Feb. 21, 1961 W. WILKE ET AL 2,972,221

METHOD OF CONVERTING INDIVIDUAL FIBERS INTO COHERENT FIBROUS BODIES

Filed July 26, 1957 2 Sheets-Sheet 1

Fig. 1

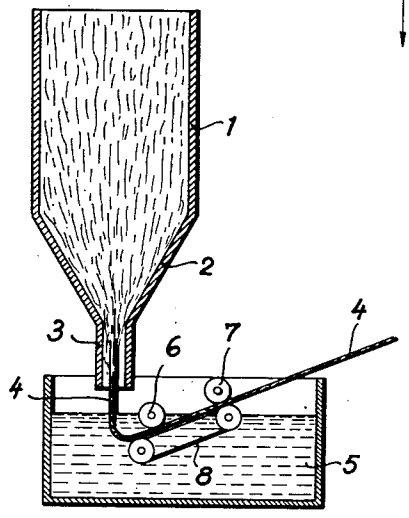


Fig. 2

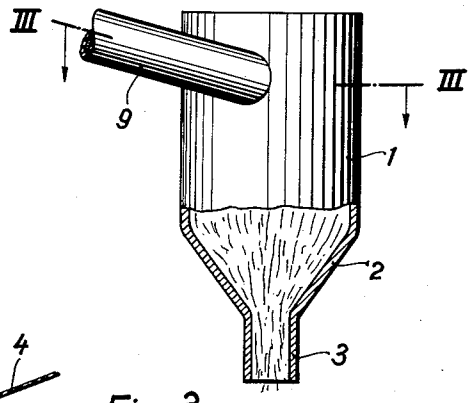


Fig. 3

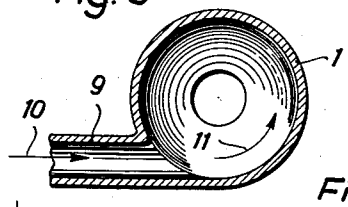


Fig. 4

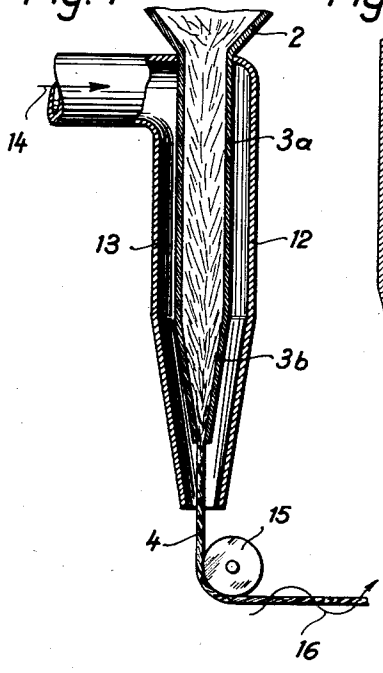


Fig. 5

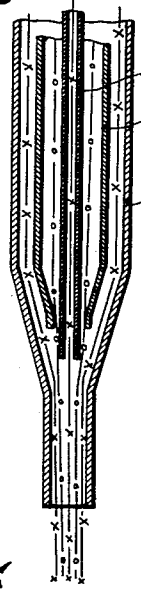
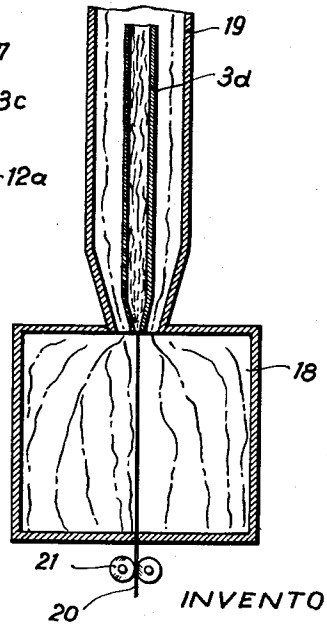


