

Jan. 12, 1960

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2,920,679

METHOD AND APPARATUS FOR PRODUCING FIBROUS STRUCTURES

Filed Jan. 16, 1956

2 Sheets-Sheet 1

FIG. 1

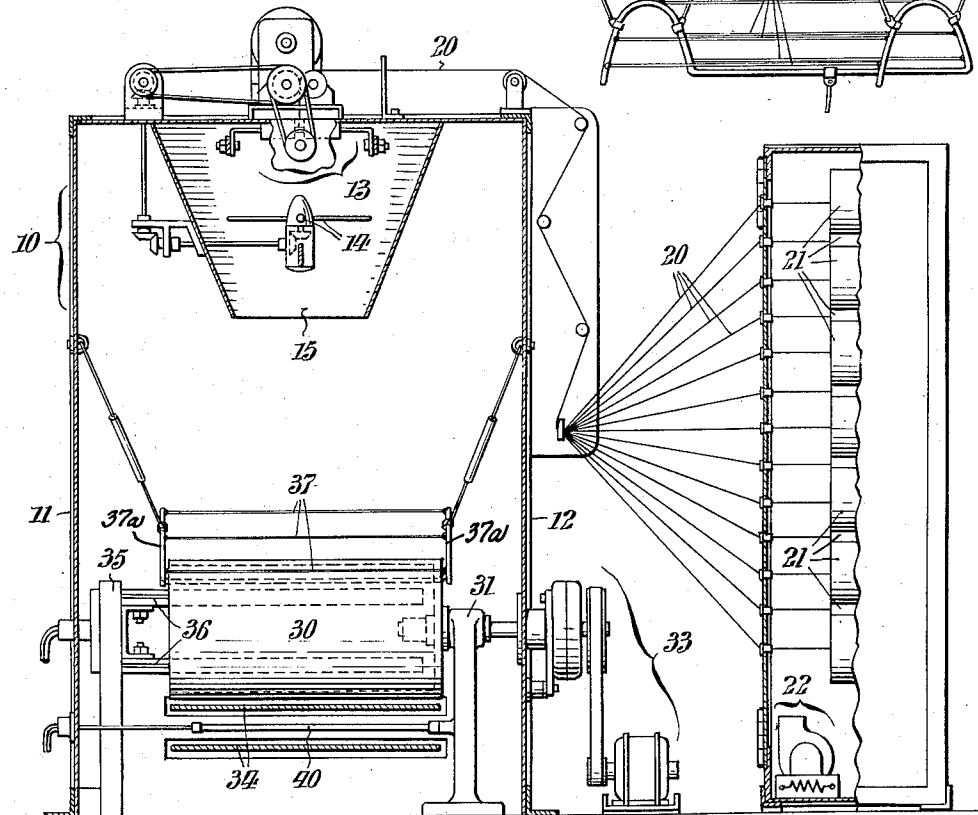


FIG. 2

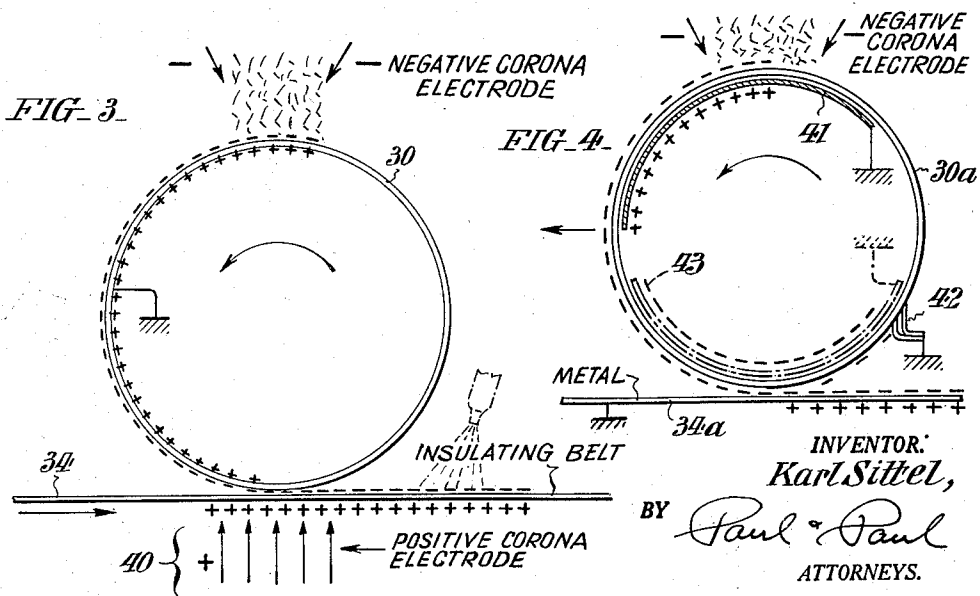


FIG. 3

FIG. 4

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FIG. 5.

