

June 1, 1954

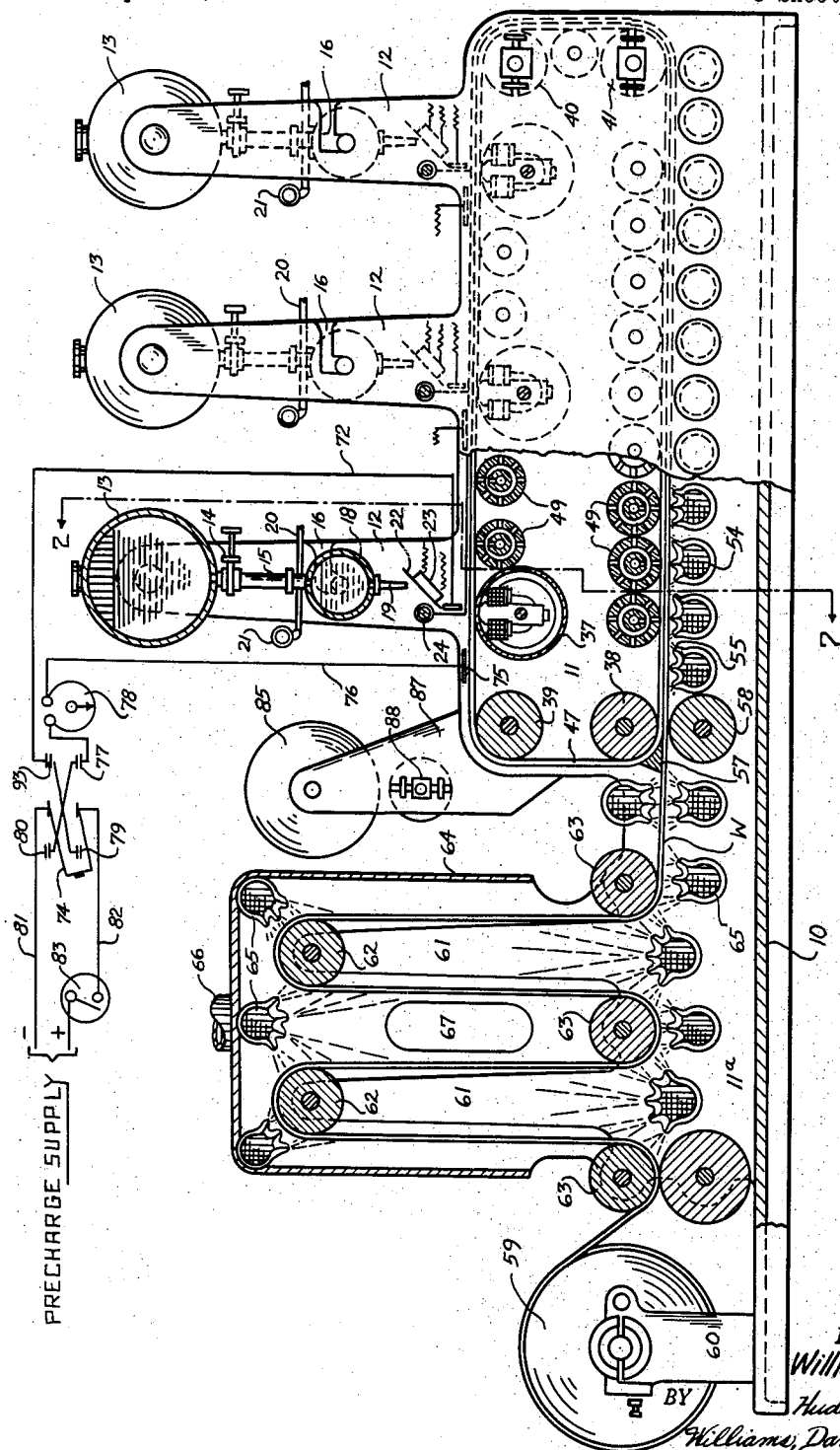
W. C. HUEBNER

2,680,079

METHOD FOR MAKING SHEET OR WEB MATERIAL

Filed April 4, 1951

