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Robinson

(54) **APPARATUS AND METHOD FOR NEUTRALIZING STATIC CHARGE ON BOTH SIDES OF A WEB EXITING AN UNWINDING ROLL**

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USPC **361/213**; 361/220

(57) **ABSTRACT**

An apparatus and a method for neutralizing static charges on a web exiting an unwinding roll are disclosed. The apparatus comprises two static dissipaters. The first static dissipater is positioned to neutralize static charges on the outside surface of the unwinding roll. The second static dissipater is positioned to neutralize static charges on the inside surface of the web. The method comprises neutralizing static charges on the outside surface of the roll using a static neutralizer, separating the web from the roll at an unwinding nip, and subsequently neutralizing static charges on the inside surface of the web using a static neutralizer. Disclosed also are the apparatus and the method adapted for a roll that may be unwound in either the clockwise or in the counter-clockwise direction and from an unwind turret having a first spindle in a load position and a second spindle in a run position.

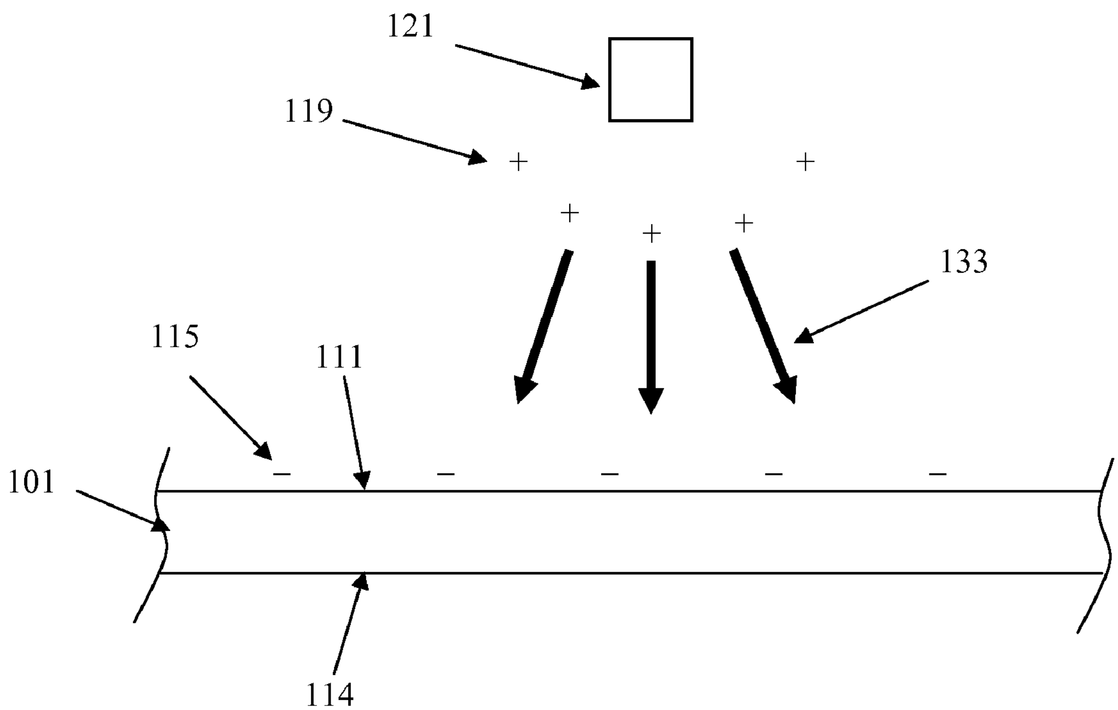


Fig. 1

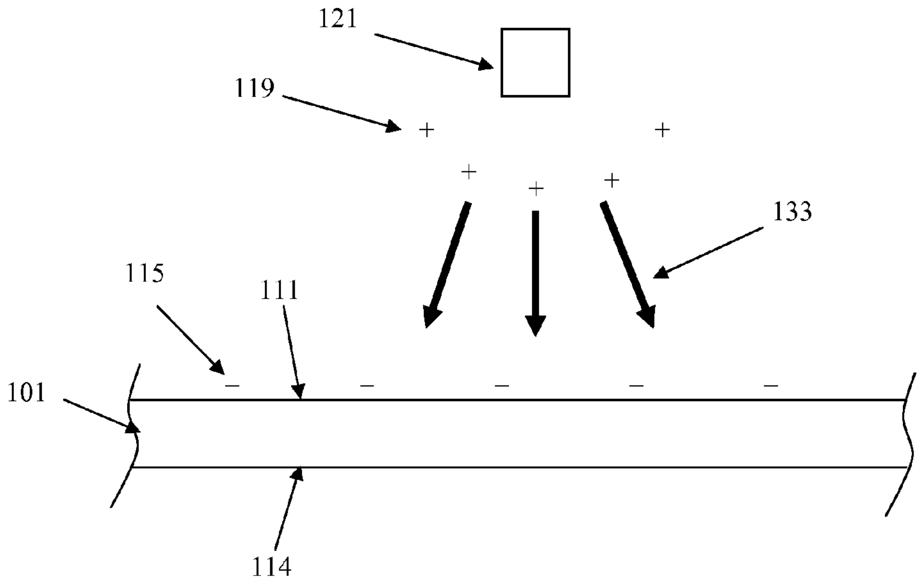


Fig. 2

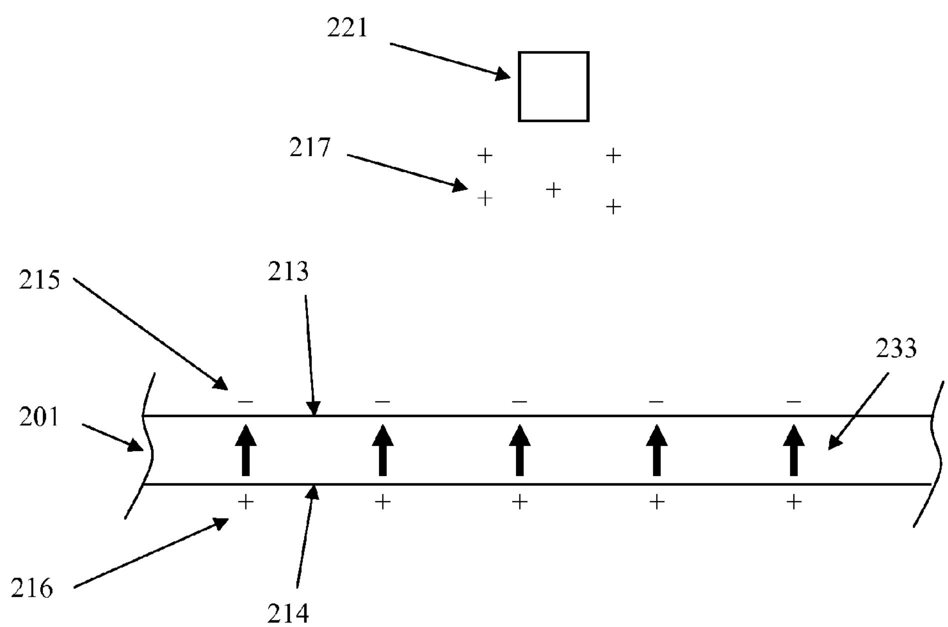


Fig. 3

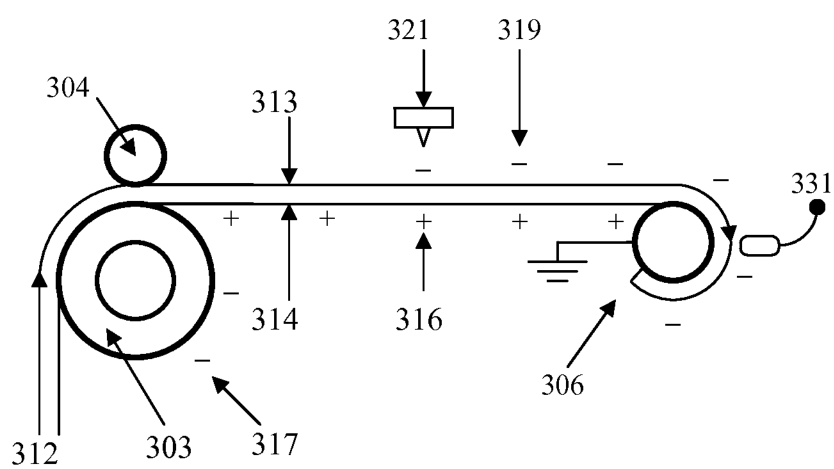


Fig. 4

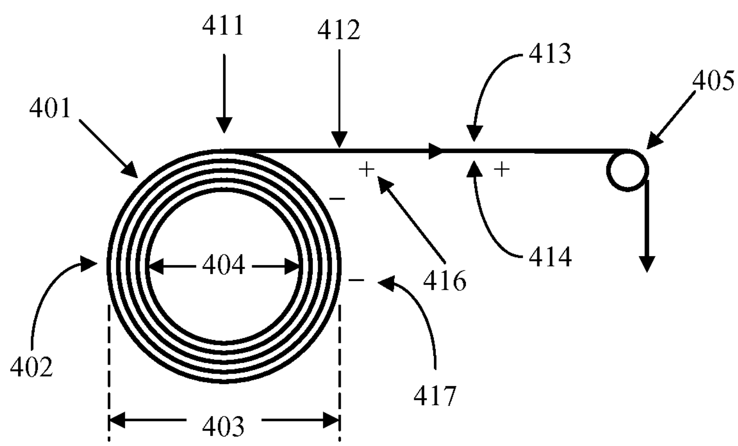


Fig. 5

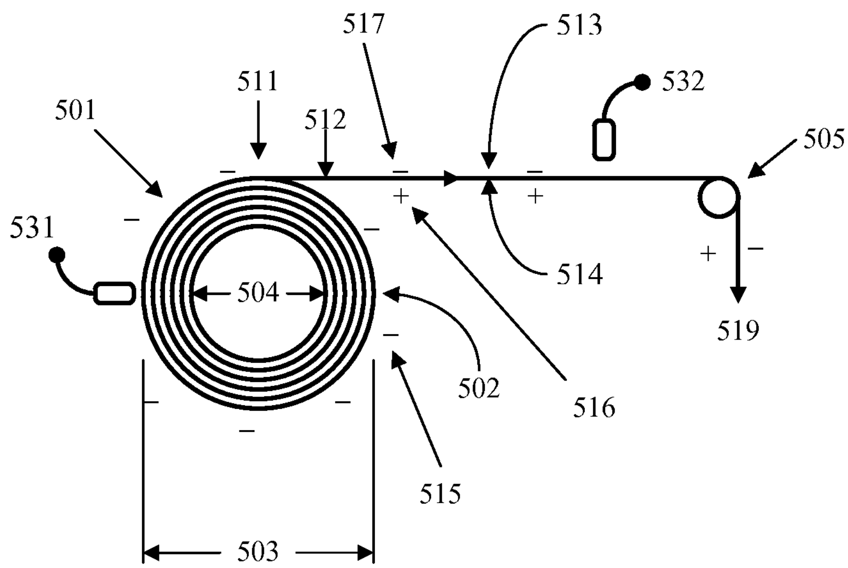
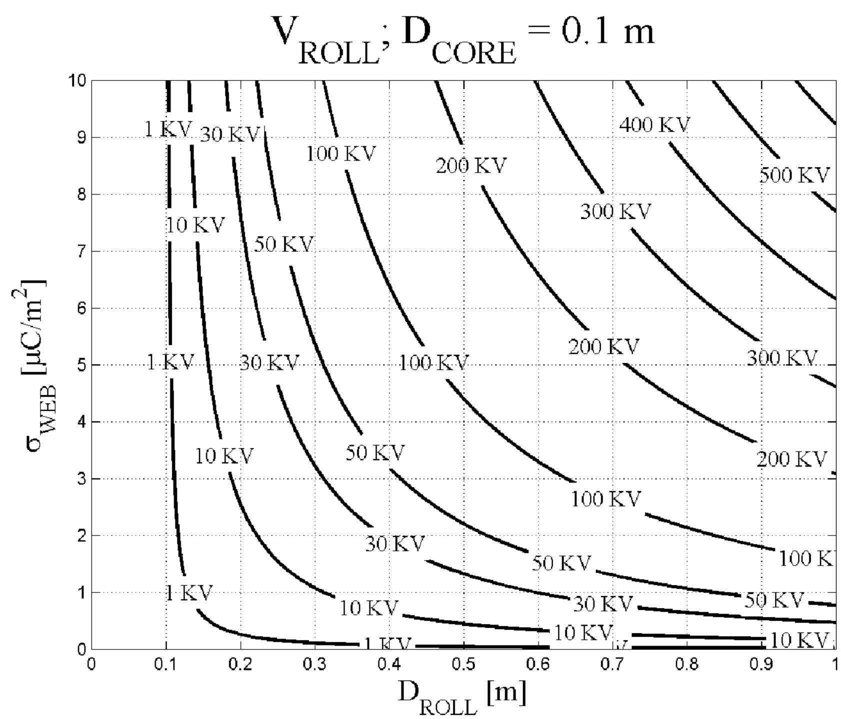


Fig. 6



V_ROLL; D_CORE = 0.1 m
σ_WEB [μC/m²]
D_ROLL [m]
0
1
2
3
4
5
6
7
8
9
10
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1 KV
10 KV
30 KV
50 KV
100 KV
200 KV
300 KV
400 KV
500 KV

