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H. CHRISTENSEN

2,407,251

RESISTOR

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FIG. 1

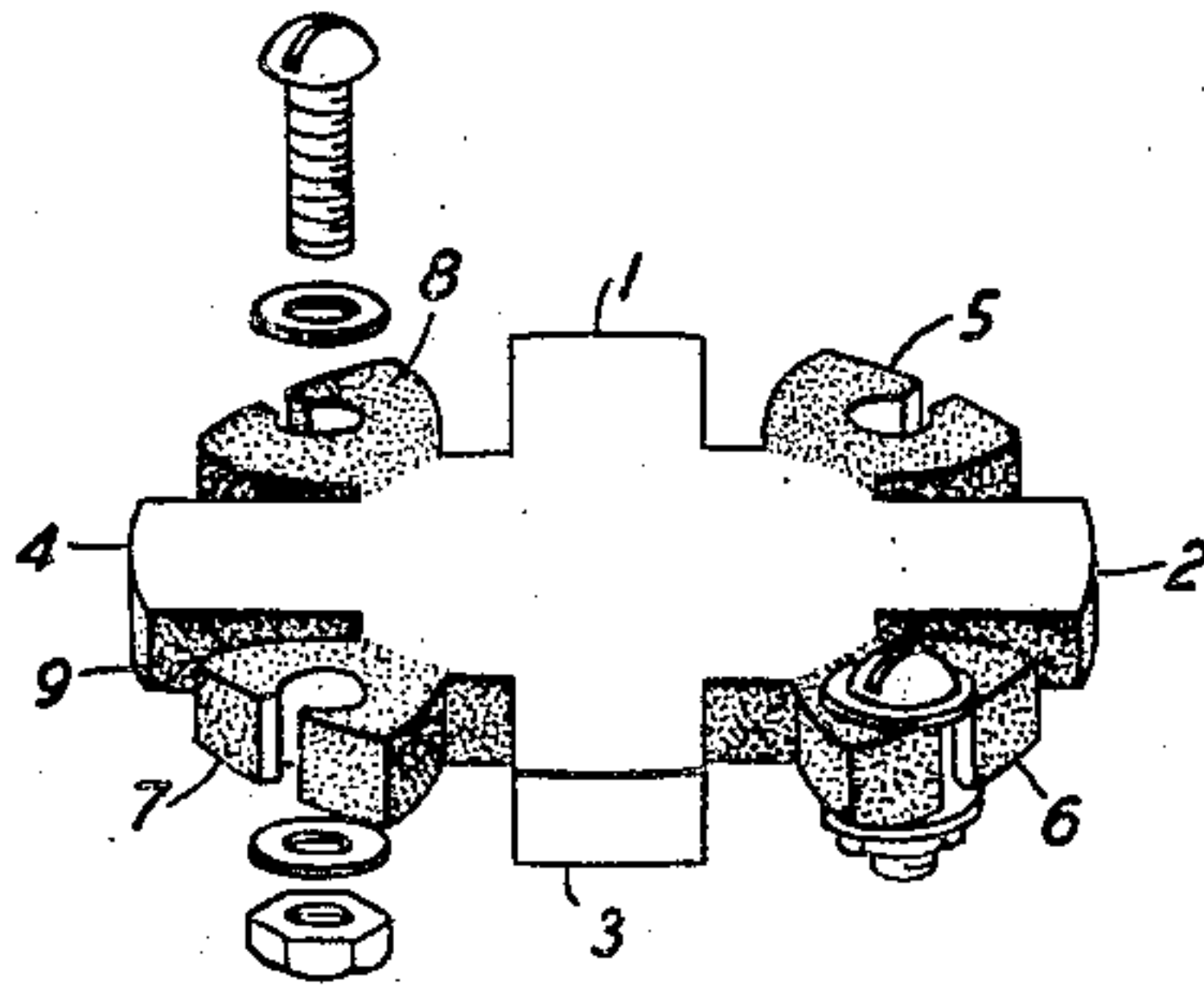


FIG. 2

