

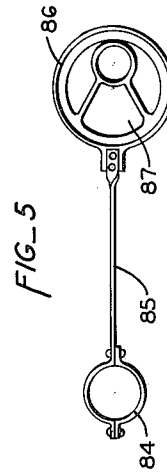
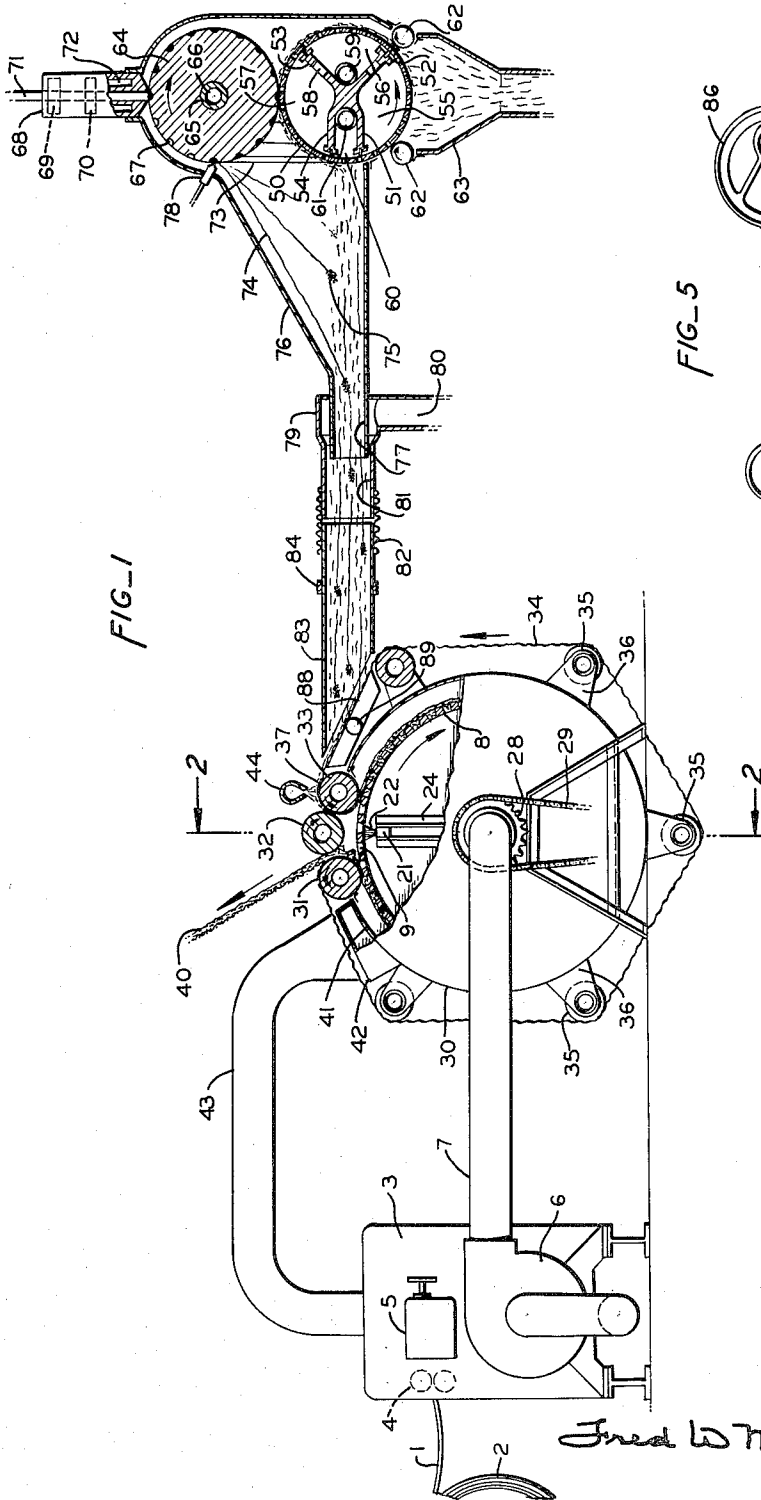
March 6, 1962

F. W. MANNING
NONWOVEN FABRICS

3,024,149

Filed July 5, 1957

2 Sheets-Sheet 1



INVENTOR.

