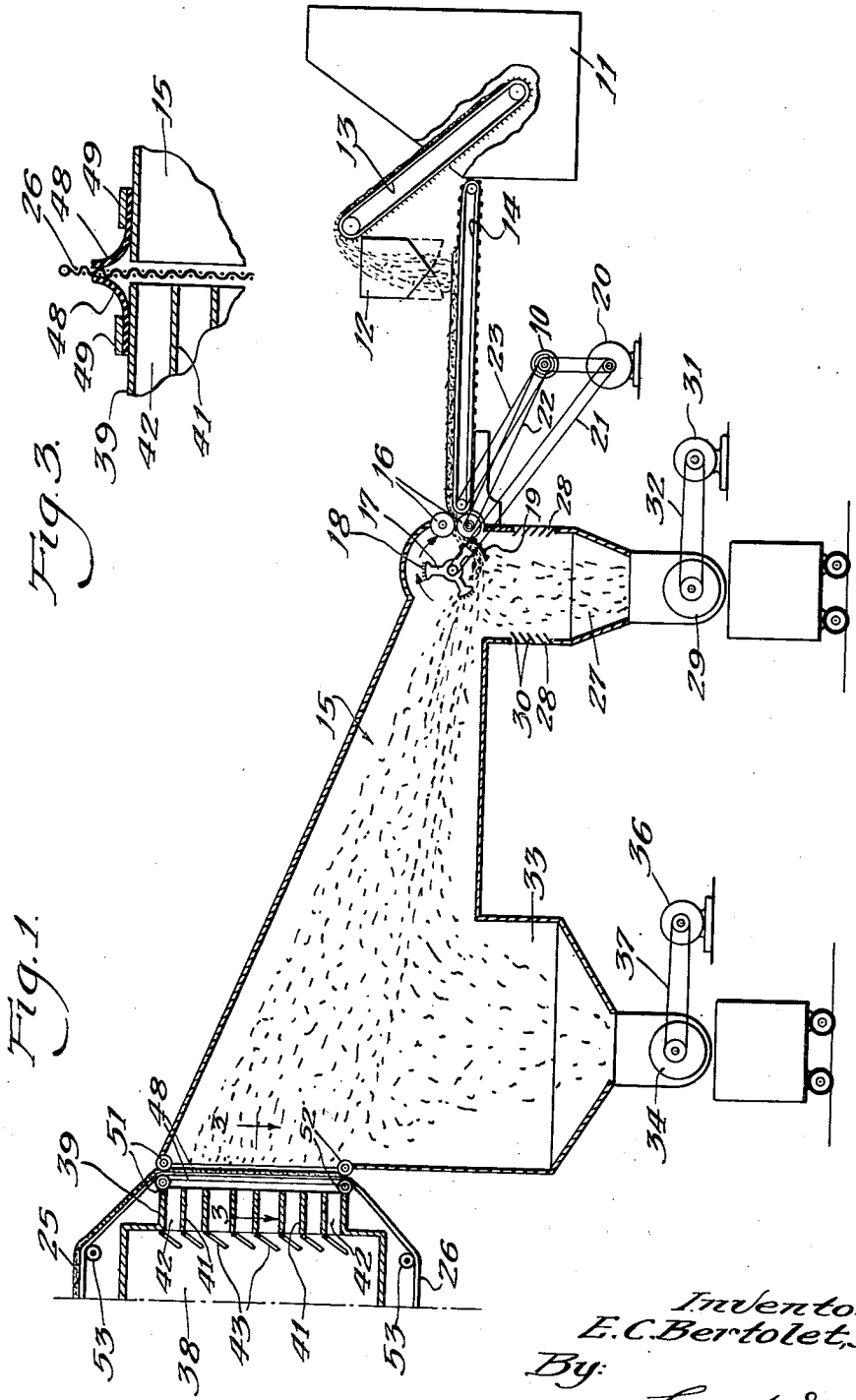
Jan. 1, 1952 E. C. BERTOLET, JR 2,581,069

APPARATUS FOR PRODUCING AIRLAID FIBROUS WEBS

Filed Sept. 24, 1945

5 Sheets-Sheet 1



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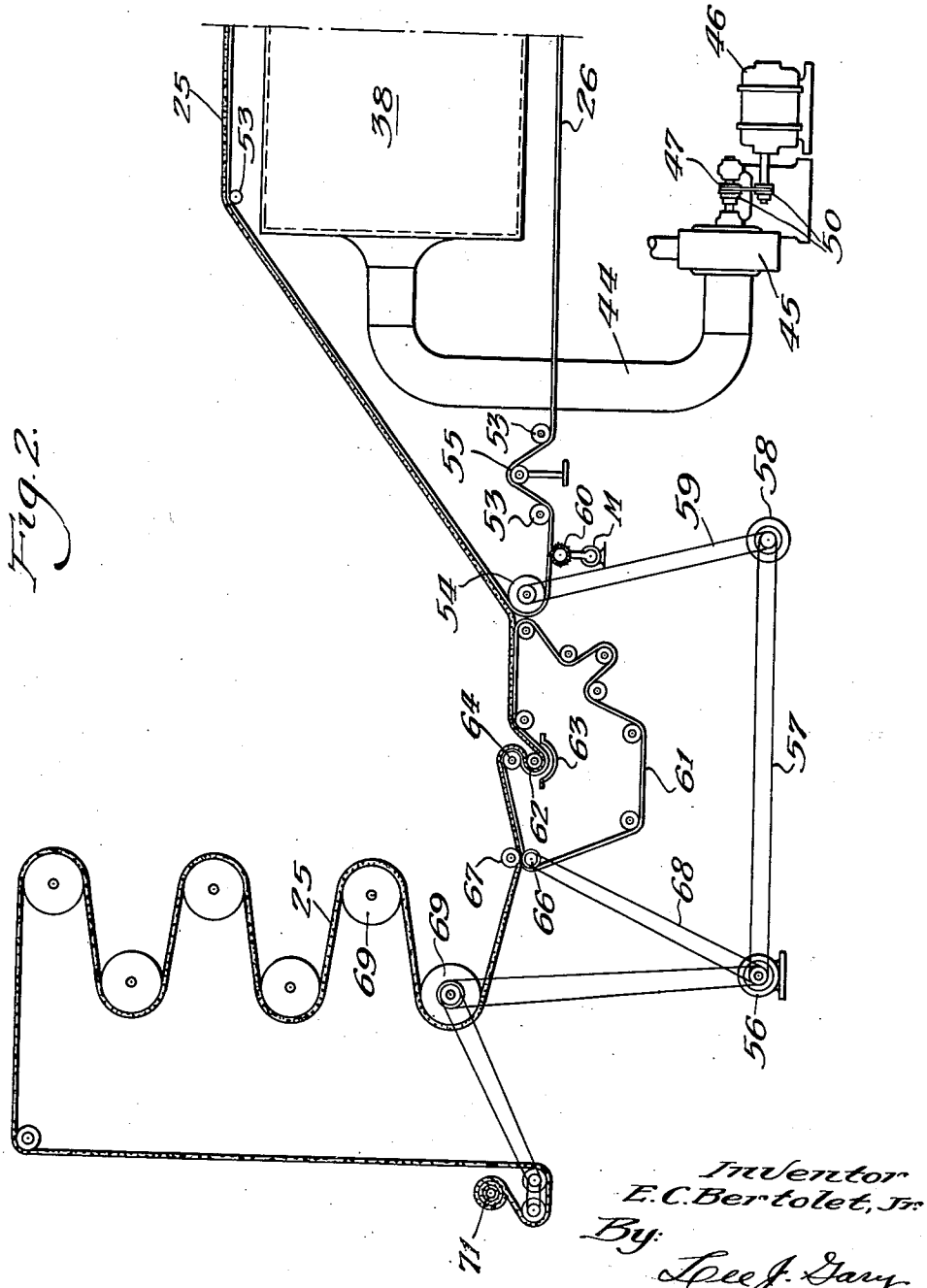
5 Sheets-Sheet 2

Fig. 2.



