

[54] **METHODS AND APPARATUS FOR ELECTROSTATICALLY PERFORMING A TACKING OPERATION**

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[51] Int. Cl.**H05, G09f 7/02**
[58] Field of Search**317/262 E**

[56] **References Cited**

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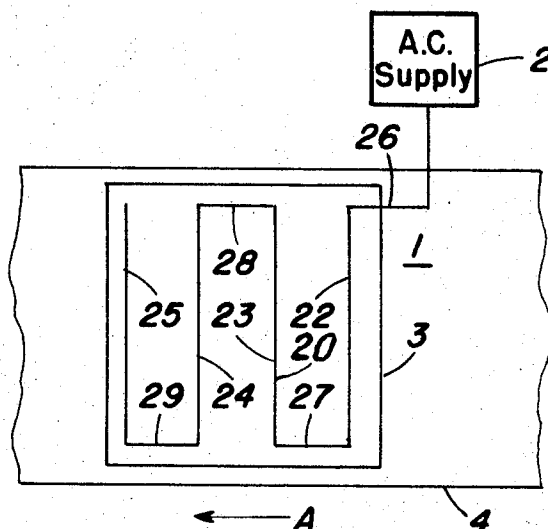
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[57] **ABSTRACT**

Methods and apparatus for electrostatically performing a tacking operation are provided in accordance with the teachings of the instant invention wherein tacking charges are imposed by a coronode connected to an ac source and disposed in a charging relationship with the medium to be tacked. As the coronode is connected to an ac source, ion charging currents delivered thereby will exhibit the periodic variation and alternating polarity of the ac source. The tacking force applied to such medium will thereby display a periodic variation having a magnitude which is sufficient to maintain the medium in a tacked relationship with a desired surface when the medium is in the immediate environment of the coronode; however, as the medium is increasingly displayed from the immediate environment of the coronode, the magnitude of such tacking force will approach a zero value because the ion charging current delivered manifests a variation resembling a damped sinusoid or the like depending upon the nature of the periodic variation of said ac source. Therefore, upon the completion of the tacking operation, stripping of the medium may be readily achieved.

19 Claims, 6 Drawing Figures



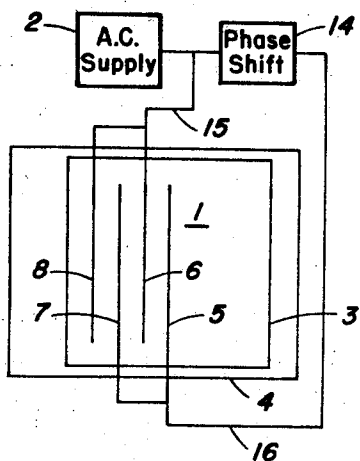


Fig. 3.

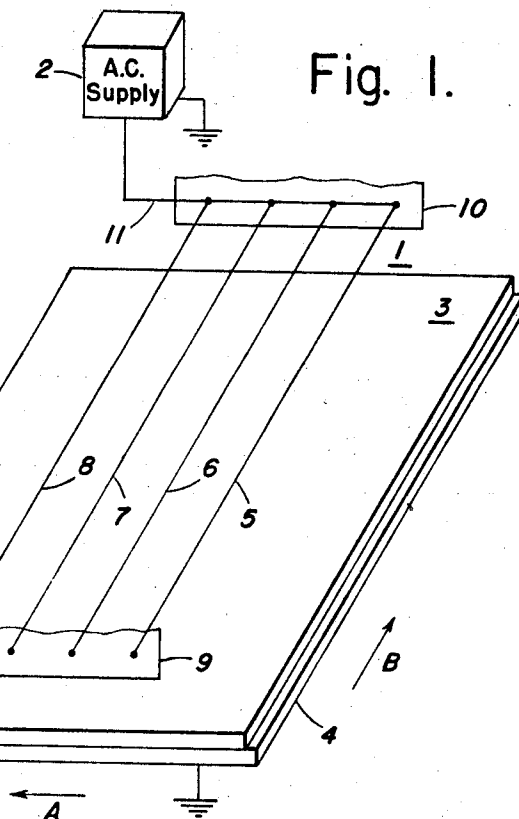


Fig. 1.

Fig. 4.

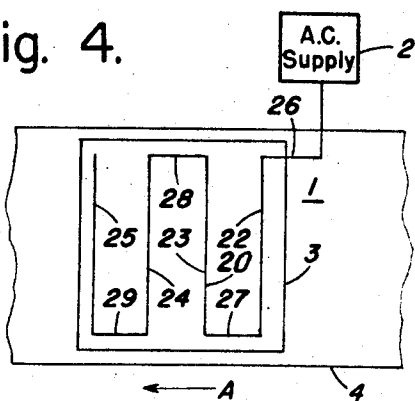


Fig. 5.

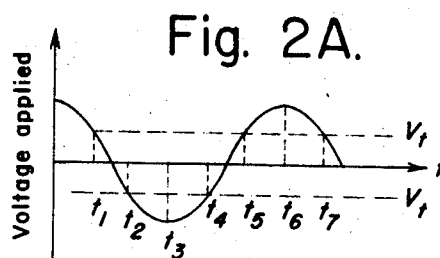
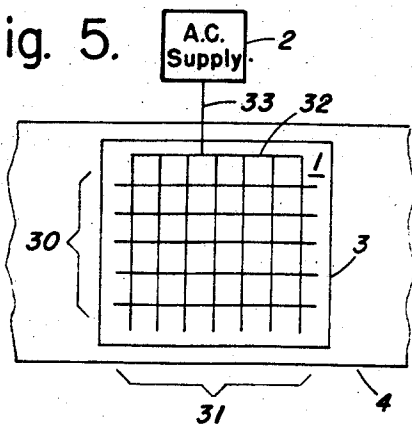


Fig. 2A.

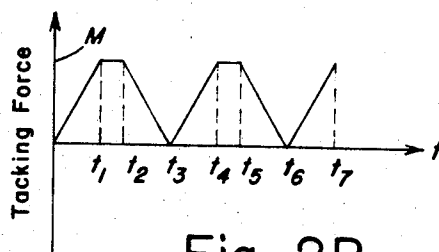


Fig. 2B.

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METHODS AND APPARATUS FOR ELECTROSTATICALLY PERFORMING A TACKING OPERATION

This invention relates to methods and apparatus for electrostatically charging a surface and more particularly to ac corona charging methods and corotron apparatus therefor usable in any application where it is desirable to tack a medium to a surface and thereafter strip such medium therefrom.

Tacking and stripping operations are relied upon in such widely varying areas of application as document transport systems, document reproduction equipment, material handling apparatus and in the wallpaper flocking arts to tack a medium in the form of a web, sheet or fibrous material to a surface while such surface is conveyed between various locations by winding and reeling techniques or the like and/or subjected to various processing steps at processing stations located adjacent to the path of motion of the surface being conveyed. When the medium arrives at a desired location and/or the selected processing steps have been completed, the medium is stripped or released from the surface whereupon other operations may be initiated or the medium placed at a desired location such as the output or return bin of the apparatus under consideration. Tacking or the physical securing of the medium to the surface has traditionally been accomplished by vacuum tacking techniques where, for example, a partially evacuated chamber is disposed beneath portions of a surface, such as an endless web, upon which tacking is to occur and such surface is apertured so that when a medium is disposed thereon and displaced to a location overlying the partially evacuated chamber, the differential pressure established between a surface of the medium associated with ambient conditions and that residing upon the apertured surface and hence in fluid communication with the partially evacuated chamber will strongly adhere the medium to the apertured surface at which tacking is to occur. Vacuum tacking techniques of the foregoing variety are advantageous because in practical application they may be implemented in a simple manner, the tacking force is readily controllable to suit the nature of the medium to be tacked and stripping is readily and easily accomplished by displacing the surface upon which the medium is tacked to a position which does not overlie the evacuated chamber whereupon the pressure differential and hence the tacking force is immediately removed without adversely affecting the medium. These advantages of vacuum tacking techniques are considered to be so substantial by some systems designers, that vacuum tacking techniques are consistently employed regardless of the application and despite the often excessive physical requirements and costs imposed by using a vacuum chamber positioned under large portions of the surface at which tacking is to occur, the pumps and sensors necessitated thereby and the often unrelated nature of a vacuum chamber to the system under design which would otherwise not require the presence of a vacuum system.

