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Richardson et al.

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[54] **STATIC ELIMINATOR**

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[52] **U.S. Cl.** ..... **317/2 F;** 317/2 F

[51] **Int. Cl.** **H01t 19/04**

[58] **Field of Search** ..... 317/2 R, 2 F, 262 A, 4

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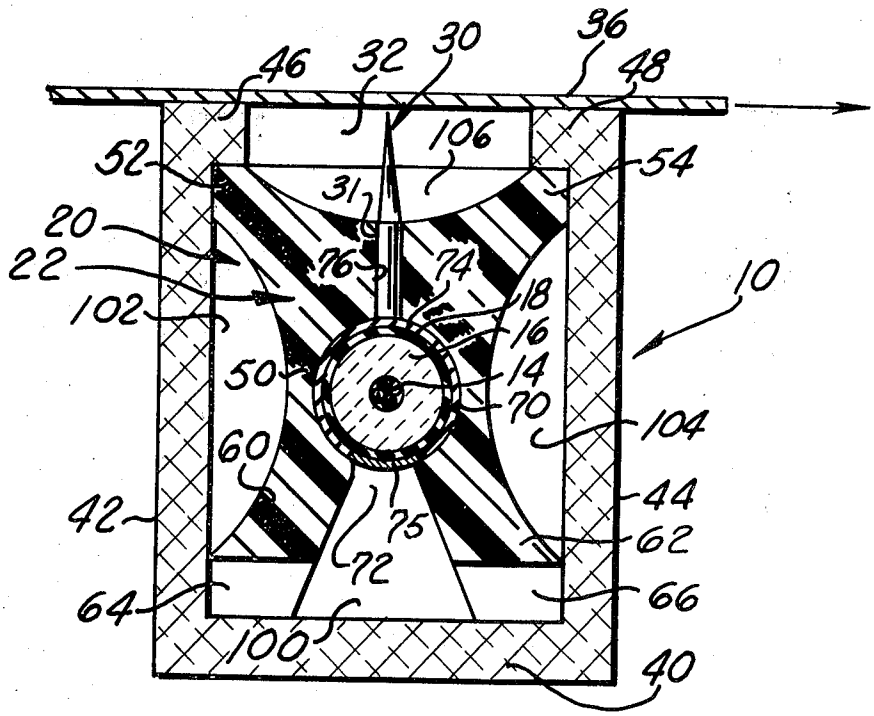
Primary Examiner—J. D. Miller

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[57] **ABSTRACT**

An improved static eliminator is provided for neutralizing accumulated electric static charge on a web or sheet material. The static eliminator includes an elongated cable of the type having an inner conductive core surrounded by a dielectric layer with the core being adapted to be connected to a high AC voltage source. A portion of the length of the cable extends longitudinally within an elongated hollow metal housing. An insulator is located within the housing and is constructed so as to mount the cable in place within the housing while minimizing electrical capacitance between the core and the housing.

