

Oct. 28, 1952

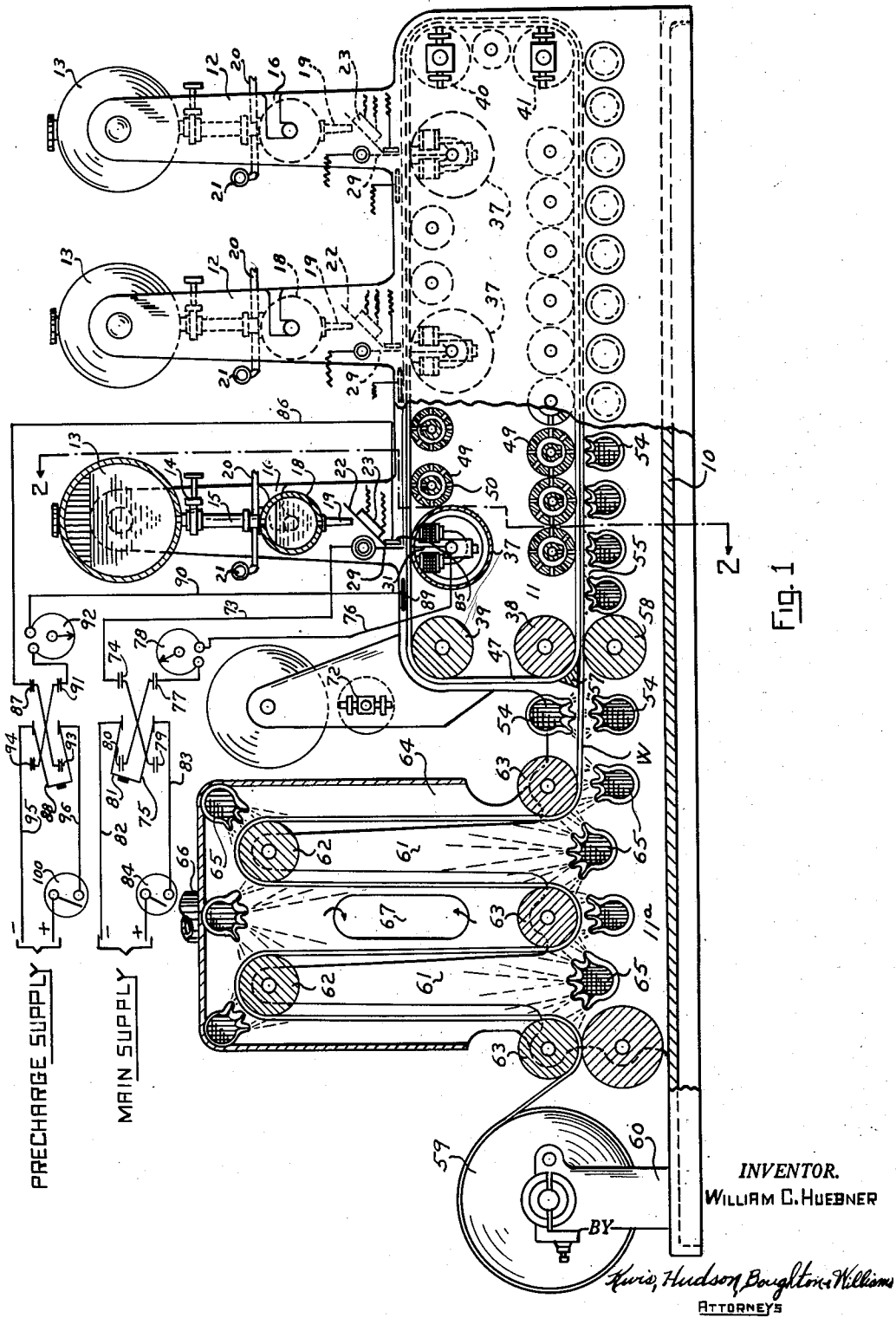
W. C. HUEBNER

2,615,822

METHOD OF MAKING SHEET OR WEB MATERIAL

Filed Feb. 21, 1946

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

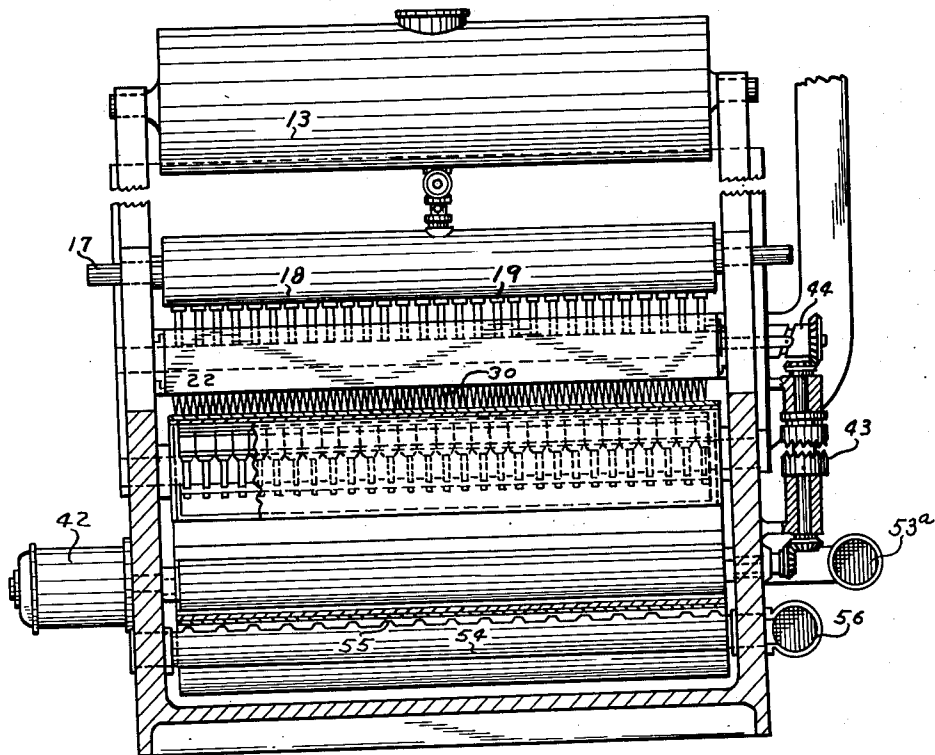


Fig. 2

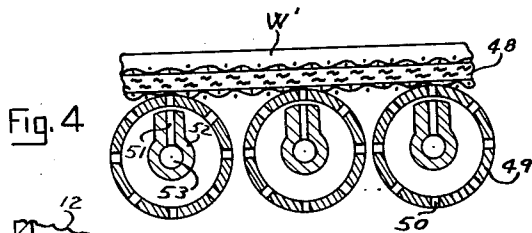


Fig. 4

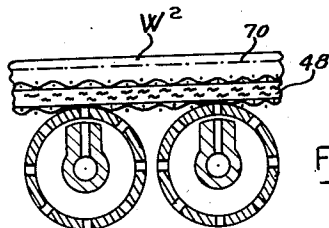


Fig. 5

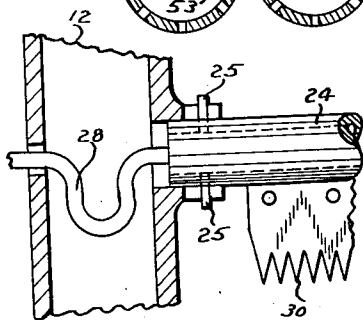