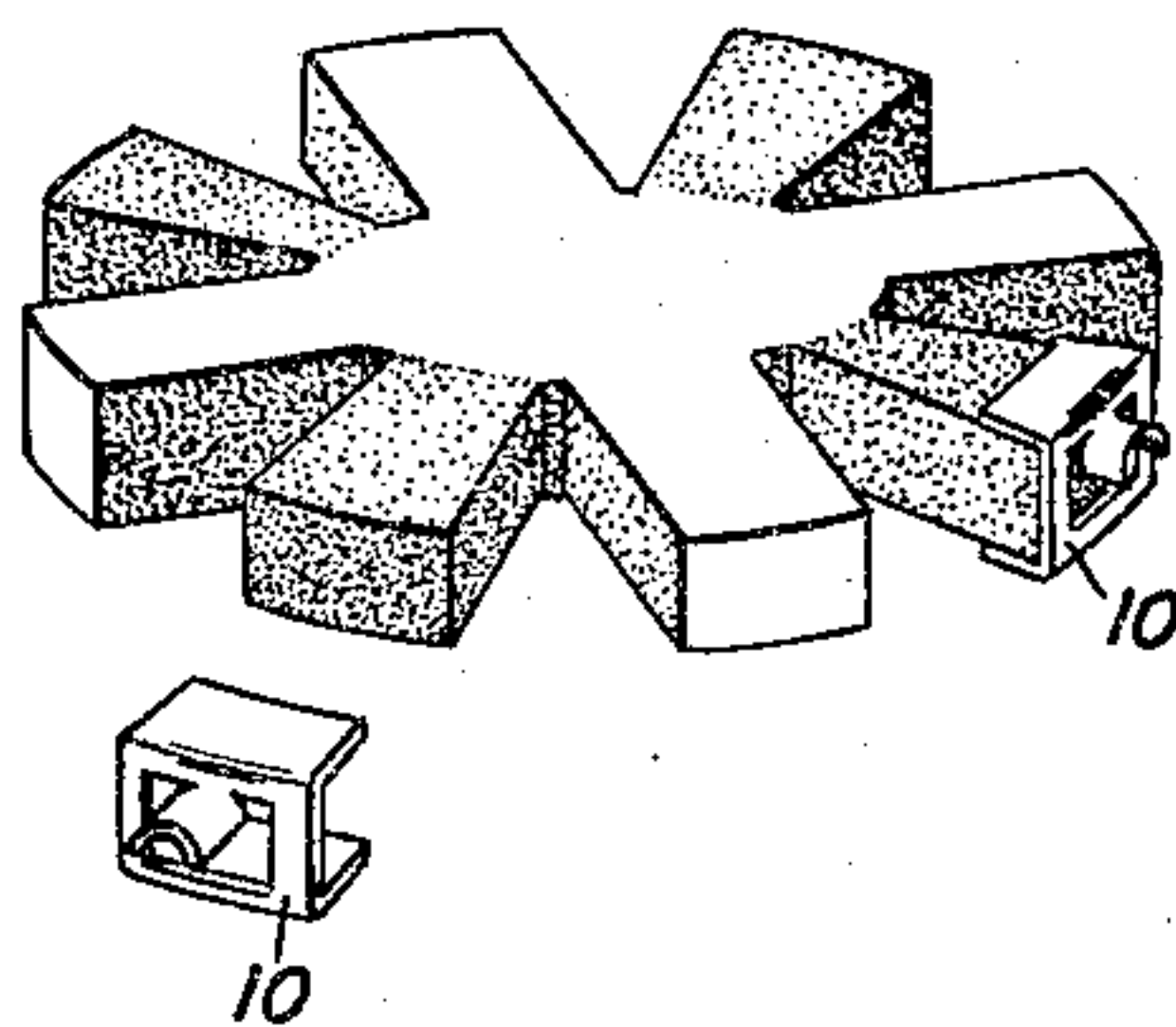


FIG. 3

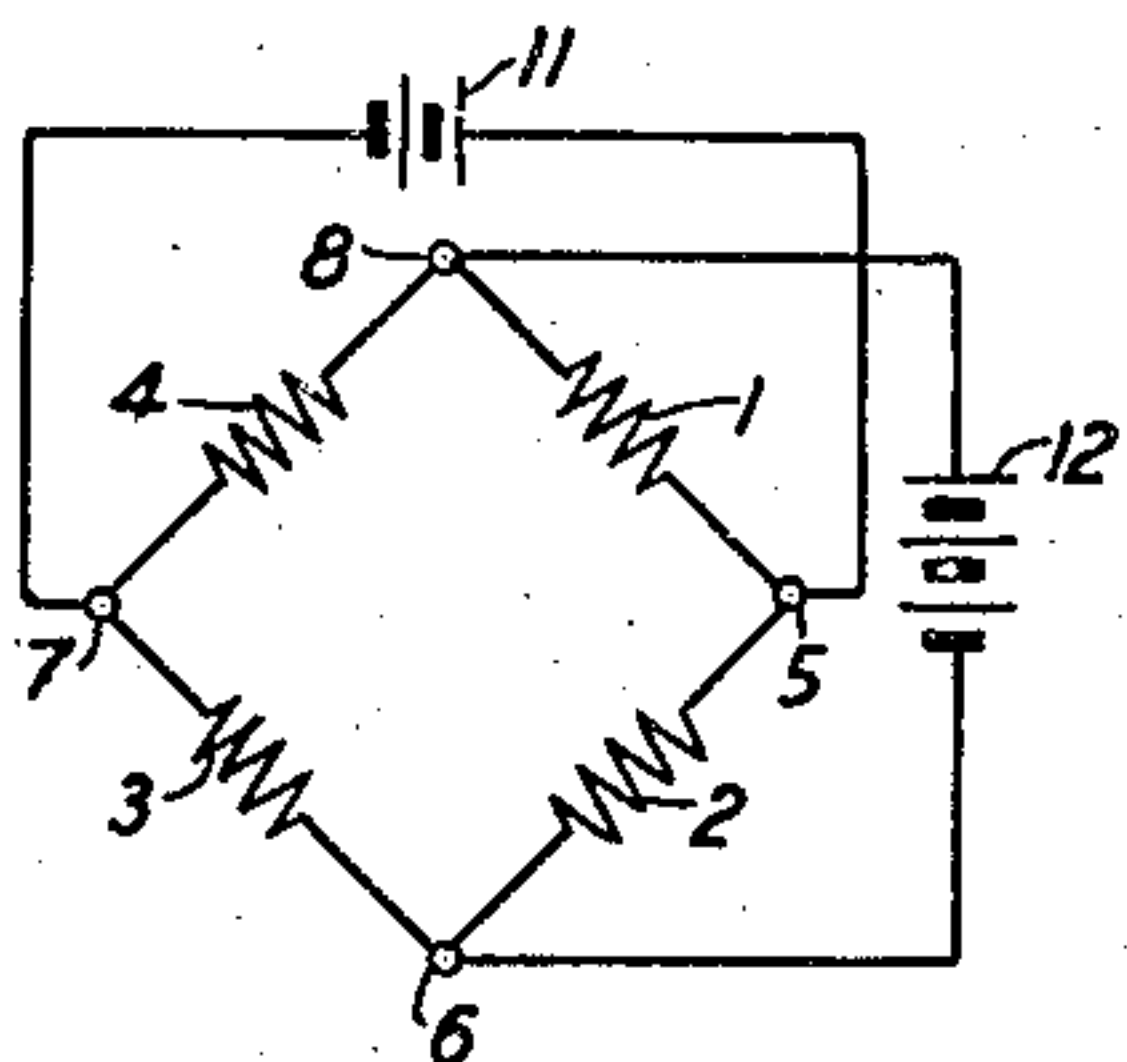
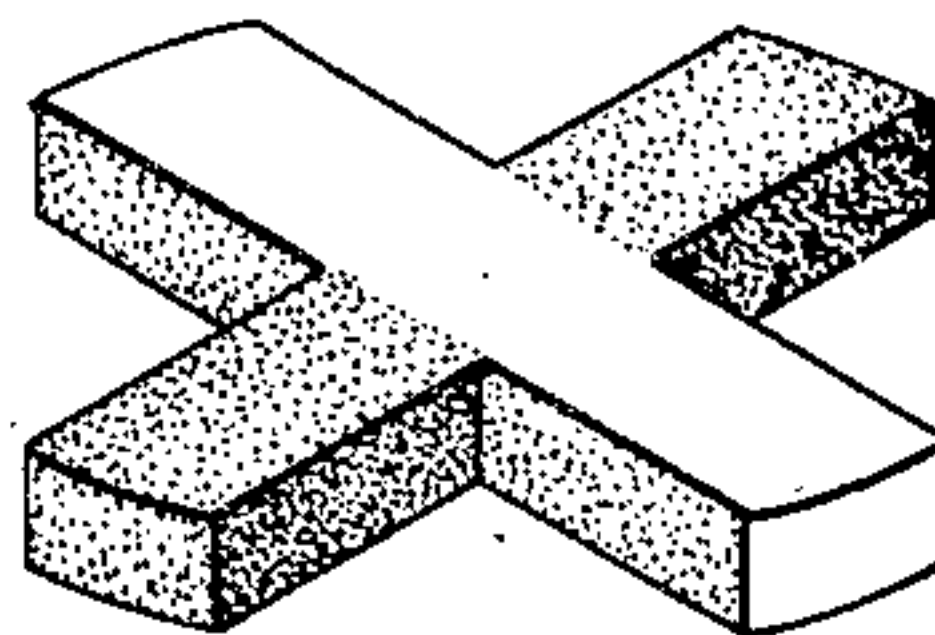


FIG. 4



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RESISTOR

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5 Claims. (Cl. 201—63)

1

This invention relates to resistors and particularly to resistors which, at some part of the characteristic, decrease in resistance with increase in current.