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5 Sheets-Sheet 3

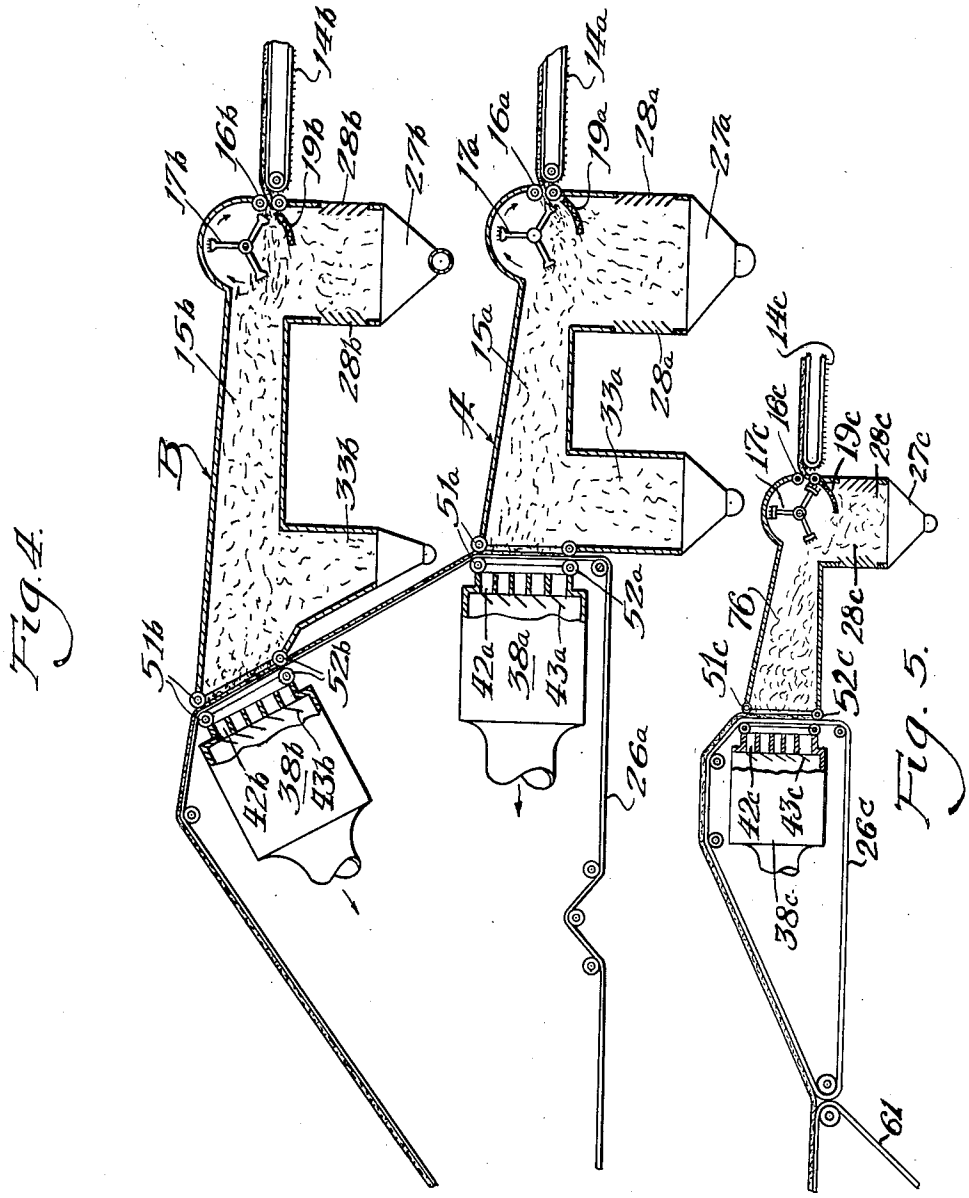

Fig. 4.

Fig. 5.

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APPARATUS FOR PRODUCING AIRLAID FIBROUS WEBS

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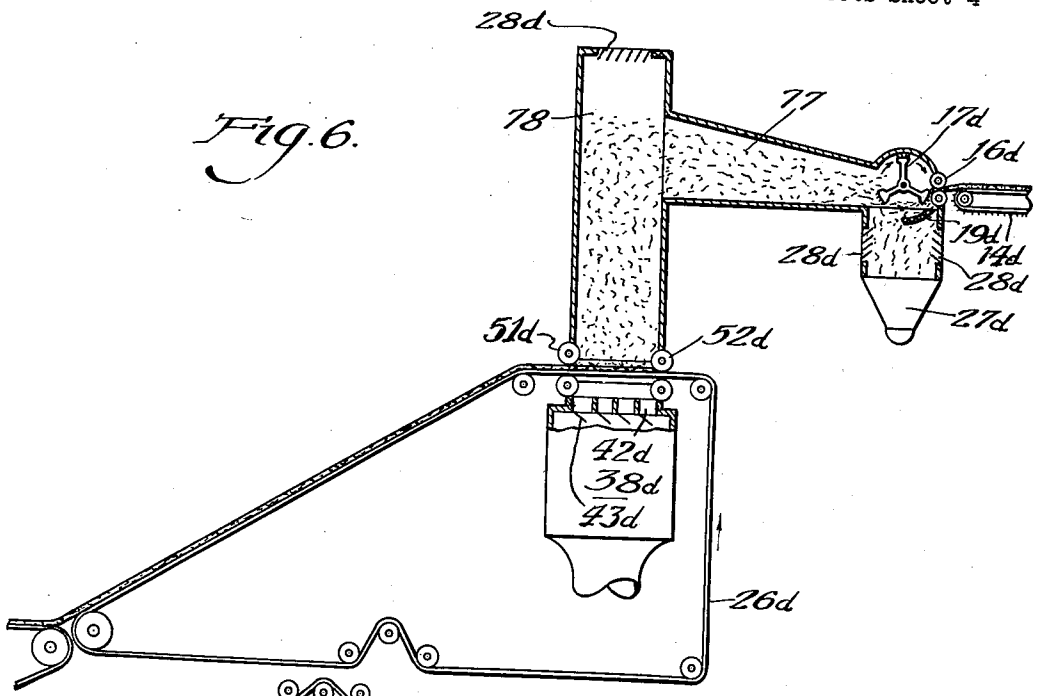
5 Sheets-Sheet 4

Fig. 6.