However, where tacking and stripping operations are employed in document transport systems or in document reproduction equipment and the tacked medium is reproduced with copying apparatus employing high resolution optical systems, the apertured surface upon

which the medium, which here would normally take the form of a document or the like, is tacked in vacuum tacking arrangement often prohibits the production of high quality copies of the original document. This occurs because the apertured surface upon which the document is tacked is in the focal plane of the optical system employed by the copying apparatus and therefore a reproduction of such apertured surface will appear in the border areas of the copy of the document produced. Furthermore, and depending to a large degree on the thickness or paper weight of the document being reproduced, a replica of the apertured surface will also be reproduced throughout the document area of the copy to thereby impart a highly grainy appearance to what would otherwise be a high quality copy.

To alleviate the foregoing difficulties which attend the use of an apertured surface in vacuum tacking arrangements employed in document transport and/or reproduction systems and equipments, and to otherwise avoid the large dimension and cost requirements imposed by the use of vacuum tacking arrangements, substantial efforts have been devoted to the development of practical electrostatic tacking techniques. This approach was taken because the art of imposing an electrostatic charge on a medium has been highly developed in conjunction with the art of electrophotography and the tacking uses associated with an electrostatic charge readily suggest themselves. One of the simplest electrostatic techniques developed contemplates the use of an insulating member as the surface at which tacking is to occur wherein the underside of such surface is associated with a conductive layer or the like. A conventional form of corona discharge unit such as disclosed in U.S. Pat. Nos. 2,836,725, to Vyverberg, and 2,879,395, to Walkup, is then employed to impose an electrostatic charge on the medium to be tacked whereby such medium is strongly secured to the surface due to the well-known attractive force exhibited between the charge imposed on the medium and the equal and opposite charge thereby induced in the conductive layer associated with the underside of the insulating surface. Although this simple electrostatic tacking technique is advantageous because it may be easily and inexpensively implemented and readily lends itself to a highly compact system, substantial problems are associated with the subsequent stripping of the tacked medium from the surface because the removal of the electrostatically tacked member must be accomplished by a peeling operation or the like and the design of means capable of consistently grabbing the leading edge of the medium tacked, to initiate such peeling operation, often presents substantial difficulties. Because the tacked medium will generally be a relatively fair insulator and is in any event insulated from its surroundings due to its disposition on the insulating surface at which tacking has occurred, the charge imposed thereon to accomplish tacking will tend to remain essentially constant as the medium is peeled from the surface at which tacking occurred so that the potential thereof will linearly increase with separation. When the separation between the medium and the surface reaches a distance equal to about 20μ , the air gap therebetween will break down resulting in a discharge taking place between the medium being stripped and

the surface. This discharge will leave a charge on the surface at which tacking occurred, which may be undesirable with respect to the subsequent use thereof. Furthermore, the use of mechanical means for grabbing the leading edge of the medium tacked, to thereby initiate the peeling operation, often causes substantial damage to the surface at which tacking occurs so that such surface must be periodically replaced.

In order to avoid the deleterious electrostatic discharge effects which occur when an electrostatically tacked medium is simply peeled from the surface at which tacking occurred to thereby accomplished stripping as well as the difficulties associated with initiating the peeling operation, as aforesaid, various attempts have been made to neutralize the tacking charge prior to or during the stripping operation so that the medium to be stripped may be readily removed from the tacking surface without any sparking or other undesirable electrostatic effects occurring and to enable stripping to be initiated without the need for mechanical means for grabbing the leading edge of the medium. Early attempts to neutralize the tacking charge were not highly successful because in each case an independent charging device was relied upon to supply the neutralizing charge and since the initial tacking charge would vary due to such factors as leakage of the initial tacking charge, power supply variations, the spacing between the tacking corotron and the medium to be charged, and the initial charge on the medium as seen by the corotron; it was difficult to determine the precise levels of neutralizing charge to be delivered to the medium to be stripped. Such early attempts to neutralize the charge on the member to be charged are illustrated, for example, in U.S. Pat. No. 2,951,433, to Dyne, within a context of image transfer in electrophotographic equipment; however, in the apparatus taught therein, the magnitude of the neutralizing charge can not be accurately ascertained on a continuing basis, and hence sparking is not completely prevented because an excess of neutralizing charge, in the form of a charge exhibiting an opposite polarity from that associated with the tacking charge on the medium will result in sparking as readily as an insufficient amount of neutralizing charge. Thus, such early attempts to neutralize the tacking charge were largely imperfect and hence undesirable electrostatic effects were not completely avoided and the need for mechanical means capable of consistently grabbing the leading edge of the tacked medium to initiate a peeling operation was retained.

The solution to the problem posed by the need to supply exact levels of neutralizing charge to a tacked medium to enable the medium to be simply and easily stripped without the occurrence of any deleterious electrostatic effects was initially presented in U.S. Pat. No. 3,244,083, issued to R. W. Gundlach on Apr. 15, 1966, and further refined in my copending application Ser. No. 108,304, filed Jan. 21, 1971, so that the techniques proposed in U.S. Pat. No. 3,244,083 could be implemented in a manner to achieve practical results approaching those theoretically predicted. Briefly, U.S. Pat. No. 3,244,083 and my copending application Ser. No. 108,304, contemplate modes of electrostatic charging wherein at least two corotrons are energized by a floating power supply. The shield of the

two corotrons utilized are interconnected and the positive terminal of the floating power supply utilized is connected to a coronode of one of the corotrons while the negative terminal of such power supply is connected to the coronode of the other corotron. Since no point in the resulting corotron circuit configuration is grounded, it can be demonstrated that at any given instant of time the positive ion charging current delivered to a common moving surface by the positively connected corotron must be exactly equal in magnitude to the negative ion current delivered to such moving surface by the negatively connected corotron. Furthermore, when this concept is modified as taught in my copending application Ser. No. 108,304, not only are the ion charging currents delivered to a common surface by the oppositely connected corotrons exactly equal in magnitude at each instant of time, such charging currents are rendered uniform with time so that no point to point variation in the charge level of the surface or medium being acted upon occurs. The foregoing mode of operation is highly advantageous because if one of the corotrons is relied upon to apply a tacking charge while the oppositely connected corotron is utilized to apply a neutralizing ion charging current to the tacked medium so that a neutralizing charging current which is precisely equal in magnitude but opposite in polarity to that relied upon in the tacking portion of an operation is utilized upon completion of the transfer or tacking step, it will be immediately appreciated by those of ordinary skill in the art that the medium to be stripped may readily be removed, due to its electrostatically neutral state, from the surface to which the medium was tacked without any sparking or other deleterious electrostatic effects occurring. Thus, in this manner electrostatic tacking and stripping operations may be accomplished without the occurrence of any deleterious electrostatic discharge when the stripping portion of the operation is carried out while the expense and large dimensional requirements of a vacuum tacking system are avoided. However, the charging techniques contemplated in both U.S. Pat. No. 3,244,083 and my copending application Ser. No. 108,304 require a floating power supply which is highly insulated from its environment, exhibits high voltage characteristics and at least when the techniques employed in my copending application Ser. No. 108,304 are employed, the floating power supply must be highly regulated. Each of these characteristics introduce parameters into the design of the floating power supply which substantially increase the expense thereof and although this expense is justified for image transfer systems in high cost electrophotographic reproduction equipments, it is preferable to avoid such high cost factors in tacking and stripping operations which are performed in less costly systems and especially under circumstances where tacking need not be accomplished in a predetermined, uniform manner such as is necessary in an image transfer operation or the like. Additionally, in both of these systems, a d.c. tacking charge is employed so that problems associated with charge leakage are not solved and hence the medium acted upon may not be retained in a tacked relationship to a desired surface for substantial periods of time due to the time limitation between charging and neutralizing imposed by such d.c. leakage.