The object of the invention is a resistor which can carry a sudden heavy current without being destroyed by breakage.

A feature of the invention is a resistor having radial indentations.

Another feature of the invention is a conductive surface on the resistor, placed so as to cause a large part of the electric current to flow in the circumference of the resistor, and the thermal energy to flow radially inward to the center of the resistor.

A further feature of the invention is a resistor shaped so as to form two mutually conjugate electrical circuits, thermally coupled in the resistor.

Other features and advantages of the resistor will be apparent from the following description, and the drawing in which

Fig. 1 shows a preferred embodiment of the invention;

Fig. 2 shows a variant of the resistor shown in Fig. 1;

Fig. 3 diagrammatically shows an electric circuit including a resistor of the type shown in Fig. 1 or Fig. 2; and

Fig. 4 shows a simpler embodiment of the invention.

Resistors which decrease in resistance with increase in temperature are becoming of increasing importance and value in the electrical arts. Such resistors may be made of a large number of materials, usually compounds of the metals. For example, the resistor may be made of a mixture of manganese and nickel oxides, or of uranium oxide, though the invention is not limited to these particular substances. In certain uses of such resistors, it may be desirable to have the resistor carry a sudden large electric current. These resistors are, naturally, rather poor conductors of electricity, and, it is generally true, a poor conductor of electricity is also a poor conductor of thermal energy. If a sudden large electric current be passed through a resistor of conventional shape, the thermal energy may be concentrated in a small volume, and, before the thermal energy can be conducted to other parts of the resistor and thus dissipated, the local heating may produce strains which may cause the resistor to be cracked or otherwise harmed.

The resistor shown in Fig. 1 is roughly circular or cylindrical in form, though the invention is

2

not limited to this particular shape, as many other shapes may be used. The resistor is radially indented to form a plurality of projections, or arms, 1, 2, 3, 4, and, intermediate these arms, a second series of projections or arms, 5, 6, 7, 8, arranged to carry connectors for the electrical circuits connected to the resistor. These connectors are shown as simple screws and nuts, but obviously, any other suitable connector may be used.

The upper and lower surfaces of the arms 5, 6, 7, 8 are covered with a surface having good electrical conductivity, and, preferably, a surface which will adhere closely to the surface of the resistor. This conducting surface extends also to the vertical faces of the arms 1, 2, 3, 4, as shown for example at 9, on the arm 4, but does not extend over the outer faces of the arms 1, 2, 3, 4. The conductive surfaces on the arms 5, 6, 7, 8 must not extend from one arm to the other, as this might short-circuit the resistor between the connectors.

The conductive surface used, and the method of applying the surface will vary to some extent with the material of the resistor, the type of connector used, and the processes available. The simplest method may be to dip the arms 5, 6, 7, 8 in some liquid alloy, such as solder, and, after cooling, to remove any surplus material off the upper and lower surfaces of the arms 1, 2, 3, 4. Or, the arms 5, 6, 7, 8 may be plated with some suitable conducting material, such as silver, chromium, nickel, copper, etc. A convenient method of applying this plating is to paint the surface with a compound known by the trade name of "burnish paste." The exact composition of this paste is not known, but it is believed to consist of powdered glass, powdered metal, and organic compounds of an oily nature. The paste is painted, or spread, on the surface, which is then heated. The organic compounds are first driven off, then, at a dull red heat, the glass melts, wetting the surface and drawing the metal into a uniform closely adherent surface. The metal used is preferably a good conductor of electricity and not easily affected by exposure to the atmosphere. Gold, silver, platinum and similar metals are well suited for this use. The desired surfaces may be covered by cathodic sputtering, followed later, if desired, by electroplating with the same, or a different conductor. Any other method may be used, chemical, electrical or thermal, to produce a surface having good electrical conductivity, and closely adherent to the resistor,

3

at least on the vertical surfaces of the arms 1, 2, 3, 4.

The conductors may be attached to the arms of the resistor by screws and nuts, as shown in Fig. 1, or, by soldering to a simple terminal 10, as shown in Fig. 2, which may be clamped or soldered to the conductive surface, or the conductors may be soldered directly to the conductive surface. The method of attaching the conductors to the resistor is not important, providing the conductors make a good, stable connection with the conducting surface.

Fig. 3 diagrammatically shows a simple electrical circuit including a resistor of the type shown in Figs. 1 and 2. The resistances 1, 2, 3, 4 symbolically represent the resistances of the arms 1, 2, 3, 4. Current from some source, represented by the battery 11 connected to the terminals 5 and 7, flows through the resistances 1 and 4 in serial relationship, and also through the resistances 2 and 3 in serial relationship. Similarly, current from a second source, represented by the battery 12 connected to the terminals 6 and 8, flows through the resistances 1 and 2 in serial relationship, and also through the resistances 4 and 3 in serial relationship.

The resistances 1, 2, 3, 4 may be constructed to have the values to form a balanced bridge. In such a bridge, the resistances 1, 2, 3, 4 may all be mutually equal, or, may be in such ratios as to form a balanced bridge in accordance with the well-known rules for such bridges. In a balanced bridge, the terminals 5 and 7 are in conjugate relationship with the terminals 6 and 8. The bridge arms may conveniently be given the desired values by grinding the upper, lower or outer surfaces of the arms 1, 2, 3, 4 to adjust the resistances of these arms, or by any other desired method. When properly adjusted, no current from the source 11 will flow through the branch circuit containing the source 12, and no current from the source 12 will flow in the branch circuit containing the source 11. Any desired energy consuming or current controlling devices may be placed in circuit with the sources 11 and 12.

Either source 11 or 12 may be used to preheat the resistor to a desired point on the characteristic before the sudden application of current from the other source, or both sources may be connected, and the current from one source adjusted to control the current flowing from the other source.

The current from a terminal, such as terminal 5, is conducted to the vertical face of an arm, say arm 2, flows through the arm to the other vertical face, then through the terminal, say terminal 6, to the vertical face of a second arm, say arm 3, to the diametrically opposed terminal, say terminal 7. The current will thus flow largely in the arms and may be termed a circumferential flow. Some current will flow diametrically across the resistor but, due to the higher resistance, this part of the current will be small, and will not upset the conjugate relationship of the two circuits. As the current flows directly across the arms 5, 6, 7, 8 in the conducting material, these arms, if desired, may be made of conducting material attached to, or pressed firmly in electrical contact with, the vertical faces of the arms 1, 2, 3, 4.

The arms 1, 2, 3, 4 may have a variety of shapes.

4

The simplest shape, as indicated in the drawing, is when the opposite edges of the arms are parallel and opposed, and the edges are vertical, or normal to the plane of the surface of the resistor. However, these relationships are not essential, thus the edges of the arms may be curved or irregular in shape, may diverge from each other and may form an angle other than a right angle with the plane of the surface of the resistor. As the heat is radiated more readily from the ends of the arms, the edges of the arms may be inclined to each other at such an angle that the effect of the added radiation is compensated and the temperature along the arm equalized.

As the currents flow largely in the outer parts of the arms 1, 2, 3, 4, the heat is efficiently radiated. These arms will have a higher temperature than the body of the resistor, thus thermal energy will flow radially from the arms into the body of the resistor. The flow of thermal energy from any arm into the body of the resistor will depend upon the temperature of the body of the resistor due to the flow of thermal energy from the other arms. Thus, although the two electrical circuits are electrically conjugate, these circuits are thermally coupled, and the current in one circuit may affect or control the current in the other circuit.

Though the invention has been disclosed in Figs. 1 and 2 embodied in a resistor having four resistive arms, the invention is not limited to any particular number of arms. For example, if only one electrical circuit is used, the resistor may have two resistive arms, as shown in Fig. 4, and if more circuits are concerned, or, if desired, may have more than four resistive arms.

What is claimed is:

1. A disc of resistive material indented to form four arms and four intervening projections, conductive material on the faces of said projections extending to the vertical faces of the adjacent arms, and electrical connectors on said projections in contact with said material.

2. A disc of resistive material indented to form four arms and four intervening projections, the resistances of said arms being adjusted to form a balanced bridge, conductive material on the faces of said projections extending to the vertical faces of the adjacent arms, and electrical connectors on said projections in contact with said material.

3. A disc of resistive material indented to form four arms of equal resistance and four intervening projections, and conductive material in contact with the faces of said projections and extending to use the vertical faces of the adjacent arms.

4. A disc of resistive material indented to form a plurality of arms and a plurality of intervening projections, conductive material on the faces of said projections extending to the vertical faces of the adjacent arms, and electrical connectors on said projections in contact with said material.

5. A disc of resistive material having two opposed surfaces, said disc being radially indented to form a plurality of arms projecting from a central area and electrically conductive material in contact with the surfaces of said arms normal to said opposed surfaces.

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