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2 Sheets-Sheet 2

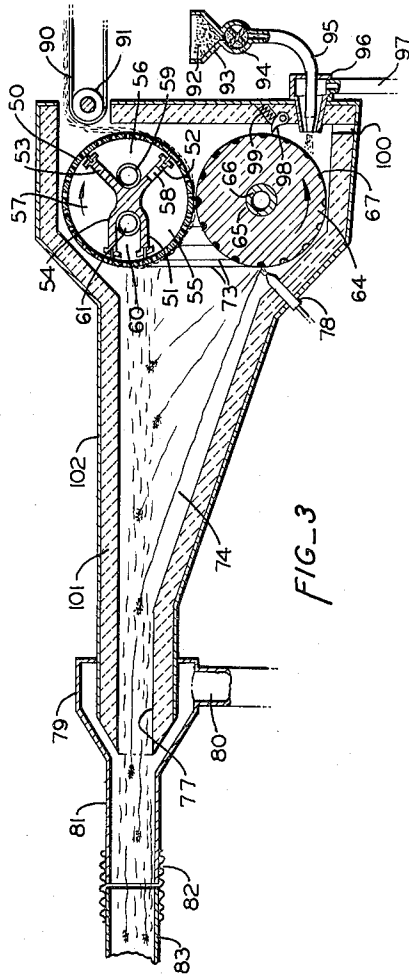


FIG-3

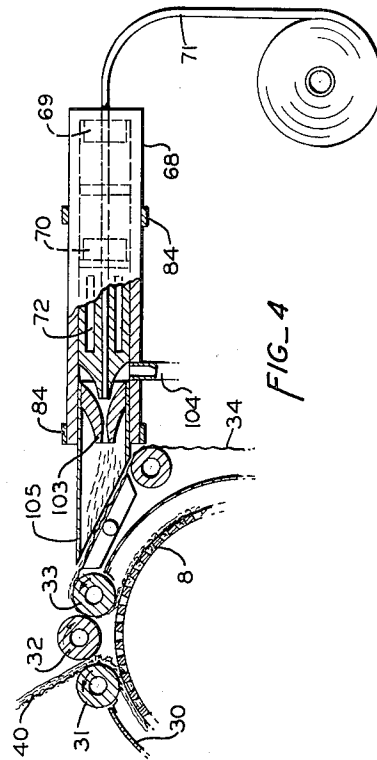
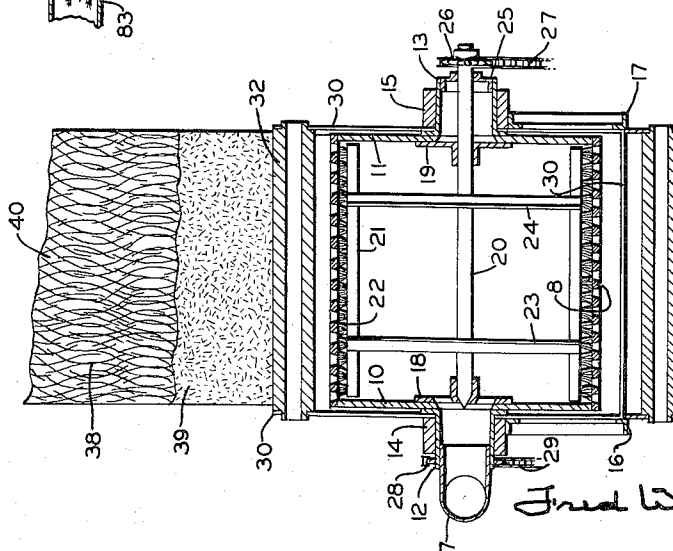


FIG-4



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3,024,149

NONWOVEN FABRICS

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16 Claims. (Cl. 156—28)

My invention relates to nonwoven fabrics, particularly to reinforced nonwoven fabrics for use in surface and depth type magazine fabric filters for clarification purposes. This application is a continuation-in-part of my copending application entitled "Fabric Filters," Serial No. 590,175, filed June 8, 1956, now abandoned.

By "surface type" I mean a fabric filter in which the first winding of a bed of windings will retain all or most of the impurities of a fluid passing therethrough, and from which bed fabric can be automatically removed with sufficient frequency to maintain the flow rate constant. "Depth type" denotes a filter in which nearly the entire bed of many fabric windings is used to remove the impurities, and the windings are automatically advanced in a direction opposed to the flow of the fluid by adding fresh fabric to the fluid outlet surface of the bed and removing contaminated fabric from the fluid inlet surface of the bed with sufficient frequency to maintain clarity and flow rate constant.

The fabric may be made of any thickness but preferably is about .01 inch in depth, which will give about 100 windings to each inch depth of filter bed. The greater the effective depth of the filter bed, the more porous is can be made and the greater will be the flow rate for any given clarity, and this flow rate can be further augmented by stretching the windings as they become clogged. Consequently, it was found that a 3-inch depth of filter bed of 300 windings in a counter-current type of fabric filter will give from 3 to 10 times the filtering rate obtained from other types of filters using one thickness of fabric for clarification purposes. For the above reasons, depth type countercurrent fabric filters are particularly suitable for the filtering of all kinds of aerosols.

Removal or renewal of filter bed windings during operation means that the fabric must have a reasonable amount of tensile strength. Accordingly, scrim or cheesecloth was used originally to reinforce and carry a web of comparatively short fibres. But scrim is a woven fabric and was found to be altogether too expensive for windings that were discarded after being extruded from a filter, and therefore it became obvious that the much cheaper nonwoven webs of filaments would have to be substituted.

In order that a web of fibres or other treating solids adsorb and retain the maximum amount of impurities of a fluid passing therethrough, the web first must be produced in like manner, i.e., by passage of a fibre conveying fluid through a foraminous, fibre-retaining wall to obtain the uniform distribution and penetration required for passage of the secondary fluid from which impurities are to be removed. And to greatly speed up the said distribution, the fibres should be sifted first through a primary foraminous wall while subject to agitation over the wall and movement of the conveying fluid passing through both walls.