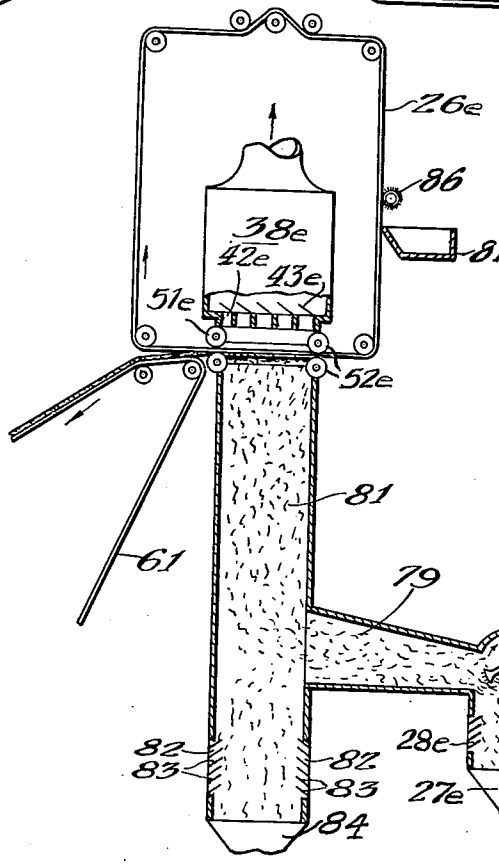


Fig. 7.

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APPARATUS FOR PRODUCING AIRLAID FIBROUS WEBS

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5 Sheets-Sheet 5

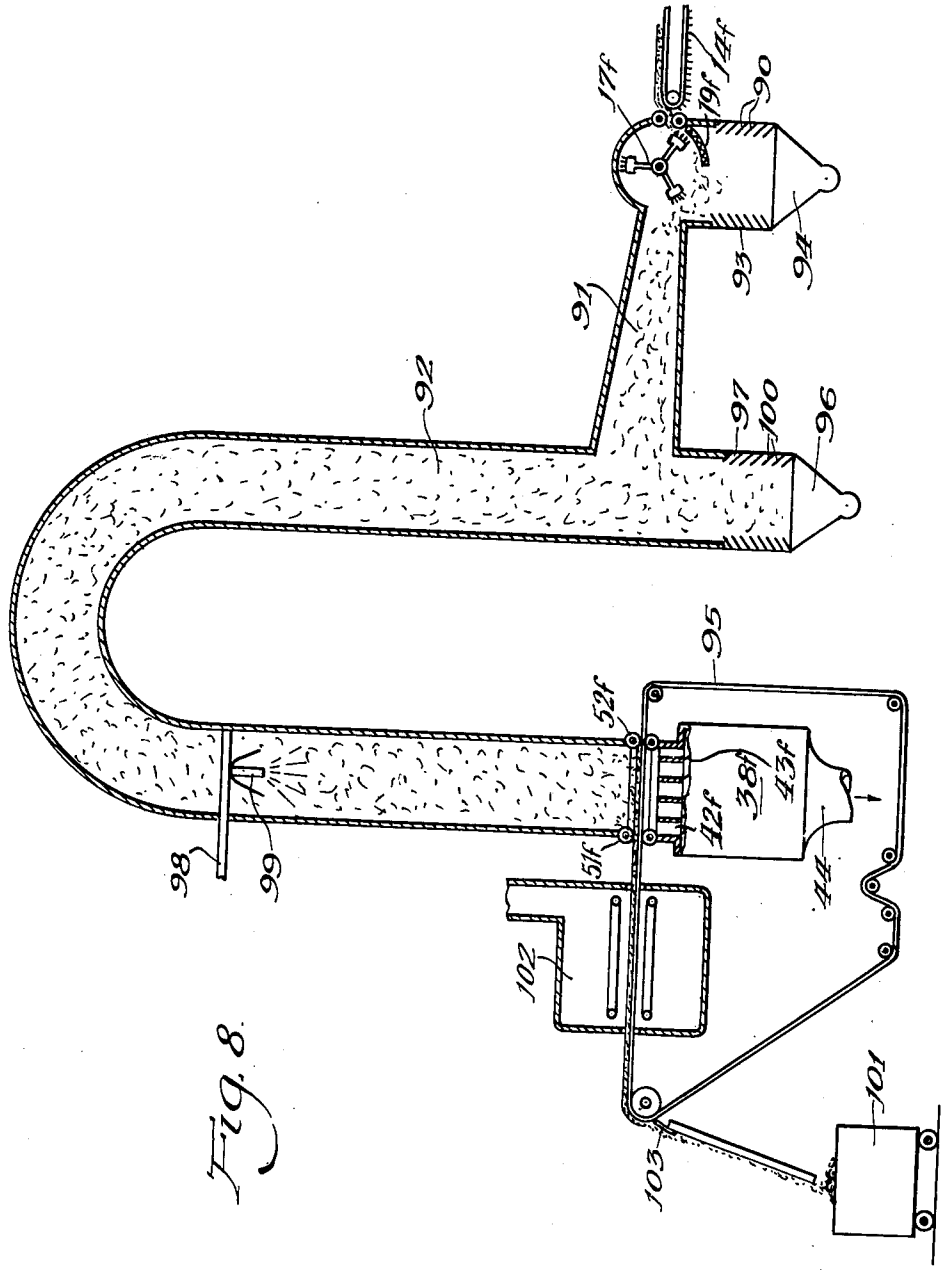

Fig. 8.

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UNITED STATES PATENT OFFICE

2,581,069

APPARATUS FOR PRODUCING AIRLAID FIBROUS WEBS

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Application September 24, 1945, Serial No. 618,247

6 Claims. (Cl. 19—156)

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This invention relates to improvements in airlaid fibrous web and to methods and apparatus for producing same. More particularly, this invention is concerned with the production of continuous self-sustaining fibrous sheets of predetermined uniform thickness formed from organic and/or inorganic fibers disposed in random orientation.

This invention further contemplates the provision of improved methods and apparatus for producing felt or paper like sheets from relatively long asbestos fibers known in this art as spinning grade fibers, and without the necessity of admixing thereto certain percentages of organic fibers of the type usually employed for the purpose of carrying the fibers through conventional textile equipment such as carding machines. However, it is contemplated that various percentages of organic and/or inorganic fibers may advantageously be admixed with the asbestos fibers for the purpose of modifying the end product for the following reasons:

1. To make less expensive products through use of lower cost organic and/or inorganic fibers.

2. To make a product with a lower specific gravity where light weight is an important factor.

3. The addition of organic fibers to add strength to the formed web to aid in processing.

4. The addition of fibers capable of coalescing and forming a bonded product either through activation by heat and/or solvents.

5. The addition of high tenacity fibers which improve the physical properties of the finished product.

6. To make a product having improved electrical properties due to the use of fibers having better electrical characteristics than absestos.

7. The use of asbestos in small quantities for the purpose of increasing bonding strength of laminates formed principally of high strength fibers having poor bonding characteristics.