Fig. 6



INVENTORS

Werner Wilke and

Hans Fetzer

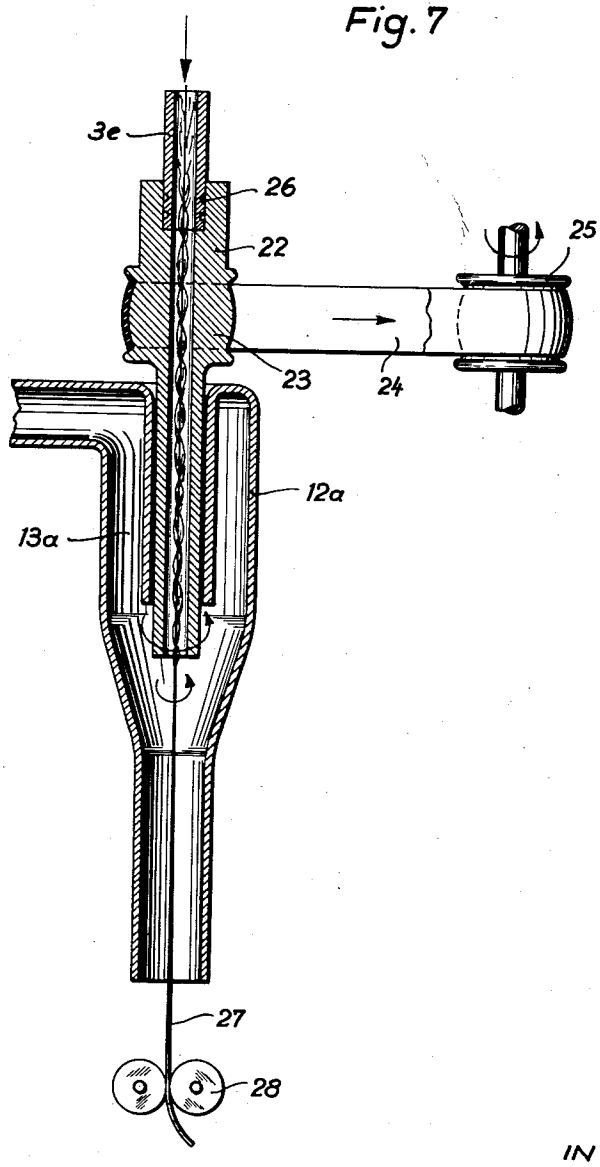
Method of converting individual fibers into coherent fibrous bodies (US Patent 2,972,221, 1961)
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Fig. 7



INVENTORS

Werner Wilke and
Hans Fetzer

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METHOD OF CONVERTING INDIVIDUAL FIBERS INTO COHERENT FIBROUS BODIES

Werner Wilke, Schwabisch Hall, and Hans Fetzer, Sussen, Germany, assignors to Rex Asbestwerke Graf von Rex K.G., Schwabisch Hall, Germany, a German corporation

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16 Claims. (Cl. 57—164)

Our invention relates to a method of converting individual fibers, particularly asbestos fibers, into a coherent body while preserving the fibrous character of the original material.

Several methods have become known for such purposes. Some of them serve to make fibrous flock suitable for being spun, by first subjecting them to scraping, carding, combing or similar operations and thereafter drawing them on spinning frames similar to those used for the spinning of cotton, worsted and carded yarn. Other known methods serve to produce mats from an aqueous fiber dispersion on a foraminous member with the aim of converting such mats into paper, cardboard or the like webs or sheets.

It is an object of our invention to devise a simpler way of converting individual fibers into coherent fibrous bodies which requires a smaller number of processing steps and affords using equipment of greater simplicity, and which offers new possibilities of fabricating asbestos fiber by methods heretofore amenable only to fibers of different type.

In order to achieve these objects, and in accordance with one of the features of our invention, we first produce a dispersion of the fibrous material, preferably individual asbestos fibers, in a liquid, preferably aqueous, medium and pass this dispersion through a forming channel whose outlet portion has a cross section corresponding to that desired in the coherent fibrous body to be formed; and we subject the formed body to solidification by subjecting it, as it emerges from the channel outlet, to a solidifying chemical and/or thermal reaction.

One way of applying this method is to form elongated fibrous bodies, for instance threads, yarn or other strands within which the individual fibers are oriented parallel to the strand axis. Suitable expedients are necessary to achieve this result. For instance, the fiber dispersion is passed through an elongated conduit within which the fibers orient themselves parallel to the direction of flow. This orienting effect is aided by introducing the fiber dispersion, prior to passing it through the preferably vertical or inclined channel outlet portion of the desired cross-sectional shape, into a funnel under formation of a whirling motion. This has the effect that the fibers, before reaching the forming channel proper, commence to orient themselves in the flow direction.

When the fibers to be processed possess sufficient adherence relative to one another, the above-mentioned means suffice to produce satisfactory products. Much better results, however, are obtained, and satisfactory results are also produced with fibers of lesser or insufficient mutual adherence, if, according to another feature of the invention, the fiber dispersion is given an addition of a dispersion medium which, by means of a chemical and/or thermal reaction can subsequently be made inactive, for instance by evaporation or disassociation, or which, preferably, can subsequently be converted into a binding agent for the fibers. According to this preferred method of the invention, the formed fibrous body, when leaving

the forming channel, is immediately subjected to the proper chemical and/or thermal reaction. For instance, when using a water soluble fatty-acid soap as an added dispersing medium, the formed body is passed through a bath which contains metal ions, such as an aqueous solution of copper sulfate.

According to another embodiment of the invention, applicable in lieu of, or together with, the above-mentioned processing, we use for the preparation of the fiber dispersion a liquid or chemical solution capable of being at least partially hardened by chemical and/or thermal reaction; and we subject the formed body, immediately upon leaving the forming channel, to the proper chemical and/or thermal treatment, for instance by passing the body through a suitable precipitation bath.

For both above-mentioned modifications of the method according to the invention it is further of advantage if the reactive solution acting upon the dispersion medium or the dispersing liquid is supplied through a duct that extends along and around the forming channel. If desired, such reactive solution may be additionally supplied through a further duct extending centrally and longitudinally within the forming channel. The supply ducts for the reactive liquid are so designed that the formed body enters into contact with the liquid immediately after leaving the forming channel.

For a similar purpose, when using a dispersion medium to be made inactive by thermal action, or when using a dispersing liquid to be solidified thermally, it is preferable, according to another feature of the invention, to pass the formed body, immediately upon its emergence from the forming channel, through a gas chamber, for instance a hot-air shaft, which may also extend about and along the adjacent portion of the forming channel.

According to still another feature of the invention, the fiber dispersion, as it travels out of the forming channel, is subjected to rotation within a nozzle so as to impart to the fibers the twist required for the production of yarn. As a result, a twisted yarn can be directly taken or drawn from the nozzle.

The above-described method according to the invention affords the production of formed fiber bodies of any desired cross section, if desired, in continuous operation. When applying the invention to the processing of a mass of individual asbestos fibers, the extremely slight diameter of such individual fibers makes it possible to produce filaments or threads of an extreme and heretofore infeasible degree of fineness.

Such fine threads can also be subjected to curling and cutting in order to obtain shorter lengths of thread which are to be fabricated by the conventional spinning processes instead of the individual fibers heretofore used.

The invention will be further understood from the embodiments of processing equipment illustrated by way of example on the drawings in which:

Fig. 1 shows schematically and in section an apparatus for performing the method according to the invention.

Fig. 2 shows a partly sectional view and Fig. 3 a cross section of a somewhat modified apparatus, the cross section of Fig. 3 being taken along the line III—III in Fig. 2.

Figs. 4 to 7 illustrate in section four different modifications respectively of the forming channel and nozzle portion of apparatus otherwise corresponding to Fig. 1 or 2.

The apparatus illustrated in Fig. 1 is provided with a tank 1 whose bottom portion 2 tapers conically downward and merges with a channel portion 3 which forms the outlet of the tank and has a cross section corresponding to that desired in the fibrous body to be formed. For the production of thread, yarn or other continuous strands, a circular cross section is suitable. A watery dispersion of asbestos fibers containing an added disper-

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sion-promoting medium is continuously supplied into the tank **1** and, when passing through the bottom portion **2**, becomes progressively compacted and gradually converted to the desired shape. The individual fibers, during their downward travel, align themselves parallel to the travelling direction. After being shaped in the channel or nozzle portion **3**, the material passes as a continuous strand into a precipitating bath **5**. Within the bath, the dispersion-promoting medium is solidified or converted into a binding agent with the result of strengthening and solidifying the fibrous strand **4**. The strand **4**, therefore, can be pulled off over guide rollers **6** and **7**. A belt conveyor **8** is preferably provided for supporting the strand **4** and transporting it in the desired direction; but in some cases, namely when the strand has sufficient inherent strength, a supporting conveyor **8** need not be used.

According to Figs. 2 and 3, showing an apparatus otherwise similar to that of Fig. 1, the fiber dispersion is supplied into tank **1** through a tangential supply duct **9** in the direction of the arrow denoted by **10**. As a result, a rotating motion, represented by an arrow **11**, is imparted to the dispersion which aids in aligning the fibers and also imparts a slight twist to the formed fibrous body. As a result, the fibrous strand emerging from the forming channel or nozzle **3** has already somewhat greater strength.

