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Patrick, Jr. [45] **Oct. 23, 1973**

[54] **STATIC BLEED RESISTOR**

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[52] **U.S. Cl.** .... **317/2 R,** 317/2 E
[51] **Int. Cl.** **H05f 3/00**
[58] **Field of Search** .... 317/2 E, 2 J, 2 R

[56] **References Cited**

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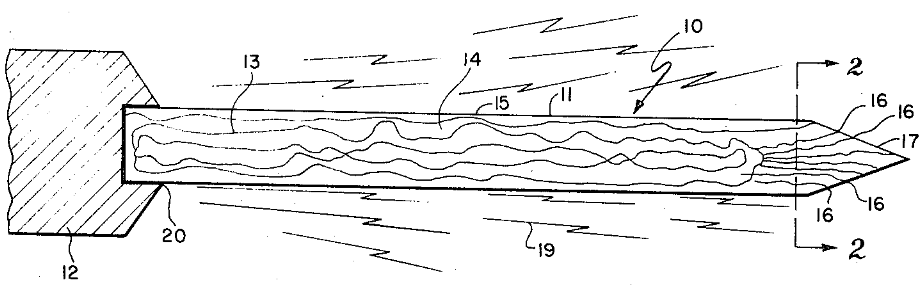
[57] **ABSTRACT**

This invention covers a drain for electrostatic charge commonly called a static bleed resistor in which a resistance element forms the core of a composite structure which includes a non-tracking plastic resinous material. The core may be made from a fibrous tow, and in this event, one end of the fibers making up the tow may be exposed to the atmosphere to constitute the active bleeding elements.

4 Claims, 3 Drawing Figures



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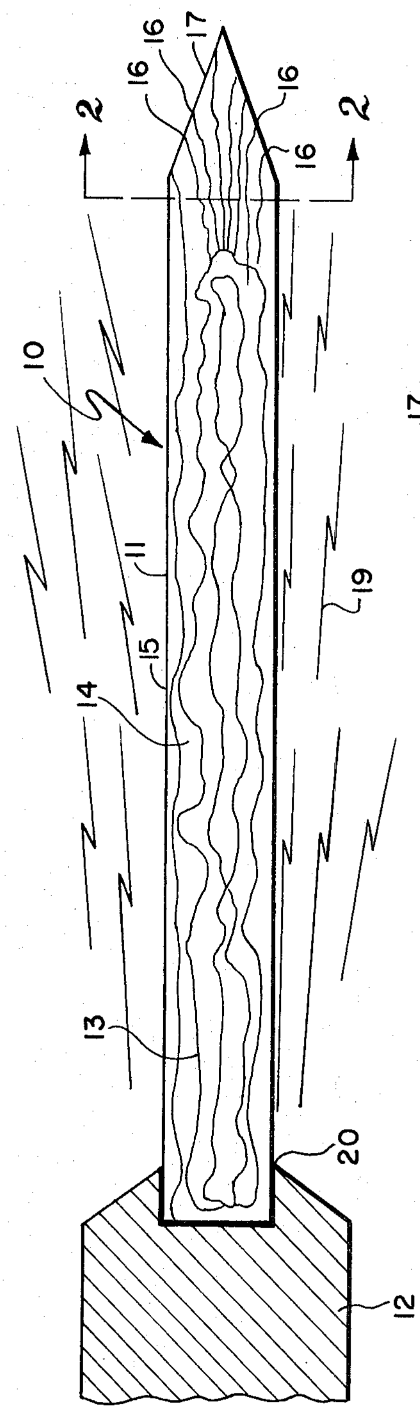

Fig. 1.

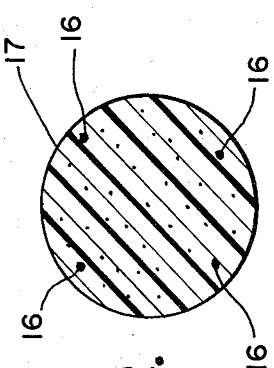

Fig. 2.