Fig. 7

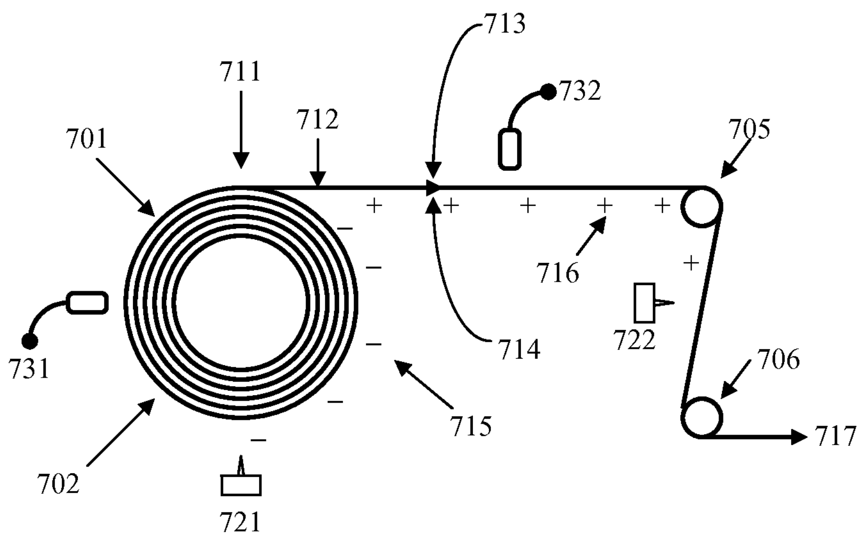


Fig. 8

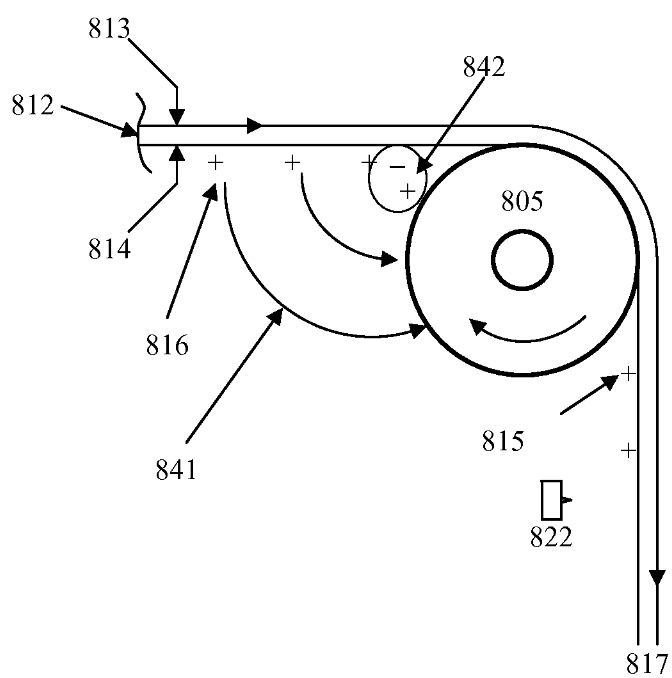


Fig. 9

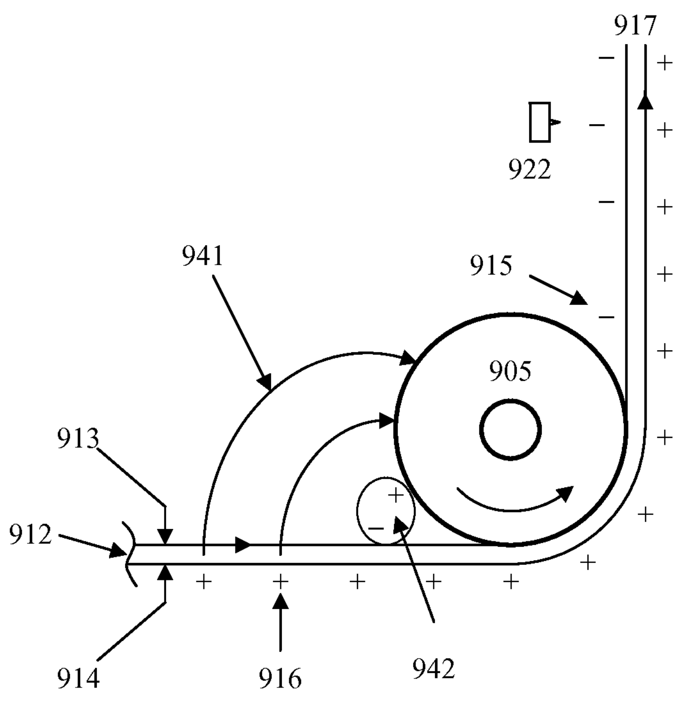


Fig. 10

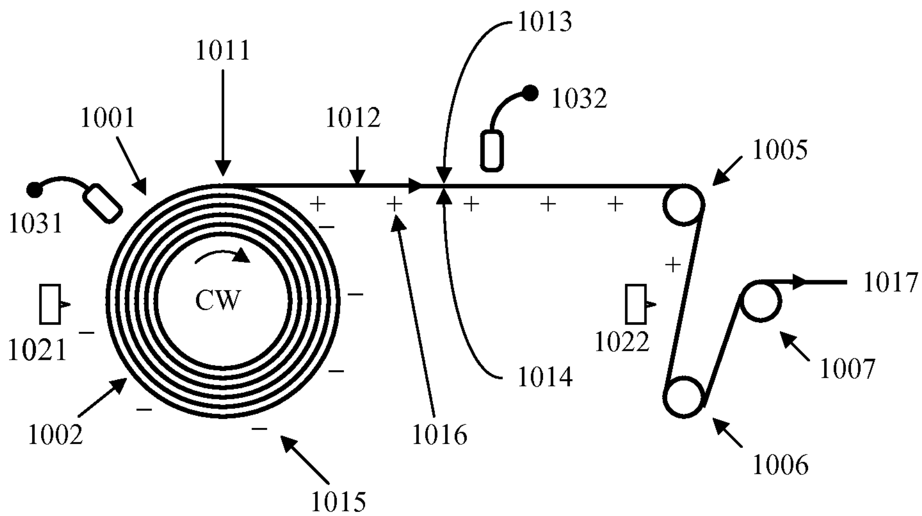

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Fig. 11

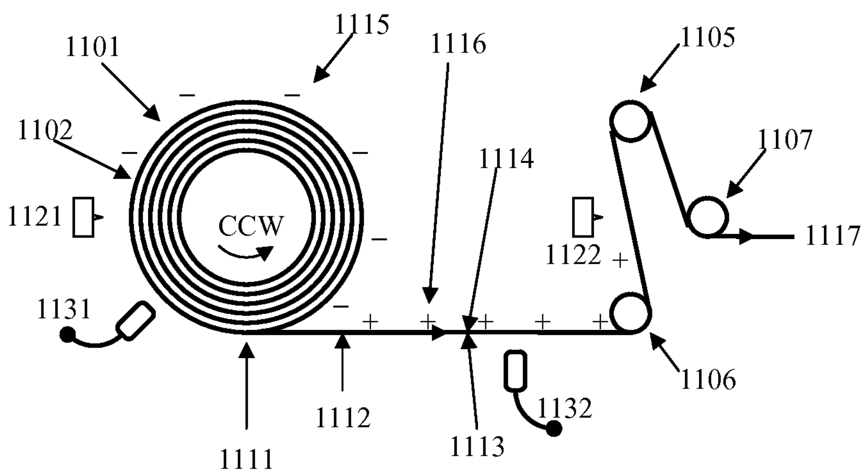
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Fig. 12

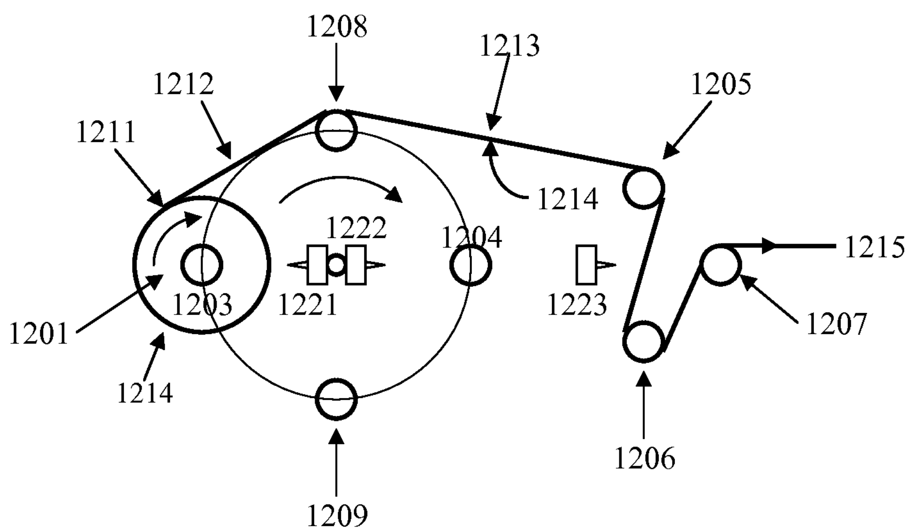
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Fig. 13

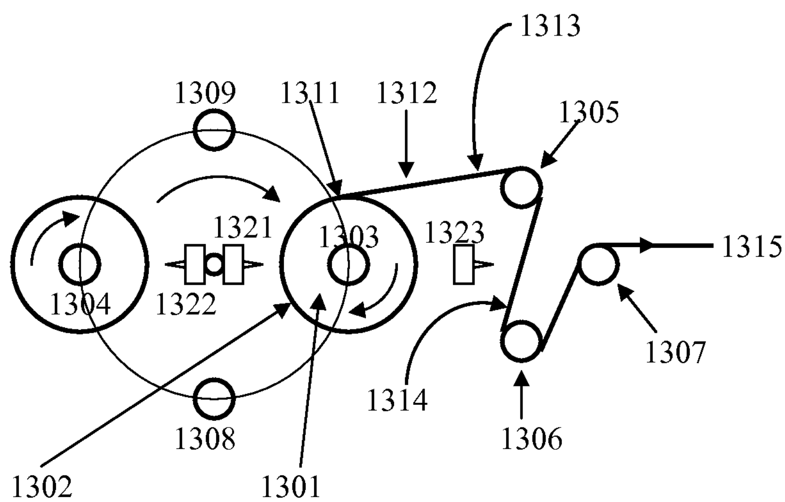
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Fig. 14

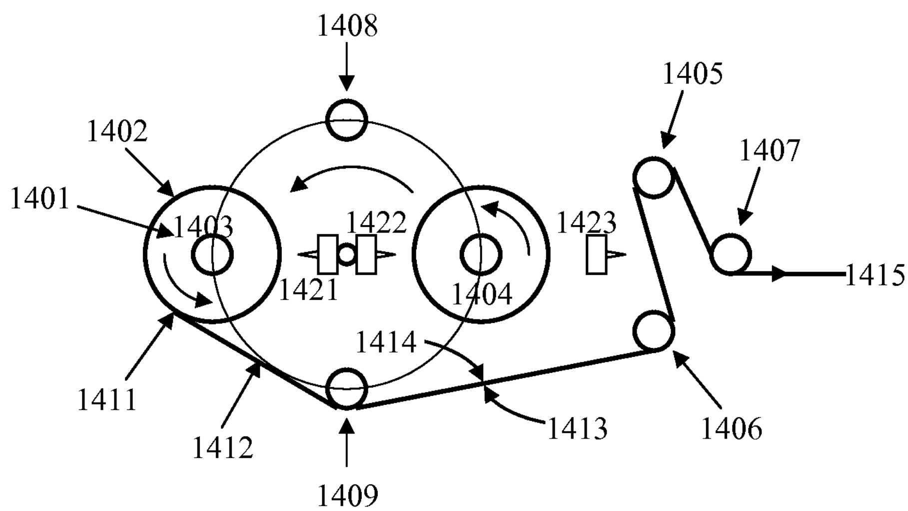
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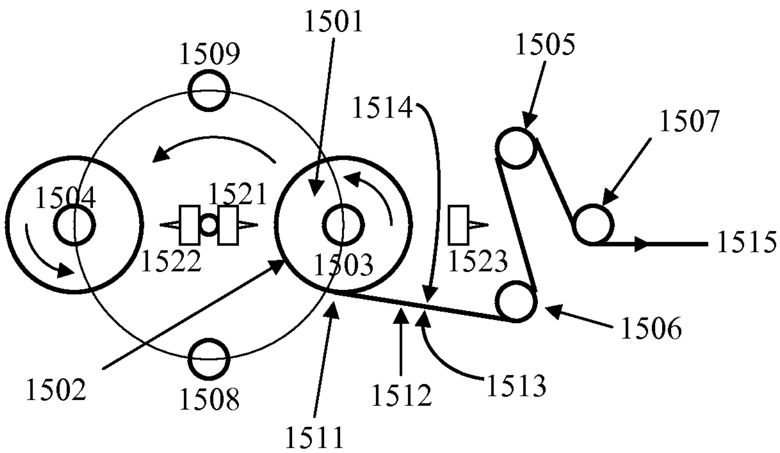
Fig. 15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APPARATUS AND METHOD FOR NEUTRALIZING STATIC CHARGE ON BOTH SIDES OF A WEB EXITING AN UNWINDING ROLL

RELATED APPLICATION

[0001] This patent application claims priority to provisional U.S. Patent Application 61/536,996 filed on Sep. 20, 2011 and entitled, "Apparatus and Method for Neutralizing Static Charge on an Unwinding Roll."

FIELD

[0002] The claimed invention generally relates to a method for neutralizing static charges, and more particularly to a method for using commercially available bipolar ion emitting devices to neutralize static charges on both sides of a web exiting an unwinding roll.

BACKGROUND

[0003] Electrostatic charges on webs cause problems for roll-to-roll manufacturing operations. Control of static on thin, flexible webs is important for the production of packaging materials. Static charges can attract dust and contaminants to the web, shock operators, ignite flammable solvents in printing or coating operations, and cause sticking in sheeting operations. Since electrically active components are susceptible to damage from electrostatic discharges, more effective charge control in roll-to-roll manufacturing is required to build or assemble electronic products including printed electronic circuits, electronic displays and inexpensive solar cells.