But filaments of substantial length for reinforcing purposes cannot be passed through the foramina of a primary sifting wall by agitation under pressure of a fluid passing through both walls, and therefore they must be deposited on the opposed side of the primary wall, and preferably used as a secondary wall to retain the fibres sifted through the primary wall.

It is therefore an object of my invention to provide a method and means for depositing fabric making materials of treating solids and reinforcing filaments on opposed sides of a primary or sifting foraminous wall before pass-

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ing one of the said materials through the wall to be united to the other of the said materials.

An additional object is to produce and deposit the said web of filaments on one side of a foraminous sifting wall immediately preceding, or simultaneously with, the agitation of discrete fibres or other treating solids on the opposed side of the wall, and to utilize the said web of filaments as a fibre retaining or secondary wall when sifting the fibres through the primary wall.

Another object is to provide an arrangement to utilize the entire peripheral area of a cylindrical wall for fibre deposition purposes and thereby greatly increase the formative speed of such laminated fabrics.

A further object is to provide a filter sheet of treating solids reinforced by cold-drawable filaments that can be extended uniformly during use to increase its capacity for retaining or adsorbing solid impurities.

A still further object is to cold-draw the bonding filaments a definite amount in the manufacture of the fabric so that the finished fabric will not only have strength but a predetermined extensibility.

An additional object is to produce an isotropic fibre-bonded sheet, i.e., a sheet having uniform strength in all directions of a two-dimensional plane.

Another object is to attenuate fibre forming pellets into filaments by propulsion of the pellets alone before their complete attenuation.

A further object is to produce discontinuous, reinforcing filaments of more uniform length, diameter, and strength than have been obtainable by prior methods.

And still another object is to provide a fabric of treating solids for bleaching, decolorizing, catalyzing, or other treatment of fluids so that when the fabric is moved counter to the flow of the fluid through a depth filter the amount of such solids required is greatly diminished.

Other objects of my invention will become apparent from the following description.

In accordance with certain aspects of my invention, fibres may be of vegetable, animal, or mineral origin, and preferably are cellular rather than solid because of their greater adsorptive areas for the retention of impurities. The fibrous material is conveyed in any suitable form into an attrition mill or other fiberizing machine that will fluff or separate one fibre from another, and when necessary shorten the fibres.

From the fiberizing machine an elastic fluid conveys the fibres onto a distributing and depositing foraminous wall. This may be an endless belt but preferably is a rotating foraminous drum in which the fibres are distributed over its inner surface and into its foramina by relative movements of the drum and an agitator during passage through the drum of the said fluid.

A web of filaments is deposited by a propulsion stream directly on the outer or opposed surface of the wall, or in close proximity thereto and carried onto the opposed surface. This web on removal from the wall retains the fibres deposited in its mesh and foramina of the wall, or therebetween, and any fibre escape therethrough is carried by the conveying fluid back to the fiberizing machine and retained on and in the said web by recirculation of the fluid through successive portions of the web. When desirable, a cyclone or other separator may intervene between the fabric making machine and fiberizing machine and the collected treating solids returned by blower to either the fiberizing or fabric making machine.

The filaments are preferably stretch-oriented before being deposited to give the web substantial strength. This can best be accomplished by attaching short fibers or other solids to one end of the filaments, or to filament-forming material, and propelling such solids through a spinning or propulsion barrel. Sufficient stretch-orientation for many purposes can also be obtained by the propulsion of

filament-forming pellets through a spinning barrel of sufficient heat and length to bring about the complete attenuation of the pellets into filaments.

Whatever the manner of stretch-orientation by propulsion of pellets or other solids, regular relative movements of the barrel and receiving wall will distribute and deposit the filaments so that they intersect and extend with substantial uniformity beyond, and in predominant alignment with,, one another, and if their depositing surface is moving with sufficient speed in the same direction as the trailing filaments the latter can be made to intersect one another and still run substantially lengthwise of the fabric.

For most filtering purposes I have found that cotton linter dust on the order of floor sweepings of less than $\frac{1}{16}$ inch in length in mixture of with similar length asbestos fibres gave excellent results, providing the amount of asbestos by weight was maintained between 25 and 33 percent of the mixture. Of course, for many purposes it may be desirable to change this ratio or substitute other fibres and granular solids, such as glass, wood, sisal, rayon, shredded scrap leather, carbon, fuller's earth, etc.; and the fibres may be of much greater length than indicated above, especially when used for easily filtrable fluids.

The materials used for the production of filaments may be organic or inorganic, and thermoplastic or thermosetting, such as the usual plastics extruded or sprayed into filaments, films, and foils. Some of the most common of these are: polymeric amides, vinylidene chloride, polyethylene, polystyrene, glass, etc., spun from a molten state; cellulose-acetate, copolymers of vinyl-chloride-acetate resins, rubber hydrochloride, and other elastomers spun from solutions, etc.

Once a thermoplastic filament has become set, cold-drawing will usually bring such a filament to its initial point of elasticity, and from there until its elastic limit has been reached it may be truly elastic. Therefore, "extensible filament" means a filament that can be extended; in a softened and adhesive condition, as by heat or solvent; in a nonadhesive condition, as by cold-drawing; or by virtue of its elastomeric characteristics.