12 Claims, 6 Drawing Figures



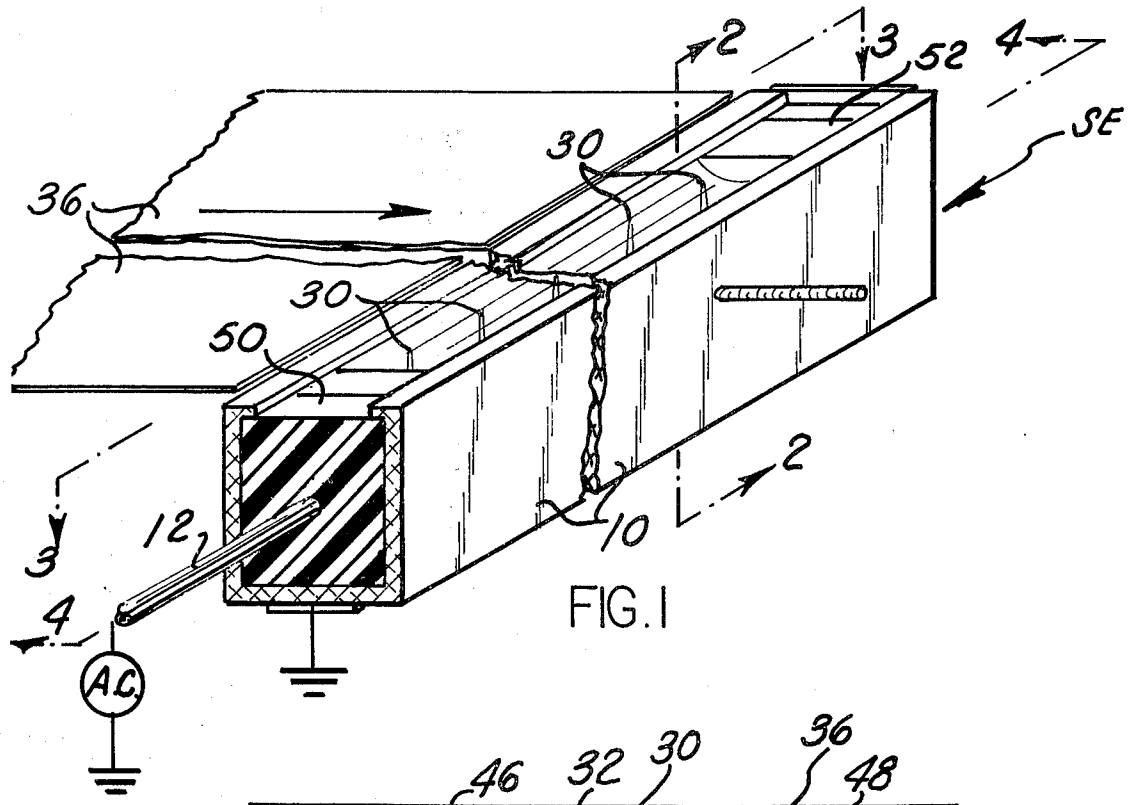


FIG. 1

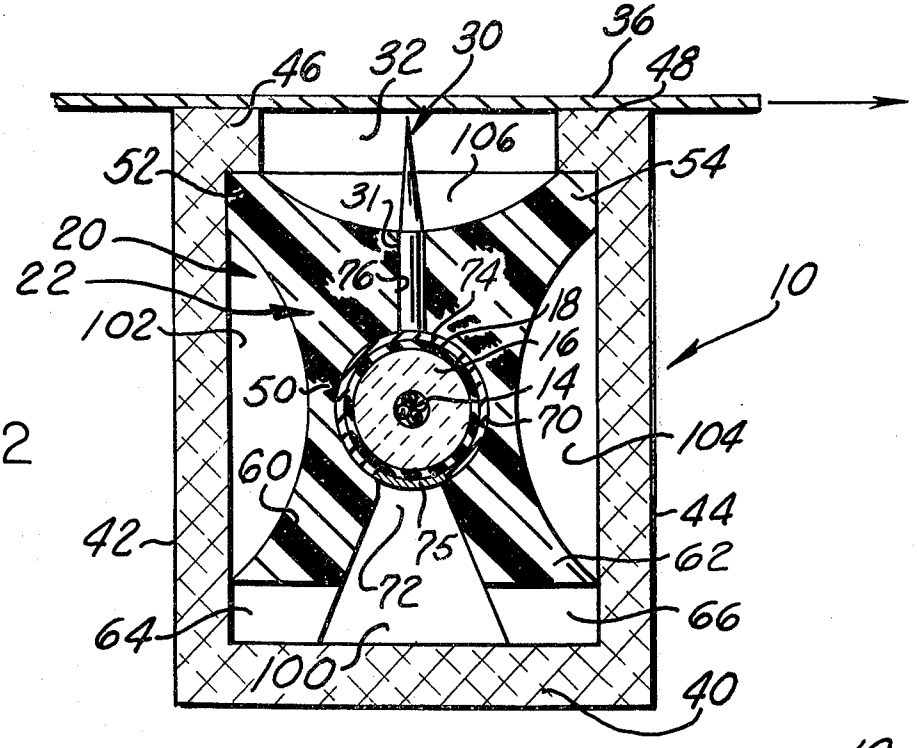


FIG. 2

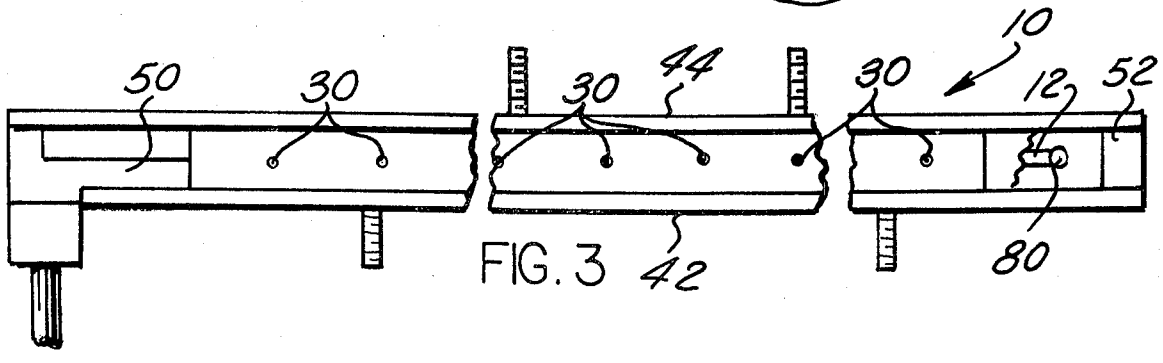


FIG. 3

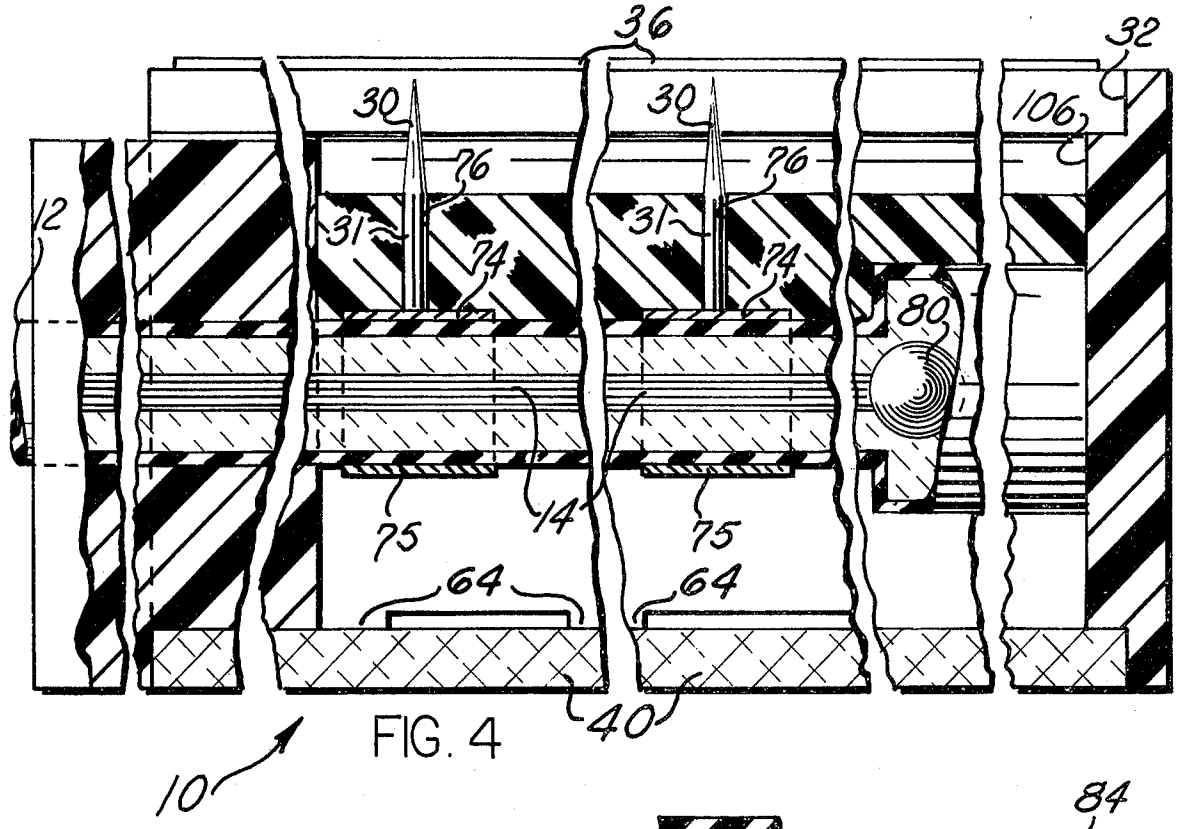


FIG. 4

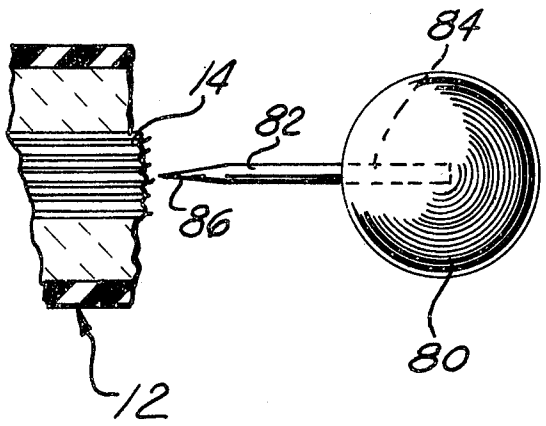


FIG. 5

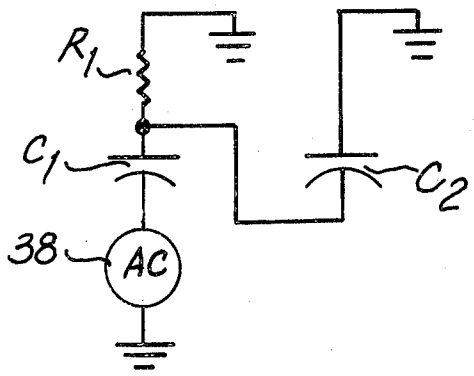


FIG. 6

STATIC ELIMINATOR

This invention relates to the art of static eliminators and, more particularly, to an improved static eliminator construction for removing or neutralizing static electricity accumulated on sheet material, such as paper or cloth when such material is processed so as to be charged with static electricity.

The invention is particularly applicable for use in conjunction with removing or neutralizing static charge on a web or sheet material processed by xerography of electrophotographic printing and will be described with particular reference thereto; although, it is to be appreciated that the invention may be utilized in various applications requiring the removal of static electric charge from material.

