/195, 308, 309; 29/620

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Primary Examiner—J. V. Truhe

Assistant Examiner—David A. Tone

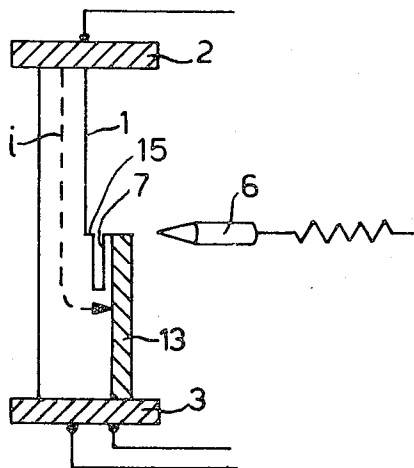
Attorney, Agent, or Firm—Ira J. Schaefer

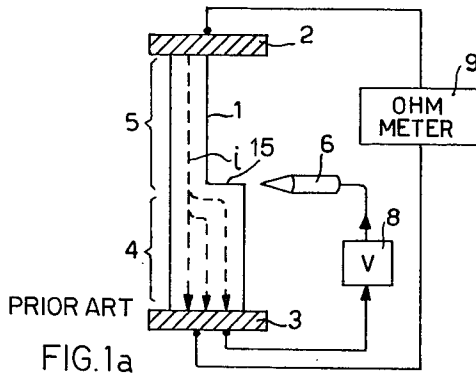
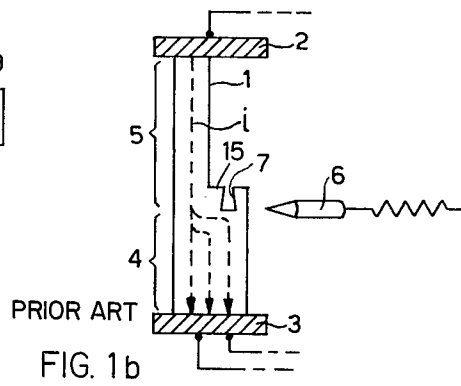
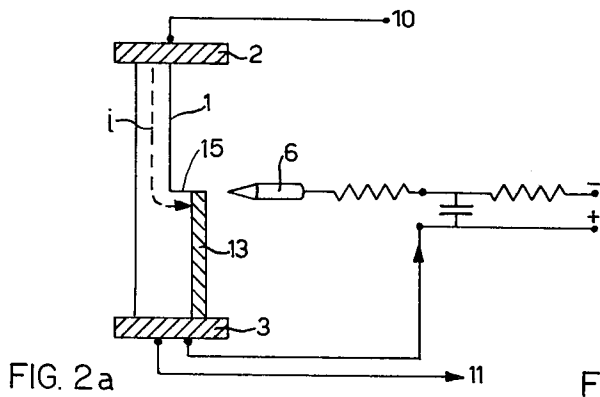
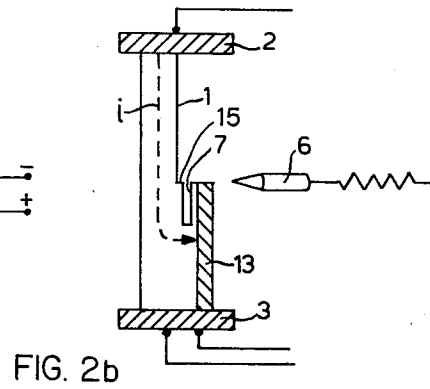
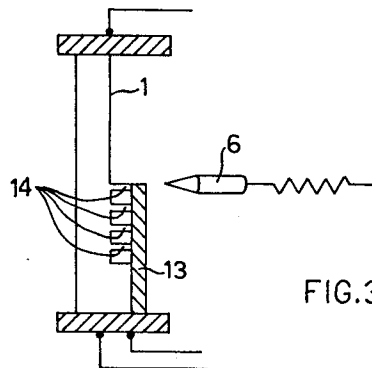
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ABSTRACT

A printed circuit resistor pattern, designed to be trimmed by electro-erosion, has affixed to the side thereof a highly conductive strip. The current path passes through a portion of the resistor pattern and through the conductive strip; as the resistor is trimmed, a gap is created along the edge of the conductive strip causing the current path to pass through a greater length of resistive material and a lesser length of the conductive strip, thereby causing the overall resistance to current flow to be increased.

5 Claims, 5 Drawing Figures





RESISTOR TRIMMING TECHNIQUE

This is a continuation of application Ser. No. 310,729, filed Nov. 30, 1972, now abandoned.

CROSS-REFERENCE

This application discloses the same subject matter as Italian application No. 70956-A/71 filed on Dec. 2, 1971 by this applicant; the prior filing date of said Italian application is claimed.