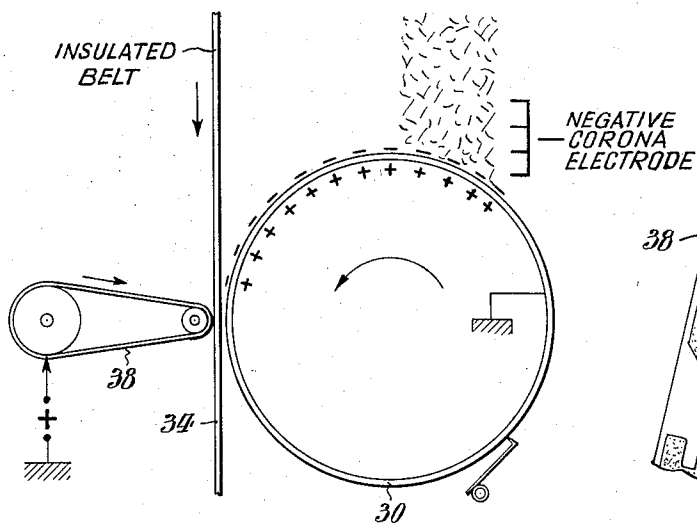


FIG. 6.

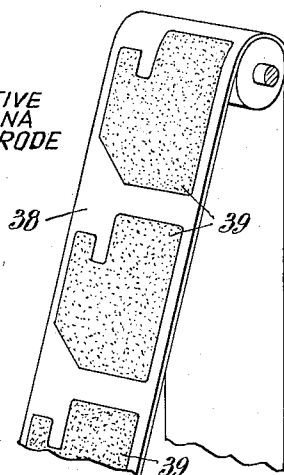


FIG. 8.

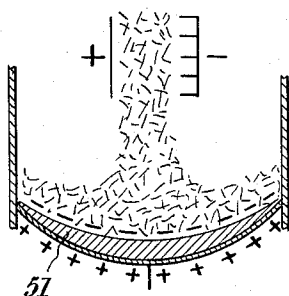


FIG. 10.

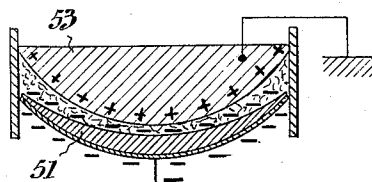


FIG. 11.

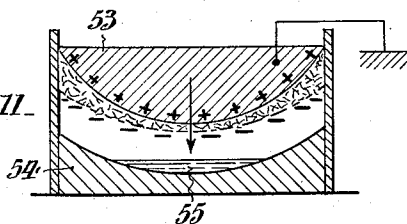


FIG. 9.

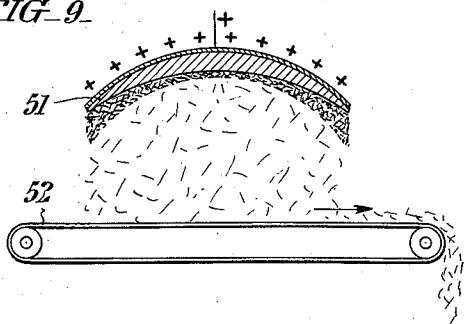
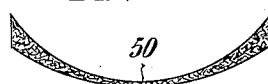


FIG. 7.



