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Wachtler et al.

[11] 3,916,270
[45] Oct. 28, 1975

[54] ELECTROSTATIC HOLDDOWN APPARATUS

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[21] Appl. No.: **466,437**

[52] **U.S. Cl.** .... **317/262 E**; 317/262 E
[51] **Int. Cl.^{2}** **H01N 13/00**
[58] **Field of Search** .... 317/262 E, 262 R

[56] **References Cited**

UNITED STATES PATENTS

3,634,740 1/1972 Stevko .... 317/262 E

FOREIGN PATENTS OR APPLICATIONS

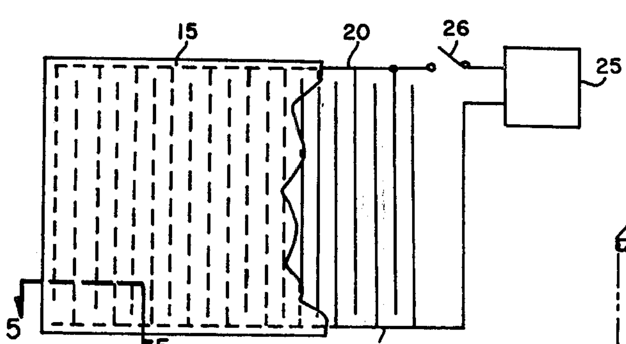
1,043,298 9/1966 United Kingdom

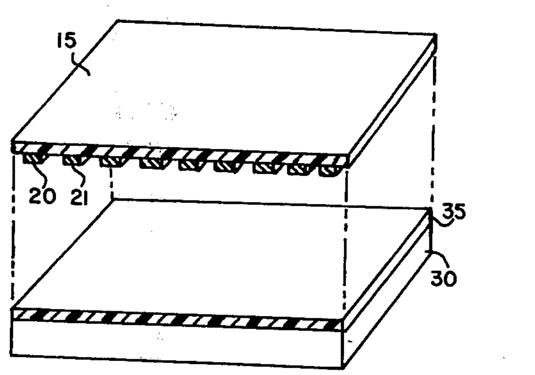
Primary Examiner—L. T. Hix
Attorney, Agent, or Firm—George T. Noe

[57] **ABSTRACT**

A flexible sheet providing a surface to which articles are adhered by electrostatic forces. A thin film of insulating material has a two-conductor electrode pattern etched or painted on the bottom surface thereof, so that the distance between the electrodes and the top surface of the film depends only on the thickness of the film. In accordance with Coulomb's Inverse Square Law, the electrostatic force developed on the top surface of the film can be optimized for a given thin film sheet. The flexible thin film sheet can be adhered to a variety of surfaces of arcuate or planar configurations.