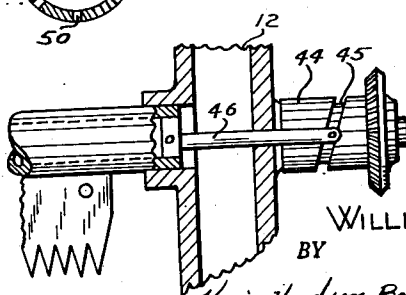


Fig. 6



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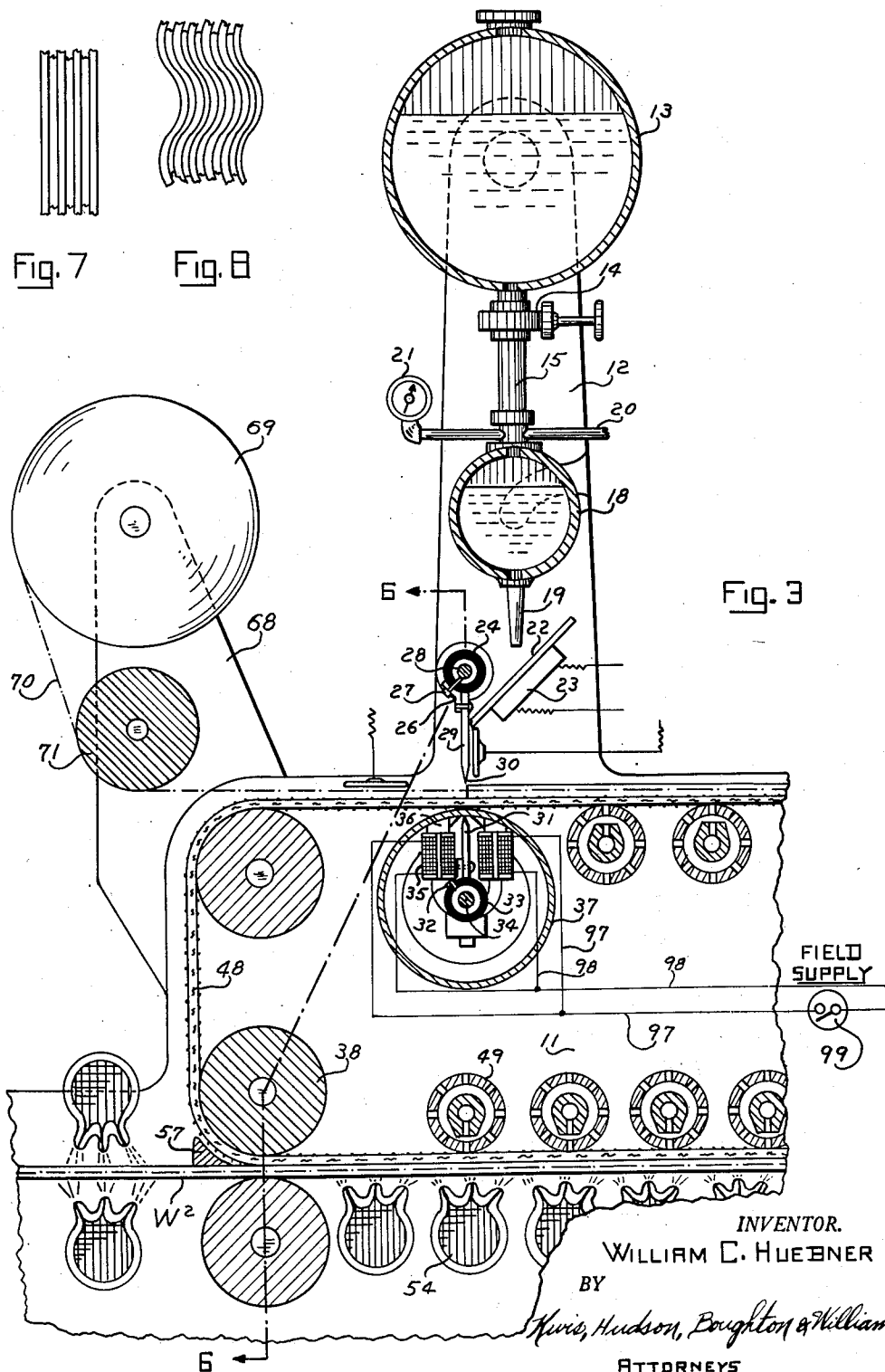
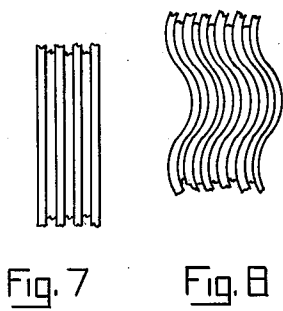
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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,615,822

METHOD OF MAKING SHEET OR WEB MATERIAL

William C. Huebner, New York, N. Y.