A typical static eliminator comprises an elongated cable having an inner conductive core surrounded by a dielectric layer. A plurality of needle-like projections are electrically connected to respectively associated conductive sleeves which are longitudinally spaced apart in close proximity to the cable. The assembly is mounted so as to be electrically insulated from a metallic housing which is, in turn, connected to electrical ground. A high voltage AC source on the order of 7,000 volts is connected between ground and the inner electrical core. The assembly is positioned such that the needle-like projections extend toward a web or sheet material having an accumulated static charge to be neutralized. The needle points do not make engagement with the web but are slightly spaced therefrom. The high AC voltage applied to the inner core produces an ionized field about the pointed ends of each needle-like projection and has the effect, when placed in the vicinity of a charged web or sheet, to neutralize the static charge accumulated thereon.

In the construction of such static eliminators, it is desirable that leakage current from the inner conductive core to the housing be minimized so as to not detract from the ability of the eliminator to provide an ionized field sufficient to neutralize static charge on a web or the like. The electrical circuit provided by such an eliminator includes capacitance between the inner core and the needles and a resistance from the needles through the web or the like to ground. An effective capacitance is also provided between the conductive core and the metal housing with this effective capacitance being in parallel with the previously mentioned resistance. The greater the effective capacitance, the greater will be the tendency to provide a path for leakage current, and hence, adversely effect the ability of the eliminator to provide an ionized field. Ideally, the conductive core should be suspended in air within the metal housing so as to minimize the dielectric therebetween and hence, minimize the magnitude of the effective capacitance. Obviously, such an idealized condition provides no means to support the cable within the housing.