BRIEF DESCRIPTION OF THE INVENTION**1. Field of the Invention**

The techniques of trimming resistive elements on printed circuit boards form the general field of the invention. More particularly, the invention relates to the geometry and composition of these resistive patterns.

2. Description of the Prior Art

While resistor trimming methods are well known, a number of substantial disadvantages are present in the known technology. The prior art utilizes a resistive pattern which is so constructed so as to cause the energy which is released through the electro-erosion device to pass through the length of the resistive pattern. Heat damage, lost time, improper resistor meter readings, and difficult operator execution are among the consequences of this. In order to fully understand the invention, the prior art techniques will be further commented in conjunction with the drawing.

SUMMARY OF THE INVENTION

The resistive pattern to be trimmed has affixed thereto a highly conductive segment; the conductive segment is placed along the side of the pattern near the region where an electro-erosion probe will be used to create a gap or cut in the resistive material. The energy released from the probe tip passes through an inconsequential length of resistive material in order to reach the conductive strip. The gap cut by the probe is made parallel to the conductive strip; therefore, the resistance facing each successive spark is quite low and remains constant.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1(a) and (b) depict the prior art trimming arrangement;

FIG. 2(a) and (b) depict the trimming arrangement according to the invention;

FIG. 3 depicts an alternative trimming arrangement constructed in accordance with the teachings of the invention.

DETAILED DESCRIPTION OF THE INVENTION

In order to more fully understand the advantages of the inventive concept, it would be helpful to first briefly consider prior art techniques of resistor trimming. FIG. 1(a) and (b) show a resistive segment 1 disposed between two relatively highly conductive segments 2 and 3; these segments 1-3 are disposed on a circuit board (not shown) of conventional design along with other resistive and conductive elements which make up the complete circuit board pattern.

The resistance between end segments 2 and 3 must be a certain, precise value, and, as the resistive segments 1 are constructed by mass manufacturing techniques, the actual resistance of each of these segments will vary a slight amount from the resistance of other segments. In order to assure that each resistive segment

of precisely the proper resistive value, the conventional technique is to so design the segments 1 so that their resistance is slightly lower than actually desired; the segments are then slowly trimmed, step-by-step, until the desired resistance is achieved.

In FIG. 1(a), the dotted lines *i* represent the current spread which would flow if a potential were impressed across end segments 2 and 3; since region 4 is wider than region 5, its resistance is substantially lower than narrow region 5. In order to slowly raise the resistance of segment 1, a high voltage probe 6 is lowered to the surface of a shoulder 15 of region 4, causing a burst of electrical energy to pass through region 4. This spark causes a small area of the wide region to be disintegrated; the probe 6 is continually brought in contact with shoulder 15 causing a gap 7 to be slowly formed in this region. As can be seen in FIG. 1(b), gap 7 causes the amount of wide region 4 available to current flow to be shortened while simultaneously elongating narrow region 5. Thus the resistance of segment 1 is slowly raised each time probe 6 causes gap 7 to be elongated.

The prior art resistor trimming technique is subject to a number of important disadvantages. When probe 6 contacts the surface of shoulder 15, the energy released through the probe passes down the length of region 4, through end segment 3, and returns to the opposite terminal of high voltage source 8. These heavy pulses of current cause highly resistive region 4 to rapidly heat up. If the gap 7 must be of substantial length, probe 6 must be lowered to the region 4 a correspondingly substantial number of times. The large amount of heat generated in region 4 can damage, not only this area, but also surrounding structure. The reliability of the resistors so trimmed is accordingly lessened because of this heat generation.

After each probe produced spark has eroded away a chip of region 4, ohm meter 9 must be monitored to see if the resistance of segment 1 has reached its desired value. Because of the surge of energy through region 4 caused by the spark, the operator must wait a period of time for the noise in region, caused by this energy, to subside. This waiting period is significant and the consequent lost time causes an appreciable drop in production. Furthermore, this noise often causes erroneous readings of meter 9 since the operator sometimes will not wait long enough for a proper reading.

Another problem which is found in the prior art method is that the amount of material removed by each spark varies as gap 7 elongates. This is because the resistance between probe 6 and end segment 3 changes as gap 7 elongates and region 4 correspondingly shortens. With each successive spark, the resistance lessens, and this, in turn, causes the energy burst to be released in a shorter time. These more intense sparks disintegrate more material than the initial less intense bursts. The result is the creation of a wedged shaped gap 7. The problem with this is that the operator never knows by how much the resistance of segment 1 will be increased with each succeeding spark. As the resistance of segment 1 closely approaches the desired value, the operator therefore will not know whether he should risk another spark or not.

FIG. 2(a) and (b) show the preferred embodiment of this invention; the arrangement is similar to that of the prior art in that resistive segment 1 is disposed between highly conductive end segments 2 and 3. Connected between terminals 10 and 11 is a bridge (not shown)

used to measure the resistance of segment 1 after each spark produced by probe 6. The resistive segments can be NiCr and the conductive segments can be gold.