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

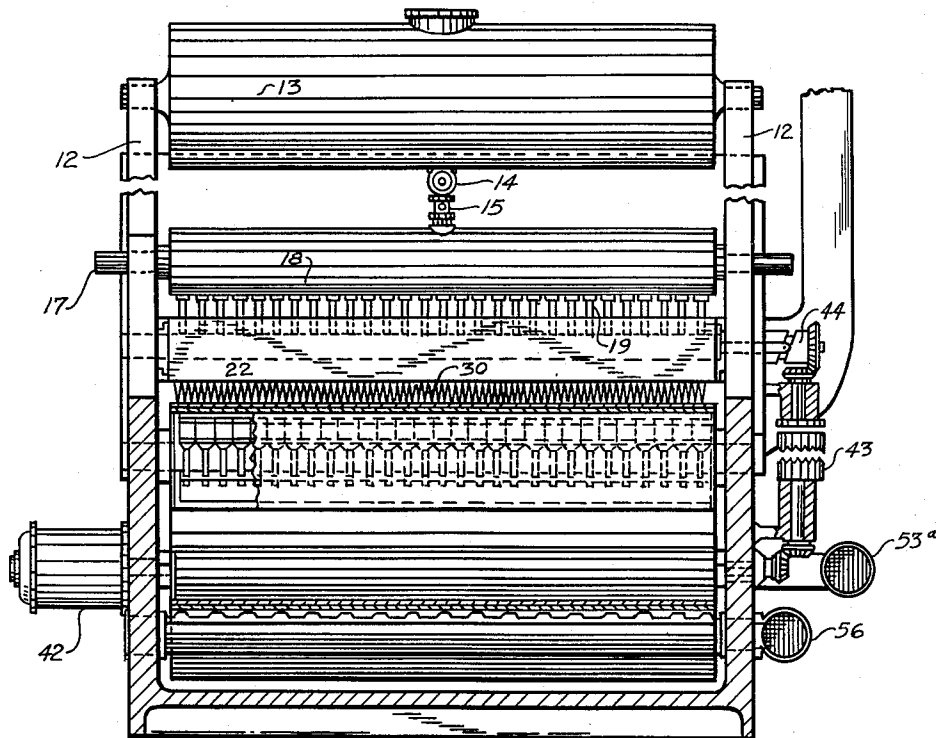


Fig. 2

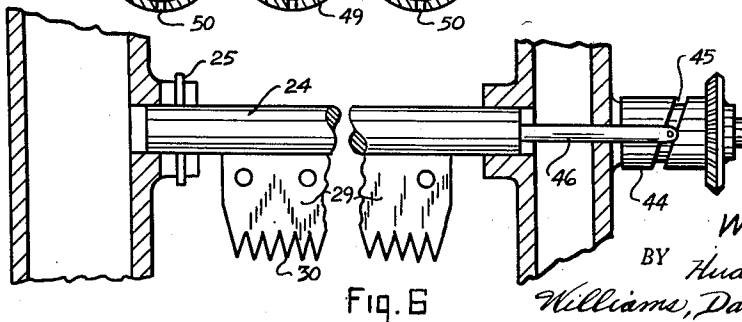
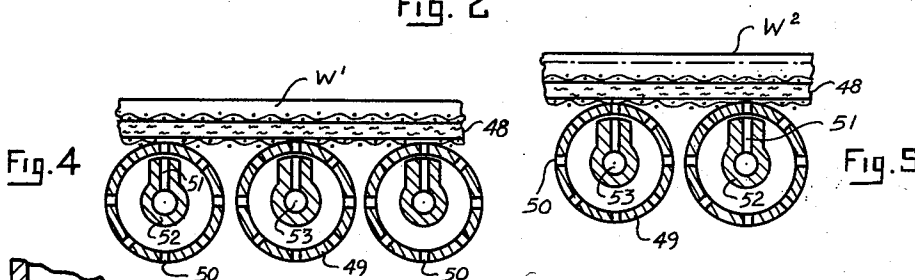


Fig. 6

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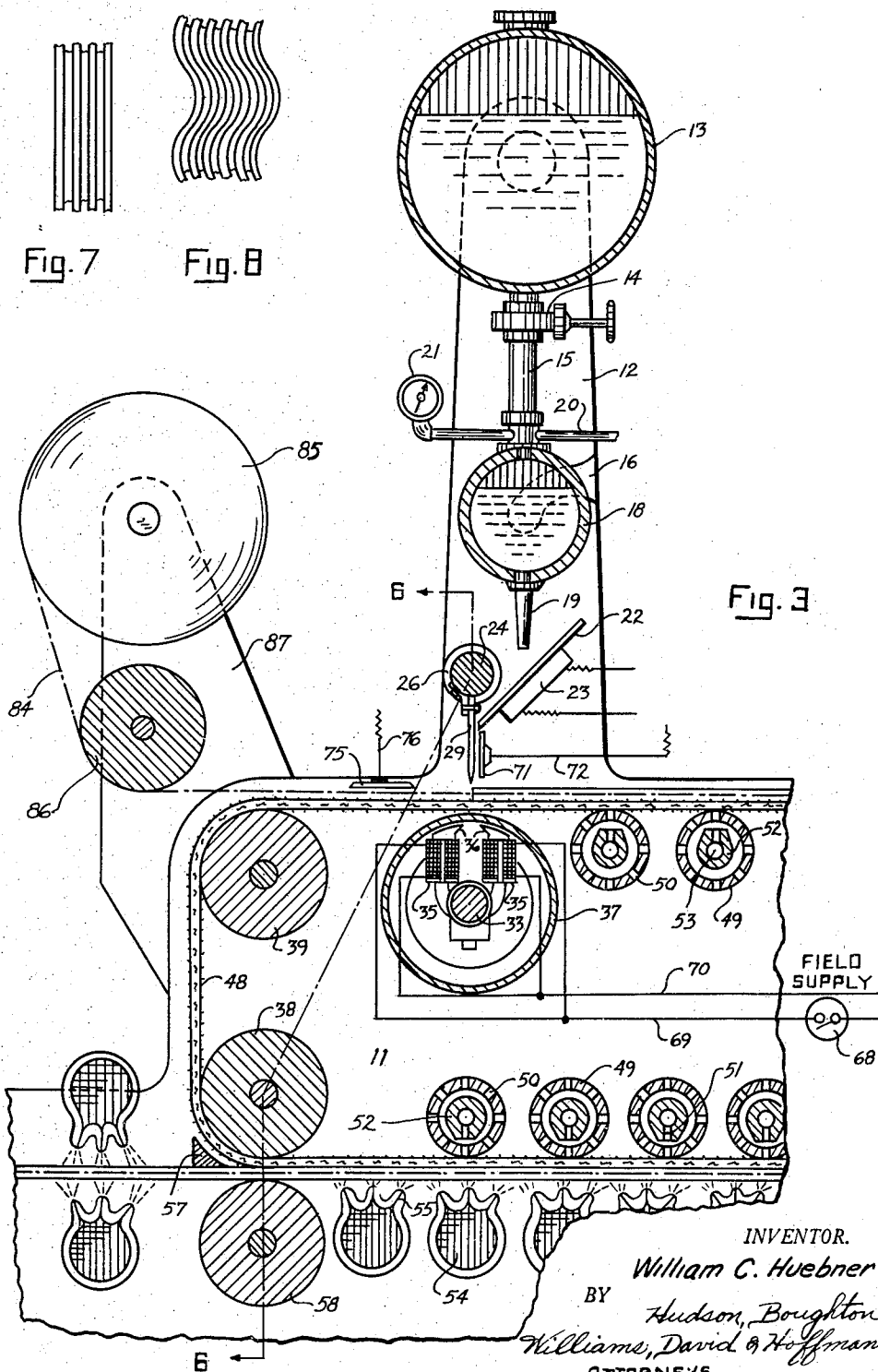
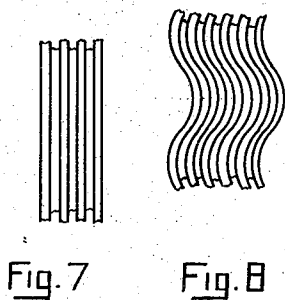
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METHOD FOR MAKING SHEET OR WEB MATERIAL

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UNITED STATES PATENT OFFICE

2,680,079

METHOD FOR MAKING SHEET OR WEB MATERIAL

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Application April 4, 1951, Serial No. 219,290

1 Claim. (Cl. 117-93)

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This invention relates to improvements in a method of 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 and ionizable 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 and ionizable material by deposits of the compositions and which deposits are then conditioned, dried or set.