5 Claims, 5 Drawing Figures





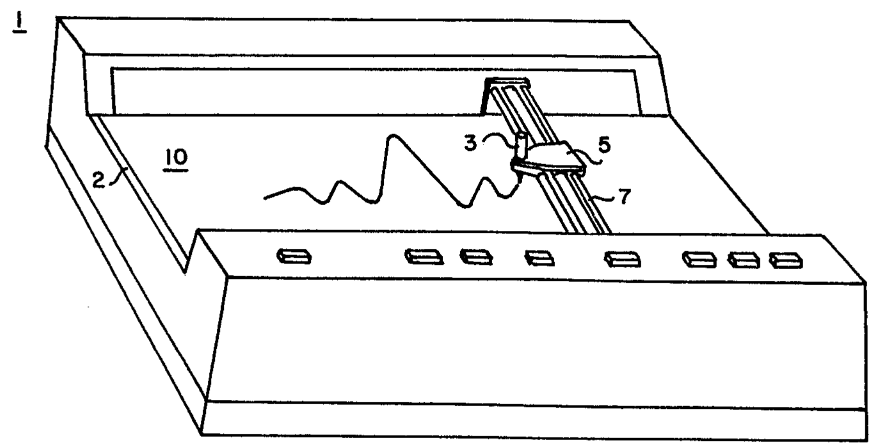


Fig-1

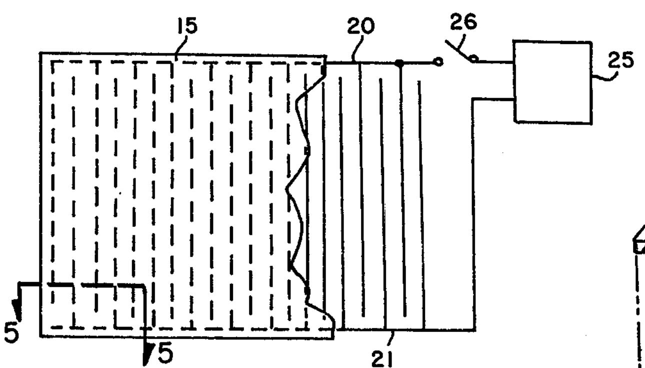


Fig-2

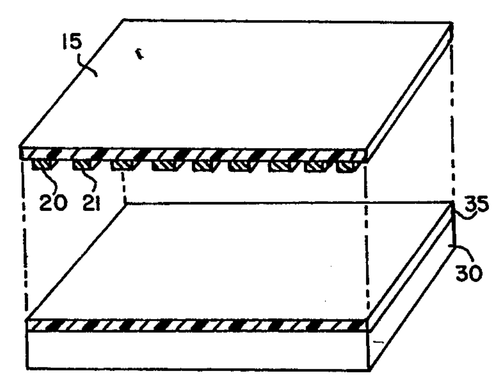


Fig-3

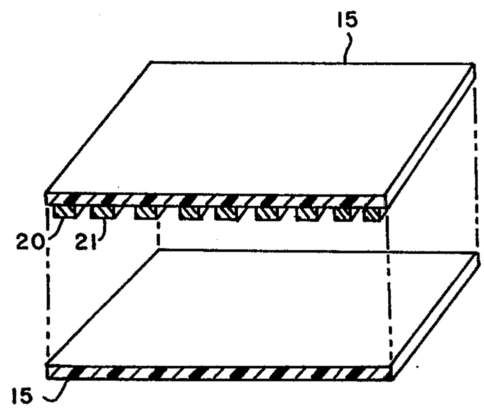


Fig-4

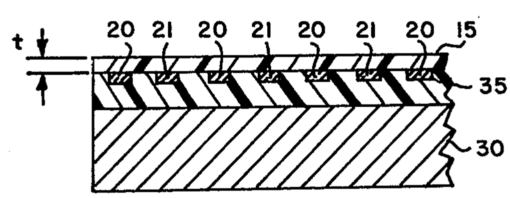


Fig-5

ELECTROSTATIC HOLDDOWN APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to an improved electrostatic holddown apparatus for use in applications such as on graphic plotters and drafting tables where it is desirable to adhere one material, such as paper, to another surface without clamps, vacuum, or adhesives, and more particularly relates to a method of fabricating such a holddown apparatus.

It is well publicized in the literature of the art that the principle of electrostatic attraction in accordance with Coulomb's Inverse Square Law can be utilized for attracting and retaining non-conductive articles and sheets to semiconductor or insulating surfaces. Coulomb's Inverse Square Law states that the force between two electrostatically charged bodies is proportional to the product of the magnitude of the charges on the bodies and inversely proportional to the square of the distance between them, expressed mathematically as $F=KQ_1Q_2/r^2$, where F is the resultant electrostatic force between the charged bodies, K is a proportionality factor representing the ratio of the absolute dielectric constant for the homogeneous dielectric medium separating the charged bodies to the dielectric constant for free space, Q_1 and Q_2 are the magnitudes of the charges on the surfaces of the two bodies, and r is the distance between them.

In order to hold material such as paper to a holddown surface by electrostatic forces, a concentration of charges of one polarity is required in the holddown apparatus and a concentration of charges of opposite polarity is required in the paper. The paper has two primary sources of charged particles that can be attracted. The first source comprises the free charged particles which are available within the paper's environment. The second source comprises the bound charge concentrations which are a result of the paper's polar characteristics.

It has been a common practice to provide a charge in a holddown surface, or a holddown board, by applying a difference in voltage potential across a pair of conductive electrodes which are intermeshed in a pattern chosen to provide a maximum stored charge without arcing between the conductors.