Among the fibrous materials suitable for admixing with asbestos in percentages of from 5% to 90% by weight for modifying the end product are; cotton, wool, silk, rayon, jute, ramie, glass, flax, hemp, vinylidene chloride "Saran" or "Velon," vinyl copolymer "Vinyon," cellulose acetate, ethyl cellulose, protein (amide, polyamide, or soy bean fibers such as "Nylon" and "Soylon"), alginates, casein "Aralac," etc.

Web or sheet material produced by the methods and apparatus hereinafter set forth may readily be distinguished in physical characteristics from a carded or combed web in that the fiber pattern or orientation shows a random distribution instead of being relatively parallelized. This distribution results in a well balanced structure in which the tensile strength is uniform in all directions. This characteristic is advantageous for many end uses where a product of balanced, uniform strength is required.

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While the foregoing description has particular reference to a product formed from relatively long fibers, the present invention also contemplates the use of relatively short fibered materials either by themselves or in combination with long fibered materials for the purpose of producing either a less expensive product or a product having a finer and smoother surface appearance due to the short fibers filling the relatively small surface voids between the long fibers. This result is attained through improved arrangements and control of air currents which direct the suspended fibers to those spots in the web which are relatively thin.

This invention further contemplates the provision of methods and apparatus adapted to produce improved fibrous web sheets at a relatively high rate of production and with a relatively low capital expenditure.

This invention further contemplates the provision of an improved method and apparatus embodying means for readily varying the thickness of the fibrous web sheets. In the use of other methods and apparatus known to me, it has been difficult to form webs having a thickness of less than .002 or .003 inch due to their lacy structure. It has also heretofore been difficult to form fibrous sheets having a thickness of more than .006 of an inch due to the tendency of same to become flaky due to choking up of the card clothing.

This invention embodies other novel features, details of construction and arrangement of parts which are hereinafter set forth in the specification and claims, and illustrated in the accompanying drawings wherein:

Fig. 1 is a diagrammatic view, partly in side elevation and partly in section, showing one form of apparatus embodying features of this invention adapted for use in carrying out the primary steps in the formation of improved airlaid fibrous web.

Fig. 2 is a digrammatic side elevational view, partly in section, showing the apparatus employed for carrying out the secondary steps in the formation of airlaid fibrous web.

Fig. 3 is a fragmentary sectional view taken along the line 3—3 of Fig. 1, showing an air seal means for the apparatus.

Fig. 4 is a diagrammatic view, partly in side elevation and partly in section, showing a modified form of apparatus for producing airlaid fibrous web.

Fig. 5 is a diagrammatic view, partly in elevation and partly in section showing another modified form of apparatus for producing airlaid fibrous web.

Fig. 6 is a diagrammatic view, partly in side

elevation and partly in section, showing another modified form of apparatus for producing airlaid fibrous web.

Fig. 7 is a diagrammatic view, partly in section and partly in elevation, showing another modified form of apparatus for forming airlaid fibrous web.

Fig. 8 is a diagrammatic view, partly in section and partly in side elevation, showing another modified form of apparatus provided with means for spraying fibers prior to arranging same in the form of an airlaid fibrous web.

Referring now to the drawings and more particularly to Figs. 1, 2 and 3 therein for a better understanding of this invention, one form of apparatus for producing airlaid fibrous web is shown as comprising a hopper 11 adapted to contain the fibers prior to forming same into an airlaid web. The fibers are delivered from the hopper 11 to a conventional weighing pan 12 by means of a suitable conveyor 13. A feed conveyor 14 is disposed under the weighing pan 12 to receive and deliver the fiber between a pair of feed rolls 16. The rolls 16 deliver the fibers to a picker wheel 17 provided with teeth 18 which coact with mote knives 19 to open up the fibers and direct same into a deposition chamber 15 in the form of a mass of light fluffy fibers. The picker wheel 17, feed roll 16 and feed conveyor 14 are driven at suitable predetermined speeds by means of a motor 20 through suitable belts 21, 22 and 23, and variable speed mechanism 10 for feed rolls and feed table.

The deposition chamber 15 is preferably in the form of an enclosed housing of gradually increasing area for the passage of the light fluffy fibers. At the far end of the deposition chamber 15 from the picker wheel 17 is provided a sealed section of an air permeable conveyor belt 26. The conveyor belt 26 may be formed of any suitable material such as Fourdrinier wire, window screening, cloth, thin perforated metal, or other flexible air permeable material adapted to permit passage of air and to prevent the passage of entrained fibers.

A primary discharge hopper 27 is disposed below the picker wheel 17 to receive relatively heavy particles of material such as incompletely opened fibers, rocks, sand, and other foreign material having a specific gravity great enough to move downwardly through an upwardly flowing stream of air entering the hopper through a plurality of air inlet openings 28. A suitable rotary discharge valve 29 is provided at the bottom of the hopper for discharging foreign material therefrom, and is driven by means of a motor 31 through a belt 32. A secondary discharge hopper 33 is provided within the deposition chamber 15 below the sealed portion of the air permeable conveyor belt 26 to receive relatively heavy particles of material having a sufficiently high specific gravity to fall downwardly out of an air stream passing through the sealed portion of the air permeable conveyor belt 26. This secondary discharge hopper 33 is also provided with a rotary discharge valve 34 driven by a motor 36 through a belt 37 for discharging accumulations of material from the hopper.

On the far side of the air permeable conveyor belt 26 from the deposition chamber 15 is provided a sub-atmospheric air chamber 38 of sufficient size to produce an even and uniform velocity of air to be drawn through the sealed portion of the conveyor belt 26 when same is running free of fibrous material. Preferably the transverse sectional area of the sub-atmospheric chamber 38 should be at least double the area of the nozzle portion 39. In order to reduce turbulence in the air stream passing through the nozzle 39, said nozzle may be provided with vertically and horizontally arranged partitions 41 to provide a plurality of relatively small air passages 42 leading from the belt 26 to the chamber 38. If desired, suitable control dampers 43 may be pivotally mounted at the outlet ends of said passages 42 to further control passage of air through selected portions of the air permeable conveyor belt 26.

An air conduit 44 leads from the sub-atmospheric chamber 38 to an exhaust fan 45 driven by a motor 46 through a belt 47 and variable speed pulleys 50. The sealed portion of the conveyor belt 26 is enclosed at the sides by means of sealing strips 48 which may be formed of sheet rubber or rubberized material having their edges secured at 49 to the adjacent side walls of the deposition chamber 15 and nozzle 39, and having their free edges disposed in sliding engagement with conveyor belt 26.

Two pairs of rubber rolls 51 and 52 serve as end seals for the sealed portion of the conveyor belt 26. Rolls 51 and 52 are preferably formed of soft rubber to prevent the leakage of air into the interior of the deposition chamber 15 or nozzle 39.

The conveyor belt 26 extends from the rubber rolls 51 and 52 around suitable idler rolls 53, a driving roll 54, and a guide mechanism 55 of the conventional type employed in the paper industry for guiding Fourdrinier belts. The driving roll 54 is driven by a motor 56 through a belt 57, variable speed drive 58, and a belt 59. A rotary brush 60 driven by a motor M is used to remove extraneous fibers adhering to belt on its return run.