Therefore, it is a principal object of this invention to provide methods and apparatus for electrostatically performing a tacking operation in such manner that the medium tacked may be held for any selected time interval while the tacking charge is automatically neutralized without the application of a specialized neutralizing charge whereby stripping of the tacked medium may readily be achieved without the occurrence of sparking or any other deleterious electrostatic discharge effect. Various other objects and advantages of the present invention will become clear from the following detailed description of several exemplary embodiments thereof, and the novel features of this invention will be particularly pointed out in conjunction with the claims appended hereto.

In accordance with the teachings of the present invention methods and apparatus for electrostatically performing a tacking operation are provided wherein tacking charges are imposed by coronode means connected to an ac source and disposed in a charging relationship with the medium to be tacked; as said coronode means is connected to an ac source, ion charging currents delivered thereby will exhibit the periodic variation and alternating polarity of said ac source, however, the tacking force applied to such medium will display a periodic variation having a magnitude which is sufficient to maintain the medium in a tacked relationship with a desired surface when the medium is in the immediate environment of said coronode means but as said medium is increasingly displaced from the immediate environment of said coronode means, the magnitude of such tacking force will approach a zero value because the ion charging current delivered manifests a variation resembling a damped sinusoid or the like depending upon the nature of the periodic variation of said ac source.

The invention will be more clearly understood by reference to the following detailed description of several exemplary embodiments thereof in conjunction with the accompanying drawing in which:

FIG. 1 illustrates one exemplary embodiment of the electrostatic tacking techniques according to the teachings of the present invention;

FIGS. 2A and 2B are graphical representations of the voltage applied to the coronodes and the tacking force applied to the medium to be tacked, respectively, in the embodiment of this invention illustrated in FIG. 1;

FIG. 3 illustrates a modification to the FIG. 1 embodiment of this invention wherein the tacking force imposed by selected ones of the plurality of coronodes employed is shifted in phase from that imposed by others of said plurality of coronodes;

FIG. 4 illustrates another exemplary embodiment of the instant invention employing differing coronode structure from the illustrated in FIG. 1; and

FIG. 5 illustrates a further exemplary embodiment of the present invention showing yet another form of suitable coronode structure.

Referring now to the drawing and more particularly to FIG. 1 thereof, there is shown an exemplary embodiment of the instant invention illustrating the methods and apparatus for electrostatically performing a tacking operation as taught herein. The exemplary embodiment of the instant invention shown in FIG. 1 comprises corotron means 1 connected to a suitable power

supply 2 and disposed in a charging relationship with a medium 3 to be tacked to a surface 4. The corotron means 1, as illustrated in FIG. 1, takes the form of a shieldless corotron having a plurality of coronodes 5-8 disposed between two supporting members 9 and 10 as indicated in the figure. Each of the coronodes 5-8 may take the form of a fine strand of conductive wire disposed longitudinally across the surface of the medium 3 to be charged between the two supporting members 9 and 10, or alternatively the coronodes 5-8 may each take the form of thin conductive strips which are suitably painted or etched on an appropriate insulating material such as glass or plastic. The coronodes 5-8 are each mounted to each of the two supporting members 9 and 10 by suitable insulating terminal means, as indicated, which are entirely conventional and may take the same form as relied upon in conventional shielded corotron apparatus. Alternatively if the supporting members 9 and 10 are formed of insulating material, the plurality of coronodes 5-8 may be mounted directly thereto. The plurality of coronodes 5-8 are positioned a suitable distance above the surface of the medium 3 which is to receive a tacking charge and this distance may typically be in the range of a quarter of an inch to an inch (0.25-1.0 inch); however, as is well known to those of ordinary skill in the art, the distance at which a coronode is disposed above a surface to be charged may vary to a large degree depending upon the potential applied to such coronodes wherein the larger the potential the greater the available spacing. Furthermore, it should also be noted that when the instant invention is employed in a document transport system or the like wherein the medium being tacked is operated upon by equipment employing an optical system, such optical system may be placed directly over the plurality of coronodes 5-8; however, care should be taken so that the plurality of coronodes 5-8 are disposed a sufficient distance away from the focal plane of such optical system which ordinarily would be the surface of the medium 3 to be tracked so that the plurality of coronodes 5-8 only obscure a small amount of light and are sufficiently removed from the depth of field of the optical system so that the resolution of the plurality of coronodes 5-8 is destroyed and would not be reproduced during the reproduction of the medium 3. The plurality of coronodes 5-8 are spaced from each other by distances which are generally comparable to the distance between the coronodes 5-8 and the medium 3 to be charged although a wide range of spacings are available so long as the spacing selected is sufficient so that ion charging current produced from one coronode will not interfere with that produced at others of said coronodes. Furthermore, it is highly desirable that the spacing between each of the coronodes 5-8 be equal so that one coronode of the plurality will not dominate and draw a majority of current from the power supply 2. Although only four coronodes have been illustrated in FIG. 1, it will be appreciated that either a larger or smaller number of coronodes may be employed in corotron means 1 depending upon the length of the surface 4 along which tacking is to occur and that the actual number of coronodes relied upon in a practical application will generally be selected in a manner such that the longitudinal distance occupied by a plurality of spaced

coronodes is substantially conterminous with the length of the surface 4 along which tacking is to occur when the plurality of coronodes 5-8 are disposed transversely to such length of the surface 4 while if the plurality of coronodes 5-8 are disposed in a parallel relationship therewith several coronodes will be employed to insure that a sufficient number of axes along which tacking will occur are established. In FIG. 1, the length of each of the plurality of coronodes 5-8 has been illustrated as similar to the corresponding dimension of the medium 3 to be tacked; however, as shall become apparent below, when the length of the plurality of coronodes 5-8 are not relied upon to establish the length of the surface 4 along which tacking is to occur, i.e., when the plurality of coronodes are disposed transversely to such length, only suitable lengths of coronode need be employed to establish a sufficient tacking force on the medium 3 or the class of mediums employed when the weight of the medium is considered.

Each of the plurality of coronodes 5-8 is commonly connected to a power supply 2 through the conductor 11. The power supply 2 may take any well-known form of ac power supply conventionally employed by those of ordinary skill in the art and would typically exhibit a plate voltage of 12-14KV peak to peak for usual spacings between the plurality of coronodes 5-8 and the medium 3 to be charged. The frequency of the power supply 2 may vary between 60Hz-3KHz and may be selected purely with a view toward availability. Similarly the output waveform produced by the power supply 2 may take the form of a conventional sinusoid although specialized waveforms such as a square wave may be employed when it is desired to vary the periodic manner in which the tacking force is imposed, as shall be described below.

The corotron 1 and more particularly the plurality of coronodes 5-8 are disposed, as aforesaid, in a charging relationship with the medium 3 to be tacked to the surface 4. The medium 3 may take the form of a web, a sheet, a plate or a fibrous grouping of any material which is desired to be tacked to the surface 4. The medium 3 is physically disposed on the surface 4 at which tacking is to occur prior to being brought into a charging relationship with the corotron 1 and this may be accomplished by any of the well-known means conventionally employed by those of ordinary skill in the document transport, electrophotography and/or material handling arts. The surface 4 at which tacking is to occur may take the form of a plate, sheet, web or drum adapted to be in relative motion with the corotron 1 and hence displaces the medium 3 thereon past the corotron 1. Thus, if the surface 4 took the form of a plate or drum, either the corotron 1 or the surface 4 could be adapted for displacement with respect to the other by conventional conveying techniques while conventional winding and reeling would be employed if the surface 4 took the form of a belt or web. Furthermore, if an endless web or a drum were relied upon, relative motion between the corotron and the surface 4 would normally be imparted by way of the rotation of the endless web or drum. In FIG. 1, the medium 3 and the surface 4 at which tacking is to occur have both been illustrated as sheet-like members to simplify the nature of the disclosure presented and it may be further assumed that the surface 4 at which tacking is to occur is

adapted for motion in the direction indicated by the arrow A; however, as the plurality of coronodes 5-8 may be disposed in a direction which is either transverse or parallel to the direction of motion of the surface 4, it will be appreciated that the surface 4 could alternatively be displaced in the direction indicated by arrow B. The surface 4 would ordinarily be formed of insulating material which is functionally consistent with the nature of the application and the type of material handling employed. For instance, in a document transport system, a mylar or teflon belt or sheet would ordinarily be employed due to the excellent insulating characteristics thereof and the surface of this material would be selected to exhibit a neutral and uniform color approximately matching that of the input document so that copies reproduced therefrom would not have a dark halo around the outer border thereof or a mottling of the area surrounding the image or in the image area for thin translucent input documents. Additionally, as indicated in FIG. 1, the surface 4 at which tacking is to occur would ordinarily have a ground plane in the form of a grounded conductive layer associated with the lower portion thereof so that the bottom side or the side of the surface 4 not having the medium 3 disposed thereon is referenced to ground. The ground plane or conductive layer associated with the bottom side of the surface 4 may be established by forming the surface 4 as a multi-layer structure having an upper insulating layer and a lower conductive layer or alternatively such ground plane could be established using conductive foil or paint disposed on the lower side of the surface 4 at which tacking is to occur. Furthermore, if the nature of the application in which this embodiment of the invention is employed is such that the medium 3 to be tacked always takes the form of a material which is insulating, such as a document, and is configured so as to be solidly interposed between the surface 4 at which tacking is to occur and the plurality of coronodes 5-8, the surface 4 may be formed of a conductive material.

The operation of the embodiment of the invention illustrated in FIG. 1 will be described in conjunction with FIGS. 2A and 2B which illustrate the waveform of the voltage applied to the corotron 1 by the power supply 2 and the manner in which the tacking force imposed by each of the plurality of coronodes 5-8 on the medium 3 varies with time, respectively. In FIG. 2A time is represented along the abscissa while the voltage applied is plotted along the ordinate and in FIG. 2B time, corresponding to the abscissa in FIG. 2A, is plotted along the abscissa while tacking force is represented along the ordinate.

In the description of the operation of the embodiment of this invention illustrated in FIG. 1, it will be assumed that the surface 4 upon which tacking is to take place is in motion in the direction indicated by the arrow A with respect to the corotron 1 and that the power supply 2 is energized and is thus applying a sinusoidally varying voltage waveform to the corotron means 1 and hence to each of the plurality of coronodes 5-8. As is well known to those of ordinary skill in the art, when a voltage whose magnitude varies with time is applied between a fine wire such as any of the plurality of coronodes 5-8 and a conductive surface, such as the ground plane associated with the

lower side of the surface 4, no breakdown of any variety will occur until the magnitude of such voltage reaches a predetermined threshold level. This threshold level will vary as a function of such factors as the spacing between the wire and the conductive surface, the radius of the fine wire, and the temperature, pressure and nature of the gas surrounding the fine wire; however, it may generally be stated that for most corotron arrangements in air the threshold level of voltage at which corona discharge is first initiated will occur between 3-3.5KV. Once this threshold corona voltage is met and then exceeded, ions will be created in the vicinity of the coronode and flow toward the conductive surface giving rise to what has now become well known as corona current or ion charging current. This ion charging current increases as the voltage applied between the coronode and the conductive surface is increased and occurs in the presence of a bluish-white glow about the surface area of the coronode. The corona charging current produced by such a coronode will be quenched as soon as the periodically varying voltage drops below the threshold voltage but will again occur with opposite polarity when the value of the voltage applied exceeds the threshold value associated with the opposite polarity voltage. The magnitudes of corona threshold voltages for positive and negative going voltages are similar with the negative corona threshold voltage being slightly smaller and the manner in which positive and negative ion charging current is produced by a coronode in each case is similar except that bright beads or reddish glow points, which increase with increasing voltage, attend the glow discharge produced from a coronode having a negative voltage applied thereto. The sinusoidal waveform produced by the power supply 2 and applied through the common conductor 11 to each of the plurality of coronodes 5-8 is indicated in FIG. 2A, as aforesaid, and the horizontal dashed lines annotated V_1 in FIG. 2A have been utilized to indicate the positive and negative levels of corona threshold voltage.

When the medium 3 residing on the surface 4 at which tacking is to occur is in a charging relationship with the plurality of coronodes 5-8, in the manner indicated in FIG. 1, the ion charging current produced at each coronode will be delivered to the medium 3 to be charged at portions thereof which underlie such coronode in the well-known manner. If it is assumed that both the medium 3 and the upper portions of the surface 4 are insulating in nature, and it will be appreciated by those of ordinary skill in the art that at least the medium 3 or the upper portions of the surface 4 must be insulating in character, each of the plurality of coronodes 5-8 will impose a charge level on the underlying surface portions of the medium 3 which is of the same polarity as the ion charging current then being produced by such coronode and is proportional in magnitude to the magnitude of the ion charging current then being delivered by such coronode multiplied by the time during which the voltage applied to that coronode exceeds the corona threshold voltage less whatever charge level is necessary to neutralize a preceding, oppositely directed charge level on the surface of the medium 3. Thus, as each of the plurality of coronodes 5-8 receives a sinusoidal input from power supply 2 of the type illustrated in FIG. 2A, at the end of

each half-cycle of the input waveform a maximum positive or negative charge will be imposed on appropriate surface portions of the medium 3 by the coronode associated therewith due to its overlying relationship. This maximum positive or negative charge, however, will be established at a time when the input waveform reaches the corona threshold voltage and will be maintained through the completion of the cycle and into the interval of the next cycle until a time is reached when the opposite polarity corona threshold value is established whereupon the charge on appropriate surface portions of the medium 3 underlying each of the plurality of coronodes 5-8 is first decreased by the oppositely directed corona charging current delivered until full neutralization is reached and thereafter an oppositely directed charge is established. This may be seen upon an inspection of FIG. 2A wherein it will be appreciated that at each of the portions of the medium underlying one of the plurality of coronodes 5-8, a maximum positive tacking charge will be imposed at time t_1 whereat the positive cycle of the input waveform drops below the corona voltage threshold level V_1 so that the flow of positive ion charging current from each of the plurality of coronodes 5-8 is terminated. The charge level thereby established is maintained until time t_2 whereupon the magnitude of the input waveform exceeds the negative corona threshold voltage so that negative ion charging current is delivered by each of the plurality of coronodes 5-8. The negative charging current delivered by each of the plurality of coronodes 5-8 will act to neutralize the previously established charge levels on the corresponding portions of the medium 3 until full neutralization is achieved and thereafter a negative charge level is imposed. Assuming that equal charging current is delivered during each of the positive and negative half cycles of the input waveform and further assuming that the medium 3 exhibits good insulating characteristics, it will be appreciated that neutralization is achieved at time t_3 and in any event a maximum negative charge level is established at time t_4 . Thereafter, the flow of negative ion charging current will cease and the negative charge level on the appropriate surface portions of the medium 3 will be retained until time t_5 whereupon positive charging current begins to flow from each of the plurality of coronodes 5-8, full neutralization under the foregoing assumptions is achieved in the vicinity of time t_6 and a maximum positive charge level is established by each of the plurality of coronodes at time t_7 . Thereafter, as will be apparent to those of ordinary skill in the art, the mode of charging displayed by the instant invention will be repeated for each succeeding half-cycle of the input waveform illustrated in FIG. 2A whereby the previously established charge level imposed on surface portions of the medium 3 underlying each of the plurality of coronodes 5-8, will first be fully neutralized and thereafter an oppositely directed charge level which is substantially equal to that previously established is imposed.