To give substantial strength and predetermined extensibility to a nonwoven fabric, the filaments may be stretch-oriented a predetermined amount during production; and heat, if used later for bonding purposes, should not reduce the temperature of the filaments to their softening point and cause a loss of stretch-orientation. The extension of the fabric when in use may be due to softening under heat, additional cold-drawing, elasticity of the filaments, or to any combination of such factors; but the amount of stretch-orientation during production must not be so great as to preclude its proper extension when in use. Furthermore, to give strength to the web, the filaments should have substantial length. This will usually range from 2 or 3 inches to many feet in length. The comparatively short length fibres bonded to or by the filaments will usually vary from dust particles to those of one inch in length.

The bonding of short discrete fibres by extensible filaments in contact therewith may be accomplished by: an adhesive spray; depositing the filaments in an adhesive condition; depositing the filaments in a cold-drawn condition and rendering them adhesive thereafter, as by a heated calender roll; incorporating in the treating solids, or the propulsion stream for the filaments, a small percentage of potentially adhesive fibres or granular adhesive solids, preferably of lower softening temperature than the filaments, and rendering them adhesive by a heated calender roll at the said lower temperature; or by means of a suitable solvent, such as acetone, to bond cotton fibres to vinyl filaments. In the latter case, the bonding should be accomplished within a closed chamber in order to recover the solvent vapors.

Stretching of a fabric uniformly reinforced by extensible filaments by renewal of filter bed windings after a certain amount of use, as described in the above mentioned copending application, results in a uniform increase in the spacing of the treating fibres or other solids and their capacity for the retention of solid impurities.

The invention is exemplified in the following description, and preferred arrangements are illustrated by way of examples in the accompanying drawings, in which:

FIG. 1 is an elevational view, partly in section, of the complete fabric making equipment.

FIG. 2 is a vertical section of the fibre depositing apparatus taken on line 2—2 of FIG. 1.

FIG. 3 is a vertical section of a modified form of the spinning arrangement shown in FIG. 1.

FIG. 4 is an elevational view, partly in section, of still another type of spinning arrangement that may be used with the fibre depositing drum.

FIG. 5 is an elevational view of an eccentric arrangement used for moving the spinning barrel.

Referring to the drawings more specifically by reference characters:

As shown in FIGS. 1 and 2, fabric 1, to be made into short, discrete fibers, is carried from roll 2 into a fiberizing machine 3, the rolls 4 and variable speed transmission 5 regulating the feeding speed. After being shortened and separated the fibres are conveyed by air pressure from a blower 6 through pipe 7 into a depositing drum 8.

This drum is foraminous, having openings 9 there-through, such as are found in perforated plate, expanded lath, or heavy wire screen. It is carried by left and right end plates 10 and 11, respectively, to which are attached left and right sleeves 12 and 13, respectively, which rotate in left and right journals 14 and 15, respectively, and the latter are supported by left and right angle frames 16 and 17, respectively. Left and right flanges 18 and 19, respectively, are rigidly attached to the end plates and support a fibre agitator. This consists of a rotating shaft 20, brush bar 21, and brushes 22, the bar being rigidly attached to the said shaft by angle irons 23 and 24. The right hand sleeve is closed by a bearing plate 25 which also supports the agitator shaft, the latter being driven through a sprocket wheel 26 and chain 27 from a source of power not shown. In somewhat similar manner, the left hand end sleeve is equipped with a sprocket wheel 28 which is driven by chain 29 from a source of power not shown.

The depositing drum is enclosed by a casing 30, the upper end portions of which support left, center, and right calender rolls 31, 32, 33, respectively. An endless foraminous belt 34 is carried over rolls 35 and the latter are supported by brackets 36 attached to the drum casing. A web 37 of reinforcing filaments 38 formed on the belt is carried by the latter into the casing between the center and right calender rolls, and after being carried around the drum and coated by short fibres or other solids 39 leaves the casing between the left and center calender rolls, as fabric 40. The fibre conveying fluid is propelled by force of blower pressure from the casing through outlet 41 into a pipe 42, both of which run lengthwise of the casing under the belt, and is returned to the fiberizing machine through pipe 43 connected to the end of tube 42. An adhesive spray is shown at 44 whose length is the width of the filamentary web.

The filament forming apparatus shown in FIG. 1 consists of a lower rotor or foraminous drum 50 which rotates about the stationary arms 51, 52, 53, and 54, the drum and arms thereby forming: three suction chambers 55, 56, and 57, the first and last being connected through openings 58 in arms 52 and 53 with the center chamber 56 and its source of suction 59; and a blowing chamber 60 having an opening 61 to a source of fluid pressure. The drum rotates upon rolls 62, one or both of which are driven from a source of power not shown, and the rolls with casing 63 form a depositing chamber for fibers or

other solids, which may be bypassed from the attrition mill 3.

The top rotor 64 rotates in contact with the lower rotor and upon a fixed hollow shaft 65 having an inlet 66 for heating fluid, and is equipped on its peripheral surface with pockets or reservoirs 67 for the material fed therein from a feeding cylinder 68. This cylinder encloses two feeding pistons 69 and 70 through which a filament forming rod 71 is moved forward and brought to filament forming fluidity by a heating fluid, such as steam, in the annular chamber 72. This feeding arrangement is described in my U.S. Patent No. 2,437,263, issued on March 9, 1948.