In forming airlaid fibrous web by means of the apparatus thus shown and described, the fibers are delivered from the hopper 11 to the weighing pan 12 by means of the conveyor 13. The fibers are distributed from the weighing pan 12 onto the conveyor 14 for delivery to and through the feed rolls 16 for fiberizing and fluffing action by the picker wheel 17 and mote knives 19. By means of the exhaust fan 45, air is drawn through the vents 28 upwardly through the primary discharge chamber 27, the deposition chamber 15, thence through the sealed portion of the conveyor belt 26, nozzle 39, sub-atmospheric chamber 38, and conduit 44 to be exhausted to the atmosphere through the outlet port of the exhaust fan 45.

Relatively heavy particles of material, such as incompletely opened fibers, rocks, grit, etc., are adapted to move downwardly through the primary discharge chamber 27 and discharge therefrom by means of the rotary valve 29. The relatively light fluffed up fibers are adapted to be carried by the air stream from the picker wheel 17 into contact with the sealed portion of the conveyor belt 26, and it will be noted that the deposition chamber 15 should be of sufficient length to prevent turbulence within the air stream in order to prevent "balling" or entanglement of the suspended fibers prior to their engagement against the conveyor belt 26. A secondary discharge chamber 33 is provided below the sealed portion of the conveyor belt 26 to receive relatively heavy particles of incompletely opened fibers, dirt or other foreign material falling from the air stream, which foreign material

is discharged from the chamber by means of the rotary valve 34.

During the operation of the apparatus, the sub-atmospheric pressure within the chamber 38 causes the fibers remaining in the air stream to be deposited upon the surface of the conveyor belt 26 which moves at a predetermined constant linear speed to convey the fibers in the form of a web of heterogeneously arranged fibers for transfer onto a porous conveyor belt 61. By careful control of the velocity of the air stream passing through the deposition chamber 15, it will be noted that only fibers of the desired openness will be deposited upon the conveyor belt 26. It will also be noted that this apparatus is adapted to produce a fibrous web consisting of the most completely opened fibers.

In the use of this apparatus, airlaid fibrous web 25 may be formed of the desired thickness by merely changing the linear speed of the conveyor belt 26. It is also possible to vary the thickness of the web by changing the exhaust fan speed with resultant change of air velocity, air volume, and static pressure. It may at times be found desirable to vary both the fan speed and the speed of the conveyor belt 36 in order to obtain the desired thickness of web. These changes however are relatively simple to accomplish and may be made while the apparatus is in operation.

It will be noted that a change in the linear speed of the conveyor belt 26 results in a variation in the interval of time during which a selected point on the sealed portion of the belt is exposed to receive fibers carried in the air stream. In this manner of adjustment, production speed on a weight basis remains relatively constant as the rate of feed of fibers to the exposed portion of the belt 26 is independent of the linear movement of said belt.

In the use of carding machinery there is a relatively fixed speed for the withdrawal of a smooth web as the withdrawal has to be synchronized with the speed of formation of the web. Therefore a reduction in withdrawal speed usually requires a decrease in feed of the uncarded asbestos fibers. In addition, it is necessary to make careful adjustment of the feed in order to obtain different weights or thicknesses of a web from a card. The range of thicknesses in weights of fibrous web from a card are also limited as webs below .002 or .003 inch are difficult to handle due to their lacy structure, and fibrous webs above .005 or .006 inch have a tendency to become flaky due to choking up of the card clothing which results in poorly carded fiber.

It has been determined that the ultimate thickness of the web formed at a definite speed and at predetermined static pressure is also dependent upon the mesh size or air spaces provided in the conveyor belt 26. The degree of openness of the fibers as well as the fiber length also governs the thickness of the deposited web. Relatively short fibers pack more closely than do relatively coarse long fibers and results in an increase in resistance to the air passing through the conveyor belt 26 and the deposited web 25 with the resultant drop in the velocity of the air stream passing through deposition chamber 15, and with a resultant decrease in attraction of the fibers toward the conveyor belt 26. When the conveyor belt 26 travels at a reduced speed to allow an equilibrium condition to be obtained, the web will build up to a thickness commensurate with the available static pressure in the sub-atmospheric

chamber 38, after which little or no additional fiber will be added to the web. In other words, for a given quality of fiber, the thickness of the web can be governed by measurement of the static pressure in the subatmospheric chamber 38.

The airlaid fibrous web is delivered from the air permeable conveyor belt 26 onto an endless porous saturator belt 61 which may be formed of woolen felt, wire mesh or the like. The belt 61 carries the fibrous web around a cylindrical mold roll 62 disposed within a trough-shaped solution pan 63 and thence around a couch roll 64 for delivery between a pair of compression rolls 66 and 67. The compression roll 66 is driven from the motor 56 by means of a belt 68. The trough shaped pan 63 is filled with a suitable sizing or bonding solution to be applied to the fibrous web, and the excess sizing or bonding material is removed from the saturated fibrous web during its passage between compression rolls 66 and 67. The roll 66 is preferably formed of semi-hard rubber, and the roll 67 is preferably formed of steel or other hard-surfaced material. These compression rolls thus act to remove the excess sizing or bonding solution from the fibrous web without crushing or distorting same, due to the slight resiliency afforded by the rubber surfaced roll 66.

The sizing or bonding solution preferably comprises a dilute water solution or suspension of boiled (swollen) tapioca flour, although other types of starches, dextrines, glues, resinous suspensions or solutions such as polyvinyl alcohol, methyl cellulose, melamine formaldehyde, urea formaldehyde, phenol formaldehyde, latex (natural or synthetic), sodium silicates, and the like may be used depending on the properties desired in the finished sheet. A solution of ½% to 1% by weight of tapioca flour is preferably employed for bonding and sizing, although solutions up to 5% (by weight) concentration may be employed when greater stiffness and less porosity of the sheet is desired. In the use of other binders, the concentration of the solution may vary considerably from those given above for tapioca flour, the concentration used being determined by the qualities of the sizing or adhesive as well as the properties desired in the finished product.

Where tapioca flour is used in ½% to 1% solution for sizing, the resultant sheet (after evaporation of the water carrier) is compact, densified, self-sustaining, and also of good absorptive characteristics with the fibers heterogeneously arranged in accordance with the method herein set forth. The product differs from waterlaid papers in that long fibers are present, which it is believed has not heretofore been possible on paper making equipment due to balling up or entanglement of the fibers in the beater or other slurry making equipment. The present product also differs from carded webs in that there is no parallelism of the fibers in the finished sheet. While fibrous carded webs used for certain purposes have inherent weaknesses in a direction transverse to the fiber length as laid in the sheet, the present web does not embody this weakness due to the heterogenous arrangement of the fibers. Furthermore, a web formed of relatively long asbestos fibers by means of the present method and apparatus also differs from a carded asbestos web in that the organic fibers usually employed to carry the asbestos fibers through the process are omitted. This feature results in a material having higher heat resistance and lower moisture

absorption due to its completely inorganic fibrous base.