[0004] Static problems in the printing industry drove the development of early static dissipating devices. In U.S. Pat. No. 836,576 to HARDWICKE, a static dissipater is disclosed that is formed using a grooved plate having needles seated and clamped in the grooves. The electrostatic charge on nearby objects induces ions to form near the tips of the needles. Static dissipaters that operate by induction are termed passive devices because no external source of power is needed for their operation. However, passive devices become inactive when the electrostatic charge on the nearby object is too small to induce ionization. As a consequence, passive devices have a characteristic of dissipating static to a low, non-zero threshold level.

[0005] Six passive static dissipaters have been disclosed; (1) a needle or an array of needles as described above, (2) a static brush, (3) tinsel, (4) a rod wrapped with tinsel, (5) an ionizing cord, and (6) an ionizing rod. In U.S. Pat. No. 1,093,491 to SMITH, a (2) static brush is claim that is formed by a slit tube holding wire fabric having conductive strands. The strands need not touch the charged object. Rather, the static brush with conductive fibers must be placed simply within the field of static electricity. In U.S. Pat. No. 1,120,984 to THOMPSON, a (3) tinsel static discharger is disclosed that is made by clamping tinsel to a light, strong rod. In U.S. Pat. No. 1,396,318 to BUNGER, a (4) rod wrapped with tinsel static discharger is disclosed that is made by a core of copper or brass pipe upon which is wound a coil of metallic tinsel. In U.S. Pat. No. 5,690,014 to LARKIN, a (5) static cord is claimed made of non-conductive fiber strands braided to form a cord. One of the strands contains conductive microfibers that provide many ionizing points. In U.S. Pat. No. 5,690,014 to LARKIN, a (6) ionizing rod is claimed made of conductive fiber strands woven into a fabric sleeve sized to fit over a non-conductive core.

[0006] An active static dissipater requires an external source of power. In U.S. Pat. No. 940,431 to CHAPMAN, a static dissipater is disclosed having one or more discharge points that are connected to an AC high voltage source. The high voltage causes ions to form at the discharge points. Active devices have the characteristic of being able to dissipate static to a very low level that is much smaller than the threshold level of static characteristic of passive devices. The non-zero, low level is caused by the difference in electronic mobility between negative ions (higher mobility) and positive ions (lower mobility). Since the negative ions move at a higher speed through air, AC static bars typically provide an abundance of negative ions.

[0007] Seven active ionizers have been disclosed; (1) the AC static bar as describe above, (2) an air assisted ionizer, (3) a grid controlled ionizer, (4) a capacitively coupled AC ionizer, (5) an AC biased brush or a pair of DC biased static brushes, (6) a radioactive dissipater, and (7) a pulsed DC ionizer. In U.S. Pat. No. 1,169,428 to ROGERS, a (2) air assisted static dissipater is claimed that is a metal tube having a row of needles and holes to allow hot air inside to tube to blow onto the charge surface. In U.S. Pat. No. 940,429 to CHAPMAN, a (3) grid controlled ionizer is claimed that is conductor with fine points energized with a DC voltage opposite in polarity to that of the surface to be neutralized and interposing a screen between the ionizer and the surface to be neutralized. In U.S. Pat. No. 2,239,695 to BENNETT, a (4) capacitively coupled AC ionizer is claimed having discharge pins that, rather than being connected directly to the high voltage power supply are instead capacitively coupled. Capacitive coupling provides two important advantages. First, the generation of positive and negative ions is balanced thus eliminating the abundance of negative ions resulting in complete neutralization of objects. A second important advantage is the elimination of accidental high voltage shocks to operators and inadvertent sparks from the static bar to nearby grounded objects. In U.S. Pat. No. 4,363,070 to KISTLER, a (5) AC biased brush is claimed for neutralizing charge. And in U.S. Pat. No. 4,517,143 to KISTLER, a (5) pair of DC biased brushes are claimed for uniformly charging a moving web. Disclosed is that the uniform charge may be zero thus neutralizing static on the moving web. In U.S. Pat. No. 2,479,882 to WALLHAUSEN, a (6) radioactive static dissipater is disclosed. And in U.S. Pat. No. 3,711,743 to BOLASNY, a (7) pulsed DC excitation for controlling electrostatic potentials. A significant improvement for pulsed DC static eliminators is claimed in U.S. Pat. No. 4,542,434 to Gehlke where the pulse shape is changed by lengthening the time between ion generating pulses. This allows ions of one polarity to move further thus extending the effective ionization range of the static neutralizer.

[0008] In roll-to-roll manufacturing operations, the statically charged object to be neutralized is the web or areas on the web that have been coated or otherwise processed. The passive or active static dissipater in FIG. **1** must be located within the field of static electricity as taught in U.S. Pat. No. 1,093,491 to SMITH. Negative static charges **115** are on the top surface **111** of web **101**. A passive or active static dissipater **121** is located within the field of static electricity **133**. Ions **119** formed by static dissipater **121** move towards static charges **115** being forced by the electric field **133**.

[0009] The effectiveness of static dissipaters may be significantly improved by locating them in specific locations. For example, in U.S. Pat. No. 2,449,972 to BEACH shows static dissipaters located where the web exits conveyance rollers facing the side of the web that is not in contact with the rollers. This location is disclosed as preferred as the most convenient position. In subsequent research, (K. L. Clum, "Equilibrium Distribution of Charge on a Moving Conducting Film Web," *IEEE Transactions on Industry Applications*, Vol. 25, No. 1, January/February 1989), shows that, in the immediate vicinity of a conveyance roller, the distribution of electrostatic charge on a web varies with the product of web speed and web electrical surface resistivity. For example, the static charge density is highest in the region where the web exits the roller for a web having a surface resistivity in the range $0.6\text{-}6\times10^{+11}$ Ohms per square moving at a speed of 1 meter per second.

[0010] The static dissipaters as previously describe are typically located to neutralize the charged web to mitigate specific problems. For example, the winding roll at the end of a roll-to-roll manufacturing process can store a large amount of static charge and consequently pose a significant risk of electrical shock to operators. U.S. Pat. No. 3,392,311 to BOETEMANN claims draping electrically grounded conductive strands (tinsel) on the winding roll so that it is substantially free of static.

[0011] However, passive and active static dissipaters are not always effective in neutralizing static charge. For example, the active or passive static dissipater in FIG. **2** is ineffective in dissipating a specific pattern of charge on an insulating web. As disclosed in U.S. Pat. No. 7,388,736 to MORIOKA, the lines of force for a sheet having positive charge on one surface and negative charge on the opposite surface, especially if the pattern has a fine pitch, are closed between the negative charges and positive charges. In FIG. **2**, web **201** has negative static charges **215** on the top surface **213** and positive static charges **216** on the bottom surface **214**. Electric field **233** extends between the positive static charges **216** and the negative static charges **215** The electric field **233** is substantially confined to the region between the top surface **213** and bottom surface **214**. Consequently, ions **217** formed by static dissipater **221** are not drawn toward the web **201**. Hence, the static eliminators as previously discussed are ineffective in neutralizing a pattern of static charge where one surface has positive charge and the other surface has negative charge.

[0012] In U.S. Pat. No. 3,470,417 to GIBBONS, this charge pattern having equal but opposite charges on opposite sides of the material is termed "polar charge." Claimed is a method of neutralizing polar charge by positioning the web carrying polar charge between two facing, grid controlled AC ionizers. The ionizers are energized in a cooperative way so that when the first ionizer is energized with the positive voltage portion of the AC sinusoidal waveform, the second ionizer is energized with the negative voltage portion of the AC sinusoidal waveform. Hence, ions generated by the first ionizer are attracted towards the web by the ions of opposite polarity generated by the second ionizer. While this method is effective, disclosed in U.S. Pat. No. 7,388,736 to MORIOKA are sequential pairs of ionizers to improve neutralization performance by extending the time that the web is exposed to ions generated by the ionizers.

[0013] Polar charge is an important problem because the electric potential of a winding roll in FIG. **3** increases with each wound lap as disclosed in U.S. Pat. No. 7,388,736 to MORIOKA. An electrically neutral web **312** enters a nip formed by polymer covered roller **303** and metal roller **304**. Triboelectric charging occurs when two chemically different surfaces touch and separate. Upon exiting the nip, the surface of polymer roller **303** having touched web **312** carries negative static charges **317**. The bottom surface of web **314** having touched polymer roller **303** carries positive static charges **316** that are equal in magnitude and opposite in polarity to charge **317** on the surface of the polymer covered roller **303**. Note that triboelectric charging between metal roller **304** and the top surface **313** of web **312** is greatly smaller and insignificant compared with the triboelectric charging between polymer roller **303** and the bottom surface **314** of web **312**. A passive or active static dissipater **321** is located in a convenient location above the web facing the top surface **313** of the web **312**. The static dissipater is positioned within the electric field of positive static charges **316**. Consequently, static dissipater delivers negative charges **319** to the top surface of the web. The web entering the winding roll **306** is electrically neutral having positive static charges **316** on the bottom surface **314** and an equal amount of negative static charges **319** on the top surface **313** deposited by the static dissipater. However, the web carries polar charge. An electrostatic voltmeter **331** measures the electric potential of the first lap of the winding roll to be non-zero. The electric potential of one lap is typically in the range ±0.5-±100 volts. For the purpose of illustration, the electric potential of the lap is taken to be −10 volts, which is typical of Tribocharge web surfaces. The voltage is additive with each layer, so that the electric potential of the winding roll with 10 laps would be −100 volts. As the roll builds with thousands of laps, the electric potential of the winding roll can exceed ±20 KV causing sparks, electrical discharges, and shocks to operators.