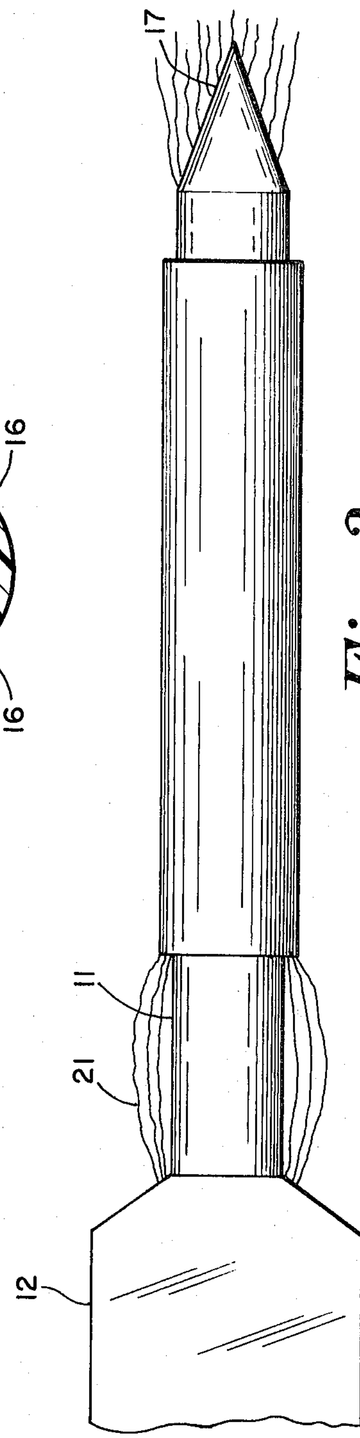

Fig. 3.

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STATIC BLEED RESISTOR

The prevention of the buildup of an electrostatic charge on an insulated conducting body is typically accomplished with a sharp pointed conducting rod attached to the body. The charge concentrates, typically, at the point. Because of the high charge density at the sharp point, ionization of the surrounding air occurs and the charge bleeds away. Generally, in most applications, it is necessary to limit the current that flows through the bleeder resistor to prevent sparking. This is accomplished by making the resistance means of the rod very high, several million ohms.

The static bleed resistor must also be able to withstand lightening strikes to the body that it is protecting because it is in itself the logical point of exodus for the lightening bolt from the body into the surrounding atmosphere.

It is an object of the invention to provide a static bleed resistor which avoids the limitations and disadvantages of such prior art devices.

It is another object of the invention to create a very durable and reliable static bleed resistor, in particular, a static bleed resistor which can successfully resist repeated lightening strikes.

Other objects of the invention are to provide a static bleed resistor which (1) is self-healing; (2) is resistant to atmospheric erosion and other deteriorating effects of the atmosphere; (3) contains an internal resistance network provided with an essentially non-conducting surface so that it can be used in improved lightening handling techniques; (4) is formed from a non-tracking matrix to maintain an essentially non-conducting surface when raised to temperatures where tracking materials char; and (5) contains a fibrous tow resistance element which prevents lightening penetration.

In accordance with the invention, a static bleed resistor comprises an electrical resistance element substantially enclosed within a non-tracking plastic resin matrix. The resistor is provided with an electrical coupling means for coupling the resistance element to the body which the static bleed resistor is intended to protect. A discharge means is also provided.

In accordance with one embodiment of the invention, the resistance element is formed from a fibrous tow formed from electrically conducting material. The terminal edges of one end of the tow may be exposed to the atmosphere so that each exposed fiber edge acts as the means for coupling the static charge to the atmosphere, a discharge means.

The novel features that are considered characteristic of the invention are set forth in the appended claims; the invention itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in conjunction with the accompanying drawings, in which:

FIG. 1 of the drawing is a cross-sectional representation of a static bleed resistor embodying the principles of the present invention.