Application February 21, 1946, Serial No. 649,315

7 Claims. (Cl. 117-47)

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This invention relates to improvements in a method for making sheets or webs. The invention contemplates producing sheets or webs similar to paper, cloth, linen, felt, asbestos or other fibrous-like sheets or webs from deposits of compositions in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable fibrous-like materials and which compositions are then conditioned, dried or set. The invention also contemplates making sheets or webs from cellulose nitrate, cellulose acetate, resins, synthetic resins or other suitable plastic compositions in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable material by deposits of the compositions and which deposits are then conditioned, dried or set.

The invention also contemplates producing sheets or webs from any other composition containing electrically chargeable material and which composition can be deposited in liquid, semi-liquid or mobile liquid particle form and then conditioned, dried or set.

The term "web" as used herein designates a ribbon of the material of substantial length and which can be wound upon a drum while the term "sheet" as used herein designates a ribbon of the material which is of relatively short length and wherein the separate sheets must be stacked as distinguished from being continuously wound on a drum.

This application is a continuation-in-part of my application Serial No. 533,500, filed May 1, 1944 and now abandoned.

The method contemplated by the invention employs a principle which is altogether novel and therefore there is no adequate term now in use covering this principle. Consequently I have originated a new term for the principle employed in the method contemplated and which term is electro-migratic. The term may be defined as follows:

"The science of subjecting compositions in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable material or materials to electric force or forces to ionize said material or materials and cause the migration of said compositions between spaced electrodes under the velocity influence of said electric force or forces and under substantially atmospheric conditions."

An object of the invention is to provide an improved method for making sheets or webs of the character referred to, rapidly, economically and with controlled uniformity of thickness and texture in accordance with desired characteristics.

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Another object of the invention is to provide an improved method for making sheets or webs of the character specified and wherein the sheets or webs can be produced in one continuous operation so as to consist of a single layer of material or of a plurality of laminated layers of the same material or of different materials with the layers being of the same or different thicknesses as desired.

Another object is to provide a method for making sheets or webs and which method can be used with equal facility for making fibrous-like sheets or webs or for making film-like sheets or webs or for producing coatings on previously formed sheets or webs.

Another object is to provide a method for making sheets or webs and wherein the sheets or webs may simultaneously with their production be reinforced by a reinforcing element integrated therewith or embedded therein.

Another object is to provide an improved method of forming upon a receiving or reinforcing base material or element a layer or coating of predetermined thickness of a composition containing electrically chargeable material and which composition is transferred to and deposited upon the base material or element while in liquid, semi-liquid or mobile liquid particle form by the lines of force of an electro field of force and thereafter is conditioned, dried or set.

Another object of the invention is to provide a method of making sheets or webs from compositions in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable material and wherein the composition is transferred from a supply source and is deposited on a movable support by the lines of force of an electro field or fields of force created at a predetermined location or locations relative to said movable support.

Further and additional objects and advantages not hereinbefore specified will become apparent during the detailed description of the method and apparatus for carrying out the method and which apparatus is illustrated in the accompanying drawings, wherein

Fig. 1 discloses, partially in front elevation and partially in section, an apparatus capable of performing the method of the invention and which apparatus in this instance is shown as comprising three composition deposit stations of such character that the composition can be deposited at only one of the stations or at a plurality of the stations as desired, depending upon the character of the sheet or web to be produced i. e., if it is to be of a single thickness of composition or of

a plurality of layers of the same composition or different materials.

Fig. 2 is a sectional view taken substantially on line 2—2 of Fig. 1 looking in the direction of the arrows.

Fig. 3 is a view on an enlarged scale of a portion of Fig. 1, i. e., the left hand deposit station of Fig. 1 but shows a different form of movable support upon which the composition is deposited than does Fig. 1.

Fig. 4 is a fragmentary enlarged view of the belt or movable support of Fig. 3 showing a deposit thereon of a composition containing fibrous material such as paper or the like and disclosing the manner in which the suction drums operate to remove moisture from the composition and belt.

Fig. 5 is a view similar to Fig. 4 but illustrates a reinforcing element integrated with the deposited composition, in this instance said element being embedded in the composition.

Fig. 6 is a fragmentary sectional view taken substantially on line 6—6 of Fig. 3 looking in the direction of the arrows, and

Figs. 7 and 8 are diagrammatic illustrations respectively of the manner in which the composition is deposited on the movable support when the discharge element is stationary and when said element is oscillated transversely of the support.

The apparatus disclosed in the drawings as illustrative of an apparatus for performing the method comprises a base 10 which is provided adjacent its right hand end and along its longitudinal edges with upstanding side walls 11. The upper edges of the side walls 11 support spaced upwardly extending standards 12, there being in the present illustration three pairs of said standards since for purposes of illustration the apparatus will be described as having three composition transfer and deposit stations. However, it will be understood that a different number of such stations may be provided as desired.

Each pair of standards 12 supports between its upper end a main or reservoir tank 13 which holds the composition in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable material that is to be transferred and deposited and formed into a sheet, web, layer or coating. Each tank 13 is provided on its underside with a valved outlet 14 to which is connected one end of a length of flexible hose 15. Each standard 12 intermediate its top and lower ends is provided with a bayonet slot 16 to receive and mount therein trunnions 17 formed on the opposite ends of a removable intermediate and smaller supply tank 18. The lower end of each flexible hose 15 is connected to the inlet of a supply tank 18, wherefore a regulated amount of the composition can flow from the reservoir 13 through the valved outlet 14 thereof, through the hose 15 and into the supply tank 18. The supply tank 18 on its underside is provided with a series of longitudinally spaced vertically extending nozzles 19, while each tank 18 has its inlet connected to a separate conduit 20 that extends to a regulated source of supply of pressure fluid, wherefore regulated pressure can be created in each tank 18 to cause a greater or lesser flow of the composition through the nozzles 19. It will be understood that the pressures in the various tanks 18 may be independently and separately regulated so as to provide for a greater flow from one of the tanks

than from another. In addition, the composition in one of the tanks may be of a different fluid consistency from the composition in another tank and hence different pressures would be required to produce the desired outward flows of the two different compositions. A pressure gauge 21 is provided for each supply tank 18 so the operator can determine when the desired pressures have been obtained for each of the supply tanks.