As is well known to those of ordinary skill in the art, when a charge level is imposed on particular surface portions of the medium 3 underlying each of the plurality of coronodes 5-8, equal and opposite charges will be induced in corresponding portions of the ground plane associated with the lower side of the surface 4 at

which tacking is to occur. Thus, the equal and opposite charge levels established between corresponding portions of the medium 3 and the surface 4 at which tacking is to occur will establish a substantial tacking force between the medium 3 and the surface 4 to be charged which is proportional to the magnitude of the charge and inversely proportional to the square of the distance therebetween. This tacking force will exhibit a periodicity which is a function of the input waveform supplied by the power source 2; however, as the direction of the tacking force remains constant, the magnitude thereof will only vary with respect to the absolute magnitude of the charge imposed and hence in relation to the absolute magnitude of the input waveform. The magnitude of the tacking force imposed by each of the plurality of coronodes on their respective underlying surface portions of the medium 3 is plotted in FIG. 2B as a function of time wherein the tacking force is plotted along the ordinate and time is plotted along the abscissa. As will be apparent upon an inspection of FIG. 2B, at time t_1 , which corresponds to time t_1 in FIG. 2A, the tacking force on the medium 3 will reside at some maximum level M which here corresponds to the imposition of a maximum positive charge level at the instant when positive charging current ceases to flow due to a drop in the input waveform below the corona voltage threshold V_c . This maximum level M of tacking force is maintained until time t_2 whereupon the tacking force is gradually reduced due to the flow of negative charging current which thereby supplies a negative charge to the requisite portions of the medium 3 to effectively neutralize the positive charge thereon due to the previous half-cycle of the input waveform. This reduction in tacking force continues until time t_3 when the tacking force on the medium 3 is completely neutralized and is subsequently increased due to the imposition of negative charge by the excess negative ion charging current produced by the negative half-cycle of the input waveform until a maximum value M of tacking force is again present at time t_4 due to the drop in the negative cycle of the input waveform below the negative corona voltage threshold V_c . However, although the value of the tacking force is gradually decreased and subsequently increased during the time interval t_2-t_4 , the tacking force present on the medium 3 only goes to zero at the instant t_3 . The maximum value of tacking force M is again maintained until time t_5 , whereupon the positive half-cycle of the input waveform exceeds the positive corona voltage threshold V_c , so that a flow of positive ion current is established to neutralize, during the time interval t_5-t_6 , the negative charge established by the previous half-cycle of the input waveform and thereafter gradually increase the tacking force during the time interval t_6-t_7 until a maximum tacking level M is again established at time t_7 .

In the embodiment of this invention illustrated in FIG. 1, the spacing of each of the plurality of coronodes 5-8 from the medium 3 as well as the spacing therebetween is such that essentially the entire surface of the medium 3 disposed beneath the plurality of coronodes 5-8 will receive a uniformly varying charging current and hence not only will the tacking force associated with each of the plurality of coronodes 5-8 vary in the manner illustrated in FIG. 2B but in addition

thereto, the tacking force on the entire surface area disposed beneath the plurality of coronodes 5-8 will vary in the manner depicted in FIG. 2B. This tacking force, though variable in magnitude as a function of time in the manner illustrated in FIG. 2B, has been found sufficient to strongly adhere or tack a medium to a desired surface so that it can be further transported in accurate registration therewith and in the absence of any relative motion therebetween or otherwise acted upon and mediums tacked in this manner have displayed no propensity to come loose or bounce up while they are tacked indicating that instances where the tacking force is momentarily zero, for example at times such as t_3 and t_6 in FIG. 2B, are too short in duration to adversely affect the overall tacking function achieved. Furthermore, as will be obvious to those of ordinary skill in the art, the duration at which the tacking force resides at a zero value may be reduced by increasing the frequency of input waveform; however, it will also be appreciated that any such increase in frequency is also attended by a reduction in the maximum value M of the tacking force produced because positive and negative charging current will be applied to the medium 3 for shorter intervals and hence unless compensated by an increase in the peak-to-peak-magnitude of the input waveform, smaller values of maximum tacking force will be achieved.

While portions of the medium 3 to be tacked directly underlying the plurality of coronodes 5-8, will be uniformly subjected to the tacking force depicted in FIG. 2B, portions of the medium not directly beneath the coronode array formed by the plurality of coronodes 5-8 will receive a reduced tacking force which varies in the same manner as illustrated in FIG. 2B but will be increasingly reduced in magnitude as the displacement of such portions from the coronode array is increased. This occurs because, as is well known to those of ordinary skill in the art, the manner in which corona current is delivered to a surface from a shieldless corotron varies as an inverse function with respect to the displacement of the surface from the coronodes and hence as discrete surface portions of the medium 3 are increasingly displaced from the array of corotrons 5-8 the ion charging current received for each cycle of the input waveform, the charge level imposed by such ion charging current and therefore the tacking force created on such displaced surface portions are all increasingly reduced. However, even though the magnitude of the charging current received by such displaced portions of the medium 3 are reduced as are the charge levels and tacking forces associated therewith, the ion current delivered, the charge levels imposed and the tacking forces established will all take on the same periodic variation described above for conditions which obtain for surface portions of the medium 3 which reside directly beneath the plurality of coronodes 5-8.

As will be recalled from the description of the embodiment of this invention shown in FIG. 1, the medium 3 to be tacked is physically disposed upon the surface 4 at which tacking is to occur and under the conditions set forth above, the surface at which tacking is to occur is conveyed beneath the plurality of coronodes 5-8 so that discrete surface portions of the medium 3 disposed in the direction of the arrow B will be sequen-

tially brought into a charging relationship with the corotron 1 and hence the array formed by the plurality of coronodes 5-8. Under these conditions, it will be readily appreciated from the description of the operation of the corotron 1 set forth above, that as the medium 3 approaches the array formed by the plurality of coronodes 5-8 from the right; ion charging current having a periodic, discontinuous waveform will begin to be received at discrete surface portions of the medium 3 disposed in the direction of the arrow B and that as such discrete surface portions of the medium get closer to the coronode 5 the magnitude of the alternately positive and negative half-cycles of ion charging current received will increase. The delivery of alternating half-cycles of positive and negative ion charging current which increase in magnitude as discrete surface portions approach the array formed by the plurality of coronodes 5-8 impose charge levels on such discrete surface portions of the medium 3 which increase in magnitude and alternate in polarity in a corresponding manner to the ion charging current delivered. Furthermore, the oppositely directed charge levels of increasing magnitude thereby imposed on the discrete surface portions of the medium 3 will establish a tacking force between such surface portions of the medium 3 and the surface 4 in the same manner described above and this tacking force will display a magnitude which increases with increasing charge levels and displays the periodicity of the waveform depicted in FIG. 2B. Thus, as discrete surface portions of the medium 3, measured parallel to the direction indicated by the arrow B, approach the array formed by the plurality of coronodes 5-8, increasing charge levels by alternating polarity and having a waveform similar to a clipped sinusoid which increases in magnitude, under the conditions here assumed, will be imposed thereon to thereby establish a tacking force between such portions of the medium 3 and the surface 4 whose magnitude increases with the charge level and displays the periodicity of the waveform depicted in FIG. 2B.

When the discrete surface portions of the medium 3, as measured in the direction indicated by the arrow B, sequentially arrive at locations underlying the plurality of coronodes 5-8, the entire area of the medium 3 underlying the plurality of coronodes 5-8 will receive ion charging current which takes the form of a discontinuous waveform exhibiting alternate cycles of opposite polarity wherein the magnitudes of each cycle are the same, for the reasons aforesaid. This results in the imposition of charge levels which are equal in magnitude and alternating in polarity for the reasons described in conjunction with FIGS. 2A and 2B and hence the establishment of a tacking force between the area of the medium 3 underlying the plurality of coronodes 5-8 and the surface 4 displaying the same characteristics as illustrated and described in conjunction with FIG. 2B. Thus, when a portion of the medium 3 is disposed beneath the charging array formed by the plurality of coronodes 5-8, the charging relationship created establishes a tacking force between the area of the medium 3 underlying the plurality of coronodes 5-8 and the surface 4 which, though variable in magnitude as a function of time in the manner illustrated in FIG. 2B, has been found sufficient to strongly adhere or tack most mediums and particularly documents and the

like to a desired surface so that they can be further conveyed or otherwise acted upon.