After the sizing and bonding solution has been applied to the fibrous web, and the excess bonding or sizing material has been removed from the web by means of the compression rolls **66** and **67**, the web is transferred to a plurality of rolls **69** forming part of a drier for removing the solvent from the sizing or bonding adhesive provided on the fibrous sheet. The drier may be of any conventional type such as steam heated drums, a convection type oven, a forced convection oven, infra-red drier, or the like. The drier preferably embodies "dry-cans" of the type used in the textile industry. After the sheet has been passed through the drier, it is rolled up around a roll **71**.

After a fibrous web has been formed on the type of apparatus illustrated in Fig. 1, it may be passed through additional chambers of the same or similar construction for the deposition of other fibers upon the surface of the web by means of the apparatus illustrated in Fig. 4 of the drawings. For example, these additional fibers may consist of very short asbestos fibers for filling all surface irregularities in the web to provide a finished product having a smooth surface approximating a surface of conventional waterlaid asbestos paper. By employing the type of apparatus illustrated in Fig. 4, it is also possible to build up laminae of different classifications of fibers. For example, a primary web of cotton may be formed on the foraminous belt **26** within the first deposition chamber, and then a rayon web deposited on the surface of the primary cotton web within the second deposition chamber. In Fig. 4, the primary web forming apparatus is designated as A and the secondary web forming apparatus is designated as B. The primary web forming apparatus A is shown as comprising a feed conveyor **14***a* to receive and deliver the fiber between a pair of feed rolls **16***a* which act to direct the fibers to a picker wheel **17***a* provided with teeth which coact with mote knives **19***a* to open up the fibers and to direct same into a deposition chamber **15***a* in the form of a mass of light, fluffy fibers. At the far end of the deposition chamber **15***a* from the picker wheel **17***a* is provided a sealed section of an air permeable conveyor belt **26***a*, the belt being formed of any suitable material adapted to permit passage of air and to prevent the passage of entrained fibers.

A primary discharge hopper **27***a* is disposed below the picker wheel **17***a* to receive relatively heavy particles of material, such as incompletely opened fibers, sand, etc. having a specific gravity great enough to move downwardly through an upwardly-flowing stream of air entering the hopper through a plurality of air inlet openings **28***a*. A secondary discharge hopper **33***a* is provided within the deposition chamber **15***a* below the sealed portion of the belt **26***a* to receive relatively heavy particles of material falling by gravity downwardly out of the air stream as the latter passes through the sealed portion of the conveyor **26***a*. A subatmospheric air chamber **38***a* is provided to produce an even and uniform velocity of air through the sealed portion of the conveyor belt **26***a* when the latter is running free of fibrous material. Two pairs of rubber rolls **51***a* and **52***a* serve as end seals for the sealed portion of the conveyor belt **26***a*. The air inlet side of the chamber **38***a* is preferably provided with a plurality of relatively small air passages **42***a* provided with suitable control dampers **43***a*.

The secondary web forming apparatus B is shown as comprising a feed conveyor **14***b* to receive and deliver the fiber between a pair of feed rolls **16***b* which act to direct the fibers to a picker wheel **17***b* provided with teeth which coact with mote knives **19***b* to open up the fibers and to direct same into a deposition chamber **15***b* in the form of a mass of light, fluffy fibers. At the far end of the deposition chamber **15***b* from the picker wheel **17***b* is provided a sealed section of the air permeable conveyor belt **26***a*.

A primary discharge hopper **27***b* is disposed below the picker wheel **17***b* to receive relatively heavy particles of material, such as incompletely opened fibers, sand, etc., having a specific gravity great enough to move downwardly through an upwardly-flowing stream of air entering the hopper through a plurality of air inlet openings **28***b*. A secondary discharge hopper **33***b* is provided within the deposition chamber **15***b* below the sealed portion of the belt **26***a* to receive relatively heavy particles of material falling by gravity downwardly out of the air stream as the latter passes through the sealed portion of the conveyor **26***a*. A subatmospheric air chamber **38***b* is provided to produce an even and uniform velocity of air through the sealed portion of the conveyor belt **26***a* when the latter is running free of fibrous material. Two pairs of rubber rolls **51***b* and **52***b* serve as end seals for the sealed portion of the conveyor belt **26***a*. The air inlet side of the chamber **38***b* is preferably provided with a plurality of relatively small air passages **42***b* provided with suitable control dampers **43***b*.

It will further be noted that the process and apparatus shown and described in connection with Fig. 1 of the drawings is also adaptable for use in cleaning fibrous materials. By embodying the principles of this invention, fibers of desired openness may be selectively deposited on the endless conveyor belt **26**, free of dirt, splints, open particles, etc., to provide a fibrous web of well opened fibers suitable for textile uses such as carding, spinning, and drafting into yarns of high quality. When the apparatus disclosed in Fig. 1 of the drawings is employed in the manner thus described, the fibrous web will not, of course, be transferred to the saturating equipment shown in Fig. 2 of the drawings.

Fig. 5 illustrates a modified form of this invention which is similar to the form heretofore described in connection with Fig. 1, but in which the secondary dirt discharge chamber **33** is omitted from the apparatus. This form of the invention is shown as comprising a feed conveyor **14***c* to deliver fiber between a pair of feed rolls **16***c* which act to transfer the fiber to a picker wheel **17***c* provided with teeth to coact with mote knives **19***c* to open up the fibers and direct same into a deposition chamber **76**. An air permeable conveyor belt **26***c* is provided at the far end of the deposition chamber from the picker wheel **17***c*, the belt being formed of flexible, air permeable material such as cloth, window screening, or the like, adapted to permit the passage of air therethrough and to prevent the passage of fibers. A discharge hopper **27***c* is disposed below the picker wheel **17***c* to receive foreign material such as incompletely opened fibers, rocks, sand, etc. The hopper **27***c* is provided with a plurality of air inlet openings **28***c* to direct air upwardly through the hopper. A subatmospheric air chamber **38***c* is provided on the far side of the belt **26***c* from the deposition chamber **76** to produce an even and uniform velocity of air

through the sealed portion of the conveyor belt 26c when the latter is running free of fibrous material. In order to reduce turbulence in the air stream passing through the nozzle portion of the chamber 38c, the nozzle may be provided with a plurality of relatively small air passages 42c provided with control dampers 43c. Two pairs of rubber rolls 51c and 52c are provided to engage the conveyor belt 26c and to prevent leakage of air into the interior of the deposition chamber 76 or the chamber 38c. In this form of the invention, all of the fibers carried by the air stream passing through the deposition chamber 76 are deposited upon the enclosed portion of the foraminous conveyor belt 26c. Apparatus of this type is adapted for use in producing a relatively heavy fibrous web of inexpensive construction, or where it is desired to include incompletely opened fibers to add to the resiliency of the resulting web. The apparatus disclosed in Fig. 5 is otherwise similar in construction and operation to the first form of invention described in connection with Fig. 1 in the drawings.