According to the modification shown in Fig. 4, the channel portion protruding downwardly from the bottom **2** of the tank has an elongated portion **3***a* with a nozzle-like taper **3***b* at its lower end. The channel-nozzle structure is surrounded by a pipe **12** whose lower end projects downwardly beyond the outlet of nozzle **3***b* and forms a peripheral chamber **13** about the channel structure **3***a*. Pipe **12** is supplied with the precipitating or otherwise reactive liquid that is to act upon the dispersion medium, the flow direction of the precipitating liquid being indicated by an arrow **14**. Due to the fact that the pipe **12** extends downwardly beyond the outlet of nozzle **3***b* and has a tapering shape at this location, the former body **4** when emerging from the nozzle outlet is immediately brought into intimate contact with the precipitating liquid and thus becomes solidified and strengthened so that it can be pulled off over a guide roller **15** and has sufficient strength to be immediately thereafter subjected to a twisting operation as schematically indicated by an arrow **16**. The device may be designed on the principle of a water-jet pump so that the precipitating liquid produces enough suction pressure to pull the formed fibrous body out of the nozzle opening.

The modification shown in Fig. 5 is similar to that described above with reference to Fig. 4. The nozzle member **3***c*, operating as a forming channel for the fibrous material, is surrounded by a pipe **12***a* for supplying reactive liquid in the same manner as described with reference to pipe **12** in Fig. 4. However, another tubular member **17** is disposed centrally within the forming nozzle **3***c* and is also used for supplying the reactive liquid. The path of the reactive liquid through both tubular member **17** and pipe **12***a* is indicated in Fig. 5 by broken lines interrupted by crosses. The product made by means of such a device is hose-shaped and the path of the fibers forming such hose-shape is indicated by broken lines interrupted by circles.

The modification shown in Fig. 6 is applicable when using a dispersion medium that is to be made inactive by thermal action or when using a dispersion liquid that is to be solidified thermally. The forming channel consisting of the nozzle portion **3***d* opens into a hot-air shaft **18** whose upper portion **19** surrounds the nozzle **3***d*. The formed strand of asbestos **20** is pulled from the nozzle through the hot-air chamber **18** of increased temperature as compared to portion **19** and the strand then is guided away by rollers **21**.

According to the embodiment illustrated in Fig. 7, the forming channel is constituted by an upper portion **3***e* which is stationary, and a lower portion **22** which is revolvable about the axis of the upper portion **3***e* and comprises a belt sheave **23** or the like member by means of which the portion **22** is kept in continuous rotation during the operation of the device. In the illustrated embodiment, the sheave member **23** is driven by an endless belt **24** from a driving sheave **25**. The rotatable member **22** is sealed against the stationary member **3***e*, for instance by means of grooves **26** machined into the member **3***e* or with the aid of piston rings seated in such grooves. Due to its tenacity and adhesion, the fiber dispersion passing from the supply tank through the forming channel in members **3***e* and **22** partakes in the revolution of the rotating member **22** thus leaving the outlet of member **22** in twisted condition. After leaving the rotating nozzle, the rotating fiber mixture passes through the chamber **13***a* of a tubular enclosure **12***a* corresponding to chamber **13** and enclosure **12** described above with reference to Fig. 4. The precipitating liquid, passing from above through chamber **13***a*, enters into intimate contact with the formed strand of asbestos material and cause it to solidify and strengthen so that the strand **27** can be pulled off, preferably guided by rollers as shown at **28**. For example, when the fiber dispersion is supplied through the forming channel at a speed of 10 meters per minute, and the rotating nozzle member **22** is kept at 3000 revolutions per minute, the twisted body of fibrous material leaving the nozzle opening is given a twist of 300 turns per meter.

As explained above, the formed body of dispersed asbestos fibers issuing from the forming channel is immediately subjected to a solidifying process such as effected by the bath **5** in the equipment of Fig. 1 or the liquid supplied through conduits **12** and **12***a* in Figs. 4, 5, 7. The choice of the particular processing agent to be used in each particular case depends upon the character and composition of the dispersing liquid for the fiber mass, as will be more fully understood from the following examples.