[0014] It is desirable to have a way to neutralize polar charge, defined to be a charge pattern having static charges on one surface of a web and an equal amount of oppositely polarity static charges on the other surface. The means for neutralizing polar charge by supporting the web between pairs of facing AC static dissipaters is expensive. In addition, as the web speed increases beyond one hundred meters per minute, the effectiveness of pairs of facing AC static dissipaters to neutralizing polar charge decreases. It is desirable to have a method to neutralize polar charge for high speed roll-to-roll manufacturing operations where the web speeds exceed one hundred meters per minute.

SUMMARY

[0015] A static control method is disclosed for neutralizing static charges on both surfaces of a web exiting an unwinding roll. The static control method uses two static dissipaters. A first dissipater is located near the outside surface of the roll and it is positioned to neutralize the outside surface of the unwinding roll. A second dissipater is positioned to neutralize the inside surface of the web exiting the unwinding roll. The second dissipater is located along the web path prior to the first conveyance roller that touches the outside surface of the web.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] It will be appreciated that for purposes of clarity and where deemed appropriate that the various elements in the drawings have not necessarily been drawn to scale in order to better show the features.

[0017] FIG. **1** illustrates the operation of a static dissipater that is located within the electric field of the static charges on the top surface of a web.

[0018] FIG. **2** shows that the same static dissipater that would be effective in neutralizing charge located on only the top surface of the web is ineffective in neutralizing polar charge, which is a charge pattern where the web has static charges on a first surface and an equal amount of static charges having the opposite polarity on the second surface.

[0019] FIG. **3** shows that polar charge is an important issue because a winding a roll of web having polar charge results in the electric potential of the outside surface of the roll that increasing with each lap and become sufficiently large to cause sparks, electrical discharge, and shock operators.

[0020] FIG. **4** illustrates triboelectric charging that occurs at the unwinding nip of an unwinding roll.

[0021] FIG. **5** shows that triboelectric charging at the unwinding nip results in an electrostatic potential on the surface of the unwinding roll and polar charge on the web exiting the unwinding roll.

[0022] FIG. **6** shows the results of a theoretical calculation of the electric potential on the outside surface of an unwinding roll where the voltage can exceed 50 KV.

[0023] FIG. **7** illustrates the first embodiment of the apparatus to neutralize static on both sides of a web exiting an unwinding roll.

[0024] FIG. **8** shows that the conveyance rollers between the unwinding roll and the second static dissipater must touch the inside surface of the web because pre-nip ionization contributes to static neutralization.

[0025] FIG. **9** shows that when a conveyance roller touches the outside surface of a web with static only on the inside surface, pre-nip ionization forms polar charge.

[0026] FIGS. **10** and **11** illustrate a second embodiment of the apparatus to neutralize both surfaces of a web exiting an unwinding roll where the apparatus is adapted for rolls that can be unwound in either the clockwise or the counter-clockwise direction.

[0027] FIGS. **12**, **13**, **14**, and **15** illustrate a third embodiment of the apparatus to neutralize both surfaces of a web exiting an unwinding roll where the apparatus is adapted for an unwinding turret having a first unwinding spindle in a load position and a second unwinding spindle in a run position.

DESCRIPTION

[0028] In roll-to-roll manufacturing operations, the statically charged object to be neutralized is the web or areas on the web that have been coated or otherwise processed. The passive or active static dissipater in FIG. **1** must be located within the field of static electricity. Negative static charges **115** are on the top surface **111** of web **101**. A passive or active static dissipater **121** is located within the electric field **133** induce by static charges **115**. Static dissipater **121** forms ions **119** that move towards static charges **115** being forced by the electric field **133**.

[0029] The active or passive static dissipater in FIG. **2** is ineffective in dissipating polar charge. In FIG. **2**, web **201** has negative static charges **215** on the top surface **213** and positive static charges **216** on the bottom surface **214**. Electric field **233** extends between the positive static charges **216** and the negative static charges **215**. The electric field **233** is substantially confined to the interior region of the web **201** between the top surface **215** and the bottom surface **214**. Consequently, ions **217** formed by static dissipater **221** are not drawn toward the web **201**. Hence, the passive or active static dissipater **221** is ineffective in neutralizing polar charge.

[0030] Polar charge is an important problem because the electric potential of a winding roll in FIG. **3** increases with each wound lap. An electrically neutral web **312** enters a nip formed by polymer covered roller **303** and metal roller **304**. Triboelectric charging occurs when two chemically different surfaces touch and separate. Upon exiting the nip, the surface of polymer roller **303** having touched web **312** carries negative static charges **317**. The bottom surface of web **314** having touched polymer roller **303** carries positive static charges **316** that are equal in magnitude and opposite in polarity to charges **317** on the surface of the polymer covered roller **303**. Note that triboelectric charging between metal roller **304** and the top surface **313** of web **312** is greatly smaller and insignificant compared with the triboelectric charging between polymer roller **303** and web **312**. A passive or active static dissipater **321** is located in a convenient location above the web facing the top surface **313** of the web **312** and located within the electric field of positive static charges **316**. Consequently, static dissipater delivers negative charges **319** to the top surface of the web. The web entering the winding roll **306** is electrically neutral having positive static charges **316** on the bottom surface **314** and an equal amount of negative static charges **319** on the top surface **313** deposited by the static dissipater. However, the web carries polar charge. An electrostatic voltmeter **331** measures the electric potential of the first lap of the winding roll to be non-zero. The electric potential of one lap is typically in the range ±0.5-±100 volts. For the purpose of illustration, the electric potential of the lap is taken to be −10 volts, which is typical of triboelectrically charged web surfaces. The voltage is additive with each layer, so that the electric potential of the winding roll with 10 laps would be −100 volts. As the roll builds with thousands of laps, the electric potential of the winding roll can exceed ±20 KV causing sparks, electrical discharges, and shocks to operators.

[0031] FIG. **4** illustrates triboelectric charging that occurs at the unwinding nip of an roll. Roll **401** with outside diameter **403** is wrapped on a core having a diameter **404**. At the unwinding nip **411**, the outer lap of web exits the roll. The first span of web **412** extends from the unwinding nip to the first conveyance roller **405**. The unwinding roll has an outside surface **402**. The first web span has an outside surface **413** that corresponds to the outside surface of the unwinding roll **402** and an inside surface **414**. At the unwinding nip, the inside surface of the first web span is peeled from the outside surface of the unwinding roll. The outside surface of the unwinding roll and the inside surface of the first web span may be chemically different when, for example, the web is a laminate or has been coated on one side. When two chemically different surfaces touch and separate, tribocharging causes one surface to carry positive static charges and the other surface to carry an equal amount of negative static charges. To illustrate tribocharging, the unwinding roll in FIG. **4** has turned a quarter turn clockwise. Here, the outside surface of the roll has negative static charges **417** and the inside surface of the first web span has positive static charges **416**. The polarities of the charged surfaces may be reversed depending on the relative positions of the materials on the triboelectric series.

[0032] FIG. **5** shows the electrostatic charge distribution as the roll continues to unwind. Roll **501** with outside diameter **503** is wrapped on a core having a diameter **504**. At the unwinding nip **511**, the outer lap of web exits the unwinding roll. The first span of web **512** extends from the unwinding nip to the first conveyance roller **505**. The roll has an outside surface **502**. The first web span has an outside surface **513** that corresponds to the outside surface of the roll and an inside surface **514**. At the unwinding nip, the inside surface of the first web span is peeled from the outside surface of the roll. Tribocharging causes the outside surface of the roll to have negative static charges **515** and causes the inside surface of the first web span to have positive static charges **516**. As the roll unwinds, the top surface of the first span carries the negative charges **517** formerly on the outside surface of the unwinding roll. Consequently, the web span exiting has polar charge, defined as positive charge on one surface and an equal amount of negative charge on the other surface. This charge distribution is confirmed by measuring the electric field near the first span of web exiting the unwinding roll using an electrostatic fieldmeter **532** to find that the electric field is nearly zero. The electric potential of the unwinding roll is measured using electrostatic voltmeter **531** to find that the potential is highly negative.

[0033] FIG. **6** shows the results of a theoretical calculation of the electric potential on the outside surface of an unwinding roll. The voltage is calculated using the capacitance of the roll.

$$Q_{ROLL}=C_{ROLL}V_{ROLL} \tag{1}$$

The charge Q_{ROLL} on the surface of the roll is written in terms of the web charge density σ_{WEB} in (2).

$$Q_{ROLL}=\sigma_{WEB}A_{ROLL}=\sigma_{WEB}(\pi D_{ROLL}W_{WEB}) \tag{2}$$

[0034] The roll capacitance C_{ROLL} is estimated in (3) as the capacitance between concentric cylinders (Smythe, W. R., "2.04. Cylindrical Capacitors," *Static and Dynamic Electricity,* 3rd ed., McGraw-Hill, New York, 1968, pg. 28).

$$C_{ROLL} = \frac{2\pi\kappa_{WEB}\varepsilon_0 W_{WEB}}{\ln\left(\frac{D_{ROLL}}{D_{CORE}}\right)} \tag{3}$$

Solve (1) for V_{ROLL} and use (2) and (3) to find (4) that is plotted in FIG. **6** for a 0.1 m (~4 inch) roll core diameter.

$$V_{ROLL} = \frac{\sigma_{WEB}D_{ROLL}}{2\kappa_{WEB}\varepsilon_0}\ln\left(\frac{D_{ROLL}}{D_{CORE}}\right) \tag{4}$$

For a surface charge density of 1 $\mu C/m^2$, which is typical of tribocharging, the voltage of large rolls (1 m diameter) can exceed 50 KV. This voltage is sufficiently high to cause sparks from the roll surface to the core along the sidewall of the roll. Sparks may also occur between the roll surface and nearby grounded objects such as the machine frame or operators.