FIG. 2 is an end view taken along line 22 showing in detail the static bleeding means.

FIG. 3 is a pictorial representation of the static bleed resistor in an operational assembly.

Referring to FIG. 1 of the drawing, there is shown a static bleed resistor **10** comprising an electrical resistance means **13** embedded within a plastic matrix **11**.

The static bleed resistor **10** is coupled to a metal body **12** through an electrical coupling means **20.** The body **12** represents figuratively the member from which static electricity is to be bled.

The electrical coupling means **20** is preferably an electrically conductive adhesive such as the adhesive sold under the designation C34 made by the National Carbon Company. Chromerics and Emerson Cummings are two other sources of conductive adhesive. A conducting adhesive is essentially an adhesive loaded with carbon, silver or other conductor. In the alternative, the electrical coupling means may comprise a threading recess portion in the body **12** with a complementary threaded end of the static bleed resistor **10.**

The static bleed resistor **10** is a composite structure with an electrical resistance means **13** embedded within a non-conducting plastic matrix **11.** In FIG. **1**, the electrical resistance means **13** is represented by a fibrous tow made up from either continuous carbon filaments or staple carbon fibers. The tow is made up of an extremely large number about 105 of extremely high resistance fibers to prevent lightening from penetrating into the tow via an occasional fiber that may be near or at the surface of the bleeder resistor.

Preferably the tow is constructed from carbon filaments formed, as is widely done from a cellulose material such as rayon or from PAN or acronym for polyacylatonitrile. Other filaments such as glass coated filaments are also applicable. The specific resistance material is not critical, though the resistance per unit length of the filament is.

The resistance per inch of each filament should exceed 10^{11} ohms. Accordingly, in the order of 100,000, about 14 micron in diameter filaments are required to make up a static bleed resistor. Typically, static bleed resistors are 8–10 inches long and have a total longitudinal resistance of 5×10^6 to 100×10^6 ohms.

An important consideration in using this fibrous tow is that the electrical resistance means **13** is made up of a large number of parallel essentially insulated longitudinal electrical conducting paths for the electrostatic charge to traverse. Theoretically, there are as many parallel essentially insulated longitudinal electrical conducting paths as there are filaments, for example. Additionally, there are a number of finite interconnections between the parallel fibers so that if one or a number of paths formed by the length of a fiber is broken, it may be circumvented by a parallel path through a pair of interconnections.

As will be seen hereinafter, an important consideration is to have the electrical resistance means **13** essentially embedded within a non-conducting, and preferably a non-tracking, plastic matrix. The term "non-tracking" as applied to the plastic resin matrix **11** is hereby defined to mean a material which does not form a carbonacious or other electrically conducting path when thermally dissipated as might occur by a spark or an arc discharge. Typical non-tracking matrix materials are homo- or copolymers of polyformaldehyde such as Delrin and Celcon. An epoxy-urethane system sold by the Assignee as the 80 21 system as well as the fluorocarbons known as Teflon and Kel-F are also suitable non-tracking materials.

Since the preferable means involves the use of fibers, a small number of these fibers will appear at the surface of the plastic as shown by the symbol **15** in FIG. **1.** These do not materially affect the operation of the static bleed resistor because these surface penetrations are essentially isolated because of the high fiber and high overall resistance. They also tend to disappear due to environmental erosion or by distruction during a lightening strike. It may be accurately stated that the surface of the static bleed resistor consists of essentially the non-tracking matrix material, except for the discharge end **17** where the fiber ends are deliberately exposed.

The static bleed resistor **10** contains a static bleed means which in this case comprises the discharge end **17.** In a conventional manner, the end **17** is in the form of a sharp pointed cone to concentrate the static electricity and to simplify the ionization of the surrounding air so that the static electricity may be bled from the resistor **10** to the atmosphere.