Fig. 6 illustrates another modified form of this invention in which the fibers are directed horizontally through a deposition chamber 77 and thence downwardly through a vertically disposed portion 78 for distribution onto a horizontally disposed sealed portion of the foraminous conveyor belt 26d. Shutter controlled air inlet openings 28d are provided at the upper end of the vertically disposed portion 78. This form of the invention is shown as comprising a feed conveyor 14d to deliver fibers between a pair of feed rolls 16d, the rolls acting to direct the fibers to a picker wheel 17d provided with teeth which coact with mote knives 19d to open up the fibers and direct same into the deposition chamber 77. A discharge hopper 27d is disposed below the picker wheel 17d to receive relatively heavy particles of material such as incompletely opened fibers, rocks, sand, and other foreign material having a specific gravity great enough to move downwardly through an upwardly flowing stream of air entering the hopper through a plurality of air inlet openings 28d. An air permeable conveyor belt 26d is provided at the lower end of the vertical portion 78 of the deposition chamber to receive the fibers passing downwardly therethrough and is engaged between two pairs of rubber seating rolls 51e and 52e. Below the endless belt 26d is provided a subatmospheric air chamber 38d which acts to produce an even and uniform velocity of air to pass through the conveyor 26d when the latter is running free of fibrous material. The chamber 38d is provided with relatively small air passages 42d controlled by suitable dampers 43d. In this form of the invention, it will be noted that the fiber is deposited upon the upper surface of the conveyor belt 26d by gravity, with a suction applied to the underside of the conveyor belt to aid in directing the fibers to the thinner spots of the web during formation of same. Due to the omission of the secondary discharge chamber illustrated at 33 in Fig. 1, there is a larger percentage of relatively heavy fibers, splints, and other foreign matter incorporated into the fibrous web, thereby increasing the production weight of the web through utilization of a higher percentage of the fibers fed into the deposition chamber 77. The apparatus thus shown and described is otherwise similar in construction and operation to the form of apparatus heretofore shown and described in connection with Fig. 1 in the drawings.

Fig. 7 illustrates another modified form of this invention in which the fiber is directed through a horizontally disposed deposition chamber 79 and thence upwardly at 81 to be deposited on the lower side of a horizontally disposed sealed portion of a foraminous conveyor belt 26e. The form of the invention illustrated in Fig. 7 is shown as comprising a feed conveyor 14e to direct fibers between a pair of feed rolls 16e which, in turn, deliver the fibers to a picker wheel 17e provided with teeth to coact with mote knives 19e to open up the fibers and direct same into the deposition chamber 79. A discharge hopper 27e is disposed below the picker wheel 17e to receive relatively heavy particles of material, such as incompletely opened fibers, rocks, sand, and other foreign material having a specific gravity great enough to move downwardly through an upwardly flowing stream of air entering the hopper through a plurality of air inlet openings 28e. An endless foraminous belt 26e is provided at the upper end of the vertical portion 81 of the deposition chamber and is engaged between two pairs of rubber sealing rolls 51e and 52e. A subatmospheric chamber 38e is disposed on the far side of the belt 26e from the deposition chamber 81 to produce an even and uniform velocity of air through the sealed portion of the conveyor belt when the latter is running free of fibrous material. The chamber 38e is provided with small air passageways 42e controlled by dampers 43e. In this form of the invention, a plurality of auxiliary air vents 82, controlled by louvers 83, are disposed at the lower end of the vertically disposed section 81 for controlling the upward flow of the fibers, and it will also be noted that the lower portion of the vertically disposed section 81 serves as a secondary dirt discharge chamber 84 to receive relatively heavy fibers or particles of foreign material. A brush 86 is provided to remove fly from the return side of the belt 26e and deposit same into a pan 87. By careful control of the velocity of air passing upwardly through the vertical portion 81 of the deposition chamber, only fibers of the desired openness will be deposited upon the conveyor belt 26. Apparatus of this type is adapted to produce a web formed of the most completely opened fibers as the heavier fibers will fall by gravity into the secondary dirt discharge chamber 84. This form of apparatus will have the lowest production rate as it utilizes the lowest percentage of fibers fed into the apparatus.

A web or sheet of asbestos material formed by the air deposition processes heretofore set forth has many practical uses and applications as it embodies strength characteristics superior to laminated sheets of woven asbestos cloth, or laminated carded webs. The present web or sheet, when impregnated with resin saturants, makes a satisfactory base for molded and laminated plastic compositions. When a thermosetting phenol-formaldehyde resin is used as an impregnant and the resultant sheet is laminated and pressed at approximately 1,000 pounds per square inch at approximately 300° F., the resulting laminate has a tensile strength of approximately 27,000 pounds per square inch. It has also been learned that a laminated sheet, made as above, with 100% asbestos fiber base shows exceptionally good moisture resistance. For example, a carded asbestos web containing 10% to 15% by weight of cellulosic fibers has a water absorption value of approximately 1.65% in 24 hours at room temperature. A phenolic laminate

made with standard short fibered waterlaid asbestos paper absorbs approximately 0.80% water in 24 hours. A standard woven asbestos cloth laminate absorbs approximately 1.80% water in 24 hours. A web formed in accordance with the present invention absorbs approximately 0.25% to 0.30% water in 24 hours with an increase to approximately 0.60% absorption after ten days of immersion in water at room temperature. The moisture stability of the present sheet material appears to far exceed that of other well known phenolic laminates containing organic fibers or relatively large quantities of hydrophyllic bonding or sizing agents of the type usually embodied in standard asbestos waterlaid papers. The structure of the present sheet material is particularly suitable for use in molding shapes of irregular contour where a drawing or even flowing effect of the material is desired. The sheet has relatively unanchored fibers in it so that when same is subjected to heat and high pressures it embodies excellent flow characteristics to allow the molding of parts with uneven contours and variable cross section without the necessity for macerating the sheet as is ordinarily necessary with long fibered molding fillers of woven structure.

Another use for the present type of sheet material resides in impregnation of the basic sheet with various varnishes and/or resinous materials to form electrical insulating tapes. Tapes of this type may be produced so that the relatively small voids between the longer fibers are filled with shorter fibers, thus resulting in a tape of uniform and smooth surface appearance and, after impregnation, results in a tape of good electrical properties, high heat resistance, low moisture absorption, and other desirable characteristics.

Fig. 8 in the drawings illustrates another modified form of this invention in which the apparatus is constructed for use in spraying the individually suspended fibers with a suitable resin of the thermo-setting type to obtain coated fibers containing from 30% to 60% by weight of resin. This form of the invention is shown as comprising an endless feed conveyor **14***f* to deliver fibers between a pair of feed rolls which act to direct the fibers to a picker wheel **17***f* provided with teeth which coact with mote knives **19***f* to open up the fibers and direct same into a deposition chamber **91**. The apparatus illustrated comprises a horizontally disposed passage **91** leading from the picker wheel **17***f* to an inverted U-shaped conduit **92**. A stream of air is drawn into the passage **91** through air vents **93** provided in a primary dirt discharge chamber **94** to draw the fluffed up material from the picker wheel through the passage **91**, and thence through the passage **92** for distribution onto a foraminous conveyor belt **95**. A secondary dirt discharge chamber **96** is provided at one end of the conduit **92** and provided with shutters **100** for controlling air openings **97**. The air is drawn through the openings **93** and **97** for passage through the conduit **92**, the foraminous conveyor belt **95**, the sub-atmospheric chamber **38***f* and conduit **44** by means of the type of power driven blower **45** illustrated in Fig. 2 of the drawings. During downward movement of the fibers through the conduit **92**, they are sprayed with a suitable resin of the thermo-setting type, the liquefied resin being directed through conduit **98** and outwardly through a suitable spray nozzle **99**. After the fibers have been coated with the resin, they are