It is, therefore, a primary object of the present invention to provide an improved static eliminator construction for minimizing the effective capacitance between the conductive core and the surrounding housing so as to thereby minimize leakage current.

It is a still further object of the present invention to provide a static eliminator wherein a conductive core is mounted within a metal housing or shield in such a manner as to minimize the dielectric constant therebetween while still providing support for the core.

In accordance with the invention, an improved static eliminator construction includes an elongated cable having an inner conductive core surrounded by a dielectric layer with the core being adapted to be connected to a high voltage AC source. A plurality of conductive needles are aligned in a spaced apart longitudinal array along the length of the cable with each needle having a sharp projection at one end facing in a direction away from the cable. An electrically conductive hollow housing has a longitudinally extending slot in communication with a longitudinally extending channel within the housing. The cable and the needles are mounted within the housing in a manner to minimize the leakage current between the core and the housing. This is accomplished with an insulator member which extends longitudinally within the housing. The insulator member has a body portion and mounting means extending from the body portion for engaging cooperating inner walls of the housing in such a manner to hold the insulator member in place. This insulator member has an inverted U-shaped groove therein and which extends longitudinally of the housing. The cable has a portion of its length received within the groove in such a manner that the cable is spaced from the walls of the housing. The needles extend through the insulator member in a direction toward the longitudinal opening in the housing and conductive means are interposed between the needles in the conductive core so as to provide capacitance therebetween.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and advantages of the invention will become more readily apparent from the following description of the preferred embodiment of the invention as taken in conjunction with the accompanying drawings which are a part hereof and wherein:

FIG. 1 is a perspective view illustrating the static eliminator constructed in accordance with the present invention;

FIG. 2 is a sectional view taken generally along line 2—2 looking in the direction of the arrows in FIG. 1;

FIG. 3 is a plan view taken generally along line 3—3 looking in the direction of the arrows in FIG. 1;

FIG. 4 is a sectional view, with parts broken away, taken generally along line 4—4 looking in the direction of the arrows in FIG. 1.

FIG. 5 is an enlarged fragmentary view illustrating the manner of installing a spherical ball to the terminated end of the cable; and

FIG. 6 is a schematic illustration of the equivalent circuit of the eliminator structure

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings wherein the showings are for purposes of illustrating a preferred embodiment of the invention only and not for purposes of limiting same, FIG. 1 is a perspective view illustrating a static eliminator SE constructed in accordance with the invention. The static eliminator includes an electrically conductive housing **10**, which may be constructed of aluminum, and is generally of rectangular shape in cross section. The housing is somewhat elongated and serves to carry a portion of the length of an insulated cable **12**. Cable **12** is conventional in the art and in-

cludes an inner electrical core **14** (see FIG. 2) surrounded by a dielectric layer **16** and an outer insulating layer **18**, which may be constructed of insulating material such as polyethelene. Housing **10** is provided with a longitudinally extending channel **20** in which there is mounted a longitudinally extending cable retaining member **22**, constructed of electrical insulating material. Retaining member **22**, in turn, carries a portion of the length of cable **12** as well as a plurality of needle-like projections **30**. These projections extend upwardly through member **22** and thence, into a longitudinally extending slot **32** defined in the upper face of housing **10**.

The housing **10** is of rectangular cross section and includes walls defining a bottom wall **40** and upstanding side walls **42** and **44** and which respectively terminate with inwardly extending flange portions **46** and **48**. The flange portions **46** and **48** terminate so as to define the slotted opening **32** which extends longitudinally of the length of the housing (see FIG. **1**). Walls **40, 42, 44** and flange portions **46** and **48** are preferably of uniform thickness, as is shown in FIG. **2**. The channel **20** defined by the walls is rectangular in cross section and extends throughout the length of the housing and is plugged at opposite ends by rectangular-shaped insulators **50** and **52**. The insulator cable retaining member **22** extends longitudinally within the housing and is interposed between plugs **50** and **52**.