As the medium is increasingly displaced from right to left in the direction indicated by the arrow A, portions of the medium measured along the direction indicated by the arrow B are displaced in a sequential manner from the environment underlying the plurality of coronodes 5-8 and thus, each of such portions will receive less positive and negative ion charging current as the displacement continues. Thus, as displacement is increased, the positive and negative charge levels which are periodically imposed on these discrete portions of the surface of the medium 3 will be gradually decreased in magnitude and therefore so will the magnitude of the tacking forces established. However, as the charge levels imposed continue to alternate in polarity as they decrease in magnitude, it will be appreciated that such discrete surface portions of the medium 3 receive decreasing charge levels of alternating polarity having a waveform similar to a clipped sinusoid which decreases in magnitude in the manner exhibited by a damped sinusoid or a demagnetizing wave. Thus, when portions of the medium reach locations where ion charging current is no longer received, no charge level will be associated with such portions because the ringing down effect with which charge levels of decreasing magnitude and alternating polarity are applied to portions of the medium 3 as they are increasingly displaced from the plurality of coronodes 5-8 ensures that a zero charge level will be associated with these surface portions of the medium 3 as they are removed from the tacking environment. This is highly advantageous because when the medium 3 thus completely leaves the tacking environment of the corotron 1 it may readily and easily be stripped by ordinary peeling or air blast techniques as no net charge or tacking force remains associated therewith. Furthermore, since no net charge remains on the medium 3 after its removal from the tacking environment, no deleterious electrostatic effects can occur upon stripping and, of course, no expensive or highly specialized equipment is required to neutralize an initially imposed tacking charge.

The methods of tacking and the apparatus therefor illustrated in the exemplary embodiment of this invention shown in FIG. 1 have demonstrated themselves to be capable of tacking a medium such as an input document firmly against a surface and is highly advantageous because the array formed by the plurality of coronodes 5-8 may be placed directly under an optical system while the tacking force imposed is completely reduced to zero when the medium to be tacked leaves the immediate vicinity of the corotron 1. Furthermore, so long as the medium to be tacked remains in the tacking environment of the corotron 1, the tacking force imposed may be maintained indefinitely. For example, in a tacking system according to this invention, when the input voltage applied by power source 2 was approximately 12 kilovolts peak-to-peak at a frequency of 60 hertz, the tacking force imposed on strips of paper 3 in. wide and having approximately 3 in. of length exposed to the coronode array was in excess of 2 oz. when a mylar belt was employed as the surface at which tacking was to occur. As will be apparent to those of ordinary skill in the art, the use of a highly in-

insulating material for the surface 4 at which tacking is to occur is highly desirable because the use of a material displaying excellent insulating characteristics allows the surface at which tacking is to occur to seek and maintain potential levels which will ensure that the positive ion current delivered by the corotron 1 during positive voltage peaks will equal negative ion current delivered during negative voltage peaks. Furthermore, such a highly insulating material serves to prevent charges from leaking off the medium to be tacked and on to the surface of the belt. As stated above, the tacking force established on the medium 3 to be tacked in the embodiment of this invention shown in FIG. 1 has been found sufficient to strongly adhere or tack most mediums to a desired surface, despite the manner in which the magnitude of the tacking force varies with time, and mediums tacked in this manner have not displayed a propensity to come loose or bounce up while they are tacked indicating that the instances where the tacking force momentarily goes to zero, for example at times such as t_3 and t_6 in FIG. 2B, are too short in duration to adversely affect the overall tacking function achieved. However, it is conceivable that under conditions where the medium has a highly puckered surface or exhibits a pre-established curvature which is different from that displayed by the surface at which tacking is to occur, instantaneous reductions in the tacking force imposed to the zero levels depicted in FIG. 2B might prove undesirable. A modification of the FIG. 1 embodiment of this invention wherein this possible disadvantage is avoided, has been shown in FIG. 3.

FIG. 3 illustrates a modification to the embodiment of this invention shown in FIG. 1 wherein the tacking force imposed by selected ones of the plurality of coronodes employed is shifted in phase from that imposed by others of said plurality of coronodes so that during the time interval when a portion of the medium to be tacked is disposed beneath the array formed by said plurality of coronodes, the waveform of the resulting periodic tacking force established will not display instances at which such tacking force goes to zero. As the embodiment of this invention illustrated in FIG. 3 is a direct modification of the exemplary embodiment of this invention illustrated in FIG. 1, a large number of the elements previously illustrated and described in detail in conjunction with FIG. 1 have again been relied upon in FIG. 3. Therefore, in order to avoid undue reiteration and repetition, elements relied upon in the FIG. 3 embodiment of this invention which correspond to structure previously described in conjunction with FIG. 1 have retained previously adopted reference numerals and the description thereof shall proceed by way of reference to the description of the FIG. 1 embodiment of this invention and this technique, where applicable, shall also be relied upon in connection with succeeding embodiments of the instant invention.

The embodiment of the instant invention depicted in FIG. 3 comprises corotron means 1 selectively connected both directly to a suitable power supply 2 and indirectly connected thereto through phase shifting means 14 and disposed in a charging relationship with a medium 3 to be tacked to a surface 4. The power supply 2, the medium 3 and the surface 4 at which tacking is to occur may each take the same form, function and cooperate in the same manner and admit of

the same variations as the correspondingly referenced elements depicted in FIG. 1. Similarly, the corotron means 1 may take the form of a shieldless corotron having a plurality of coronodes 5-8 which are adapted to be brought into a charging relationship with the medium 3 as the same is conveyed from right to left therebeneath. In the embodiment of the invention illustrated in FIG. 3, however, coronodes 6 and 8 are connected directly to the power supply 2 through conductor 15 while coronodes 5 and 7 are connected to the power supply 2 through conductor 16 and phase shifting means 14. The phase shifting means 14 may take any of the conventional forms of this well-known class of devices, such as a delay line or resonant transformer, which is capable of inserting a predetermined phase shift into the voltage waveform applied thereto. Preferably the phase shifting means 14 is designed to insert a 90° or 270° phase shift into the input signals applied thereto; however, as shall become apparent below, any phase shift other than 180° and 360° is suitable and the phase shift inserted need not be fixed but may vary. The purpose of connecting the phase shifting means 14 in series between the coronodes 5 and 7 and the power supply 2 is to displace the phase of the input waveform applied to coronodes 5 and 7 from that applied to coronodes 6 and 8 so that the magnitude and phase of ion charging current produced by adjacent coronodes will vary and cause an attendant variation in the magnitude and phase of the charge levels imposed thereby whereupon the average magnitude of the resulting tacking force imposed thereby will exhibit a variation having a certain minimum value and hence one which does not approach zero. For this reason, the charging current delivered and hence the charge levels imposed on the medium 3 may tend to interfere and cancel at surface portions of the medium underlying positions intermediate adjacent coronodes and hence it may be desirable in practicing this embodiment of the present invention to increase the spacing between each of the plurality of coronodes 5-8 from that specified in conjunction with the embodiment of this invention described in connection with FIG. 1. Furthermore, if the total tacking force produced by the plurality of coronodes 5-8 is reduced according to this embodiment of the present invention below a desired level, the total tacking force may be suitably increased by appropriately increasing the number of coronodes relied upon.

As will be appreciated by those of ordinary skill in the art, the operation of the embodiment of this invention illustrated in FIG. 3 is the same as that set forth for the embodiment of the invention depicted in FIG. 1, except that the phase shifting means 14 acts to insert a selected phase shift into the input voltage waveform applied from the power supply 2 to the coronodes 5 and 7. This means that while the input voltage applied to coronodes 6 and 8 will vary as illustrated in FIG. 2A to produce in attendant tacking force, for the reasons aforesaid, whose magnitude will vary in the manner depicted in FIG. 2B; the input voltage applied to coronodes 5 and 7 and hence the magnitude of the attending tacking forces imposed thereby will vary in magnitude in the manner illustrated in FIGS. 2A and 2B, respectively, but will be displaced in phase therefrom by a time interval equal to the phase shift in-