As the rotors move through divergent paths short discontinuous filaments 73 are formed which are attenuated into long discontinuous filaments 74 by the propulsion of discrete solids 75 from the lower rotor. A casing 76 is used to enclose both rotors and is extended on one side to form a barrel 77. A flame from a jet 78 may be used to cut any trailing filaments from nonexhausted pockets. The barrel leads into an ejector 79 having an inlet 80 and an outlet 81 which is connected by a flexible connection 82 to a distributing pipe 83. This pipe is moved back and forth over the depositing belt by means of (see FIG. 5) strap 84, connecting rod 85, eccentric strap 86, and eccentric 87, the latter being driven from a source of power not shown. A suction box 88 is positioned under that portion of the depositing belt moving across the outlet of the distributor pipe, and has a connection 89 to a source of suction.

In FIG. 3 the rotors are the same as in FIG. 1 but in reverse position, there is no opening in arm 53, and chamber 57 is not subject to suction. Discrete solids are deposited on the suction roll by belt 90 passing over the roll 91, and filament forming material 92 is introduced into a hopper 93 in discrete and finely divided portions, as from 50 to 200 mesh. The rate of feed of this material is regulated by rotary valve 94 at the entrance to the feed pipe 95, and the material is delivered in fibre-forming fluidity against the periphery of the rotor by a blast from the burner 96, which is supplied by fuel and air under pressure through pipe 97 from a source of supply not shown. A scraper 98, pressured by a spring 99, removes excess from the surface of the rotor and the drip escapes through a drain 100 in the refractory wall 101 and steel casing 102.

FIG. 4 shows an arrangement in which the filaments are distributed on the belt directly from a feeding arrangement, similar to 68 shown in FIG. 1 and described in the above mentioned patent, except that an ejector 103 with a fluid blast inlet 104 is used to disrupt the fibre-forming fluid material into filaments and force them through a distributing pipe 105 without the aid of pulling solids. Straps 84 connected to the eccentrics, shown in FIG. 5, give the spinning gun a lateral movement across the top of the belt.

The operation of the apparatus described above has been indicated, in part, in connection with the foregoing description. The following examples will more completely illustrate the methods that can be used in the practice of my invention.

Example 1

Filter fabrics comprising a mixture of cotton and asbestos fibres and bonded by polyamide filaments can be manufactured by the arrangement shown in FIG. 1.

Short asbestos fibres of less than $\frac{1}{16}$ inch in length are carried by an air current from a blower not shown into the casing 63, and deposited on that portion of an 18-inch diameter foraminous drum 50 passing through the orbit of the casing. This is accomplished under a differential pressure produced by the blower and/or suction from the chamber 55, having open connections described above to suction outlet 59. As the drum rotates fresh fibres are deposited in the same way on successive portions of the

drum and are held in position by the said differential pressure as the drum rotates about interconnected suction chambers 55, 56, and 57.

A polyamide rod $\frac{3}{4}$ inch in diameter is propelled through the heating zone of the cylinder 68 by the feeding pistons 69 and 70, described in the above-mentioned patent, where it is brought to filament-forming fluidity at a temperature of about 290° F. The fluid polyamide is then forced into pockets 67 of about $\frac{1}{8}$ inch in diameter on the peripheral surface of a secondary 18-inch diameter rotor 64, heated to a similar temperature by steam in the axial shaft 65.

Contact between the pocket charges and the fibres held by suction on the adjacent rotor with the rotors moving through diverging arcuate paths at a speed of 60 r.p.m. cold-draws the fluid charges of the pockets into filaments 73 of from 15 to 18 inches in length. Propulsion of the fibres adherent to one end of the filaments, as the drum moves over the pressure chamber 60, greatly increases the attenuation of the filaments, particularly if the blast occurs slightly in advance of exhaustion of the pockets, or shearing of the filaments by jet flames 78.

This propulsion means is a blast of elastic fluid below the softening point of the filaments, 275° F. in the present example, such as air or nitrogen at room temperature, saturated steam, etc., and is of sufficient force to give the fibres a theoretical initial velocity of 20,000 feet per minute, and increase the attenuation of the filaments by cold-drawing them to within a predetermined percent of the initial point of their elasticity. The extent of cold-drawing of the filaments 73 to filaments 74 can be regulated by temperature, the size of the pocket charges, force of the blast, and the time elapse between blast and separation of the filaments from the upper rotor. The potential cold-drawable stretch of the filamentary web should be at least 10 percent for later extension in six-foot diameter depth filters, and up to 25 percent for later extension in laboratory size depth filters. However, sometimes it may be found desirable to cold-draw the filaments to their initial point of elasticity and depend altogether on their elastic stretch for extension when in use.

Under pull of fibres adherently connected to one end of the filaments, the latter will move endwise through the propulsion chamber and are deposited in an integral web 37 on the foraminous belt 34 as the latter travels over suction box 88. The belt with enclosed drum preferably travel at a speed at least equal to that of the filaments in the distributing pipe 83 at the time of their deposition; and lateral movements of the pipe actuated by eccentric 87 through straps 86, 85, and 84, will result in the belt being coated uniformly. In such a case, the filaments will be found to extend beyond one another fairly uniformly in a succession of overlaps, and to run predominantly in alignment with one another and substantially lengthwise of the belt, as shown by the filaments 38 from which the fibre coating 39 has been removed in FIG. 2.