deposited upon the foraminous conveyor belt **95**, dried by means of oven **102**, and discharged therefrom into a suitable storage container **101**. The oven **102** may embody any suitable type of heating means such as steam heating coils, infra-red circulating convection type, etc. A scraper or doctor blade **103** aids in removing resin coated fibers from the belt. Resinous coated fibers of this type, when subjected to predetermined heat and pressures, form a strong compact plastic mass somewhat similar to that obtained through molding of the impregnated sheets as heretofore set forth. Resinous coated fiber of this type is adapted for such practical uses as straight plastics molding, or for incorporation into friction materials where the fiber coating serves to increase frictional characteristics or wearing qualities. In the operation of this apparatus, it may be found to be desirable to provide adjustable shutters **90** for controlling the passage of air through the air inlet openings **53**. It is contemplated that the use of adjustable shutters **39** may prove to be desirable for controlling the flow of air through the air inlet openings **28** illustrated in Figs. 1, 4, 5, 6 and 7. Two pairs of rubber rolls **51***f* and **52***f* serve as end wheels for the conveyor belt **95**. The sub-atmospheric chamber **38***f* is also preferably provided with relatively small air passages **42***f* provided with control shutters **43***f*.

While this invention has been shown in several forms, it is obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modifications without departing from the spirit and scope of the claimed invention.

I claim as my invention:

1. In an apparatus for forming airlaid fibrous web, a pair of deposition chambers having air inlet and outlet openings, a continuous foraminous conveyor belt for movement past the air outlet openings of said deposition chambers, blower means for drawing a stream of air through each deposition chamber and said conveyor belt, fiberizing means disposed at the air inlet ends of each of said deposition chambers for opening the fibrous material and projecting same into their respective air streams in a fluffed-up condition for distribution upon said conveyor belt as same moves past the respective air outlet openings of said deposition chambers, a dirt discharge chamber formed in each deposition chamber below said fiberizing means to receive relatively heavy particles of material dropping by gravity from a fiber charged air stream, said air inlet openings for said deposition chambers being formed in the side walls defining the dirt discharge chambers.

2. In an apparatus for forming airlaid fibrous web, a pair of deposition chambers having air inlet and outlet openings, a continuous foraminous conveyor belt for movement past the air outlet openings of said deposition chambers, blower means for drawing a stream of air through each deposition chamber and said conveyor belt, fiberizing means disposed at the air inlet ends of each of said deposition chambers for opening the fibrous material and projecting same into their respective air streams in a fluffed-up condition for distribution upon said conveyor belt as same moves past the respective air outlet openings of said deposition chambers, a dirt discharge chamber formed in each deposition chamber below said fiberizing means to receive relatively heavy particles of material dropping

by gravity from a fiber charged air stream, said air inlet openings for said deposition chambers being formed in the side walls defining the dirt discharge chambers, and means for controlling the flow of air through said air inlet openings.

3. In an apparatus for forming airlaid fibrous web, a pair of deposition chambers having air inlet and outlet openings, a continuous foraminous conveyor belt for movement past the air outlet openings of said deposition chambers, blower means for drawing a stream of air through each deposition chamber and said conveyor belt, fiberizing means disposed at the air inlet ends of each of said deposition chambers for opening the fibrous material and projecting same into their respective air streams in a fluffed-up condition for distribution upon said conveyor belt as same moves past the respective air outlet openings of said deposition chambers, a dirt discharge chamber formed in each deposition chamber below said fiberizing means to receive relatively heavy particles of material dropping by gravity from a fiber charged air stream, and a secondary dirt discharge chamber formed in each of said deposition chambers below their respective air outlet openings to receive relatively heavy particles of material dropping by gravity from their respective fiber charged air streams.

4. In an apparatus for forming airlaid fibrous web, a pair of deposition chambers having air inlet and outlet openings, a continuous foraminous conveyor belt for movement past the air outlet openings of said deposition chambers, blower means for drawing a stream of air through each deposition chamber and said conveyor belt, fiberizing means disposed at the air inlet ends of each of said deposition chambers for opening the fibrous material and projecting same into their respective air streams in a fluffed-up condition for distribution upon said conveyor belt as same moves past the respective air outlet openings of said deposition chambers, a dirt discharge chamber formed in each deposition chamber below said fiberizing means to receive relatively heavy particles of material dropping by gravity from a fiber charged air stream, a secondary dirt discharge chamber formed in each of said deposition chambers below their respective air outlet openings to receive relatively heavy particles of material dropping by gravity from their respective fiber charged air streams, and a sub-atmospheric chamber for creating a sub-atmospheric pressure condition between each of the air outlet openings of said deposition chambers and said blower means.

5. In an apparatus for forming airlaid fibrous web, a deposition chamber having an inlet and outlet, said deposition chamber having a dirt discharge chamber leading downwardly from said deposition chamber inlet, a sub-atmospheric chamber leading from the outlet of said deposition chamber, a movable foraminous continuous conveyor belt having an air-sealed portion thereof interposed between said deposition chamber and said sub-atmospheric chamber, means for drawing a stream of air upwardly through said dirt discharge chamber and thence laterally through said deposition chamber and sealed portion of said foraminous conveyor belt and said sub-atmospheric chamber, means defining a plurality of passageways at the inlet end of said sub-atmospheric chamber, control means associated with each of said passageways to selectively control the flow of air therethrough, fiberizing means for opening the fibrous material and projecting same laterally into the upper end of said dirt discharge chamber to cause the open fibers to be carried upwardly and thence laterally by said air stream for passage through said deposition chamber, whereby said open fibers will be distributed in heterogeneous interlocking arrangement upon the air-sealed portion of said conveyor belt, said dirt discharge chamber being formed to receive relatively heavy particles of incompletely open fibers and foreign material falling thereinto from the fiber-charged air stream.

6. In an apparatus for forming airlaid fibrous web, a deposition chamber having inlet and outlet openings, said deposition chamber having a dirt discharge chamber leading downwardly from said deposition chamber inlet opening, a continuous foraminous conveyor belt for movement past the outlet opening of said deposition chamber, blower means for drawing a stream of air through said dirt discharge chamber, deposition chamber and conveyor belt, fiberizing means disposed at the juncture of said dirt discharge chamber and the inlet end of said deposition chamber for opening the fibrous material and projecting same laterally in a fluffed-up condition into the upper end of said dirt discharge chamber to cause the open fibers to be carried upwardly and thence laterally for distribution upon the portion of the conveyor belt moving past the outlet opening of said deposition chamber, said dirt discharge chamber being formed to receive relatively heavy particles of material dropping by gravity from the fiber charged air stream and having air inlet openings in the side walls thereof, means for controlling the flow of air through the air inlet openings of said dirt discharge chamber, a sub-atmospheric chamber for creating a sub-atmospheric pressure condition between the outlet opening of the deposition chamber and said blower means, means defining a plurality of passages at the inlet end of said sub-atmospheric chamber, and means to control the flow of air through said passages.

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