The pointed end **34** of each projection **30** extends to a point just under the upper surfaces of inwardly extending flanges **46** and **48** of housing **10**. These upper surfaces are essentially flat and sheet material **36**, having an accumulated static charge, is passed over these flat surfaces so as to be located proximate to the pointed ends of projections **30**. The housing **10** is connected to electrical ground and an AC voltage source **38**, on the order of 7,000 volts is impressed between ground and the inner core **14**. This develops an ionizing field around the point **34** of each projection **30** for purposes of neutralizing the accumulated electric charge on the sheet material as it is passed over the upper surfaces of flanges **46** and **48**.

The cable retaining member **22**, as best shown in FIGS. **2** and **4**, has a body portion **50** spaced inwardly from the facing surfaces of walls **40, 42, 44** and flanges **46** and **48**. A pair of upwardly and outwardly facing leg members **52** and **54** extend from the body portion **50**. As will be noted from FIG. **2**, the inner surface of flange **46** and wall **42** forms a corner. Leg portion **52** extends to and is configured to conform with the corner so as to fit snugly therewith. Similarly, the inner faces of wall **44** and flange **48** define a corner and leg portion **54** extends to this corner and is configured so as to conform therewith for a snug fit. A pair of leg portions **60** and **62** extend downwardly and outwardly from the body portion **50** and terminates in non-continuous feet portions **64** and **66**. The feet portion **64** on leg portion **60** are spaced longitudinally along the insulator member **20** and are configured to conform with the inner corner defined by walls **40** and **42** so as to make snug fitting engagement therewith. Similarly, the feet portion **66** on leg portion **62** are spaced longitudinally along retainer member **22** and are configured so as to conform with the corner defined by walls **40** and **44** so as to make a snug fit therewith. During assembly, retainer member **22** is slid into the housing, with one of the end plugs **50** or **52** being removed, so the retainer member makes a sliding but snug fit with the inner corners of the housing.

The retainer member **22** has a cable carrying groove **70** extending longitudinally throughout its length with the groove being located approximately at the center of the body portion **50**. Groove **70** is essentially circular in cross section but is of slightly less diameter than cable **12**. The retainer member is constructed of material exhibiting some degree of resiliency so that leg portions **60** and **62** may be spread apart somewhat permitting a portion of the length of cable **12** to be snapped into place into the groove **70** by way of longitudinally extending slot **72**. Since the groove **70** is normally of smaller diameter of that than the cable, it will tightly hold the cable once the cable is snapped into place. This automatically positions the conductive core **14** of cable **12** at a location corresponding with the geometric center of the housing. The inner walls of groove **70** are painted at longitudinally spaced apart locations with a conductive layer so as to define a plurality of longitudinally spaced apart conductive layers **74** (see FIGS. **2** and **4**). Each conductive layer **74** is associated with one of the electrically conductive needles **30**. Each needle **30** has a cylindrical base portion **31** which extends through a suitable aperture **76** in the roof portion of retainer member **22**. The pointed end of each needle is exposed in the channel area of slot **32** and the cylindrical portion is mounted in the aperture **76** so as to make electrical contact with an associated electrically conductive layer **74**. Once the cable **12** has been snapped into place in groove **70**, the exposed lower surface (FIG. **2**) is painted at spaced apart portions to define conductive layers **75**, each of which corresponds with an associated conductive layer **74** to define a circular ring about the cable. Thus, these conductive circular rings define capacitor plates which are spaced along and extend coaxially about the inner conductive core **14**.