A sheet of cotton linter dust, in which is incorporated 5 percent by weight of short length polyethylene fibres, is fed from roll 2 into an attrition mill or other fiberizing machine 3 where the fibres are separated one from another. They are then carried by an air current from the blower 6 through pipe 7 into the foraminous drum 8 of about 6 feet in diameter and rotating clockwise between 5 and 10 r.p.m.

The blower pressure, aided by suction from pipe connection 43 and rotation of the brush shaft, preferably in a direction opposed to the drum movement, results in the fibres filling the openings or foramina of the drum and being retained in and by the mesh of the filamentary web 37 described above which encircles the drum and with the aid of the belt backing holds the deposited fibres against the blower air current passing through web and belt. As the openings in the drum are flared out-

wardly and the fibre filling are tied in with the fibres held in the mesh of the filamentary web, the fillings readily leave with the web as it separates from the drum by movement between calender rolls 31 and 32.

Calender rolls 31 and 32 are steam heated internally sufficiently to bring the fabric as it passes therebetween to a temperature of 230° F. The heat and pressure of the rolls result in the foramina fillings being smoothed out and consolidated and the small percentage of polyethylene fibres becoming activated and adhesive, and bonding the linter dust to the polyamide reinforcing web without softening and loss of stretch-orientation to the polyamide filaments. Obviously, a granular thermoplastic can be substituted for the polyethylene fibres and introduced into the linter dust and activated in the same way.

However, it is usually desirable that there should be as little bonding as possible of fibres or other treating solids in filter fabrics for such bonding always reduces the adsorptive areas of the fabric. Therefore, better results can be obtained usually by depositing the reinforcing filaments as a very open mesh web and in a sufficiently tacky condition to bond the filaments together and to the sifted fibres. In this tacky condition results from the high temperature of the spinning operation, curing can be effected at the time the web is passed between the water cooled calender rolls 31 and 32. If the filaments are deposited on the belt in a nonadhesive condition and made sufficiently adhesive for the said bonding purposes by a liquid epoxy or other resin spray from nozzle 44, the curing can be effected either at room temperature, or by rolls 31 and 32 heated to a temperature just below the softening point of the filaments.

Or for purposes where maximum strength of reinforcing web is not required, the temperature of the calender rolls 31 and 32 can be carried sufficiently high, 290° F. in the present example, to make the filaments tacky, but with loss of stretch-orientation. In any event, the bonding for filter fabrics preferably is at the fluid outlet surface of the fabric, and the curing accomplished by heated rolls 31 and 32 for a thermosetting adhesive resin, or chilled rolls 31 and 32 for a thermoplastic resin.

The total amount of asbestos used to aid in the attenuation of filament forming material and introduced with the linter dust should be between 25 and 33 percent of the total weight of the finished fabric for ordinary filtration purposes. Because of the thinness of the fabric, the method of introduction of the asbestos fibres will not greatly affect its filtering characteristics as long as it is uniformly distributed. However, to speed up the manufacture of fabric, as much as possible of the asbestos fibres should be incorporated with the linter dust by way of fiberizing machine 3.

Obviously, bleaching, decolorizing, and other treating solids, such as fuller's earth, bone char, etc., with or without a mixture of fibres, can be sifted and deposited through the foraminous drum 8, and bonded by a filamentary web as described above for fibres alone. When such solids are used in windings that move counter to the flow of fluid passing therethrough, the amount will be greatly diminished and often can be cut in half.

Example II

Leather replacement compositions for handbags, brief cases, luggage, etc., can be made from shredded waste leather reinforced by a thermoplastic material, such as polyamide filaments, in much the same way as indicated by the above example.

Waste leather is fed into the attrition mill 3 where it is shredded to fibres of any suitable length, as for instance $\frac{1}{16}$ to $\frac{1}{2}$ inch, and then conveyed into the foraminous drum 8, in mixture with an elastomeric binder, such as polyethylene fibres. Since the fibres are much longer than in Example I, the openings in the drum preferably may be slots milled of suitable length and width and outwardly flared for easy exit of the fibres under

agitation and air pressure. A coiled wire drum with coils spaced $\frac{1}{16}$ inch apart and spot-welded together every two inches will also be found suitable for such a purpose.

If reinforcing filaments of only moderate strength are required, the spinning gun shown in FIG. 4 and described in my U.S. Patent No. 2,437,263 can be used. A polyamide rod 71 is propelled by pistons 69 and 70 through cylinder 68 in which it is brought to filament-forming fluidity at a temperature of about 290° F. and is then subjected to a blast of saturated steam from ejector 103 which produces filaments of various lengths in a tacky condition for their bonding into an integral web under pressure and curing of the calender rolls 32 and 33. These rolls may be coated with polytetrafluoroethylene to prevent sticking of the filaments. The shredded fibres are bonded together and to the said integral web by the polyethylene fibres under pressure and heat of 230° F. from the calender rolls 31 and 32. Obviously this temperature is sufficient to aid the above curing of polyamide filaments.