Each pair of standards 12 supports an inclined plate 22 which extends beneath the row of outlet nozzles 19 and each plate 22 may be provided with suitable means for heating the same as for instance an electric heater 23. It will be understood that in some instances the composition will be of such character that it is desirable to heat the same as it flows along the inclined plate 22 either to maintain the composition in the proper consistency or to facilitate the flow thereof onto a discharge element later to be referred to.

As previously stated, the invention contemplates transferring the composition to and depositing the same on a movable support by means of the lines of force of an electro field of force. In the present machine there are three units disclosed for creating three separate electro fields of force and each of these units is identical with the others and hence only one need be described in detail.

The standards of each pair of standards 12 are provided on their adjacent faces with bossed openings in which an insulator tube 24 is mounted for limited endwise movement, said tube being held against rotation in the openings by pins 25 carried by the tube and located in slots formed in one of the bosses, see Fig. 6.

An angle strip 26 is secured to the outer circumference of each tube 24 and said strip is electrically connected by means of one or more connections with an electrical conduit 28 that extends longitudinally within the tube 24 and which is connected to a source of electrical energy as will later be explained. A vertically extending discharge element 29 has its upper end secured and electrically connected to the angle strip 26, while its lower end is, in this instance, in the form of a longitudinal series of comb-like fine pointed teeth 30. The discharge element 29 is spaced slightly from the lower longitudinal edge of the plate 22, wherefore composition on the plate 22 can flow down said plate and onto the discharge element and thence to the comb-like teeth 30 thereof where it will be held by capillary action.

Each unit also includes an attraction element 31 in the form of a blade and vertically aligned with the discharge element 29 with its knife-like upper edge vertically spaced from the lower ends of the pointed teeth 30 of the discharge element. The attraction element 31 is secured to an angle strip 32 similar to the angle strip 26 and attached to the exterior of an insulator tube 33 which is rigidly supported by the walls 11. The angle strip 32 is electrically connected to an electrical conduit 34 extending longitudinally within the tube 33 and connected to the opposite side of the source of electrical energy to which the conduit 28 is connected as will later be explained. A series of electro magnets 35 are mounted on each side of the attraction element 31 and said magnets are provided with field bars 36 shaped to provide sharp edges adjacent to the knife edge of the attraction element 31. The magnets 35

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will be connected to a suitable source of electrical energy and when energized will create magnetic fields of force on each side of the electro field of force between the discharge element 29 and attraction element 31 and said magnetic fields of force will act as a shield to prevent dispersion of the electro field of force and to concentrate the same within a narrow zone.

The attraction element 31, tube 33 and magnets 35 are mounted within a supporting cylinder 37 rotatably supported in and insulated from the side walls 11, with the field bars 36 of the magnets and the knife edge of the attraction element 31 closely adjacent to the inner circumference of the cylinder. Inasmuch as there are three units in the apparatus disclosed three such cylinders 37 are illustrated and such cylinders contact the underside of and support the movable member upon which the composition is deposited to maintain the desired spacing between the member and the discharge element, such member being illustrated as an endless belt.

The side walls 11 adjacent their left hand ends as viewed in Fig. 1 rotatably support driving roller 38 and idler roller 39 arranged parallel to each other with the roller 39 spaced vertically above the roller 38. The walls 11 adjacent their right hand ends rotatably support idler rollers 40 and 41 which also are arranged in vertically spaced parallelism and are mounted for adjustment in a horizontal plane. The rollers 38, 39, 40 and 41 are adapted to mount various forms of endless belts later to be referred to and which constitute the movable support for the deposited composition, it being understood that the adjustment of the rollers 40 and 41 in the horizontal plane provides the proper tautness to the endless belt.

The roller 38 is driven by a variable speed motor unit 42 which may have a geared reduction embodied therein and the shaft on which said roller 38 is mounted is operatively connected by suitable drive trains indicated generally at 43 and each train including a clutch and a rotatable cam drum 44 having a cam groove 45 in which travels a follower carried by a rod 46 that is connected to the insulator tube 24. It will be understood that the shaft of the roller 38 is thus operatively connected with each of the insulator tubes 24 and hence when said shaft is rotating and the clutch of each train is engaged each insulator tube 24 will be given a predetermined limited endwise oscillating movement with a resultant movement of the discharge element 29. The purpose of this will later be referred to.

As previously stated the composition is deposited on a movable support which is in the form of an endless belt, the deposit being made either directly on the support or upon a receiving or reenforcing base element or member traveling over or upon said support. In Fig. 1 the endless belt is shown as a thin smooth or polished steel or metal belt 47 extending around the rollers 38, 39, 40 and 41 and driven by the roller 38. This form of belt will be employed when sheets or webs of film-like composition are to be produced.

In making sheets or webs from compositions in liquid, semi-liquid and mobile liquid particle form and containing electrically chargeable fibrous materials, a foraminous endless belt is used in place of the steel belt 47 and such foraminous bent is indicated at 48 in Figs. 3, 4 and 5 and consists of a layer of felt or other suitable and similar material interposed between fine

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screen mesh. It will be understood that the purpose of using such a belt is to allow the moisture to be withdrawn from the composition previously deposited on the belt by the electro field of force between the discharge and attraction elements so that the fibers of the composition will be felted together when the composition dries.