One prior art reference, a U.S. Pat. application, Ser. No. 302,544, filed Aug. 16, 1963 corresponding to British Patent Specification No. 1,043,298, teaches the use of two individual sets of conductors alternately intermeshed to which voltages are applied to provide the holddown board with areas of concentrated positive charge and areas of concentrated negative charge. The conductors may be fabricated by etching a conductive sheet which has been affixed to an insulating base layer, then a thin sheet of insulating material, such as fiberglass, is placed over the base layer and conductors to provide a protective layer. This protective layer is several mils in thickness, and it is difficult to control the distance r between the electrodes and the top surface of the protective layer because of irregularities in electrode thickness and the adhesives used to bond the materials. Consequently, a potential of 2000 volts is required to develop a suitable electrostatic field.

Another prior art device, U.S. Pat. No. 3,634,740, discloses an interdigitated electrode grid affixed to a base material, which is covered by a sheet of semiconductor material to permit the electrostatic field to quickly decay when the voltage is removed. This patent teaches that the top coating should be at least 10 mils thick as a practical limitation to minimize shock hazard, and that electrostatic holding action is created by applying an electrical potential between the electrodes of from 1,000 to 4,000 volts.

SUMMARY OF THE INVENTION

According to the present invention, an improved electrostatic holddown apparatus relying on the principles of Coulomb's Inverse Square Law in its application is provided. Two individual sets of conductors arranged in an intermeshed pattern are disposed on one side of a thin film sheet of insulating material, the other side of which provides the surface to which non-conductive materials such as paper may be adhered by electrostatic force when a difference in electrical potential is applied to the conductors. The distance between the conducting paths and the holddown surface is dependent only on the thickness of the insulating material, which can be as little as one-half mil and still provide the required insulation. Since the force of attraction between unlike charges will vary inversely with the square of the distance, a higher holding force can be developed for a given difference in voltage potential than was capable in prior art devices. Irregularities in conductor thickness are therefore not critical because the conductor-to-surface distance is uniform. Also, there is no adhesive between the conductors and the insulating material to increase the conductor-to-surface distance.

The holddown apparatus thus provided can be adhered to a variety of conductive or non-conductive base surfaces of either planar or arcuate configurations. Additionally, if no base surface is required, the insulating material including the conductor electrodes can be heat sealed to another sheet of the material to form a complete flexible holddown apparatus.

It is therefore one object of the present invention to provide an electrostatic holddown apparatus in which the electrical conductor-to-holddown surface is minimized.

It is another object of the present invention to provide an electrostatic holddown apparatus in which the holding force is increased for a given voltage.

It is a further object of the present invention to provide an electrostatic holddown apparatus in which the voltage required to produce a given electrostatic holding force is substantially lower than previous devices.

It is yet another object to provide a flexible electrostatic holddown apparatus which can be operated as a flexible unit or can be adhered to a variety of conductive and non-conductive base surfaces of arcuate and planar configurations.

Further objects, features, and advantages will be apparent from consideration of the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows a typical graphical plotter which utilizes an electrostatic holddown apparatus according to the present invention;

FIG. 2 shows a basic intermeshed electrode pattern for producing an electrostatic force field;

FIG. 3 shows an exploded view section of the holddown apparatus according to one embodiment of the present invention;

FIG. 4 shows an exploded view section of the holddown apparatus according to an alternative embodiment of the present invention; and

FIG. 5 shows a cross-sectional view taken along the line 5—5 of FIG. 2.

DETAILED DESCRIPTION

Turning now to the drawings, FIG. 1 shows a graphical plotter **1** having a platen **2** which has a planar plotting surface over which a pen **3** is passed to produce a graphical display in X-Y coordinates. The pen **3** is mounted in a pen holder **5** which moves along a bar assembly **7** in the Y-coordinate direction in accordance with electrical signals applied to the Y input channel of plotter **1**. The bar assembly **7** including the pen holder **5** moves across the plotter **1** in the X-coordinate direction in accordance with electrical signals applied to the X-input channel of plotter **1**. A sheet of paper **10** is positioned on the platen **2** to provide a record of the graphical display drawn by pen **3**, and it is imperative that paper **10** be adhered entirely smooth to the plotting surface without wrinkles to prevent display aberrations.