With this type of spinning gun, the filaments cannot be deposited in alignment with one another but the lateral movements of the propulsion barrel through pull on eccentric straps 84, with the forward movement of the belt 34, will result in the filaments overlapping, intersecting, and extending beyond one another with substantial uniformity.

Example III

In the manufacture of chairs, soft facings of leather, cotton, rayon, etc., for comfort can be produced, as indicated in Example II; and these facings may be laminated for strength to glass backings which can be produced by the apparatus of FIG. 3.

In FIG. 3 a sufficient amount of asbestos fibres for propulsion purposes is conveyed on the belt 90 and uniformly distributed over suction areas of a rotor 50, described above. Small discrete particles of fibre-forming glass 92, such as from 100 to 200 mesh, are charged into the hopper 93 and fed as required by rotary valve 94 through pipe 95 to the burner 96, which is supplied by fuel under pressure by pipe 97 from a source of supply not shown. The blast of burning fuel reduces the discrete particles of glass to a fibre-forming fluidity at a temperature of about 1900° F., and in that condition they are deposited on the peripheral surface and in the pockets of a bottom rotor 64; or the particles, if deposited in a solid condition, will adhere to and be reduced to fibre-forming fluidity by the rotor heated to about 2100° F. from a series of jet flames 78 or other suitable means. The molten glass in either case is scraped by a spring pressured blade 98 into the pockets 67, and the excess is removed entirely from the rotor and drained through outlet 100.

Converging paths of the two rotors bring the discrete asbestos fibres and the pockets filled with filament-forming glass into adhesive contact, and their diverging paths cause the glass in their respective reservoirs to neck down into positively stretched filaments 73 until finally the fibres are cut off from their suction contact with the peripheral surface of the top rotor and blasted therefrom by heated air or steam pressure within the pressure chamber 60. The blast gives the fibres a theoretical initial velocity of at least 20,000 feet per minute, and the force exerted on the fibres, to which the filaments are adhesively connected, produces filaments 74. Both are deposited at a temperature of about 230° F. and bonded to a sifted leather web, described in Example II, by an epoxy resin in granular form introduced by ejector 79 and brought to an adhesive temperature at the said deposition temperature for the glass filaments; and the resin is cured at room temperature. When desirable, short chopped glass fibres, perlite, metal flakes, micaceous materials, etc., of higher softening tempera-

ture than the filament-forming glass, can be substituted for asbestos.

Obviously, a solid rotor similar to 64 but without pockets can be substituted for the foraminous rotor 50, and the charges 67 given a positive attenuation by contact with the substituted rotor. In such a case, jet flames 78 are used to shear the filaments 73 from the rotors, and the propulsion blast can be introduced at any convenient location between the shearing points.

It will also be obvious that a filamentary web may be deposited directly on the foraminous drum 8, providing a suction chamber, such as 56, is incorporated within the drum; but in such a case, the movement of the agitator brush would be restricted and it would have to oscillate back and forth without moving through an endless circuit.

The above examples are descriptive of various ways in which the propulsion of adherent solids can be used to attenuate filament-forming material into filaments, stretch-orient the filaments, and propel the stretch-oriented filaments endwise through a propulsion tube to aid in their deposition in intersecting relation and predominantly in alignment with one another.

However, it is obvious that filament-forming material in pellet form, without the aid of pulling solids, can also be attenuated into filaments and the filaments stretch-oriented and propelled endwise through the propulsion barrel, providing attenuation is completed just prior to deposition, and the filaments will be deposited in intersecting relation and predominantly in alignment with one another.

To produce such filaments only the lower rotor, shown in FIG. 1, is required, the pellets being brought into contact with the suction areas of the drum's periphery in any suitable manner, as by blower conveyance through casing 63. The pellets in nonadherent condition are propelled from the rotor with sufficient force to carry them through the ejector, at which point they are subjected to a more forcible blast of superheated steam at sufficient temperature to reduce them to a fluidity that will produce trailing filaments during flight through a propulsion barrel of substantial length. This temperature for the polyamide filaments of Example III will be somewhere between 400° F. and 500° F. for a 15-foot length propulsion barrel, the entire surface of which may be given a coating of polytetrafluoroethylene to prevent sticking thereto of the filaments, and of course the greater propulsion force will centralize the flow of the filaments.

Or the pellets may be deposited in the pockets or distributed on the periphery of the one rotor 64 with only a surface portion of the pellets sufficiently tacky to adhere to the rotor, and the rotor speeded up to 3,000 r.p.m. or more to throw off the pellets by centrifugal force. The pull of the pellets will produce stretch-oriented, pellet-entrained filaments, and the heat and blast from the ejector will increase the length of the filaments as the pellets are attenuated into filaments. Of course, the pellets may be deposited on the rotor 64 in filament-forming fluidity and then thrown off by centrifugal force, but the filaments will not have the length or stretch-orientation possessed by solid, surface-adherent pellets thrown off, as described.