It is proposed to employ two series of rotatable tubes 49 which are supported by the side walls 11 and extend transversely of the endless belt with the tubes of one series located intermediate the cylinders 37 and contacting the underside of the upper reach of the belt while the tubes of the other series are positioned to contact the upper side of the lower reach of the belt. Each tube 49 is provided with a plurality of circularly spaced series of longitudinally spaced radially extending ports 50 which are adapted to register as the tubes rotate with longitudinally spaced passages 51 in a stationary elongated nozzle 52 extending longitudinally within the tube as clearly shown in the drawings. The passages 51 in each nozzle 52 communicate with a longitudinally extending bore 53 in the nozzle and said bore 53 is connected to a suitable suction device 53a, wherefore the nozzles and tubes act to withdraw moisture from the belt and particularly from the foraminous belt 48 shown in Figs. 3, 4 and 5 and the composition deposited thereon. It will be understood that when the metal belt 47 is used as the composition supporting member the suction device just described need not be operated. A series of air pipes 54 is located beneath the lower reach of the endless belt and said pipes extend transversely of the belt and are provided with a plurality of longitudinally spaced radially projecting outlet nozzles 55. The pipes 54 communicate with a manifold conduit 56 and said manifold conduit 56 is in communication with a suitable source of supply of hot, warm or cold air under pressure, depending upon the type of composition which is being formed into sheets or webs and such air blasts act on the composition on the belt 47 or the belt 48 to condition, dry or set the composition as the case may be.

The walls 11 just to the left of the roller 38 support suitable separating device 57 which separates the now conditioned sheet or web from the belt, it being noted that a supporting roller 58 is rotatably carried by the walls 11 directly beneath the roller 38 so as to support the sheet or web as it is separated from the belt.

If sheets are being produced by the apparatus the separated sheets will be carried over a suitable horizontal conveyor and through a drier and then stacked. However, in the apparatus shown in the drawing a web is illustrated as currently being produced by the apparatus and the separated web W passes through a dried chamber now to be described and is wound upon a drum or reel 59 rotatably supported by suitable standards 60 projecting upwardly from the base 10, it being understood that said reel can be driven in any suitable manner well known in the art. The drier chamber through which the web W passes includes side walls 11a extending upwardly from the base 10 and merging into upwardly projecting standards 61 which rotatably support at their upper ends rollers 62. The walls 11a rotatably support adjacent the base of the standards 61 rollers 63 and the web W is reeved around the rollers 63 and 62 so as to provide a plurality of reaches of the web within the hous-

ing 64 of the drier chamber. The walls 11a and the housing 64 support air pipes 65 similar to air pipes 54 with the outlet nozzles of said pipes directed to admit blasts of air or other drying medium into the drying chamber and along both sides of the web at each of the reaches thereof. The housing 64 is provided with a stack 66 that communicates with the interior of the housing 64 through the opening 67 to draw away the moisture laden air from the drier. Also, if desired, an air pipe 65 may be so located that the air blasts from the nozzles will engage the upper side of the web intermediate the drive roller 38 and the right hand roller 63 as viewed in Fig. 1.

It will be understood that in place of the air pipes 54 and 65 other suitable drying or conditioning devices might be employed to raise or lower the temperature of the sheets or webs to effect the conditioning, drying or setting thereof to enable the sheets or webs to be handled. It will also be understood that when said sheets or webs are stripped from the belt they will by that time have attained sufficient strength to permit them to be reeved through the drying chamber and wound upon the reel 59 or in the case of sheets to be handled and stacked.

In addition it will be appreciated that at the start of the operation of producing the web a sufficient length of the web will first be produced until a short length thereof has been stripped from the belt by the separating element 57 and that such short length can be attached to a suitable lead-in strip which is connected to the reel 59 and is reeved around the rollers of the drying chamber and thus the newly formed web can be reeved around the pulleys of the drying chamber and onto the reel 59.

The left hand upper corner of the walls 11 as viewed in Figs. 1 and 3 have upwardly extending therefrom supporting arms 68 that rotatably mount at their upper ends a roll 69 of a suitable reinforcing or receiving base material or element as, for instance, open mesh screen or cloth 70 and said screen or cloth extends around a guide roller 71 carried by the supporting arms 68 and vertically adjustable by adjusting means indicated at 72. The adjustment of the roller 71 is for the purpose of providing desired spacing, if any, between the reinforcing or receiving material 70 and the endless belt and said material extends over the upper reach of the endless belt and around the rollers 40 and 41. The reinforcing or receiving material is utilized when it is desired to have the same integrated or coated with or embedded in the composition containing electrically chargeable material that is deposited on the belt to form a sheet or web including the base material or element and the deposited composition and this is clearly indicated in Fig. 5. It will be understood that the reinforcing or receiving base material or element can be arranged to lie directly on the belt and to have the composition containing electrically chargeable material deposited thereon and integrated therewith in the form of a coating, or in other instances the reinforcing material can be spaced from the belt and the composition deposited so as to embed the reinforcing material therein. The adjustment of the pulley 71 determines the spacing of the base material or element from the belt at the first deposit station and thereafter the base material is held in proper relationship to the belt by the composition containing electrically chargeable material deposited at the first deposit station.

It will be understood that in those instances where the base material or element is employed said material can first be reeved through the drying chamber and onto the reel 59 before commencing to deposit the composition containing electrically chargeable material upon the base material and hence the base material will, in this instance, act as the lead-in for the web.

The left hand discharge element 29, as viewed in Fig. 1, is connected by a lead 73 to the contact 74 of a reversing switch 75. The left hand attraction element 31 is connected by a lead 76 to the contact 77 of said reversing switch 75 and a suitable adjustable rheostat 78 is included in the lead 76. The contact 74 of the switch 75 is connected to the contact 79 thereof while the contact 77 is connected to the contact 80. The switch blade 81 is connected to leads 82 and 83 which extend to a source of high potential electrical energy. It will thus be seen that the discharge element 29 and the attraction element 31 can be placed in a high potential circuit and that the polarities of said elements can be selectively changed by means of the reversing switch 75. It will also be seen that the voltage of the high potential current can be regulated by means of the rheostat 78.