As shown in FIGS. **4** and **5**, cable **12** is terminated within the housing, leaving the conductive core exposed. This conductive core may be formed of stranded wires and the severed end of each wire may define a sharp point providing a source of corona discharge. If this is permitted, it might adversely effect the operation of the static eliminator by reducing the corona field at each needle **30**. Also, the corona discharge at the ends of such wire strands would tend to burn away the surrounding insulating material and conceivably provide a burn-out hole through the static eliminator housing. This effect is minimized by employing a corona ball **80** which is mounted flush up against the exposed end of cable **12**. Ball **80** may be constructed of electrically conductive material, such as aluminum. The ball carries a projecting pin **82** which extends radially outward therefrom and is secured to the ball, as by a press fit into a radially extending recess **84** or by welding. Preferably, pin **82** is constructed of relatively hard material, such as stainless steel, and is provided with a pointed end **86**. On assembly, the pointed end **86** is forced into the cable so as to engage the core **14** until the ball **100** abuts the exposed end of the cable, as is shown in FIG. **4**. Thereafter, a portion of the length of the end of the cable, including ball **80**, is encapsulated in an encapsulating cap **88**, which is preferably constructed of insulating bonding material to resist corona effects.

Reference is now made to FIG. 6 which provides an approximate equivalent circuit of the static eliminator. Here, electrical ground corresponds with the metal housing or shield **10.** Capacitor C_1, connected to the AC voltage source **38,** is comprised of two plates with one plate corresponding with conductive core **14** and the second plate corresponding with needles **30** in electrical contact with conductive layers **74.** Resistance R_1 represents the resistance taken from needles **30** through the air gap thence through the web material **36** to the grounded housing. In parallel with resistor R_1, there is shown a capacitor C_2 between the voltage source **38** and ground. This represents what may be termed as the stray capacitance between the conductive rings **74 – 75** and the surrounding metal housing **10.** The greater the magnitude of capacitor C_2 the greater will be the leakage current drawn thereby, leaving less current for the corona discharge needles **30.** As the value of capacitance C_2 increases relative to that of capacitance C_1, the leakage current will increase. If the capacitance of capacitor C_2 is great enough, leakage current will be sufficient to effectively eliminate corona discharge from needles **30.** Consequently then, the capacitance of capacitor C_2 should be such that it is substantially less than that of capacitor C_1 and the impedance of capacitor C_2 should be substantially greater than that of resistor R_1.

In constructing the static eliminator then, an ideal construction would be to have cable **12** suspended in air with no other dielectric medium interposed between the cable and the surrounding metal housing. Obviously, however, some support is required. The support must be of electrical insulating material to prevent short circuits between the conductive core or the capacitor plates or the needles and the surrounding housing. However, if the channel **20** is totally filled with an insulator block, the dielectric constant will be quite high, resulting in a very large capacitance value of capacitor C_2.

In accordance with the present invention, the insulator member **22** has been constructed so as to have longitudinally extending cut away recesses **100, 102** and **104** providing longitudinally extending air pockets between the insulator member and the respectively corresponding walls **40, 42** and **44.** Similarly, the upper portion of insulator member **22** has a longitudinally extending recess **106** extending longitudinally so as to define a somewhat enlarged channel opening for needles **30.** These cut away portions defined by recesses **100,** 102, 194, and **106** decrease the dielectric between the conductive paint **74–75** and the metal shield. This decreases the magnitude of capacitor C_2 while, at the same time, provides sufficient structural strength for the retainer member **22** to provide support for the cable **12** and the needles **30.** The leakage current is also minimized by increasing the surface distance by which current might flow from conductive layer **72** (FIG. **2**) to the metal housing **10** by orienting the structure such that the distance from the core **14** to wall **40** is greater than that to either side wall **42** or **44.** Also, the cut away portions leaving only spaced feet **64** connected to leg portion **60** or spaced apart feet **66** connected to leg portion **62,** the distance from the conductive layer **72** to the housing **10** is effectively increased.

From the foregoing then, it is seen that the static eliminator constructed in accordance with the present invention provides both mechanical and electrical improvements. From a mechanical standpoint, the snap fit of cable **12** into groove **70** and retainer member **22** permits a construction which does not require potting material or the like to hold the cable in place. This, then, provides for relatively quick assembly. In addition, by minimizing the dielectric between the conductive layer **74–75** and the metal housing **10,** the leakage current is minimized to thereby effectively increase the efficiency of the static eliminator.