When the dispersing liquid for the fibers consists mainly of water with a minor addition of dispersion-promoting water-soluble substance, such as polyglycol ether of short chain length, then the formed body emerging from the forming channel can simply be passed through a drying zone, such as shown in Fig. 6, which is so heated that the body first traverses a zone of an elevated temperature not higher than the boiling point of water (100° C.) and thereafter passes through a zone of increased temperature **18**, such as 180 to 200° C.

For solidifying the formed fibrous body by chemical action, a precipitating bath (at **5**, **13**) is used which may consist of an aqueous solution of water-soluble fatty-acid soaps, water-soluble resinates, water-soluble alginates, water-soluble sodium silicates, or highest methylated methyl cellulose. Such compounds effect precipitation and thus increase the binding ability of the fibers. They are applied singly or in mixture with each other within precipitation baths which preferably contain two- and three-valent metal ions or heavy-metal ions.

The dispersing liquid used for the fibers may also consist of the known spinning solutions of cellulose-xanthogenate or cellulose solutions, and the formed fibrous body is then passed through a precipitating bath formed of a metal-salt solution such as copper oxide ammonia.

The method according to the invention may also be performed by using as the dispersion liquid for the raw fibers such liquids as alkaline solutions of proteins, for instance, of casein, albumin, fish protein. Also applicable as dispersion medium are rubber dispersions and/or dispersions of resinous plastics capable of coagulating under given conditions. In such cases the emerging formed fibrous body is solidified by drying under heat, or by passing the body through a coagulating acid or metal-salt bath prior to drying.

Solidification of the formed body simply by heating is applicable in cases where the fiber dispersing medium is a rubber dispersion, a solution of cellulose acetate, a solution or dispersion of synthetic resinous plastics such as of polyvinyl compounds, polyacryl compounds, silicone, polyethylene, polyfluorethylene, polyamides, polyurethane, polyesters, phenoplasts. The emerging formed fibrous bodies containing such substances can be solidified by evaporating the solvent or dispersion medium from the body. This also applies to the use of benzol and other organic solvents as dispersion medium.

A chemical reaction within a bath, initiated catalytically and/or thermally, is applicable to fiber dispersions in pre-condensates of phenoplasts, dimethyl urea, trimethylmelamine, methyl-allyl urea, glycuronyl compounds of aromatic or aliphatic diisocyanates and glycols or hydroxyl-group-containing polyesters, rubber solutions or dispersions that contain vulcanizing additions.

The formed bodies obtained by the method according to the invention may be subjected to any desired further mechanical processing. For instance the formed bodies may be twisted in separate machines into thread and yarn, or they may be converted by rolling, pressing or winding into compacted fibrous sheets, tapes, tubes or the like.

If desired, the products obtained by the process according to the invention, can be subsequently liberated from any foreign constituents, for instance skeleton substances contained therein, or such foreign substances can also be removed from the products resulting from further fabrication, particularly asbestos-base products. Such subsequent liberation is effected, for instance, by extracting the foreign substances with the aid of a suitable solvent, by washing with water or aqueous dispersions of solvents, or by thermal disassociation used with the above-mentioned compounds whose disassociation temperature is below the temperatures at which the asbestos fiber itself becomes damaged. As a result of such subsequent processing, completely pure asbestos products are obtained as desired, for instance, for protective coverings, tent canvas, accessory parts for vehicles and other conveyances, and the like.

We claim:

1. A method for producing continuous shapes from non-adhesive fibers all of the same material, comprising the steps of dispersing said fibers in a liquid medium containing a dispersing agent to form a colloidal dispersion, then rendering the dispersing agent inactive so as to precipitate the fibers out from the liquid medium, and simultaneously compacting and extruding the precipitated fibers into a predetermined shape.

2. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises the steps of preparing a dispersion of the fibers in a liquid medium capable of solidification by chemical reaction, passing the dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be formed, and passing the formed body from the channel outlet through a precipitating liquid reactive with said liquid medium, supplying the precipitating liquid along and around the flow of said dispersion and in the direction of said flow so as to place the precipitating liquid in intimate touch with said formed body immediately where said body emreges from said forming channel, passing another flow of precipitating liquid centrally along the flow of said dispersion in said forming channel, whereby the precipitating liquid acts upon the formed body from within as well as from without, and whereby said body is solidified as it emerges from said forming channel.

3. The method of converting a mass of individual asbestos fibers into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual asbestos fibers all of the same material and having a colloidal size in a liquid medium containing a dispersing agent, passing the colloidal dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be produced, and simultaneously with said step of passing through the forming channel inactivating said dispersing agent to solidify the asbestos body being formed.