serted by the phase shifting means 14. Therefore, it will be seen that so long as a phase shift other than 180° or 360° is relied upon, the waveform of the composite average values of the tacking forces produced by each of the plurality of coronodes 5-8 will exhibit both a time varying component and a steady state component and hence will not approach a zero value for each half-cycle of the input voltage as was the case for the embodiment of this invention described in conjunction with FIG. 1. The nature of the composite waveform of the value of the tacking forces produced by each of the plurality of coronodes 5-8 under the conditions imposed in the FIG. 3 embodiment of the invention, may be clearly appreciated by assuming that a 90° phase shift is inserted by the phase shifting means 14, whereupon the tacking forces imposed by coronodes 6 and 8 would be that associated with FIG. 2B, the tacking forces imposed by coronodes 5 and 7 would take the same waveform as shown in FIG. 2B but are displaced in time by a factor of $\pi/2$ or to the point where the input waveform in FIG. 2A crosses the abscissa and the composite waveform would be the sum of each of the preceding waveforms and would, as will be obvious to those of ordinary skill in the art, exhibit a large steady state value. It should be noted in regard to the exemplary embodiment of this invention depicted in FIG. 3 that although adjacent coronodes were connected directly to the power supply 2 and the phase shifting means 14 in an alternating sequence, any combination of the plurality of coronodes 5-8 could be selected for connection directly to the power source 2 and the phase shifting means 14. Additionally, if charge cancellation proved to be a problem, coronodes 5 and 6 could be connected to the phase shifting means 14, coronodes 7 and 8 could be connected directly to the power source 2 and the spacing between coronodes 6 and 7 increased to avoid this problem. Thus, it will be seen that the embodiment of the invention illustrated in FIG. 3 provides an electrostatic tacking configuration wherein the average magnitude of the tacking forces imposed beneath the coronode array does not go to zero while maintaining the automatic charge neutralizing feature of the instant invention whereby through a ringing down of the alternatively imposed oppositely directed charge levels, as aforesaid, the tacking force on the medium to be tacked goes to zero after such medium has left the environment of the charging array formed by the plurality of coronodes 5-8.

Turning now to FIG. 4 there is shown another exemplary embodiment of the instant invention employing differing coronode structure from that illustrated in FIG. 1. Accordingly, the exemplary embodiment of the instant invention shown in FIG. 4 comprises corotron means 1 connected to a suitable power supply 2 and disposed in a charging relationship with a medium 3 to be tacked to a surface 4. The power supply 2, the medium 3 and the surface 4 at which tacking is to occur may each take the same form, function and cooperate in the same manner and admit of the same variations as the correspondingly referenced elements depicted in FIGS. 1 and 3; however, in FIG. 4, the surface 4 at which tacking is to occur has been illustrated as a portion of a belt or web which, as will be obvious to those of ordinary skill in the art, would preferably include the insulating layer and conductive ground plane mentioned in

the description of the surface 4 illustrated in FIG. 1. Similarly, the corotron means 1 may take the form of a shieldless corotron; however, in the exemplary embodiment of this invention illustrated in FIG. 4 the coronode structure relied upon takes the form of a single coronode 20 configured in such manner as to make a plurality of passes over the surface of the medium 3 to be tacked and further to include discrete portions thereof which are both transverse and parallel to the direction of relative motion between the corotron 1 and the surface 4 at which tacking is to occur. Thus, it will be appreciated that if the surface 4 at which tacking is to occur is again assumed to be adapted for motion in the direction indicated by the arrow A to thereby bring the medium 3 into a charging relationship with the corotron 1, coronode portions 22-25 will be disposed in a direction transverse to the motion of the medium 3 and hence across the width of the surface 4, which here takes the form of a belt or web, while coronode portions 26-29 are disposed in a parallel relationship to the direction of motion and hence along the longitudinal axis of the surface 4. The spacing between the coronode 20 and the medium 3 as well as the spacings between the parallel coronode portions 22-25 may be precisely the same as the coronode spacings mentioned in conjunction with FIG. 1 and similarly the coronode 20 may be formed of the same materials and in the same manner described above in connection with FIG. 1. Additionally, although the coronode 20 has been illustrated as making a particular number of passes over the medium 3, it will be obvious to those of ordinary skill in the art that either a greater or smaller number of coronode portions 22-25 may be relied upon depending upon the tacking forces sought to be imposed.

The operation of the exemplary embodiment of this invention illustrated in FIG. 4 is the same as that described above for the embodiment of this invention shown in FIG. 1 except that an edgewise tacking force is additionally imposed on the medium to be tacked due to the longitudinally disposed coronode portions 26-29. This occurs because while the transversely disposed coronode portions 22-25 impose charge and thereby establish essentially the same tacking force configuration described in conjunction with FIG. 1, the longitudinally disposed coronode portions 26-29 additionally impose charge levels of alternately positive and negative polarity on the surface portions of the medium disposed thereunder. These charge levels establish a tacking force in the same manner described above and add to that established by the coronode portions disposed transversely to the direction of motion of the medium 3. Thus, it will be seen that in the exemplary embodiment of this invention illustrated in FIG. 4, the medium 3 is firmly tacked to the surface 4 by the imposition of alternately positive and negative levels of charge imposed by coronode portions which are disposed in parallel with and transversely to the direction of motion of the medium 3 to be tacked.

FIG. 5 shows a further exemplary embodiment of the present invention which illustrates yet another suitable form of coronode structure. Except for the coronode structure relied upon, the apparatus depicted in FIG. 5 is the same as is illustrated in FIG. 4 and is therefore shown as comprising corotron means 1 connected to a

suitable power supply 2 and disposed in a charging relationship with a medium 3 to be tacked to a surface 4. The power supply 2, the medium 3 and the surface 4 at which tacking is to occur may each take the same form, perform the same functions and admit of the same variations as the commonly referenced structure shown in FIG. 4 and described above. Additionally, shieldless coronode means 1 are again relied upon; however, the coronode structure employed here takes the form of a grid or screen. In the screen form of coronode structure depicted in FIG. 5 either the filamentary elements 30 disposed in the horizontal direction or the vertically disposed filamentary elements 31 may be formed of fine strands of conductive material and hence constitute coronodes while the other group of filamentary elements may be formed of insulating material woven therewith in the conventional manner to form a structurally firm screen arrangement which may be disposed above the path of motion of the medium 3 to be charged without external support or alternatively be supported by a frame or partial frame arrangement. Alternatively, both groups of horizontally disposed and vertically disposed filamentary elements 30 and 31 may comprise fine strands of conductive wire whereupon all of such filaments 30 and 31 would comprise coronodes capable of delivering ion charging current to the medium 3 to be tacked. This latter coronode structure is not preferred; however, because as will be apparent to those of ordinary skill in the art, the coronode cross-points established in such a configuration are not highly desirable from the standpoint of the imposition of uniform charge levels by the entire array and also the feature of this invention whereby the tacking force on the medium is quickly removed after the medium 3 has left the tacking environment is altered to a certain degree because the ringing down effect previously discussed would be modified due to the charging appearance of this form of array as the medium is displaced therefrom. Therefore in FIG. 5, the group of vertically disposed filamentary elements 31 have been illustrated as commonly connected to the power supply 2 through conductors 32 and 33 and it should be assumed for the purposes of the explanation which follows that the group of vertically disposed filamentary elements are formed of conductive material while the horizontally disposed group of filamentary elements 30 are formed of appropriate insulating material such as plastic.

Under these conditions the spacing of the coronode structure illustrated in FIG. 5 from the surface of the medium 3 to be charged would be the same as that described in conjunction with FIG. 1 as would also be the spacing between each of the conductive filamentary elements in the vertically disposed group 31. The spacing of the horizontally disposed group of filamentary elements 30 is not critical and is preferably selected to allow the woven screen or grid formed to exhibit sufficient structural rigidity. However, should an embodiment of the invention be relied upon wherein the filamentary elements in both directions are conductive and hence act as coronodes, the spacing in each direction would normally be equal and in actual grid formation could be relied upon rather than a weaving technique to form the desired structure. The operation of the exemplary embodiment of the invention de-

picted in FIG. 5, under the conditions imposed above, would be precisely that set forth in the operation of the FIG. 1 embodiment of this invention and hence does not require repetition. Thus, the exemplary embodiment of this invention shown in FIG. 5 presents a readily available alternative to the other coronode structure presented herein while retaining each of the attributes of the tacking methods and apparatus taught by this invention as discussed above.