Although the invention has been described in conjunction with a preferred embodiment, it is to be appreciated that various modifications may be made without departing from the scope of the appended claims.

We claim:

1. A static eliminator comprising an elongated hollow metal housing having walls defining internally facing bottom and side walls and a continuous longitudinally extending slot disposed opposite said bottom wall for defining a channel opening, an elongated cable having a portion of its length located within and extending longitudinally of said housing, said cable having an inner conductive core surrounded by a dielectric layer with said core adapted to be connected to a high voltage AC source; an array of longitudinally spaced electrically conductive needles, each having a sharp projection at one end facing in a direction away from said cable; said means for mounting said cable and said needles within said housing comprising a longitudinally extending insulator member mounted within said housing, said insulator member having a body portion and mounting means extending from said body portion for engaging said housing to hold said member in place, said member having an inverted U-shaped groove therein extending longitudinally of said housing, said cable having a portion of its length within said housing received in said groove, said needles extending through said member in the direction away from said groove so as to extend beyond said member in a direction toward said slotted opening.

2. A static eliminator, as set forth in claim **1,** wherein said insulator member has a plurality of recesses therein between said body portion and said housing to define air pockets and thereby minimize the dielectric constant between said core and said metal housing.

3. A static eliminator, as set forth in claim **2,** wherein said plurality of recesses extend longitudinally of said insulator member.

4. A static eliminator, as set forth in claim **3,** wherein said housing member has a plurality of longitudinally extending walls, each said recess being located so as to face one of said walls to define a said air pocket therebetween.

5. A static eliminator, as set forth in claim **4,** wherein said housing channel is essentially rectangular in cross section and is defined by said walls including a flat bottom wall and upstanding flat first and second side walls, said recesses including first, second and third recesses, respectively, interposed between said body portion and said bottom wall and said first side wall and said second side wall.

6. A static eliminator as set forth in claim **5,** wherein said housing includes first and second flange portions which extend inwardly from the upper ends of said first and second sidewalls and terminate so as to define said longitudinally extending slot.

7. A static eliminator as set forth in claim **6,** wherein said sidewalls, flange portions and said bottom wall de-

fine four inwardly facing longitudinally extending corner areas, said insulator mounting means including four leg portions extending from said body portion with each leg member engaging one of said corners to thereby mount said insulator member within said housing.

8. A static eliminator as set forth in claim **7**, wherein at least two of said leg portions are each configured to conform with its associated corner area so as to provide a snug, longitudinally slideable fit therewith.

9. A static eliminator as set forth in claim **8**, wherein each said leg portion extends longitudinally along said insulator member.

10. A static eliminator as set forth in claim **1**, wherein said insulator member has a longitudinally extending slot communicating with said groove to permit access for said cable.

11. A static eliminator as set forth in claim **10**, including downwardly extending leg portions straddling said access slot, said slot being normally of a width less than the diameter of said cable, said leg portions exhibiting sufficient resiliency that they may be spread apart to increase the width of said access slot so as to receive said cable therethrough for mounting in said groove.

12. A static eliminator comprising an elongated cable having an inner conductive core surrounded by a dielectric layer, said core adapted to be connected to a high voltage AC source; an array of longitudinally spaced electrically conductive needles, each having a sharp projection at one end facing in a direction away from said cable; an electrically conductive hollow housing having a longitudinally extending slot communicating with a longitudinally extending channel in said housing; and means for mounting said cable and said needles within said housing in such a manner to minimize leakage current between said core and said housing comprising a longitudinally extending insulator member mounted within said housing, said insulator member having a body portion and mounting means extending from said body portion and engaging cooperating facing walls of said housing to hold said member in place, said member having a substantially inverted U-shaped groove therein extending longitudinally of said housing, said U-shaped groove having an exposed opening facing in a direction opposite said longitudinal opening in said housing with the walls of said groove being spaced substantially away from said housing, said cable having a portion of its length received within said U-shaped groove such that said cable is spaced from said housing, said needles extending through said member in a direction toward said longitudinal opening in said housing, and conductive means interposed between said needles and said conductive core so as to provide capacitance therebetween.

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