[0035] FIG. **7** illustrates the first embodiment of the apparatus to neutralize static charges on both sides of a web exiting an unwinding roll. The web **712** exits the roll **701** at the unwinding nip **711**. Tribocharging causes the outside surface **702** of the roll to have negative static charge **715** and causes the inside surface **714** of the web exiting the roll to have positive static charge **716**. Static dissipater **721** is positioned to neutralize static charge on the outside surface of the roll. Electrostatic voltmeter **731** confirms that the electric potential of the outside surface of the unwinding roll is zero. As a result of neutralization by static dissipater **721**, the outside surface **713** of the web exiting the roll is now electrically neutral. Electrostatic fieldmeter **732** confirms that the electric field near the web exiting the unwinding roll is highly positive due to the positive charge on the inside surface of the web span. Static dissipater **722** is positioned after the first conveyance roller **705** and prior to the second conveyance roller **706** to neutralize static charge on the inside surface of the web. As a result, the exiting web **717** is electrically neutral.

[0036] The neutralizing performance of a passive or active static dissipater decreases with increasing distance from the charged object. Static dissipater **721** is positioned to neutralize the outside surface of the roll. However, the outside diameter of the roll decreases with time. For mechanical simplicity, static dissipater **721** is preferably mounted in a fixed position. As the roll diameter decreases, the distance between dissipater **721** and the outside surface **702** of the unwinding roll increases. While static dissipater **721** can be a passive or active, using an active dissipater is preferred because active static dissipaters have a greater range of neutralization than passive static dissipaters. Most preferred is to use a pulsed DC energized ionizer where the pulse shape is changed by lengthening the time between ion generating pulses. This allows ions of one polarity to move further thus extending the effective ionization range of the static neutralizer as describe in U.S. Pat. No. 4,542,434 to Gehlke.

[0037] Static dissipater **722** could be located along the first web span **712** exiting the roll **701**. However, the outside diameter of the roll **701** decreases with time. For mechanical simplicity, static dissipater **722** is preferably mounted in a fixed position. As the diameter of the unwinding roll **701** decreases, the unwinding nip **711** moves towards the core and the physical location of the first web span **712** moves. Hence, the distance between static dissipater **722** and the first web span **712** would decrease with time changing the neutralizing performance of the dissipater. Locating static dissipater **722** after the first conveyance roll is preferred because the position of the web span is determined by the fixed locations of conveyance rollers **705** and **706**. Consequently, the distance between the dissipater **722** and the web is constant. This constant spacing enables good performance of static dissipater **722** when using either passive or active devices. Preferably, static dissipater **722** is a pulsed DC device with balance ion output as taught by U.S. Pat. No. 3,711,743 to BOLASNY.

[0038] After neutralizing the static charges on the outside surface of the roll, the web **812** in FIG. **8** exiting the roll will have static charges **816** located on the inside surface **814**. On the web path between the unwinding roll and static dissipater **822**, all conveyance rollers must touch the inside surface of the web. As the charged web **812** approaches the first conveyance roller **805**, an electric field the electric field **841** will extend between the static charges **816** and the roller **805**. Because roller **805** touches the inside surface **814** of the web, the electric fields **841** do not cross through web **812**. When the density of static charges **816** exceeds a threshold level of approximately ±4 $\mu C/m^2$, the electric field exceeds the breakdown strength of air forming a region of ionization **842**, commonly called pre-nip ionization. Within the region of ionization, positive and negative ions are formed. The ions with a polarity the same as static charges **816** deposit on the roller. The ions with a polarity opposite to static charges **816** deposit on the inside surface **814** of the web and partially neutralize the static. The result is that static charges **815** on the inside web surface exiting the roller are partially neutralized. Static dissipater **822** facing the inside web surface **814** located along the web path after roller **805** neutralizes the static charges **815** remaining on the inside surface **814** of the web. As a consequence, the exiting web **817** is fully neutralized and carries no static charge.

[0039] In contrast to the roller **805** in FIG. **8**, roller **905** in FIG. **9** touches the outside surface **913** of the web exiting the roll. FIG. **9** illustrates that static neutralization is compromised by a roller that touches the outside surface of the web prior to static dissipater **922**. After neutralizing the static charges on the outside surface of the roll, the web **912** in FIG. **9** exiting the roll will have static charges **916** located on the inside surface **914**. As the charged web **912** approaches conveyance roller **905**, an electric field the electric field **941** will extend between the static charges **916** and the roller **905**. Because roller **905** touches the outside surface **913** of the web, the electric fields **941** cross web **912**. When the density of static charges **916** exceeds a threshold level of approximately ±4 $\mu C/m^2$, the electric field exceeds the breakdown strength of air forming a region of ionization **942**, commonly called pre-nip ionization. Within the region of ionization, positive and negative ions are formed. The ions with a polarity the same as static charges **916** deposit on the roller. The ions with a polarity opposite to static charges **916** deposit on the outside surface **913** of the web. The result is that static charges **915** deposited by pre-nip ionization reside on the outside web surface exiting the roller. Charges **916** on the inside surface of the web are unchanged and remain on the exiting web **917**. The charges **915** and **916** on the web exiting roller **905** are a combination of polar charge, paired positive and negative charges residing on opposite surfaces of the web, and an abundance of unpaired positive charges residing on the inside surface **914** of the web. Static dissipater **922** facing the outside web surface **913** located along the web path after roller **905** responds only to the unpaired positive charges on the inside surface and deposits additional negative charges on the outside surface **913** equal in magnitude to the number of unpaired positive charges on the inside web surface **914**. The consequence it that the exiting web **917** carries polar charge were each charge on the inside surface **914** of the web **912** exiting the roll has a paired charge of opposite polarity on the outside surface **913**.

[0040] FIG. **10** illustrates a second embodiment of the apparatus to neutralize static charges on both surfaces of a web exiting an unwinding roll where the apparatus is adapted for rolls that can be unwound in either the clockwise or the counter-clockwise direction. The advantage of this second embodiment is that only a simple change in web path is needed when the unwind direction of the roll is changed. The locations of the static dissipaters are fixed and unchanged.

[0041] In FIG. **10**, a roll **1001** is unwound in the clockwise direction. A web **1012** exits the roll **1001** at an unwinding nip **1011**. Tribocharging causes the outside surface **1002** of the unwinding roll to have negative static charge **1015** and causes the inside surface **1014** of the web exiting the roll to have positive static charge **1016**. Static dissipater **1021** is positioned to neutralize static charge on the outside surface of the roll. Electrostatic voltmeter **1031** confirms that the electric potential of the outside surface of the unwinding roll is zero. As a result of neutralization by static dissipater **1021**, the outside surface **1013** of the web exiting the roll is now electrically neutral. Electrostatic fieldmeter **1032** confirms that the electric field near the web exiting the roll is highly positive due to the positive charge on the inside surface of the web. Static dissipater **1022** is positioned after the first conveyance roller **1005** to neutralize static charge on the inside surface of the web. The web is subsequently conveyed over a second conveyance roller **1006** and a third conveyance roller **1007**. As a result, the exiting web **1017** is electrically neutral.

[0042] FIG. **11** illustrates the second embodiment of the apparatus to neutralize static charges on both surfaces of a web exiting an unwinding roll where the apparatus is adapted for rolls that can be unwound in either the clockwise or the counter-clockwise direction. In FIG. **11**, a roll **1101** is unwound in the counter-clockwise direction. The web **1112** exits the roll **1101** at the unwinding nip **1111**. Tribocharging causes the outside surface **1102** of the roll to have negative static charge **1115** and causes the inside surface **1114** of the web exiting the roll to have positive static charge **1116**. Static dissipater **1121** is positioned to neutralize static charge on the outside surface of the unwinding roll. Electrostatic voltmeter **1131** confirms that the electric potential of the outside surface of the unwinding roll is zero. As a result of neutralization by static dissipater **1121**, the outside surface **1113** of the web exiting the roll is electrically neutral. Electrostatic fieldmeter **1132** confirms that the electric field near the web exiting the roll is highly positive due to the positive charge on the inside surface of the web. Static dissipater **1122** is positioned after the first conveyance roller **1106** to neutralize static charge on the inside surface of the web. The web is subsequently conveyed over a second conveyance roller **1105** and a third conveyance roller **1107**. As a result, the exiting web **1117** is electrically neutral.

[0043] In FIG. **10** and FIG. **11**, the positions of corresponding static dissipaters **1021** & **1121** located to neutralize the unwinding roll, corresponding static dissipaters **1022** & **1122** located to neutralize the inside surface of the web, and corresponding conveyance rollers **1005** & **1105**, **1006** & **1106**, and **1007** & **1107** are fixed. The advantage of this second embodiment of the apparatus to neutralize static charges on both sides of a web exiting an unwinding roll is that only a simple change to web path is needed when the unwind direction of the roll is changed. The locations of the static dissipaters are fixed and unchanged.