Affixed to the side of segment 1 is a strip 13 of highly conductive material. Strip 13 can be of the same material as end terminals 2 and 3 (e.g., gold). The current path *i* now does not traverse the entire length of resistive segment 1 to reach end terminal 3; rather the current path *i* ends at conductive strip 13 as is shown in the drawing. Each successive spark, produced by probe 6 elongates gap 7, thereby increasing the length of the current path *i* through resistive segment 1.

Each successive spark, applied to gap 7, causes a burst of electrical energy to pass to end segment 3, not through resistive segment 1, but rather through highly conductive strip 13. For practical purposes, one can speak of the resistance of highly conductive strip 13 as being zero since it is so low when compared with that of segment 1. Each spark, or energy burst, therefore faces the same resistance no matter how long gap 7 becomes. This means that each burst will be of the same intensity; therefore, each spark will remove exactly the same amount of material as the preceding sparks. The operator can then tell by how much the resistance will change after each spark and will be able to know when to stop the cutting.

Furthermore, as the spark energy passes through only a very thin strip of segment 1 before reaching strip 13, no appreciable heat is generated and no heat damage to segment 1 or other elements in the environment is possible. Again because of the fact that the spark energy traverses an inconsequential amount of high resistance material 1, there is little noise generated in segment 1 and the operator need not wait an extra period of time after each spark to obtain a proper resistance reading.

FIG. 3 shows another embodiment of the invention which utilizes a plurality of thin strips 14 to connect resistive segment 1 to conductive strip 13. Spark probe 6 is then used to cut strips 14, in succession, until the resistance of strip 1 has been raised to the desired value. Strips 14, which are drawn greatly enlarged for clarity, are thin enough so that a single spark from probe 6 will break a single strip. Using this arrangement one can alter the resistance of strip 1 in precisely defined steps; the amount of change in resistance after each spark may be set to a desired value by designing the strips 14 to be at a particular distance from each other.

Other changes in the geometry of segment 1 and strip 13 which utilize the concepts of this invention will suggest themselves to those skilled in the art. The limits of this inventive concept are defined in the following claims.

What we claim is:

1. A resistor trimming arrangement comprising:
 - a resistor pattern having a first and second end with an initial resistance between these ends, said pattern including a first portion of relatively resistive material and a second portion of relatively conductive material so that an electrical current passing through said pattern from said first to said second end will pass through a first length of said resistive material and a second length of said conductive material;
 - electrically operable means for removing an amount of said resistive material; and

circuit means electrically connected to said removing means and electrically connected to the second end of the resistor pattern for operating said removing means to effect the removal of an amount of resistive material to increase the length of resistive material through which an electrical current passing between said ends passes to a length of said resistive material which is greater than said first length and to decrease the length of conductive material through which the electrical current passes to a length of said conductive material which is shorter than said second length, thereby causing the resistance between said ends to be increased.

2. A resistor trimming arrangement comprising:
 - a relatively resistive element having a given resistance between its extremities;
 - a relatively conductive element positioned in electrical contact with said resistive element, the path of least resistance between said extremities including a first length of said conductive element;
 - electrically operating means for removing an amount of said resistive element; and
 - means electrically connected to said removing means and to one extremity of said resistive element for operating said removing means to create an electrical open circuit through a portion of said resistive element so that the path of least resistance between said extremities includes a second length of said conductive element, said second length being shorter than said first length.

3. A resistor trimming technique for increasing the electrical resistance between at least two points including the steps of:

- providing a relatively resistive element extending between said points;
- providing a relatively conductive element in contact with a portion of said resistive element so that electrical current passing between said two points through said resistive element will also pass through said conductive element;
- electro-eroding a gap in said resistive element adjacent and parallel to a portion of said conductive element so that said electrical current will not pass through a portion of said conductive element adjacent to said gap.

4. A combination for increasing the resistance between at least two points comprising:

- a strip of resistive material extending between said two points, said strip having a shoulder;
- a strip of conductive material extending between one of said points and said shoulder, said conductive strip being contiguous to said resistive strip between said shoulder and said one of said points;
- means for electro-eroding a gap through said resistive strip starting at said shoulder and extending parallel to said conductive strip; and
- circuit means causing the electrical energy released by said electro-erosion to pass to said one of said points through said conductive strip.

5. A method of increasing the resistance between selected points on a circuit board comprising the steps of:
 - constructing a strip of relatively resistive material between said points, said strip having a relatively narrow portion and a relatively wide portion;
 - constructing a strip of relatively conductive material;

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said strips being constructed in electrical contact with each other with said conductive strip being contiguous to said wide portion and extending from the area where said wide portion meets said narrow portion to the end of said wide portion;

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forming a gap in said resistive strip, said gap extending parallel to said conductive strip and starting from said area where said wide portion meets said narrow portion.

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