It will be understood that a similar and individual arrangement is provided for the sets of discharge and attraction elements of the other two or more stations of the apparatus so that the polarities of said elements can be selectively changed and the voltage of the high potential circuits selectively varied.

An "on" and "off" switch 84 may be located in the main inlet leads 82 and 83 in order to interrupt the high potential circuit to the discharge and attraction elements and thus interrupt the transfer to and the deposit of the composition on the belt. The main "on" and "off" switch can be manually operated or automatically operated at predetermined time intervals and particularly when the apparatus is being employed to produce sheets, it being understood that when the high potential circuit is interrupted no composition will be deposited on the belt and thus the length of the sheets can be controlled.

In order to facilitate the transfer of the composition from the discharge element to the belt or the base material or element it is proposed to impress on the electrically chargeable material of the composition on the discharge element and to impress on the belt and the base material an electrical precharge of predetermined polarity correlated to the polarities of the discharge and attraction elements. The precharge impressed on the electrically chargeable material of the composition on the discharge element causes such material to be ionized and to render the composition susceptible to migration under the velocity influence of the electro field of force between the discharge and attraction elements. A terminal 85 is located closely adjacent to the discharge element 29 and is connected by a lead 86 to the contact 87 of a reverser switch 88 similar to the reverser switch 75. A terminal 89 is located closely adjacent to the upper surface of the belt in advance of the transfer zone and is connected by a lead 90 to the contact 91 of the reverser switch 88. An adjustable rheostat 92 is located in the lead 90. The contacts 87 and 91 of the reverser switch 88 are connected respectively with the contacts 93 and 94 of said switch while the movable switch blade is connected with leads 95 and 96 that extend to a source of high

potential electrical energy and in which leads is located a main "on" and "off" switch 100. It will thus be seen that the polarities of the terminals 85 and 89 and the voltages impressed thereon can be selected by the reverser switch 88 and the adjustable rheostat 92 and said polarities and voltages will be correlated to the polarities of the discharge and attraction elements and to the voltages impressed thereon. The terminals 85 and 89 impress precharges on the electrically chargeable material of the composition on the discharge element and on the belt or base material and these precharges ionize the said electrically chargeable material and supplement and assist the lines of force of the electro field of force between the discharge and attraction elements to transfer the composition containing the electrically chargeable material from the discharge element and to deposit the same on the belt or upon the base material.

It will be understood that a similar arrangement is employed for each of the transfer and deposit stations with the understanding that the terminal 89 at those stations beyond the first station will impress a precharge on the composition containing the electrically chargeable material previously deposited on the belt or base material and also on the belt and base material.

The magnets 35 are connected by leads 97 and 98 to a suitable source of electrical energy. A main "on" and "off" switch 99 is located in the leads 97 and 98 so that the current to the magnets can be interrupted and said switch may be manually operated or automatically operated.

Assuming that a web of film is to be produced in the apparatus and that all three depositing stations of the apparatus are to be utilized to provide the desired thickness in the web the reservoir tanks 13 will be supplied with a suitable composition in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable material and the valve means 14 will be opened until the desired amount of the composition has flowed into the auxiliary or supply tanks 18, after which the valve means 14 will be closed and pressure fluid admitted to the conduits 20 to create the desired pressure heads in the tanks 18. As already stated, the pressure heads established in the tanks 18 are for the purpose of facilitating the flow of the composition from said tanks through the nozzles 19 and onto the plates 22 and thus the pressure of such pressure heads will vary in accordance with the particular type of composition employed. The composition on the plates 22 flows downwardly of said plates and onto the comb of the discharge elements 29 with the composition being retained on the comb and in the space between the plates 22 and the discharge elements by capillary action. Certain types of composition may require the application of heat to facilitate the flowing of the composition and in such cases the heaters 23 can be utilized.

The operator now causes the motor 42 to function to move the steel belt 47 at the desired speed and adjusts the rheostats 78 and 92 to produce the desired voltages in the circuit to the discharge and attraction elements and in the circuit to the precharging terminals 85 and 89. In addition, the operator positions the reverser switches 75 and 88 to effect the polarities for the discharge and attraction elements and for the terminals 85 and 89 in accordance with the polarities best suited for transferring the particular composition. Likewise, the operator

causes air to be supplied to the pipes 54 and, as already stated, this air may be cool, warm or hot depending upon the character of the composition. The electrostatic field of force between the discharge and attraction elements assisted by the ionizing precharges impressed on the electrically chargeable material of the composition on the discharge elements and the precharges on the belt causes the composition to be transferred by electro lines of force from the discharge elements and onto the belt, it being understood that the composition from the discharge element at the first station is deposited directly on the belt while the composition from the discharge elements at the succeeding stations is deposited on the previously deposited composition.

The thickness of the deposits of the composition on the belt can be regulated in three ways, i. e., by the air pressures in the tanks 18 to control the volume of flow of the composition; by the voltages of the electro field of force, and by the speed of travel of the belt.

As the deposited composition moves with the belt to the lower reach thereof said composition becomes dried or set or conditioned by the action of the air blasts from the pipes 54. As soon as the separating device 57 has separated a short length of the deposited and conditioned composition from the belt this length of the composition is quickly attached by the operator to a lead-in which extends from the reel 59 and has been reeved around the rollers in the drying chamber as previously explained. The process then continues and the web as it is formed and preliminarily dried, set or conditioned is separated from the belt by the separating device 57 and passes through the drier where it is further dried, set or conditioned and is then wound upon the reel 59. During the operation of the apparatus the operator will observe the air gauges 21 to make sure that the desired air pressures are maintained in the tanks 18.

If the clutches in the drive trains 43 are disengaged the discharge elements 29 will be stationary and the deposits of the composition from the comb teeth of the discharge elements will be straight line deposits, as indicated in Fig. 7, but such deposits are closely spaced and will merge together on the belt. If the clutches in the drive trains 43 are engaged the discharge elements 29 will be oscillated and the deposits on the belt will be of wavy formation, as indicated in Fig. 8, and will then merge together on the belt.

Assuming that it is desired to produce a web of three different film-like compositions arranged in three laminated layers, the reservoir tanks 13 and the respective supply tanks 18 will be supplied respectively with the three different compositions so that the composition from the left hand or first station is deposited directly on the belt, the composition from the intermediate station is deposited on the first deposit of composition while the composition from the third station is deposited on the second deposit of composition. It may be that the three different compositions have different flow characteristics which makes it desirable to have three different pressure heads created in the tanks 18 and the operator can very readily regulate the pressure in the tanks for the desired purpose. It may also be that the three different compositions will each react to transfer and deposit by electro fields of force of different voltages or of different polarities and the operator can take care of this situ-

ation because of the individual control circuits for each station, whereby the voltages and polarities of the fields of force and of the ionizing precharges can be selectively varied to suit the characteristics of the composition to be deposited. It will be understood that a laminated web with the differences above pointed out may be produced in the same way as the web formed of a single composition as above explained.

It will also be understood that in order to concentrate the electrostatic fields of force and to shield the same against dispersion it is preferable to have the magnets 35 energized to create shielding magnetic fields of force when the composition is being transferred and deposited by the electrostatic fields of force.

The use of the apparatus in practicing the method has been explained above in connection with the making of film-like webs. When it is desired to use the apparatus to make film-like sheets the switches 84 or 99, as the case may be, can be opened momentarily at predetermined intervals, either manually or automatically, to interrupt the electro fields of force, to momentarily interrupt the transfer and deposit of the composition so as to provide intervals between the successive sheets on the belt 47.

As already explained, the sheets thus formed when separated from the belt will be conveyed through a similar drier by a modified form of conveyor.

Assuming that it is desired to produce a fibrous-like web or sheet from a composition in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable fibers then the metal belt 47 is removed and the belt 48 of Figs. 3 and 4 is substituted. The composition is introduced into the reservoir tanks 13 and supply tanks 18 and the pressure heads for the tanks 18 are regulated to cause the desired flow of the composition and the voltages and polarities of the transfer circuits and the precharging circuits are regulated as required. The composition will then be transferred from the discharge elements 29 onto the belt 48 and the thickness of the deposits can be regulated by regulating the speed of the belt as well as by regulating the pressure heads and the voltages. Inasmuch as the belt 48 is foraminous, being formed of felt interposed between fine mesh, the suction nozzles 52 in the rotatable tubes 49 will act to draw the moisture from the composition deposited on the belt to dry said composition and to cause the fibers thereof to become felted together. This drying action is commenced in the upper reach of the belt and is carried on through the lower reach thereof being facilitated in the latter instance by the air blasts from the pipes 54. Preferably when fibrous-like webs or sheets are being formed the discharge elements 29 will be oscillated to effect the wavy line deposits of Fig. 8, since such wavy deposits of the composition facilitate and strengthen the felting together of the fibers as it tends to cause the same to interlock with each other. It will be understood that fibrous-like webs or sheets W' can be produced similarly to the production of webs or sheets of film as already explained.

It will also be understood that laminated fibrous-like webs or sheets can be formed by depositing two or more layers of suitable compositions on the belt similarly to the production of laminated film-like webs or sheets as already explained.

It may be desired to produce reenforced film-

like or fibrous-like webs or sheets W''. In such case the reenforcing cloth or element 70 is passed from the rolls 69 over the upper reach of the belt and around the pulleys 40 and 41 with the belt and then through the drier to the reel 59, the guide roller 71 being suitably adjusted to provide the desired space between the reenforcing element and the belt at the first deposit station. The apparatus is then operated in the manner already explained to cause a deposit of a suitable composition to be made on the belt and either on the element 70 or to embed the element 70.

It will be understood that the deposit of the composition occurring at the first deposit station then maintains the reenforcing element in the desired relationship with respect to the belt for the other deposit stations. Thus the reenforcing element will be uniformly embedded or positioned in the webs or sheets produced.

In Fig. 5 the reenforcing element is shown as embedded in a fibrous-like web or sheet W'' but it will be readily understood that said element can be similarly embedded in a film-like web or sheet.

It will be understood that when reenforced sheets are produced, said sheets, due to the reenforcing element 70, can be conveyed through the drier as shown in Fig. 1 and wound upon the reel or drum 59, after which the reenforcing element can be severed intermediate the ends of the sheets.

As previously pointed out, the composition containing the electrically chargeable material may be deposited on the receiving base material or element in the form of a layer or coating and in such instances the base material or element need not be spaced from the support.

It will also be recalled that a sheet or web formed of one composition may be deposited or preformed at the first station and then a layer or coating of another or the same composition deposited on the web or sheet at a subsequent station. The term "electrically chargeable material" as used herein means any material which will be ionized when subjected to an electric charge or to the influence of an electric force.

It will be understood that the present invention contemplates using compositions in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable material in such a proportion that the ionization of said material under electrical influence renders the composition susceptible to migration between spaced electrodes under the velocity influence of an electrical force and under substantially normal atmospheric conditions. As illustrative of this reference is made to a composition in liquid, semi-liquid or mobile liquid particle form and containing electrically chargeable fibers and wherein the proportion of fibers present in the composition would be from sixty to seventy percent while the liquid content of the composition would range from thirty to forty percent.

It will be noted that the illustrative composition referred to in the example differs substantially from ordinary paper pulp as used in the conventional manufacture of paper since such paper pulp contains only ten or less percent of fibrous material and ninety or a greater percent of liquid. The low liquid content of the compositions contemplated herein has the decided advantage that the deposition of the composition can be quickly dried, conditioned or set, par-

ticularly as compared to depositions of ordinary paper pulp.

It will be understood that the invention is not to be limited to the specific forms or constructions herein illustratively disclosed, but is susceptible of such modifications and adaptations as fall within the scope of the appended claims.