Referring particularly to FIGS. **1** and **2,** there is shown ends **16** of the fiber resistance means **13** exposed to the atmosphere on the surface of the conical discharge end **17.** Each of these ends exposed per se represents a high electrical stress region so that each one acts as an effective coupling means between the static bleed resistor **10** and the atmosphere. Each of these ends **16** acts as a substitute for the tip of a metal cap, the conventional discharge end.

At the discharge end **17,** the filaments—assuming an essentially parallel orientation with the surface of the static bleed resistor **10**—are angularly disposed with relation to the conical surface of the discharge end **17.** Though the discharge end **17** is eroded or worn, there are always filament ends **16** exposed.

Referring to FIG. **3,** the static bleed resistor **10** is shown within an assembly. The assembly includes in addition to the static bleed resistor, a metal sleeve **23,** securely fastened to the cylindrical surface of the static bleed resistor **10.** The metal sleeve does not affect the performance of the static bleed resistor since it is isolated from the electrical resistance means **13** by the plastic matrix **11.** The metal sleeve **23** operates to protect the static bleed resistor in the event of a lightening strike to the body **12.**

Referring briefly to FIG. **1,** in the event lightening strikes the body **12,** the flow of electricity tends to gravitate to the static bleed resistor **10** on the body in an ionized sheath along the surface of the body. The lightening bolt would, if it could, enter the resistor and traverse the resistance element. If this occurs, the static bleed resistor would be destroyed. This, in fact, occurs in prior art devices. It does not happen on the static bleed resistor described herein. The lightening traveling along the surface of the body encounters either the matrix or an isolated fiber. The air surrounding the

static bleed resistor offers less resistance than the fiber having 10 inches ohm/in. Characteristically, therefore, the air around the static bleed resistor is converted into an ionized sheath. The lightening current is dissipated into the atmosphere through this sheath.

In the past, static bleed resistors were constructed with the resistance element on the surface. If an attempt was made to insulate the resistance element, it was enclosed in a ceramic or a tracking matrix. The rush of current around the static bleed resistor cracks the ceramic or burns the tracking matrix. In either case, the static bleed resistor must be replaced.

In the FIG. **3** configuration, the lightening strike ionizes the air between the body **12** and around the metal sleeve **23.** Since the metal sleeve **23** covers the major portion of the static bleed resistor surface, most of the lightening current is dissipated around the metal sleeve. The sleeve is able to withstand damage because of its excellent conductive qualties. The exposed surface areas of the static bleed resistor **10** are stressed less, and to the extent that the surfaces are burned, there is no conducting residue from the non-tracking matrix. The metal sleeve merely increases the reliability of the static bleed resistor against lightening strikes; its presence is not a necessity.

The various features and advantages of the invention are thought to be clear from the foregoing description. Various other features and advantages not specifically enumerated will undoubtedly occur to those versed in the art, as likewise will many variations and modifications of the preferred embodiment illustrated, all of which may be achieved without departing from the spirit and scope of the invention as defined by the following claims.

I claim:

1. A static bleed resistor comprising a longitudinal resistance element having a large number of parallel and essentially insulated longitudinal electrical conducting paths embedded within a non-tracking plastic matrix, each of said conducting paths having a resistance per length of about 10^{11} ohms per inch.

2. A static bleed resistor as described in claim **1** where said resistance element is a tow of about 10^5 longitudinal fiber or filament conducting paths, each of said fibers or filaments having a resistance of about 10^{11} ohms per inch.

3. A static bleed resistor as described in claim **2** where one terminal end of said low is exposed to the atmosphere.

4. A static bleed resistor as described in claim **2** where said one terminal end is conically shaped.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,767,971 Dated October 23, 1973

Inventor(s) Alexander J. Patrick, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 21, for "105", read --- 10^5 ---; Column 4, line 2, for "10 inches", read --- 10^{11} ---; and Column 4, line 48, for "low", read "tow".

Signed and sealed this 2nd day of April 1974.

(SEAL)
Attest:

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Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

PO-1050
(5/69)

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