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METHOD AND APPARATUS FOR PRODUCING FIBROUS STRUCTURES

Karl Sittel, Philadelphia, Pa., assignor, by mesne assignments, to Walsco Company, a partnership

Application January 16, 1956, Serial No. 559,221

14 Claims. (Cl. 154—1)

This invention relates to a method and apparatus for producing fibrous structures, and more specifically to a method and apparatus which utilizes electrostatic forces.

Fibrous products of different size and shape are presently manufactured. Of particular interest are products made of resin reinforced with glass fibers or rods such as Fiberglas. These products are satisfactory for some purposes and have a wide field of application. However, the processes by which they are produced include steps that are laborious, time consuming and uneconomical. Further, a number of obstacles must be eliminated before major progress can be made in the mass production of such fibrous articles. Accordingly, this invention relates to the uniform deposition of fibers on a support to form a coherent mat, such deposition being accomplished by the utilization of electrostatic forces. These fibers may be of any vegetable, animal, mineral, or synthetic fibrous material. The fibrous mat may be bound by any suitable binding material of a sticky, adhesive, glutinous, tacky character, such as resin, or by a powdered, granular or other type of curable binder.

This invention relates to mats formed of cut glass fibers, and methods and apparatus for making them; and is an improvement upon the invention described in my co-pending application, Serial No. 476,733, filed December 21, 1954.

In the formation of mats from glass fibers by electrostatic deposition, it has been found that the efficiency of the deposition is greatly reduced as the thickness of the mat is increased. The reduction in deposition efficiency is caused by the potential build-up on the deposited mat produced by the continuous influx of ionization current required to charge the fibers.

It is a purpose of this invention to provide a relatively heavy mat of glass fibers formed by electrostatic deposition.

It is a further object of the invention to provide a method and apparatus for depositing glass fibers in quantity in which the deposition efficiency is not seriously limited by the thickness of the mat deposited.

It is another object of the invention to provide a method and apparatus for making fibrous mats of glass fibers by electrostatic deposition in which the build-up of potential on the mat during deposition is minimized.

It is also an object of the invention to provide a continuous method of depositing glass fibers to form mats of predetermined shapes and sizes on flat and irregular curved surfaces, and apparatus therefor.

Other objects and advantages of the invention will be apparent from the following description and the drawings of which:

Fig. 1 is a front elevation of apparatus illustrating one embodiment of the invention;

Fig. 2 is a perspective view of the charging electrode;

Fig. 3 is a diagrammatic view illustrating the fiber deposition apparatus and method shown in Fig. 1;

Fig. 4 is a diagrammatic view illustrating the fiber

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deposition apparatus and method of another embodiment of the invention;

Fig. 5 is a diagrammatic view showing the apparatus and method for continuous deposition of glass fibers in a predetermined shape;

Fig. 6 is a perspective view of the secondary belt of Fig. 5 showing the metalized patterns;

Figs. 7—11 illustrate a particular adaptation of the apparatus illustrated in Fig. 4.

In forming mats of glass fibers by electrostatic deposition as described in my co-pending application, the fibers are cut in suitable lengths and dropped through a charging area. In the charging area the fibers are subjected to an electrical charge, which may be provided by any suitable means, such as corona discharge. The charged fibers are then deposited on the collecting electrode which is grounded or charged opposite to the fibers. As the fibers build up to form a mat on the collecting electrode, however, a surface charge builds up which is of the same polarity as the charge on the falling fibers. This, of course, reduces the efficiency of further deposition.

In my co-pending application, Serial No. 476,733, there is described a method of discharging the surface of the build-up mat by intermittent deposition of resin particles charged opposite to the fibers.

I have found that the charge build-up on the glass fiber mat can be limited by separating the collecting area from the deposition area, so that the collection of fibers takes place in one area and the deposition on the mat in another area.