Obviously, one of the main fabrics of my invention consists of a web of uniformly distributed fibres positioned at random to make the fabric uniformly fluid-penetrable, and bonded to stretch-oriented, intersecting filaments predominantly in alignment with, and extending beyond, one another in a succession of overlaps. Such fabrics may have substantially uniform strength in all directions of a two-dimensional plane, and, if so, would be considered isotropic in that plane.

It will be understood throughout the specifications and appended claims that: "short fibres" mean fibres that are short in length in comparison to the reinforcing fila-

ments that give strength and bonding to the said fibres; and "random fibres" means fibres whose axes exist in all three dimensional planes. Short nonbinder fibres will usually be less than $\frac{1}{16}$ of an inch in length, the binder fibres somewhat longer, and neither, as a rule, will exceed one inch in length. The reinforcing filaments will vary for different purposes between several inches and many feet in length. The word "contiguous" means in actual contact.

I claim as my invention:

1. In a method of making a nonwoven fabric from different types of discontinuous fibres, the steps comprising: continuously moving a foraminous wall through an endless path; depositing discontinuous primary and secondary fibres on opposed surfaces of the said wall during the said movement, the primary fibres intersecting one another at random, and the secondary fibres successively intersecting and overlapping one another with sufficient uniformity in a two-dimensional plane to form a foraminous web of substantial strength; moving the said web in contiguous relation with one side of the said wall, and simultaneously agitating the primary fibres on a side of the wall opposed to the said one side while conveying the fibres in measured amounts into the foramina of both wall and web by force of a fluid stream passing through the wall and web; and consolidating and bonding the primary fibres with substantial uniformity about the said web of secondary fibres whereby the primary fibres are reinforced by the secondary fibres to form the said fabric.

2. The method of claim 1 in which one of the said types of fibres contains potentially adhesive solids, and including the step of activating the said potentially adhesive solids to accomplish the said bonding.

3. The method of claim 1 in which the said primary fibres are a mixture of binder and nonbinder fibres, the binder fibres being potentially adhesive, and including the step of activating the said binder fibres to accomplish the said bonding.

4. The method of claim 1 including the step of removing the said primary fibres from out of the said foramina of the wall, subsequent to their bonding to the said web, by movement of the said web away from the wall.

5. The method of claim 1 in which the said primary fibres are natural, and the said secondary fibres are thermoplastic and selected from the group consisting of polymeric amides, vinylidene chloride, polyethylene, polystyrene and glass.

6. The method of claim 1 in which the said primary fibres are by weight 67 to 75 percent cotton in mixture with 33 to 25 percent asbestos fibres, and the said secondary fibres are polyamide fibres.

7. The method of claim 1 in which inorganic solids selected from the group consisting of glass, asbestos, perlite, micaceous and metallic materials are bonded in the said fabric by at least one of the said types of fibres.

8. The method of claim 1 in which the said secondary fibres are stretch-oriented and of predetermined softening point, and at least a portion of the said primary fibres are potentially adhesive and are binder fibres of lower adhesive temperature than the said softening point, and including the step of activating the said binder fibres at the said lower temperature without loss of the said stretch-orientation.

9. In a method of making an extensible nonwoven fabric, the steps of claim 1, and including the step of attenuating fibre-forming material into the said secondary fibres, the fibres being cold-drawable and having predetermined potential stretch.

10. The method of claim 9 including the steps of: adherently contacting discrete solids to finely divided portions of the said material; and propelling the said solids to accomplish the said attenuating.

11. The method of claim 9 in which the said material

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is in the form of pellets, and the said attenuating is accomplished by propelling the pellets through an atmosphere heated sufficiently to reduce the pellets to fibre-forming fluidity.

12. The method of claim 9 in which the said attenuating is accomplished by centrifugal force supplemented by force of an elastic fluid stream.

13. In an apparatus for making a nonwoven fabric from different types of discontinuous fibres, the combination of: a foraminous wall moving through an endless circuit through which wall primary discontinuous fibres may be conveyed; means for depositing a foraminous web of reinforcing secondary discontinuous fibres on one side of the said wall; means for conveying the said web contiguously with the said one side of the wall through a portion of the said circuit; means for agitating the primary fibres on a side of the wall opposed to the said one side while the fibres are subject to the force of a fluid stream to convey the fibres in uniform amounts into the foramina of the wall and web during the said contiguous conveyance of the web; and means for consolidating and bonding the said amounts of primary fibres about the said web of reinforcing fibres.

14. The combination of claim 13 for making the said nonwoven fabric, in which the said wall is a primary wall, and including: a secondary foraminous wall, adjacent to the said primary wall, moving through an endless circuit, and on which wall the said web is formed; and means for transferring the said web from conveyance

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on the secondary wall to the said contiguous conveyance on the primary wall during the said movements of both walls.

15. The combination of claim 13 for making the said nonwoven fabric in which at least a portion of the said primary fibres are potentially adhesive, and including means for activating the said potentially adhesive primary fibres to accomplish the said bonding.

16. The combination of claim 13 for making the said nonwoven fabric in which at least a portion of the reinforcing secondary fibres are potentially adhesive, and including means for activating the said potentially adhesive secondary fibres and maintaining them in an adhesive condition during the formation of the said web on the secondary wall to cause the said reinforcing fibres to be bonded one to another in an integral web.

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