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

The invention further contemplates producing sheets or webs from compositions containing magnetically responsive material, such as metal particles or powder, and which compositions 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. 40,374, filed July 23, 1948, and now abandoned, which was a division of my copending application Serial No. 649,315, filed February 21, 1946, now Patent No. 2,615,822, issued October 28, 1952, which, in turn, is a continuation-in-part of my application Serial No. 533,500, filed May 1, 1944, 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 "electromigratetics." The term may be defined as follows:

"The science of subjecting compositions in liq-

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uid, semi-liquid or mobile liquid particle form and containing magnetically responsive materials or materials rendered magnetically responsive by being electrically charged and ionized to electromagnetic force to cause the migration of the compositions from a retaining element to a receiving surface by the lines of force of the magnetic field or fields of said electromagnetic force 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.

Another object 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 deposited layer or of a plurality of laminated deposited layers of the same composition or of different compositions 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 simultaneously with their production may 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 magnetic responsive or electrically chargeable and ionizable 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 electromagnetic 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 magnetically responsive or electrically chargeable and ionizable material and wherein the composition is transferred from a supply source and is deposited on

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a movable support by the lines of force of an electromagnetic field or fields of force and 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 of an 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 compositions.

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 from 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 composition retaining element is stationary and when said element is oscillated transversely of the support within the electromagnetic field.

The apparatus disclosed in the drawings and capable of carrying out the method comprises a base 10, which is provided adjacent its right hand end and along its longitudinal edges with up-standing 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 liquid, semi-liquid or mobile liquid particle composition containing magnetic responsive material or material which becomes magnetically responsive when electrically charged and ionized and which composition 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 flexible hose 15. Each standard 12 intermediate its top and lower ends is pro-

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vided 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, see Fig. 2.

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 is at 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 the other. In addition, the composition in one of the tanks may be of a different liquid 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 created 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 liquid consistency or to facilitate the flow thereof onto a composition retaining element later to be referred to.

As previously stated, the apparatus embodying the invention effects the transfer of the composition to and the deposit thereof on a movable support by means of the lines of force of an electromagnetic field of force. In the present machine there are three units disclosed for creating three separate electromagnetic forces 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 a supporting rod 24 is mounted for limited endwise movement, said rod being held against rotation in the openings by pins 25, see Fig. 6, carried by the rod and located in slots formed in one of the bosses. The rod 24 mounts a clamping member 26 and which in turn is secured to and supports a vertically extending composition retaining element 29 extending longitudinally of the rod and provided at its lower end with a longitudinal series of comb-like fine pointed teeth 30. The composition retaining 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 retaining element and thence to the comb-like teeth 30 thereof whereon it will be held or retained by capillary action.

A second supporting rod 33 is rigidly supported by the walls 11 and mounts throughout its longitudinal length a series of electromagnets 35 provided with field bars 36 shaped to provide sharp

edges that are slightly spaced apart with the center of the spacing vertically in line with the points of the teeth 30 of the retaining element 29. The magnets 35 are connected to a suitable source of electrical energy as will later be explained and when energized will create a magnetic field of force between the field bars 35 and including the space between said field bars and the points of the teeth 30 of the retaining element 29. As will later be explained, the lines of force of the electromagnetic field or fields of force act to cause the migration of the composition from the teeth 30 of the retaining element 29 through the space and onto a movable supporting member later to be referred to.

The supporting rod 33 and magnets 35 are mounted within a supporting cylinder 37 rotatably supported in and preferably insulated from the side walls 11, with the field bars 35 of the magnets 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 retaining element 29, such member being illustrated as an endless belt. The retaining element 29 and the series of electromagnets are of such longitudinal length that they extend substantially the full transverse width of the endless belt or other movable support.

The side walls 11 adjacent their left hand ends as viewed in Fig. 1 rotatably support a driving roller 38 and an idler roller 39 arranged parallel to each other with the roller 38 spaced vertically above the roller 39. 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, see Fig. 2, which may have a geared reduction embodied therein, while the shaft on which said roller 38 is mounted is operatively connected by suitable drive trains indicated at 43, and each train includes a clutch and a rotatable cam drum 44, see Figs. 2 and 6, having a cam groove 45 in which travels a follower carried by a reduced portion 46 of the rod 24.

It will be understood that the shaft of the roller 38 is thus operatively connected with each of the rods 24, and hence when said shaft is rotating and the clutch of each train is engaged each rod 24 will be given a predetermined limited endwise oscillating movement with a resultant oscillating movement of the retaining element 29. The purpose of this arrangement will be explained later.

As previously stated, the composition is deposited on the 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 reinforcing 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 ex-

tending around the rollers 38, 39, 40 and 41 and driven by the roller 38. This form of belt will be employed in the apparatus when producing by the method sheets or webs of felt-like composition.

When sheets or webs from liquid, semi-liquid or mobile liquid particle compositions containing electrically chargeable and ionizable fibrous or pulp materials by the method a foraminous endless belt is used in place of the steel belt 47 and such foraminous belt 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 screened 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 electromagnetic field of force between the field bars of the electromagnets so that the fibers of the composition will be felted together when the composition is dried.

The compositions which may be employed in the apparatus and in the practice of the method are in liquid, semi-liquid or mobile liquid particle form and contain magnetically responsive material or material which becomes magnetically responsive when electrically charged and ionized in such a proportion that the ionization of said material under electrical influence renders the composition mobile and susceptible to migration from the retaining element 29 to the belt under the influence of the magnetic lines of force of the electromagnetic field of force and under substantially normal atmospheric conditions. It is known that when certain materials are electrically charged they are ionized and when mobile become susceptible to the action of a magnetic field of force and advantage is taken of this phenomenon in the practice of the method embodying the invention. As illustrative of such a composition reference is made to a liquid, semi-liquid or mobile liquid particle composition containing electrically chargeable and ionizable fibers and wherein the proportion of fibers present in the composition is from 60 to 70% while the liquid content of the composition would range from 30 to 40%.

It will be noted that the illustrated composition referred to 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 which it is contemplated using in the apparatus by which the method of the present invention is carried out provides the decided advantage that the deposition of the composition can be quickly dried, conditioned or set, particularly as compared to deposits of ordinary paper pulp.

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 upper side 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 formed in a stationary elongated nozzle 52 that extends longitudinally within the tube as clearly shown in the drawings.

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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 the moisture from the belt and particularly from the foraminous belt 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 devices 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, see Fig. 2, 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 same as the case may be.

The walls 11 just to the left of the roller 38 support a suitable separating device 57 which separates the 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 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 (Fig. 1) passes through a drier 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 and at the proper take-up speed.

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 housing 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 eject 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

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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 corners of the walls 11 as viewed in Figs. 1 and 3 have supporting arms 87 upwardly extending therefrom and which rotatably mount at their upper ends a roll 85 of a suitable reinforcing or receiving base material or element as, for instance, open mesh screen or cloth 84 and said screen or cloth extends around a guide roller 86 carried by the supporting arms 87 and vertically adjustable by adjusting means indicated at 88. The adjustment of the roller 86 is for the purpose of providing desired spacing, if any, between the reinforcing or receiving material 84 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 the magnetically responsive or 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 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 86 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 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 upon the base material and hence the base material will in this instance act as the lead for the web.

The "on" and "off" switch 68 may be located in the lead 69 of the electrical circuit of the field windings of the electromagnets 35, the other lead of said circuit being the lead 70. It will be understood that the leads 69 and 70 extend to a suitable source of supply of electrical energy and that the main "on" and "off" switch 68 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 electrical circuit is interrupted and the field windings of the electromagnets de-energized no composition will be deposited on the belt and thus the length of the sheets can be controlled.

In order to ionize the electrically chargeable materials in the compositions to render the same mobile and thus magnetically responsive and thus to effect the transfer of the composition from the retaining element 29 to the belt or to the base material or element under the action of the electromagnetic field or fields of force it is proposed to impress on the electrically chargeable materials of the compositions on the retaining element 29 and to impress on the belt and the base material an electrostatic charge with a resultant electrostatic field of force extending to the belt and including the composition on the retaining element. As already stated, the electrical charge impressed on the electrically chargeable materials of the compositions on the retaining element 29 causes such materials to be ionized and the electrostatic field of force established by the charges on the composition and the belt initiates migration of the composition and renders the mobile composition susceptible to the electromagnetic forces, with the result that migration of the composition from the retaining element to the receiving member is initiated by the electrostatic field of force and then finally is effected under the influence of the electromagnetic field or fields of force combined with the influence of the electrostatic field of force.

A terminal 71 is located closely adjacent to the retaining element 29 and is connected by a lead 72 to the contact 73 of a reverser switch 74. A terminal 75 is located closely adjacent to the upper surface of the belt in advance of the transfer zone and is connected by a lead 76 to the contact 77 of the reverser switch 74. An adjustable rheostat 78 is located in the lead 76. The contacts 73 and 77 of the reverser switch 74 are connected, respectively, with the contacts 79 and 80 of said switch, while the movable switch blade is connected with leads 81 and 82 that extend to a source of high potential electrical energy and in which leads is located a main "on" and "off" switch 83. It will thus be seen that the polarities of the terminals 71 and 75 and the voltages impressed thereon can be selected by the reverser switch 74 and the adjustable rheostat 78 and said polarities and voltages will be selected in accordance with the particular electrically chargeable material in a given composition, that is determination will be made as to the most effective polarity and voltage for ionizing the electrically chargeable material in order to initiate the migration thereof and make it responsive to magnetic influence.

The terminals 71 and 75 impress electrical charges on the electrically chargeable material of the composition on the retaining element 29 and on the belt or base material and these charges ionize the electrically chargeable material and establish an electrostatic field of force which initiates migration of the composition rendering the same responsive to magnetic forces and thereafter assisting the magnetic lines of force of the electromagnetic field of force to cause the migration of the composition from the retaining element 29 and onto the belt or base material in the form of a deposit.

It will be understood that a similar arrangement is employed for each of the transfer and deposit stations and that the terminal 75 at those stations beyond the first station will impress an electrical charge on the composition previously deposited on the belt or base material and also on the belt and base material.

It has already been explained that the magnets 35 are connected by leads 69 and 70 to a suitable source of electrical energy and that the main "on" and "off" switch 68 is located in the lead 69, so that the current to the magnets can be interrupted by manually or automatically operating said switch.

It will be understood also that a suitable adjustable rheostat can be arranged in the circuit to the magnets to vary the current to the field windings thereof and thus to vary the strength of the magnetic field.

Assuming that a film-like web is to be produced in the apparatus and that all three deposit 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 or semi-liquid form and containing magnetically responsive or electrically chargeable and ionizable material.

Further assuming that the valve means 14 has been opened until the desired amount of the composition has flowed into the auxiliary or supply tanks 18, after which the valve means has been 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 compositions on the plates 22 flow downwardly of said plates and onto the combs of the retaining elements 29 with the compositions being retained on the combs and in the space between the plates 22 and the combs 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 rheostat 78 to produce the desired voltage in the circuit to the terminals 71 and 75. In addition, the operator positions the reverser switch 74 to effect the polarities for the terminals 71 and 75 in accordance with the polarities best suited for the particular composition. Also the switch 68 in the circuit to the electromagnets 35 is closed to energize said magnets and create the magnetic field of force between the field bars 36 of the magnets. 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 terminals 71 and 75 electrically charge the material in the composition and the belt 57. This charging of the material in the composition, if such material is not normally susceptible to magnetic influence, ionizes the material, initiates migrating movement of the composition and renders it susceptible to magnetic influence. Consequently the electromagnetic field of force created by the energized electromagnets acts on the now mobile and magnetically responsive material on the retaining element 29 and effects the transfer of the composition containing such material from said retaining element to the belt 47. In addition, the electrical charges on the material of the composition and on the belt produce an electrostatic field of force which initiates and then assists the electromagnetic field of force in

the migration of the composition from the retaining element 29 to the belt.