One specific embodiment of the invention is illustrated in Fig. 1. There, the housing 10 having vertical supports 11 and 12, contains the fiber cutting mechanism 13, distributing bar 14 and distributing funnel 15 in the upper end thereof. The glass fiber filaments 20 are fed from the spools 21, which are heated by the heater 22, to the cutting mechanism 13. By regulating the cutter 13, the size of the fibers cut may be changed to any desired size.

The cut glass fibers fall through the rotating distributor bar 14 and are guided by the funnel 15 to fall past the charging electrodes 37. The electrodes 37 are supplied with current at high voltage to provide a corona discharge at the charging area. As the fibers pass the electrodes 37, they receive the charge of the same polarity as the electrodes. If desired, a solid binder resin may be added to the fibers as they pass through the funnel 15. This resin would be subject to the same treatment in subsequent operations as the fibers themselves and could be cured to form a binder for the fibers when the mat is formed. The charging electrodes 37 are curved frame members 37a which are preferably shaped to conform to the shape of the collecting drum 30.

Below the charging electrodes 37 is the revolving collecting drum 30, mounted on the pedestal 31 and driven by the rotating mechanism 33 comprising a motor, reduction gearing and suitable belting to turn the drum 30 on its axis. The charged fibers fall on the drum 30, which is grounded. The ion current from the electrodes 37 which would otherwise build a charge upon the drum 30 is thus discharged to the ground, while the fibers themselves, being insulators, are not discharged and are carried around on the surface of the drum. The drum 30 is basically a means for collecting the charged fibers and transforming them from a charging area to a separate depositing area, and it may be replaced by any equivalent means such as a conveyor belt which serves the same purpose.

The conveyor belt 34 is placed beneath the drum 30. The belt is made of an insulating material and is charged on the side opposite the drum by a depositing electrode

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40 of opposite charge to the fibers. The depositing electrode 40 may be either corona wire or metal plate. As the drum 30 rotates over the upper span of the conveyor belt 34, the fibers are attracted to the belt and are thus transferred from the drum to form a mat on the belt. Once the mat is formed on the belt 34, it can be electrostatically transferred or be cured and mechanically transferred to a storage place.

With the method and apparatus described above it is possible to achieve many variations in the characteristics of the mat produced. The rate of fiber delivery to the charging electrodes 37 may be controlled by the cutting mechanism 13. The thickness of the mat may be varied by changing the speed of the conveyor belt 34 or the rate of delivery of fibers from the cutters. A particular shape of mat may be produced by changing the shape of the depositing electrode 40. The mat will conform to the outline of the electrode 40, and will continuously reproduce the widthwise shape on the conveyor belt 34.

The method and apparatus may be modified as shown in Figs. 5 and 6, wherein the depositing electrode behind the insulating belt is formed of metal foil patterns 39 on a continuous insulating belt 38. The belt 38 can also be replaced by an insulating drum. The metalized patterns 39 are kept at high potential opposite to the fibers.

As shown in Fig. 4, the collecting drum 30 and the depositing belt 34 may be altered in the apparatus of Fig. 1. The drum 30a may be of an insulating material rather than metal, with an electrode 41 connected to the ground or to a potential of polarity opposite the charge on the fibers located inside the drum and a brush 42 to the ground to remove excess charges from the drum surface after the removal of the fibers. In this case the depositing area is metal 34a and it need not be charged. Where the drum is rolled over a grounded conducting surface, such as metal, the induced surface charges on the conducting surface cause them to transfer to this grounded surface from the drum 30. This phenomenon is particularly significant in that it makes it possible to deposit a fiber mat on a grounded metal surface such as a conveyor belt or part of any irregularly curved surface without the need of a charged collecting electrode behind the pattern. The pattern itself being grounded will cause the collected fibers to transfer. The fibers collected on the insulated drum 30a may also be transferred to an insulating surface, provided an additional electrode 43, shown in dot-dash in Fig. 4, is placed inside the drum and connected with a potential source of the same polarity as the charge on the fibers.