[0044] FIGS. **12** through **15** illustrate a third embodiment of the apparatus to neutralize static charge on both sides of a web exiting an unwinding turret. Many roll-to-roll manufacturing operations use an unwinding turret a first unwind spindle A in a load position farther from the conveyance path of the operation and a second unwind spindle B in a run position nearer to the conveyance path of the operation. While an old roll unwinds on spindle B in the run position, a new roll may be loaded onto spindle A in a load position typically using cranes and other roll handling equipment. The unwind turret is often designed to unwind rolls in either a clockwise or a counter clockwise direction. The advantage of this third embodiment is that the locations of the static dissipaters are fixed and unchanged. Static is neutralized effective while the roll on either spindle A or B is unwound in either the clockwise or the counter-clockwise direction, and while the turret rotates in either the clockwise or the counter clockwise direction.

[0045] FIG. **12** shows a turret unwinder where spindle B **1204** in a run position nearer to conveyance roller **1205**, **1206** and **1207** and spindle A **1203** is farther from the conveyance rollers. No web remains on the roll on spindle B and a new roll **1201** on spindle A **1203** is rotating in the clockwise direction to unwind web **1212**. The web **1212** exits the roll **1201** at the unwinding nip **1211**. Tribocharging causes the outside surface **1202** of the roll to have negative static charge (not shown) and causes the inside surface **1214** of the web exiting the roll to have positive static charge (not shown). Static dissipater **1221** is positioned to neutralize static charge on the outside surface of the roll on spindle A. As a result of neutralization by static dissipater **1221**, the outside surface **1213** of the web exiting the roll is now electrically neutral. The web is conveyed over roller **1208** that is mounted on the turret and subsequently over roller **1205** that is mounted in a fixed location. Static dissipater **1223** is positioned after the conveyance roller **1205** to neutralize static charge on the inside surface of the web. The web is subsequently conveyed next over conveyance roller **1206** and conveyance roller **1207**. As a result, the exiting web **1215** is electrically neutral.

[0046] While roll **1201** in FIG. **12** is unwinding, the turret rotates in the clockwise direction to move the unwinding roll **1201** from the load position that is farther away from conveyance rollers **1205**, **1206** and **1207** to the run position that is nearer to the conveyance rollers as shown in FIG. **13**. Conveyance roller **1208** located above static dissipaters **1221** and **1222** with unwinding roll **1201** in the load position in FIG. **12** rotates with the turret to become conveyance roller **1308** in FIG. **13** located below static dissipaters **1321** and **1322** with unwinding roll **1301** in the run position.

[0047] FIG. **13** shows a turret unwinder where spindle B **1204** in a load position farther from conveyance roller **1305**, **1306** and **1307** and spindle A **1303** is in the run position nearer to the conveyance rollers. The roll **1301** on spindle A **1303** is rotating in the clockwise direction to unwind web **1312**. The web **1312** exits the roll **1301** at the unwinding nip **1311**. Tribocharging causes the outside surface **1302** of the unwinding roll to carry static charges (not shown) and causes the inside surface **1314** of the web exiting the roll to carry static charges (not shown) having equal magnitude and opposite polarity to the charges on the roll. Static dissipater **1321** located on the turret so that it rotates with the turret is positioned to neutralize static charge on the outside surface of the roll on spindle A. As a result of neutralization by static dissipater **1321**, the outside surface **1313** of the web exiting the roll is now electrically neutral. With the spindle **1303** in the run position, the web is conveyed directly from the unwinding nip **1311** to roller **1305** that is mounted in a fixed location. Static dissipater **1323** in a fixed location after the conveyance roller **1305** is positioned to neutralize static charge on the inside surface of the web. The web is subsequently conveyed next over conveyance roller **1306** and conveyance roller **1307**. As a result, the exiting web **1315** is electrically neutral.

[0048] FIG. **12** shows the unwinding roll **1201** on spindle A in the load position where the outside surface **1214** of the roll is neutralized by static dissipater **1221**. When a roll is on spindle B **1204**, static neutralizer **1222** is located to neutralize the outside surface. The geometry is akin to FIG. **13** showing roll **1301**.

[0049] Similarly, FIG. **13** shows the roll **1301** on spindle A in the run position where the outside surface **1314** of the roll is neutralized by static dissipater **1321**. When a roll is on spindle B **1304**, static neutralizer **1322** is located to neutralize the outside surface of the roll. The geometry is akin to FIG. **12** showing roll **1201**.

[0050] In FIG. **12** and FIG. **13**, the positions of corresponding static dissipaters **1221** & **1321** located to neutralize the unwinding roll, corresponding static dissipaters **1223** & **1323** located to neutralize the inside surface of the web, and corresponding conveyance rollers **1205** & **1305**, **1206** & **1306**, and **1207** & **1307** are fixed. The roll loading operations and turret rotation can proceed with no change to the location of the static neutralizers. The advantage of this third embodiment of the apparatus to neutralize both sides of a web exiting an unwinding roll is that the locations of the static dissipaters are fixed and unchanged. Static is effectively neutralized while a roll on either spindle A or spindle B unwinds and while the turret rotates in a clockwise direction.

[0051] FIG. **14** shows the turret unwinder where spindle B **1404** in a run position nearer to conveyance roller **1405**, **1406** and **1407** and spindle A **1403** is farther from the conveyance rollers. No web remains on the roll on spindle B and a new roll **1401** on spindle A **1403** is rotating in the counter-clockwise direction to unwind web **1412**. The web **1412** exits the roll **1401** at the unwinding nip **1411**. Tribocharging causes the outside surface **1402** of the roll to have static charge (not shown) of a first polarity and causes the inside surface **1414** of the web exiting the unwinding roll to have static charge (not shown) of the second opposite polarity. Static dissipater **1421** is located on the turret so that it rotates with the turret and it is positioned to neutralize static charge on the outside surface of the roll **1401** on spindle A. As a result of neutralization by static dissipater **1421**, the outside surface **1413** of the web exiting the roll is now electrically neutral. The web is conveyed over roller **1409** that is mounted on the turret and subsequently over roller **1406** that is mounted in a fixed location. Static dissipater **1423** is positioned after the conveyance roller **1406** to neutralize static charge on the inside surface of the web. The web is subsequently conveyed next over conveyance roller **1405** and conveyance roller **1407**. As a result, the exiting web **1415** is electrically neutral.

[0052] While roll **1401** in FIG. **14** is unwinding, the turret rotates in the counter-clockwise direction to move the unwinding roll **1401** from the load position farther away from conveyance rollers **1405**, **1406** and **1407** to the run position nearer to the conveyance rollers as shown in FIG. **15**. Conveyance roller **1409** located below static dissipaters **1421** and **1422** with unwinding roll **1401** in the load position in FIG. **14** rotates with the turret to become conveyance roller **1509** in FIG. **15** located above static dissipaters **1521** and **1522** with unwinding roll **1501** in the run position.

[0053] FIG. **15** shows a turret unwinder where spindle B **1504** in a load position farther from conveyance roller **1505**, **1506** and **1507** and spindle A **1503** is in the run position nearer to the conveyance rollers. The unwinding roll **1501** on spindle A **1503** is rotating in the counter-clockwise direction to unwind web **1512**. The web **1512** exits the roll **1501** at the unwinding nip **1511**. Tribocharging causes the outside surface **1502** of the roll to have static charge (not shown) of a first polarity and causes the inside surface **1514** of the web exiting the unwinding roll to have static charge (not shown) of a second, opposite polarity. Static dissipater **1521** located on the turret so that it rotates with the turret is positioned to neutralize static charge on the outside surface of the roll on spindle A. As a result of neutralization by static dissipater **1521**, the outside surface **1513** of the web exiting the roll is now electrically neutral. The web is now conveyed directly to roller **1506** that is mounted in a fixed location. Static dissipater **1523** is located in a fixed position after the conveyance roller **1506** and it is positioned to neutralize static charge on the inside surface of the web. The web is subsequently conveyed next over conveyance roller **1505** and conveyance roller **1507**. As a result, the exiting web **1515** is electrically neutral.

[0054] FIG. **14** shows the unwinding roll **1401** on spindle A in the load position where the outside surface **1414** of the roll is neutralized by static dissipater **1421**. When a roll is on spindle B **1404**, static neutralizer **1422** is located to neutralize the outside surface of the roll. The geometry is akin to FIG. **15** showing roll **1501**.

[0055] Similarly, FIG. **15** shows the unwinding roll **1501** on spindle A in the run position where the outside surface **1514** of the roll is neutralized by static dissipater **1521**. When an roll is on spindle B **1504**, static neutralizer **1522** is located to neutralize the outside surface of the roll. The geometry is akin to FIG. **14** showing unwinding roll **1401**.

[0056] In FIG. **14** and FIG. **15**, the positions of corresponding static dissipaters **1421** & **1521** located to neutralize the unwinding roll, corresponding static dissipaters **1423** & **1523** located to neutralize the inside surface of the web, and corresponding conveyance rollers **1405** & **1505**, **1406** & **1506**, and **1407** & **1507** are in fixed locations. The roll loading operations and turret rotation can proceed with no change to the locations of the static neutralizers. In FIGS. **12**, **13**, **14**, and **15**, the positions of corresponding static dissipaters **1221**, **1321**, **1421** & **1521** located to neutralize the inside surface of the web are unchanged with the rolls being unwound in either the load or run positions, while the turret rotates in either the clockwise or in the counter-clockwise direction, and while the rolls are unwound in either the clockwise or counter-clockwise direction. The advantage of this third embodiment of the apparatus to neutralize static on both surfaces of a web exiting an unwinding roll is that the locations of the static dissipaters are fixed and unchanged. Static is effectively neutralized while a roll on spindle A or on spindle B unwinds in the clockwise direction or in the counter-clockwise direction and while the turret rotates in a clockwise direction.