It will be understood that the composition from the retaining element 29 at the first deposit station is deposited directly on the belt, while the composition from the retaining element 29 at the succeeding deposit 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 variations in the current to the terminals 71 and 75 and in the current to the electromagnets 35 to vary the intensity of the magnetic field of force, and by variations in 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 retaining elements 29 will be stationary and the deposits of the composition from the comb teeth of the retaining 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 driven trains 43 are engaged the retaining 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 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 in 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 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 electromagnetic fields of force of different intensities and also will require electrical charges on the materials in the compositions of different strength and polarities. In such a situation the operator can take care of it by means of the individually controlled circuit at each station for the electromagnets and for the terminals 71 and 75.

It will be understood that a laminated web may be produced in the apparatus in the same way as the web formed of a single composition as previously explained but with the differences above pointed out.

The use of the apparatus and the practice of the method has been explained above in connection with the making of film-like webs. When it is desired to use the apparatus and practice the method to make film-like sheets the switch 68 or both the switch 68 and the switch 33 can be opened momentarily at predetermined intervals either manually or automatically to interrupt the electromagnetic fields of force and the electrical charges on the material in the composition 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 or semi-liquid form and containing electrically chargeable and ionizable fibers, then the metal belt 47 is removed and the foraminous 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 are regulated to cause the desired flow of the composition while the strength of the magnetic field of force and the polarities and strength of the circuit to terminals 71 and 75 are regulated as required.

The electrically chargeable fibers of the composition on the retaining elements 29 are charged and ionized by the terminal 71 and thereupon the composition becomes mobile and susceptible to the action of the magnetic field of force and will be transferred under the influence of said field of force and assisted by the influence of the electrostatic field of force created by the terminals 71 and 75 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 the fine mesh, the suction nozzles 52 in the rotatable tubes 49 will act to draw the moisture from the deposited composition 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 retaining 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 W¹ will be produced similarly to the production of webs or sheets of film as already explained. It will be understood also 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 heretofore described.

It may be desired to produce reenforced film-like or fibrous-like webs or sheets W². In such

case the reenforcing cloth or element 84 is passed from the rolls 85 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 86 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 84 or to embed the element 84.

It will be understood that the deposit of the composition occurring at the first deposit station then maintains the reenforcing element 84 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 W² but it will be readily understood that said element can be similarly embedded in a felt-like web or sheet.

It will be understood that when reenforced sheets are produced the said sheets due to the reenforcing element 84 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 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 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.

It will be understood that when the composition contains magnetic responsive material such as metal particles or powder then it is not essential to electrically charge and ionize the material and in such instances the circuit to the terminals 71 and 75 may remain open and the composition will be caused to migrate from the retaining element 29 to the belt by the action of the electromagnetic field of force.

The term "atmospheric gap" as used herein means a gap between the retaining element and the belt or base material which is subject to the atmospheric conditions and pressures of the room in which the apparatus is located and used as distinguished from the space between electrodes or between elements located in a small confined vacuum chamber or the space between a cathode and anode located in an electrochemical bath.

The term "magnetic responsive material" or the term "magnetically responsive material" as used in the specification and claims refers to metal particles or powder formed of iron, nickel or cobalt.

It will be understood that the invention is not limited to the specific forms herein referred to but can be varied within the scope of the appended claim.

10 Having thus described my invention, I claim:

The method of making webs, sheets or coatings which comprises creating and maintaining an electromagnetic field of force throughout a zone extending the complete transverse width of the web, sheet or coating to be produced and including an atmospheric gap between an elongated depending retaining element and a spaced elongated electromagnetic device, simultaneously and continuously during the maintenance of the electromagnetic field of force moving an intercepting member linearly through said atmospheric gap at a predetermined rate, simultaneously and continuously during the maintenance of the electromagnetic field of force flowing at a regulated flow rate liquified composition in flowable form and containing electrically chargeable material onto said retaining 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, simultaneously and continuously during the maintenance of the electromagnetic field of force inducing electrostatic charges on the film of composition on the retaining element and on the intercepting member to ionize the electrical chargeable material and to create an electrostatic field of force of such strength as to initiate migration of the composition from the retaining element across the atmospheric gap toward the intercepting member and thus render the composition responsive to the electromagnetic field of force to effect the complete migration of the composition across the atmospheric gap to the intercepting member in the form of a continuous deposit on the member for the required transverse width of the web, sheet or coating, and then passing the moving member and the deposited composition when outside the zone of the two fields of force through air currents to solidify the deposited composition by the thermal and dehumidifying action of the air currents.

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