The adaptation of the transfer method to deposition on irregular surfaces which might be part of another stationary apparatus, such as a matched die mold, is illustrated in Figs. 7-11. A model 50 of a fiber-reinforced plastic article to be produced is illustrated in cross section in Fig. 7. As illustrated, this method may be employed to reproduce three dimensional articles of varying thickness such as the model 50. It is characterized by being curved and thicker at the ends than in the middle. A form 51 cut out of an insulating material proportional to a negative to the model is shown in Fig. 8. The form is characterized as curved and thicker at the middle than at the ends. The lower surface of the form is metalized. As shown in Fig. 8, charged fibers which may be mixed with a binder material are deposited on the form while the lower metal surface is charged opposite to the fibers. If a binder is added, the metal surface may be heated to partially cure the binder and to enhance the attachment to the metal surface. The fibers are then settled on the form, as by mechanical vibration, and the form is inverted and subject to further vibration to remove surplus fibers, producing a thickness of glass fibers on the form which is inversely proportional to the form thickness, to the belt 52 shown in Fig. 9. If binder has been added, the article is placed in a heating oven to completely cure the binder. The form is then placed under a grounded

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matched male die 53 conforming to the upper surface of the model as shown in Fig. 10, and at the same time the polarity of the metal surface of the form 51 is reversed. The fiber mat is thus released from the form and transferred by electrostatic force to the male die 53. The male die 53 and fiber mat are then applied to a female die 54 carrying a moulding material 55 as shown in Fig. 11 to form the finished product under pressure.

The application of binder materials to the mats formed in accordance with the invention may be by any known method such as immersion, spraying or the like, such as that illustrated in Fig. 11, where the mat was simply immersed in the binder. While it is one of the advantages of the invention that no intermediate binder is needed to hold the fibers in place since the electrostatic forces perform that function, it is possible to introduce resin at any stage of the process without departing from the invention so long as the electrostatic charges are not thereby destroyed contrary to the method. As shown in Fig. 3 in dot-dash, the binder may be applied in the form of a spray as the mat is built upon the belt 34.

By experiment it has been determined that a mat of glass fibers up to three ounces per square foot in weight may be produced by the apparatus and method illustrated in Figs. 1 and 2, using a drum of twenty inch diameter by maintaining the following conditions:

Charging potential	-----	-50 kv. to 80 kv.
Depositing potential	-----	+30 kv. to +50 kv.
Depositing belt speed	-----	0.5 to 1 in./sec.
Drum speed	-----	40 r.p.m.
Drum surface temperature	-----	180° F.
Relative humidity in deposition area	-----	35%

It will be appreciated that many variations are possible in the method and apparatus of the invention, and that they may be produced by substitution of equivalent elements without departing from the spirit of the invention as defined by the appended claims.

Having thus described my invention, I claim:

1. A method of forming a mat from separate elongated fibers comprising subjecting a plurality of said fibers to an electrostatic charge in a charging area, transferring said fibers to a place removed from the charging area and subjecting said fibers to an electrostatic charge of opposite polarity to the charge on said fibers to deposit said fibers in mat form.

2. A method of forming molded fibrous articles comprising subjecting a plurality of fiber particles to an electrostatic charge, depositing said particles on a negative model of the article to be produced, the surface of said model remote from said particles being subjected to a charge of opposite polarity to the charge on said particles, inverting said model with said charged particles attached thereto to remove excess particles, applying said particles to a grounded male die and reversing the polarity on the surface of said model remote from said particles, removing said model and inserting said male die and said particles in a female die containing a binder material.

3. Apparatus for electrostatically forming a mat of elongated fibers comprising a corona charging electrode, a grounded metallic revolving drum beneath said charging electrode forming an electrostatic field with said corona charging electrode, fiber collecting means beneath said drum and a depositing electrode having a charge of opposite polarity to said charging electrode beneath said collecting means, said depositing electrode forming an electrostatic field with said grounded drum.