4. The method of converting a mass of individual asbestos fibers into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual asbestos fibers all of the same material and having colloidal dimensions in a liquid medium containing a dispersing agent, passing the colloidal dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be produced, and simultaneously with said step of passing through the forming channel inactivating said dispersing agent to solidify the body being formed by chemically precipitating said fibers from their colloidal state under the effect of heat as the body leaves the forming channel.

5. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual fibers all of the same material and having colloidal dimensions in a liquid medium containing a major amount of solvent and a minor amount of a dissolved dispersing agent convertible to the solid state, passing the dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be produced, and simultaneously subjecting the body being formed as it emerges from said channel to a chemical solidifying reaction so as to convert said dispersing agent into a binding agent for the fibers in said body.

6. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual fibers all of the same material and in a liquid medium containing a major amount of solvent and a minor amount of a dissolved dispersing agent convertible to the solid state, passing the colloidal dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be produced, and passing the body, as it emerges from said channel, through a liquid bath reactive with respect to said dispersing agent so as to simultaneously precipitate said fibers from their colloidal state to solidify said component in said body.

7. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual fibers all of the same material and having colloidal dimensions in a liquid medium containing a dispersing agent, passing the colloidal dispersion through a formng channel having an outlet cross section corresponding to that of the fibrous body to be produced, and simultaneously chemically converting the dispersing agent into a binding agent for the fibers as the body being formed leaves the forming channel.

8. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual fibers all of the same material and having colloidal dimensions in a viscous liquid medium containing a dispersing agent, passing the dispersion through a forming channel of elongated shape tapering toward the channel outlet and having at the channel outlet a cross section corresponding to that of the fibrous body to be produced, whereby the fibers passing through the channel align themselves parallel to the flow direction, and simultaneously solidifying the body being formed by chemically inactivating the dispersing agent as the body leaves the forming channel.

9. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion

of individual fibers all of the same material and having colloidal dimensions in a liquid medium containing a dispersing agent, precipitating said fibers from ther colloidal state by inactivating said dispersing agent, simultaneously with the last-mentioned step passing the dispersion, to form a rotational whirlpool action in said liquid medium, tangentially into a funnel-shaped forming channel which tapers toward its outlet and has an elongated outlet portion whose cross section corresponds to that of the fibrous body to be produced, whereby the fibers passing through the channel align themselves parallel to the flow direction, and the formed body emerges with the individual fibers in helical formation as the body leaves the forming channel.

10. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual fibers all of the same material and having colloidal dimensions in an aqueous liquid containing water-soluble fatty-acid soap as a dispersion medium, passing the dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be formed, and passing the formed body from the channel outlet through a bath containing metal ions to inactivate said dispersion medium, whereby the formed body is solidified.

11. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual fibers all of the same material and having colloidal dimensions in a liquid medium containing a dispersing agent capable of chemical transformation into the solid state under heat, passing the dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be formed, and heating the emerging fibrous body being formed, whereby the body becomes solidified.

12. The method of converting a mass of individual fibers, particularly asbestos fibers, into a coherent fibrous body, which comprises preparing a colloidal dispersion of individual fibers all of the same material and having colloidal dimensions in a liquid medium containing a dispersing agent capable of solidification by chemical reaction, passing the dispersion through a forming channel having an outlet cross section corresponding to that of the fibrous body to be formed, and passing the body being formed from the channel outlet immediately through a precipitating liquid reactive to inactivate the dispersing medium, whereby the body becomes solidified as it emerges from said outlet.

13. In the method according to claim 12, the step of supplying the precipitating liquid along and around the flow of said dispersion and in the direction of said flow so as to place the precipitating liquid in intimate touch with said body being formed immediately where said body emerges from said forming channel.

14. The method according to claim 3, said inactivating step comprising passing the asbestos body from the outlet of the forming channel through a hot-gas chamber containing an ionized gas so as to chemically precipitate said fibers from their colloidal state.

15. The method according to claim 3, said inactivating step comprising subjecting the outside of said forming channel as well as the body emerging therefrom to a heated ionized gaseous atmosphere to chemically precipitate said fibers from their colloidal state.

16. The method according to claim 3, including the step of passing the fibrous body at the outlet of said channel tangentially into and downwardly through a nozzle, and mounting said nozzle so as to place said body in whirlpool rotation as said body passes therethrough so as to impart a twist to the fibers in said body being formed.

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