[0057] Accordingly, the claimed invention is limited only by the following claims and equivalents thereto.

What is claimed is:

1. A static charge neutralizing apparatus, comprising:

a roll of web wound on a core;

the roll having a first lap of web and remaining laps between the first lap and the core;

the first lap of web having an exposed outside surface and an inside surface in contact with the remaining laps;

an unwinding nip where the outer lap of web exits the roll;

a first static neutralizing device located in proximity to the roll that is positioned to neutralize static on the exposed outside surface of the first lap;

a first roller located in proximity to the unwinding nip;

a web path comprising a first web span extending from the unwinding nip to the first roller;

the first web span having outside and inside surfaces corresponding respectively to the outside and inside surfaces of the first lap of web;

the first roller positioned to touch the inside surface of the first web span;

a second roller located in proximity to the first roller;

the web path further comprising a second web span extending from the first roller to the second roller;

the second web span having outside and inside surfaces corresponding respectively to the outside and inside surface of the first web span; and

a second static neutralizing device located in proximity to the second web span positioned to neutralize static charges on the inside surface of the second web span.

2. The static charge neutralizing apparatus of claim **1** wherein the first static neutralizing device is selected from the group consisting of a tinsel, an antistatic brush, an ionizing string, an ionizing rod, a radioactive ion emitter, an AC powered corona ion emitter, a pulsed DC powered corona ion emitter, and a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

3. The static charge neutralizing apparatus of claim **1** wherein the first static neutralizing device is a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

4. The static charge neutralizing apparatus of claim **1** wherein the second static neutralizing device is selected from the group consisting of a tinsel, an antistatic brush, an ionizing string, an ionizing rod, a radioactive ion emitter, an AC powered corona ion emitter, a pulsed DC powered corona ion emitters, and a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

5. The static charge neutralizing apparatus of claim **1** wherein the second static neutralizing device is a pulsed DC powered corona ion emitter.

6. The static charge neutralizing apparatus of claim **1** wherein a line extending from the center of the core to the unwinding nip defines an angular position of 0 degrees around the roll, the direction of increasing angle is the direction of rotation of the unwinding roll, and the first static neutralizing device has an angular position not less than 30 degrees and not exceeding 330 degrees.

7. A method for neutralizing a web exiting an unwinding roll comprising;

neutralizing static charges on the outer surface of a roll using a static dissipater located in the proximity of the outer surface of the roll;

separating the web from the roll at an unwinding nip;

conveying the web over a first conveyance roller positioned to touch in inside surface of the web; and

neutralizing static charges on the inside surface of the web using a static dissipater located after the first conveyance roller.

8. A static charge neutralizing apparatus, comprising:

a roll of web wound on a core;

the unwinding roll having a first lap of web and remaining laps between the first lap and the core;

the first lap of web having an exposed outside surface and an inside surface in contact with the remaining laps;

an unwinding direction that can be clockwise or counter-clockwise;

an unwinding nip where the outer lap of web exits the roll;

a first static dissipater positioned to neutralize the exposed outside surface of the first lap;

a line drawn from the center of the core to the unwinding nip when unwinding direction is clockwise defines an angular position around the unwinding roll of 0 degrees and the angular position increases in the clockwise direction;

a first roller located in proximity to the angular position of 0 degrees;

a second roller located in proximity to the angular position of 180 degrees;

a web path when the unwinding direction is clockwise comprising a first web span extending from the unwinding nip to the first roller;

a web path when the unwinding direction is clockwise further comprising a second web span extending from the first roller to the second roller;

a web path when the unwinding direction is counter-clockwise comprising a first web span extending from the unwinding nip to the second roller;

a web path when the unwinding direction is counter-clockwise further comprising a second web span extending from the second roller to the first roller;

the first web span having outside and inside surfaces corresponding respectively to the outside and inside surfaces of the first lap of web;

when the unwind direction is clockwise, the first roller positioned to touch the inside surface of the first web span;

when the unwind direction is counter-clockwise, the second roller positioned to touch the inside surface of the first web span;

the second web span having outside and inside surfaces corresponding respectively to the outside and inside surfaces of the first web span;

a second static dissipater located in proximity to the second web span positioned to neutralize static on the inside surface of the second web span.

9. The static charge neutralizing apparatus in claim **8** wherein the first static dissipater has an angular location not less than 30 degrees and not exceeding 150 degrees.

10. The static charge neutralizing apparatus in claim **8** wherein the first static dissipater has an angular location not less than 210 degrees and not exceeding 330 degrees.

11. The static charge neutralizing apparatus of claim **8** wherein the first static neutralizing device is selected from the group consisting of a tinsel, an antistatic brush, an ionizing string, an ionizing rod, a radioactive ion emitter, an AC powered corona ion emitter, a pulsed DC powered corona ion emitter, and a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

12. The static charge neutralizing apparatus of claim **8** wherein the first static neutralizing device is a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

13. The static charge neutralizing apparatus of claim **8** wherein the second static neutralizing device is selected from the group consisting of a tinsel, an antistatic brush, an ionizing string, an ionizing rod, a radioactive ion emitter, an AC powered corona ion emitter, a pulsed DC powered corona ion emitter, and a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

14. The static charge neutralizing apparatus of claim **8** wherein the second static neutralizing device is a pulsed DC powered corona ion emitter.

15. A static charge neutralizing apparatus, comprising:

a unwind turret having a first spindle in a first load position that is farther away from a plurality of fixed conveyance rollers;

the unwind turret having a second spindle in a second run position that is nearer to the plurality of fixed conveyance rollers;

the turret having a means to move the first spindle from the first load position to the second run position and a means to move the second spindle from the second load position to the first load position;

a roll of web wound on a core;

the roll having a first lap of web;

the first lap of web having an exposed outside surface and an inside surface;

the roll being loaded on the first spindle in the first load position;

a first static dissipater located to neutralize the exposed outside surface of the first lap;

an unwind direction that is clockwise or counter-clockwise;

an unwinding nip where the outer lap of web exits the roll a line drawn from the center of the core to the unwinding nip when the unwind direction is clockwise defines an angular position of 0 degrees;

the angular position increasing in the direction of unwinding;

a first roller located in proximity to the angular position of 0 degrees that is located on the turret and moves with the first spindle when the turret moves the first spindle in the first load position to the second run position;

a second roller located in proximity to the angular position of 180 degrees that is located on the turret and moves with the first spindle when the turret moves the first spindle in the first load position to the second run position;

a third roller located in proximity to the angular position of 0 degrees when the roll is on the spindle in the second run position;

a fourth roller located in proximity to the angular position of 180 degrees when the roll is on the spindle in the second run position;

a web path when the unwinding direction is clockwise comprising a first web span extending from the unwinding nip to the first roller;

a web path when the unwinding direction is clockwise further comprising a second web span extending from the first roller to the third roller;

a web path when the unwinding direction is clockwise further comprising a third web span extending from the third roller to the fourth roller;

a web path when the unwinding direction is counter-clockwise comprising a first web span extending from the unwinding nip to the second roller;

a web path when the unwinding direction is counter-clockwise further comprising a second web span extending from the second roller to the fourth roller;

a web path when the unwinding direction is counter-clockwise further comprising a third web span extending from the fourth roller to the third roller;

the first web span having outside and inside surfaces corresponding respectively to the outside and inside surfaces of the first lap of web;

when the unwind direction is clockwise, the first roller positioned to touch the inside surface of the first web span;

when the unwind direction is counter-clockwise, the second roller positioned to touch the inside surface of the first web span;

the second web span having outside and inside surfaces corresponding respectively to the outside and inside surfaces of the first web span;

when the unwind direction is clockwise, the third roller positioned to touch the inside surface of the second web span;

when the unwind direction is counter-clockwise, the fourth roller positioned to touch the inside surface of the second web span; and

a second static dissipater located in proximity to the third web span and positioned to neutralize static charges on the inside surface of the second web span.

16. The static charge neutralizing apparatus in claim **15** wherein the first static neutralizing device has an angular location not less than 30 degrees and not exceeding 150 degrees.

17. The static charge neutralizing apparatus in claim **15** wherein the first static neutralizing device has an angular location not less than 210 degrees and not exceeding 330 degrees.

18. The static charge neutralizing apparatus of claim **15** wherein the first static neutralizing device is selected from the group consisting of a tinsel, an antistatic brush, an ionizing string, an ionizing rod, a radioactive ion emitter, an AC powered corona ion emitter, a pulsed DC powered corona ion emitter, and a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

19. The static charge neutralizing apparatus of claim **15** wherein the first static neutralizing device is a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

20. The static charge neutralizing apparatus of claim **15** wherein the second static neutralizing device is selected from the group consisting of a tinsel, an antistatic brush, an ionizing string, an ionizing rod, a radioactive ion emitter, an AC powered corona ion emitter, a pulsed DC powered corona ion emitter, and a pulsed DC powered corona ion emitter with where the pulse shape is changed by lengthening the time between ion generating pulses.

21. The static charge neutralizing apparatus of claim **15** wherein the second static neutralizing device is a pulsed DC powered corona ion emitter.

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