Therefore, it will be seen that the methods and apparatus for electrostatically performing a tacking operation as taught by the instant invention allow a medium to be firmly held or tacked against a desired surface for a selected interval and upon the termination of such selected interval the tacking force imposed is automatically neutralized without the application of a specialized neutralizing charge whereby stripping may be readily achieved without the occurrence of sparking or any other deleterious electrostatic discharge effect. Accordingly, the present invention allows tacking and stripping operations to be performed without the use of specialized charge neutralizing apparatus while the difficulties normally attending the removal of the tacked medium in the absence of such specialized charge neutralizing apparatus are avoided.

Although the present invention has been disclosed in conjunction with several exemplary embodiments thereof, various alternatives and modifications to the specific structure set forth herein will be obvious to those of ordinary skill in the art. For instance, other coronode configurations could be readily substituted for the specific configurations illustrated, shielded corotrons capable of delivering the alternating polarity charge configurations contemplated herein could be substituted for the shieldless corotrons disclosed and any form of alternating waveform could be employed in providing a voltage input to the corotron. Furthermore, under certain circumstances it may be desirable to extend the ringing down technique employed by the instant invention to automatically dissipate the tacking force when the medium leaves the tacking environment of the corotron means to conditions which obtain when the corotron means and hence the tacking apparatus employed is turned off even though the medium remains in the tacking environment of the corotron means and hence the tacking force would not otherwise be removed. This could be accomplished by providing the output stage of the power supply with resonant or ferroresonant transformer means or other inductive coupling means which act to store current and hence would automatically act to ring down the input waveform when the power supply was de-energized. Additionally, as will be appreciated by those of ordinary skill in the art, the specific values, materials and parameters set forth herein are to be viewed only as exemplary and not in a limiting sense.

While this invention has been described in connection with several exemplary embodiments thereof, it will be understood that many modifications will be readily apparent to those of ordinary skill in the art; and that this application is intended to cover any adaptations or variations thereof. Therefore, it is manifestly intended that this invention be only limited by the claims and the equivalents thereof.

What is claimed is:

1. Apparatus for electrostatically tacking a medium to a surface comprising:

a translatable surface for transporting said medium in accurate registration therewith in the absence of any relative motion therebetween;

corotron means including a coronode configuration to be brought into a charging relationship with said medium when said medium is disposed on said surface in an appropriate manner to be tacked thereto, said coronode configuration occupying a sufficient spatial extent relative to said medium to deliver, when energized, ion charging current thereto over a sufficient surface area of said medium to firmly tack said medium to said surface for a selected spatial interval of motion of said medium, said selected spatial interval of tacking obtaining only when said medium is transported into a charging relationship with said coronode configuration; and

means for applying a time varying input signal to said coronode configuration to accomplish the energization thereof, said time varying input signal exhibiting a waveform having equal and opposite half-cycles disposed about a reference level and magnitude portions exceeding the positive and negative corona threshold potentials of said coronode configuration, whereby said coronode configuration imposes positive and negative levels of charge on said medium in an alternating manner determined by said time varying input signal to firmly tack said medium to said surface for said selected spatial interval while said charge levels are reduced to zero when said medium is transported past said spatial interval.

2. The apparatus for electrostatically tacking according to claim 1 wherein said surface is unidirectionally translatable and said selected spatial interval of tacking occurs along a distance of displacement similar in length to an axis of the spatial extent occupied by said coronode configuration parallel to the direction in which said medium is transported.

3. The apparatus for electrostatically tacking according to claim 1 wherein said coronode configuration comprises a plurality of parallelly disposed individual coronode means connected to said means for applying a time varying input signal, said coronode means being disposed in a plane parallel to said surface.

4. The apparatus for electrostatically tacking according to claim 3 wherein said plurality of parallelly disposed individual coronode means comprise a plurality of substantially equally spaced strands of conductive wire.

5. The apparatus for electrostatically tacking according to claim 3 wherein said plurality of parallelly disposed individual coronode means comprise strands of conductive wire woven in a screen arrangement with transversely disposed insulating elements.

6. The apparatus for electrostatically tacking according to claim 3 wherein said surface is unidirectionally translatable and said plurality of parallelly disposed individual coronode means are disposed transversely to the direction in which said medium is transported.

7. The apparatus for electrostatically tacking according to claim 6 wherein said plurality of parallelly disposed individual coronode means comprise a plu-

ality of substantially equally spaced strands of conductive wire.

8. The apparatus for electrostatically tacking according to claim 6 wherein said plurality of parallelly disposed individual coronode means comprise strands of conductive wire woven in a screen arrangement with transversely disposed insulating elements.

9. The apparatus for electrostatically tacking according to claim 3 wherein selected ones of said plurality of parallelly disposed individual coronode means are connected directly to said means for applying a time varying input signal while others of said plurality of parallelly disposed individual coronode means are connected to said means for applying a time varying input signal through phase shift means.

10. The apparatus for electrostatically tacking according to claim 9 wherein said surface is unidirectionally translatable and said plurality of parallelly disposed individual coronode means are disposed transversely to the direction in which said medium is transported.

11. The apparatus for electrostatically tacking according to claim 10 wherein said plurality of parallelly disposed individual coronode means comprise a plurality of substantially equally spaced strands of conductive wire.

12. The apparatus for electrostatically tacking according to claim 11 wherein said selected ones of said plurality of parallelly disposed individual coronode means which are directly connected to said means for applying a time varying input signal comprise alternate ones of said plurality of parallelly disposed individual coronode means.

13. The apparatus for electrostatically tacking according to claim 12 wherein said phase shift means inserts a ninety degree phase shift into input signals applied thereto.

14. The apparatus for electrostatically tacking according to claim 1 wherein said coronode configuration comprises unitary coronode means formed of a substantial length of conductive material shaped in a manner to exhibit a plurality of turning points in a plane parallel to a major surface of said medium, said unitary coronode means thereby threading back and forth in serpentine fashion above said surface of said medium when said medium is in a charging relationship therewith, said spatial extent being defined by the area in space occupied by said substantial length of conductive material shaped as aforesaid.

15. The apparatus for electrostatically tacking according to claim 14 wherein said surface is unidirectionally translatable and said plurality of turning points are each substantially right angles, said coronode means formed by said substantial length of conductive material and shaped in the aforesaid manner thereby having portions disposed transversely to the direction in which said medium is transported and other portions disposed parallel to said direction.

16. The apparatus for electrostatically tacking according to claim 15 wherein said portions of said coronode means disposed transversely to said direction in which said medium is transported are equally spaced from one another.

17. The apparatus for electrostatically tacking according to claim 16 wherein said portions of said

coronode means disposed transversely to said direction in which said medium is transported are substantially equal in length to the axial dimension of said medium in a direction transverse to said direction of transport.

18. A method for electrostatically tacking a medium to a surface comprising the steps of:

placing said medium in relative motion with coronode means when said medium is disposed on said surface in an appropriate manner to be tacked thereto so that said medium is transported by said surface into a charging relationship with said coronode means and subsequently removed therefrom;

applying a time varying input signal to said coronode means to achieve the energization thereof, said time varying input signal being selected to exhibit a waveform having equal and opposite half-cycles disposed about a reference level and peak magnitude portions exceeding the positive and negative corona threshold potentials associated with said coronode means, and

delivering positive and negative ion charging current in an alternating manner determined by said time varying input signal to sufficient surface area of said medium to firmly tack said medium to said surface for a selected spatial interval of relative

motion between said coronode means and said medium corresponding substantially to an interval when portions of said medium are disposed in a charging relationship to said coronode means whereby said coronode means imposes positive and negative levels of charge on said medium in an alternating manner determined by said time varying input signal to firmly tack said medium to said surface in the absence of any relative motion therebetween for said selected spatial interval while said charge levels are reduced to zero when said medium is transported past said spatial interval.

19. The method for electrostatically tacking a medium to a surface according to claim 18 wherein the step of delivering positive and negative ion charging current to sufficient surface areas of said medium to firmly tack said medium to said surface in the absence of any relative motion therebetween for a selected spatial interval is carried out by configurating said coronode means to occupy a sufficient spatial extent relative to said medium so that ion charging current is delivered to a sufficient portion of the surface areas of said medium to define said selected spatial interval in combination with the entire surface area of said medium.

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