According to the present invention, the paper **10** is adhered to the surface of the platen **2** by electrostatic forces. Beneath the insulative surface **15** of the platen **2**, which is to be described in detail later, is an electrode grid such as the configuration shown in FIG. **2**. Two individual sets of conductive electrodes **20** and **21** respectively are alternately intermeshed and evenly spaced so that an electrical potential may be applied therebetween to produce an electrostatic field. A suitable D.C. voltage source **25** may be connected to and disconnected from the electrodes by switch **26**. In accordance with the novel construction of the holddown apparatus comprising the platen **2**, a D.C. voltage in the range of 400 to 900 volts applied between the electrodes **20** and **21** will develop an effective electrostatic force.

The platen **2** including the holddown apparatus according to the present invention is constructed as illustrated by the enlarged, exploded view of a section of the platen shown in FIG. **3**. A thin insulative sheet **15** having a thickness of from 0.5 mils to 2 mils has electrodes **20** and **21** disposed in intimate contact with the bottom surface thereof in accordance with the grid pattern shown in FIG. **2**. Depending on the material used for insulative sheet **15**, the electrodes may be applied using conventional photoprocessing techniques or using conductive paint. The holddown assembly thus constructed may then be adhered to a rigid base surface **30** by an adhesive **35** to provide a rigid holddown board, or may be adhered to another sheet of insulative material **15** to provide a flexible holddown apparatus as shown in FIG. **4**.

It has been determined that a polyvinyl flouride film, such as Tedlar, has excellent properties for use as the insulative sheet **15**. In addition to excellent dielectric characteristics and availability in thicknesses from 0.5 mils to 2 mils, it is smooth, durable, light in color, stain resistant, and readily cleaned with available cleansers.

In the preferred embodiment, a thin metal film is evaporated onto the lower surface of a sheet of polyvinyl flouride film. The metal film, which may be for example aluminum, copper, silver, etc., may vary from about 100 Angstroms to many thousands of Angstroms in thickness. For this process, a good rule of thumb in determining the thickness desired is to build up the metal film until it is substantially smooth to the touch. The desired electrode pattern is then etched, removing the undesired metal by conventional photoprocessing techniques.

The holddown apparatus thus constructed can be adhered to a variety of base surfaces because it is completely flexible. The base surfaces can be flat, cylindrical, or rectangular, and therefore provides an excellent electrostatic holddown surface for drum-type recorders and the like. Additionally, the base surfaces can be either rigid or flexible. A non-conductive glue may be used to adhere the holddown apparatus to a non-conductive surface. Mylar tape having adhesive on both sides can be used to adhere it to conductive surfaces such as aluminum. If no adhesive or base surface is required, polyvinyl flouride film can be heat sealed to itself to form a complete flexible holding unit.

FIG. **5** shows a cross-sectional view of the holddown apparatus according to the present invention, taken along the line **5—5** of FIG. **2**. The insulative sheet **15** supports the electrodes **20** and **21** as previously described, and is adhered to the base **30** by the adhesive **35**. As can be determined from FIG. **5**, the conductor-to-surface distance is the thickness t of the insulative sheet, so that in accordance with Coulomb's Inverse Square Law, the electrostatic holding force F is

$$F = K \frac{Q_1 Q_2}{t^2}$$

Since the thickness t is known and uniform, the holding force can be increased for a given voltage. More significantly, a lower voltage can be utilized to produce a sufficient electrostatic field, lower the shock hazard.

While we have shown and described the preferred and alternative embodiments of our invention, it will be apparent to those skilled in the art that many changes and substitutions may be made without departing from our invention in its broader aspects.

We claim:

1. An electrostatic sheet holddown apparatus, comprising:

a sheet of insulating material of substantially uniform thickness having a top surface and a bottom surface;

a plurality of intermeshed electrodes superposed on said bottom surface of said sheet in intimate contact with said sheet, said electrodes connected in two individual sets which are insulated from each other;

a base member; and

means for applying a difference in electrical potential between said two sets of electrodes so as to develop a uniform electrostatic field adjacent said top surface of said sheet of insulating material to electrostatically attract a sheet article thereto.

2. The apparatus according to claim **1** wherein said sheet of insulating material is from 0.5 mil to 2 mils thick, and said difference in electrical potential is from 400 volts to 900 volts.

3. The apparatus according to claim **1** wherein said sheet of insulative material is polyvinylflouride.

4. The apparatus according to claim **1** wherein said base member is substantially rigid and the surface thereof describes one of planar and arcuate shapes.

5. The apparatus according to claim **1** wherein said base member is substantially flexible.

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