Having thus described my invention, I claim:

1. The method of making webs or sheets which comprises creating and maintaining an electrostatic field of force throughout a zone extending the complete transverse width of the web or sheet to be produced and across an atmospheric gap between an elongated depending discharge element and a spaced elongated attraction element with both elements connected into a high potential electrical circuit, simultaneously and continuously during the maintenance of the field of force flowing at a regulated flow rate a liquified composition in flowable form and containing electrically chargeable material onto said discharge element in the form of a film of predetermined thickness such that the film of composition normally would be retained on said element by surface tension but is migrated therefrom by the lines of force of the electrostatic field of force through said atmospheric gap toward said attraction element, simultaneously and continuously during the maintenance of the field of force substantially horizontally moving an intercepting member linearly through said atmospheric gap at a predetermined rate to intercept the migrating composition in the form of a continuous deposit on the member and having the required transverse width of the web or sheet, and then passing the moving member and the deposited solution thereon when outside the zone of the field of force through air currents to solidify the deposited composition by the thermal and dehumidifying action of the air currents.

2. The method of making webs, sheets or coatings which comprises creating and maintaining an electrostatic field of force throughout a zone extending the complete transverse width of the web, sheet or coating to be produced and across an atmospheric gap between an elongated depending discharge element and a spaced elongated attraction element with both elements connected into a high potential electrical circuit, simultaneously and continuously during the maintenance of the field of force flowing at a regulated flow rate, a liquified composition in flowable form and containing electrically chargeable material onto said discharge element in the form of a film of predetermined thickness such that the film of composition normally would be retained on said element by surface tension but is migrated therefrom by the lines of force of the electrostatic field of force through said atmospheric gap toward said attraction element, simultaneously and continuously during the maintenance of the field of force substantially horizontally moving an intercepting member linearly through said atmospheric gap at a predetermined rate to intercept the migrating composition in the form of a continuous deposit on the member and having the required transverse width of the web, sheet or coating, simultaneously and continuously during the maintenance of the field of force inducing an electrical precharge on the film of composition on the discharge element and an electrical precharge on the intercepting member before it enters the electrostatic field of force from an electrical source independent of the elec-

trical source of the electrostatic field of force, and then passing the movable member and the deposited solution thereon when outside the zone of the field of force through air currents to solidify the deposited composition by the thermal and dehumidifying action of the air currents.

3. The method of making webs, sheets or coatings as defined in claim 2 and including imparting oscillatory movement to the electrostatic field of force in a direction transverse of the intercepting member and during the maintenance of said field of force to cause wavy form of deposits of the composition on the intercepting member.

4. The method of making webs, sheets or coatings as defined in claim 2 and including linearly moving a continuous strip of the transverse width of the web, sheet or coating in correlation with the intercepting member through the atmospheric gap and in predetermined relationship with respect to the upper surface of the intercepting member to be integrated with the deposited solution.

5. The method of making webs or sheets which comprises creating and maintaining an electrostatic field of force throughout a zone extending the complete transverse width of the web to be produced and across an atmospheric gap between an elongated depending discharge element and a spaced elongated attraction element with both elements connected into a high potential electrical circuit, simultaneously and continuously during the maintenance of the field of force flowing at a regulated flow rate a liquified composition in flowable form and containing electrical chargeable material onto said discharge element in the form of a film of predetermined thickness such that the film of composition normally would be retained on said element by surface tension but is migrated therefrom by the lines of force of the electrostatic field of force through said atmospheric gap toward said attraction element, simultaneously and continuously during the maintenance of the field of force moving an intercepting member linearly through said atmospheric gap at a predetermined rate to intercept the migrating composition in the form of a continuous deposit on the member and having the required transverse width of the web or sheet, simultaneously and continuously during the maintenance of the field of force inducing an electrical precharge to the film of composition on the discharge element and an electrical precharge to the intercepting member before it enters the electrostatic field of force from an electrical source independent of the electrical source of the electrostatic field of force, then passing the moving member and the depositing solution thereon when outside the zone of the field of force through air currents to preliminarily solidify the deposited composition to give it tensile strength to enable it to be removed from said member as a web or sheet, then separating said preliminarily solidified deposited composition from said member as a web or sheet, and then passing the separated web or sheet through air blasts to finally solidify the same.

6. The method of making laminated webs, sheets or coatings which comprises creating and maintaining at spaced successively arranged deposit stations electrostatic fields of force each extending throughout a zone of complete transverse width of the web, sheet or coating to be produced and across an atmospheric gap between an elongated depending discharge element and a spaced elongated attraction element with both of said elements connected into a high potential

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electrical circuit, contemporaneously with the maintenance of the fields of force flowing liquified compositions in flowable form and containing electrically chargeable material at regulated flow rates and onto said discharge elements in the form of films of the compositions of predetermined thickness such that the films normally would be retained on said elements by surface tension but are migrated therefrom by the lines of force of the electrostatic fields of force through the atmospheric gaps at the deposit stations toward said attraction elements, simultaneously and continuously during the maintenance of the fields of force moving an intercepting member linearly through said successive atmospheric gaps at a predetermined rate to intercept successively the migrating compositions in the form of a continuous base deposit on the number at the first deposit station and in the form of a continuous superimposed deposit at succeeding deposit stations and having the required transverse width of the web, sheet or coating, simultaneously and continuously during the maintenance of the fields of force inducing electrical precharges to the films of compositions on the discharge elements and electrical precharges to the intercepting member before it enters each of the electrostatic fields of force from electrical sources independent of the electrical sources of the electrostatic fields of force, and then passing the moving intercepting member and the deposited compositions through air currents to solidify and integrate the deposited compositions by the thermal and dehumidifying action of the air currents.

7. The method of making laminated webs,

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sheets or coatings as defined in claim 6 and including flowing different compositions onto the discharge elements at the various deposit stations and regulating the polarities of the discharge and attraction elements as well as the polarities of the induced precharges together with the potentials of the electrical circuits in accordance with the determined characteristics of the particular compositions as respects their tendencies to take electrical charges and migrate across the atmospheric gaps in response to the lines of force of the electrostatic fields of force.

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