4. In the apparatus of claim 3, a fiber charging electrode comprising a plurality of substantially parallel wires of conductive material, a pair of substantially parallel curved frame members connected to the ends of said wires and supporting means connected to said frame members adapted to support said members from said apparatus.

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5. The apparatus of claim 3 wherein the depositing electrode comprises an endless belt of non-conductive material, rotatable spaced belt moving and supporting means within said belt, electrode means of conductive material affixed to the outside surface of said belt and means for producing an electric charge in said electrode means.

6. Apparatus for forming a mat of elongated fiber particles comprising a negative corona charging electrode, a revolving metallic drum spaced beneath said charging electrode, heating means in said drum, a belt of non-conductive material spaced beneath said drum and a positive corona depositing electrode spaced beneath said belt.

7. Apparatus for forming a fibrous mat from a plurality of electrostatically charged fiber particles comprising depositing means upon which said mat is to be formed, means for conveying said charged particles to said depositing means and discharging free electrostatic charges, a rotatable belt spaced from said depositing means and on the opposite side thereof from said conveying means, and electrode means on said belt opposite in polarity to the charge on said particles.

8. Apparatus for continuously forming a mat of elongated glass fibers comprising a charging electrode, means for supplying electric potential to said charging electrode, a rotatable cylindrical drum spaced beneath said electrode, the axis of rotation of said drum being disposed in a horizontal plane and said electrode curved to conform substantially to the shape of said drum, heating means disposed within said drum, means for discharging free ions produced by said charging electrode, an endless belt disposed beneath said drum and spaced therefrom, a depositing electrode disposed within said belt beneath said drum, said depositing electrode having predetermined shape and dimensions and means for discharging the electrostatic charge produced on said fibers by said charging electrode.

9. Apparatus for forming a mat from elongated fiber particles comprising charging means for charging a plurality of fibers with an electrostatic charge, rotating drum means for carrying said fibers to a position adjacent a collecting electrode, a collecting electrode maintained at a potential of opposite polarity to the charge on said fibers and collecting means for collecting said fibers from said drum interposed between said drum and said collecting electrode, said charging means further comprising means for creating an electrostatic field with said rotating drum for impelling said fiber particles toward the surface of said drum.

10. Apparatus for forming a mat of elongated fiber particles comprising means for subjecting said particles to a negative corona discharge, a drum of non-conductive material, a grounded conductor in said drum for dis-

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charging the free ion current produced by the corona discharge and a grounded metal surface adjacent said drum for removing said particles from the drum.

11. A method of forming a mat from a plurality of separate elongated fibers comprising separating said fibers and distributing them in space, subjecting said fibers to an electrostatic charge, impelling the fibers so charged to a carrier under the influence of an electrostatic field independent of the charges on said fibers, transferring said fibers on said carrier to a point substantially outside the influence of said electrostatic field and subjecting said fibers at said point to the influence of a second electrostatic field thereby removing them from said carrier and depositing in mat form.

12. The method of claim 11 further characterized by the step of adding a binder material to the fibers after they are deposited in mat form.

13. A method of forming a mat from Fiberglas comprising cutting said Fiberglas into a plurality of separate elongated fibers, distributing said elongated fibers in space, subjecting said fibers to an electrostatic charge in a charging area, transferring the fibers to a depositing area removed from the charging area and subjecting them to an electrostatic charge of opposite polarity to the charge on said fibers to deposit them in mat form.

14. Apparatus for forming a mat from a plurality of separate elongated fibers comprising means for distributing said fibers in space, corona electrode means for electrostatically charging said particles, fiber collecting and transferring means adjacent said corona electrode means and forming an electrostatic field therewith for collecting the fibers charged by said corona electrode, transferring them to a depositing area removed from said charging area and discharging excess ions formed by said corona electrode, fiber depositing means disposed beneath said fiber collecting and transferring means providing an electrostatic field for depositing said fibers in mat form.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,920,679

January 12, 1960

Karl Sittel

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 66, for "transforming" read -- transferring--.

Signed and sealed this 14th day of June 1960.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents