

[54] METHOD AND APPARATUS FOR FORMING YARN

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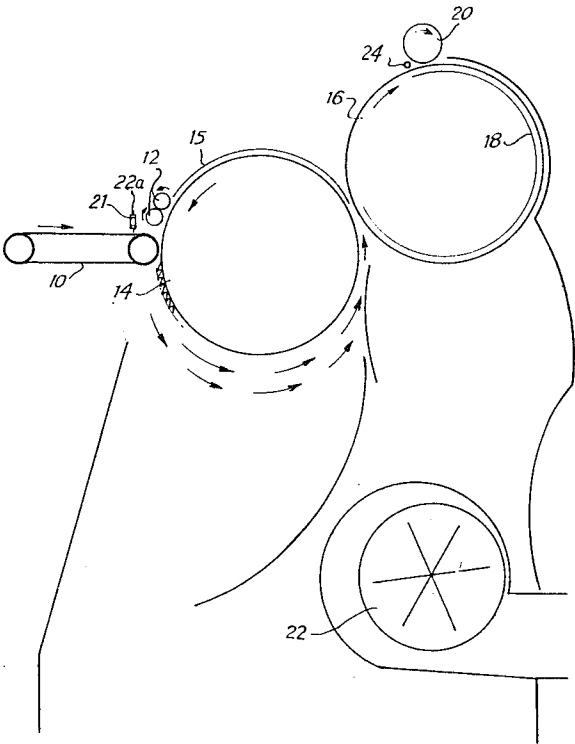
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[57] ABSTRACT

This invention comprises methods of and apparatus for making a yarn or like fiber assembly by twisting fibrous material together while reducing the extent to which individual fibers are twisted about their own axes. This is achieved by causing the fibers to roll about each other rather than be twisted as a bundle as in conventional spinning process for making textile yarn.

18 Claims, 2 Drawing Figures



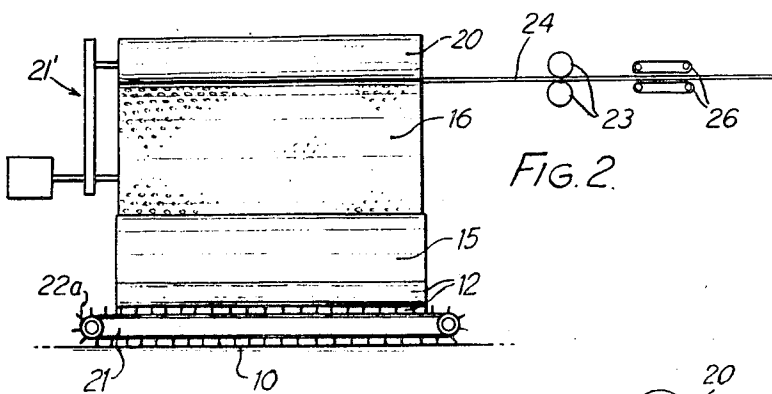


FIG. 2.

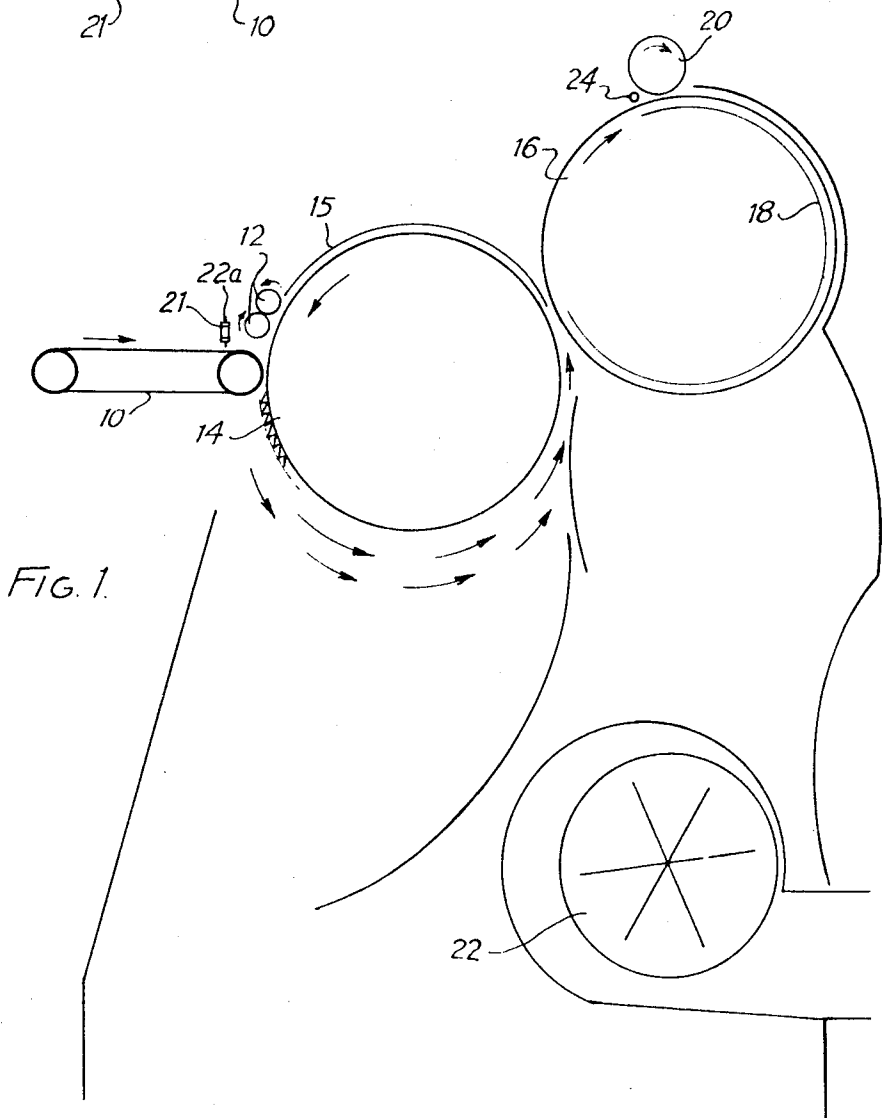


FIG. 1.

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The initial twisted accumulation can be picked off and led out sideways from the apparatus to drawoff rolls (not shown) to be finally collected in a can. Advantageously before collection the yarn is passed through a consolidating apparatus comprising cooperating conveyors 26 which move at the same speed in the direction of yarn travel and are simultaneously oscillated transversely relative to one another. This treatment has the effect of smoothing or consolidating the surface of the yarn.

In initial experiments without the cross conveyor 21 it was found that, when producing finer yarns at least, the last portion of each group of fibers did not separate well in the apparatus and appeared as an unacceptable "lump" in the yarn. This problem was overcome by use of the cross conveyor which ensures that the ends of the fibers are fed into the yarn adjacent to the takeoff end of the cylinder where they become more readily incorporated in the yarn. Moreover the ends are fed in a few at a time at the same point rather than all at once across the full width of the cylinder.

The problem may also be overcome without using the cross conveyor if the last inch or so of each group of fibers is treated with an adhesive, all the fiber ends then being held firmly together and being heavy enough not to pass to the perforate cylinder 16, but rather falling as waste to the bottom of the apparatus. The method of producing the fiber bundles may readily be modified to produce bundles with the fibers at one extremity all adhering together, thus rendering unnecessary a separate operation. This technique is however rather wasteful and use of a cross conveyor is preferred.

It should be noted that the fiber length may be controlled in various ways. For example, by feeding the fibers more obliquely to the taker-in cylinder the final fiber length may be reduced; by spacing the taker-in cylinder at a greater distance from the feed conveyor the final fiber length may be increased; and by using an endless conveyor as the feed means and passing the fibers between a pair of small-diameter rollers adjacent the taker-in cylinder as illustrated in the drawings, the final fiber length may be reduced, due to the close proximity of the nip between the rollers to the surface of the taker-in cylinder.

It is surprising that a coherent yarn was produced as the carbonized fibers exhibit high torsional recovery characteristics. It appears that the reason that it is possible to form a coherent yarn is that the action on the fibers is such that they roll about one another and there is little tendency to twist them about their own axes although the final structure of the yarn can be regarded, for all practical purposes, as a twisted structure. The less the fibers are twisted about their own axes, the greater is the permanence of the final product. The fibers used in the embodiment were carbonized from acrylic filaments.

The extent to which an individual fiber will be twisted about its own axis depends on the torsional recovery of the fiber. Some fibers resist twisting about their own axes more than others, and when drawn off at 24 in a yarn strand they will tend to move to reduce the twist about their axes, i.e., to reduce the torsional stress in the fibers. Carbon fibers strongly resist torsional stress. If they were given high torsional stress, they would untwist and the yarn strand would fall apart and have little permanence. There is little tendency permanently to twist them about their own axes because they are constantly resisting torsional stress. The fibers are however sufficiently twisted together for them to form a strand. If cotton fibers were used, they will accept higher torsional stresses and the strand will not tend to fall apart to the same extent if the fibers are twisted about their own axes.

The speed of operation of the various parts of the apparatus were as follows:

Conveyor	10	0.5 feet per minute
Feed roller	12	1 r.p.m.
Taker-in cylinder	14	900 r.p.m.
Perforate cylinder	16	80 r.p.m.
Consolidating roller	20	250 r.p.m.
Yarn drawoff rate		10 feet per minute

The various drives are preferably variable, and the directions of movement are as indicated by the arrows in the drawings.

Before using the product of the apparatus it was found desirable gently to compact or consolidate it, as for example, by a gentle reciprocal transverse rubbing action. This may be achieved by passing the yarn between the cooperating endless conveyors referred to above. The handling characteristics of the product may be improved by applying polyvinyl alcohol to the compacted product.

In use the yarn may be wound round a former, on which is then moulded a metal (or perhaps a resin) component. The presence of the carbon fibers gives great strength to the component in the direction or directions in which the yarn lies.

We claim:

1. A method of making a yarn or like fiber assembly comprising providing a nip between two surfaces moving continuously in opposite directions, causing fibers to accumulate continuously at a location in the nip with their axes at substantially right angles to the directions of movement of the surfaces, the fibers engaging the surfaces at said location, providing a fluid flow acting to assist twisting together of the fibers at said location, and withdrawing the material from said location as a continuous strand of twisted fibers transversely to the directions of movement of the surfaces.

2. A method according to claim 1, comprising firstly feeding fibrous material to a preceding continuous moving surface, transferring said fibrous material therefrom to one of said two surfaces forming said nip, the nature of said preceding surface and said one surface and the manner of feeding and transferring enabling the fibrous material to approach the preceding surface in a generally endwise manner but finally to lie in discrete lengths on said one surface generally transversely to its direction of movement, and drawing off the fibrous material continuously from said one surface, in the form of a yarn or like fiber assembly from said location thereof at which said discrete lengths of material are caused to accumulate at an appropriate rate and become twisted together as said one surface moves relative thereto.

3. A method according to claim 2, in which the material is transferred from said preceding to said one surface entrained in a moving fluid.

4. A method according to claim 3, in which said preceding surface and said one surface are cylindrical, said material being fed generally radially to said preceding surface and generally tangentially to said one surface and being withdrawn off said one surface in a direction parallel to the axis of the cylinder.

5. A method according to claim 2, in which the yarn or fiber assembly is subsequently consolidated.

6. A method according to claim 1, including the step of reducing the fiber length to approximately one inch before twisting.

7. A method according to claim 1, in which the yarn or fiber assembly is subsequently treated with polyvinyl alcohol to improve its handling properties.

8. A method according to claim 1, in which the fibers comprise carbon fibers.

9. Apparatus for making a yarn or like fiber assembly comprising two continuously movable surfaces arranged to form a nip and to move in substantially opposite directions in the region of the nip, means for feeding fibrous material to a location in the nip with the fiber axes lying substantially at right angles to the directions of movement of the two surfaces so that the fibers are engaged by the surfaces, means for providing a fluid flow at the location to assist in twisting the fibers together, and means for drawing off the material as a continuous strand of twisted fibers transversely to the directions of movement of the surfaces.

10. Apparatus according to claim 9, including a preceding continuous movable surface to which said material is fed before said nip and means for transferring the fibrous material from said preceding surface to one of said two surfaces forming said nip.

METHOD AND APPARATUS FOR FORMING YARN

This invention concerns yarns and like fiber assemblies, that is to say, in the broadest sense, continuous elongated coherent assemblies of fibrous material, and methods and apparatus for making them.

According to the present invention there is provided a method of making a yarn or like fiber assembly comprising twisting fibrous material together while reducing as much as possible the extent to which individual fibers are twisted about their own axes. This may be achieved by causing the fibers to roll about each other rather than be twisted as a bundle as in conventional spinning processes for making textile yarns.

Preferably the fibers are caused to accumulate continuously at a surface, there being relative movement between the accumulation of fibers and the surface in a direction at right angles to the longitudinal axes of the fibers to cause rolling of the fibers about each other.

According to a preferred embodiment a method of making a yarn or like fiber assembly comprises feeding fibrous material to a first continuous moving surface, transferring said fibrous material therefrom to a second continuous moving surface, the nature of said surfaces and the manner of feeding and transferring enabling the fibrous material to approach the first surface in a generally endwise manner but finally to lie in discrete lengths on the second surface generally transversely to its direction of movement, and drawing off the fibrous material continuously from the second surface, in the form of a yarn or like fiber assembly, from a part thereof at which said discrete lengths of material are caused to accumulate at an appropriate rate and become twisted together as the second surface moves relative thereto.

The invention also includes apparatus for carrying out this method, the first surface preferably being that of a taker-in cylinder, and the second surface that of a perforate cylinder, means being provided for causing material struck down by the taker-in cylinder to be entrained in a moving fluid, preferably air, and carried to a region where the cylinder peripheries approach closely to each other for transfer to the surface of the perforate cylinder, the fluid passing away through the perforations.

We have found the invention to be particularly useful for producing yarn or like fiber assembly (hereinafter called "yarn") from carbon fibers, which cannot be spun on conventional spinning machinery owing to their physical characteristics, especially their brittleness. Such yarn is capable of being employed as a reinforcement in metal structures and components which in use will be subjected to high stresses of various kinds, and is particularly convenient in use when the structure or component is of other than simple rectilinear shape.

Carbon fibers may be readily produced in discrete bundles of substantial length (e.g., many inches) whilst the production of a carbon fiber yarn in the manner just referred to is greatly facilitated if the fibers reach the region of accumulation as staple fibers of the order of 1 inch in length in a regular flow. The apparatus according to the invention serves to reduce the length of the fibers and to convey them to the region of accumulation, both as part of a continuous process.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

FIG. 1 is an end view of apparatus for carrying out the invention; and

FIG. 2 is a front view of the apparatus shown in FIG. 1.

Referring to the drawings, the apparatus consists essentially of a feed conveyor 10, a pair of soft rubber covered feed rollers 12, a taker-in cylinder 14 covered by a shield 15, a perforate cylinder 16, fitted with a baffle 18, a consolidating roller 20 means 21 for driving cylinder 16 and roller 20, a fan 22, and means 23 for drawing off yarn 24 formed between the cylinder 16 and the roller 20. A cross conveyor 21 provided with a series of pins 22a is located above the conveyor 10 immediately ahead of the feed rollers 12.

In use bundles of fibrous material, for example fully carbonized approximately half denier fibers, each fiber being approximately 14 inches long, are processed. Each bundle is originally about one-eighth inch diameter but prior to processing in the apparatus is spread out, i.e., made substantially coplanar, and placed on the left-hand side of the conveyor 10, as viewed from the front, i.e., the left side of FIG. 2. The fibers are fed over the cross conveyor 21 between the feed rollers 12 generally endwise and radially with respect to cylinder 14 to be struck down by the taker-in cylinder 14. This causes the fibers to be reduced to a length of about 1 inch and the fibers are then entrained by the stream of air induced by the fan 22 and follow the path indicated by the arrows in the diagram, being caused to pass between the taker-in cylinder 14 and the perforate cylinder 16, and to be deposited on the surface of the latter as the air continues through the perforations to be exhausted.

The characteristics of the airstream are such that the fibers lie in a direction generally parallel to the cylinder axis and when they reach the consolidating roller 20 they accumulate as indicated in the diagram and are caused to roll about each other whereby a twisted structure arises. Thus advantage may be taken of the fact that there is a reduction in the speed of air flow above a moving surface in a direction away from and normal to the surface. Such an airflow will tend to cause a random mass of fibers to settle in planes parallel to the surface. Again use is made of the characteristics of convergent and divergent airflows. The former will tend to cause fibers to align themselves along the flow whilst the latter will tend to cause fibers to align themselves across the flow. It will readily be appreciated, therefore, that by using certain combinations of air or other fluid flows the required orientation may be brought about.

Specifically, if a fiber is in a converging duct, with the fiber lying at an angle to the duct axis, and air flows through the duct, the air speed at the leading end of the fiber is greater than the air speed at the trailing end because of the duct convergence. Therefore, the force on the leading end due to the air is greater than that on the trailing end. Consequently, the fiber will tend to move to a position parallel to the duct axis. Conversely, in a diverging duct the fiber will tend to move to a position transverse to the duct axis. In the present arrangement, the cutoff lengths of fiber in moving from rollers 12 to cylinder 16 enter the zone beneath cylinder 14, and are therefore in a converging duct. The fibers, initially generally radial to the surface of cylinder 14, are in a somewhat random mass entering this zone. In that zone they are subject to airflow having certain characteristics. Firstly, the air speed decreases radially away from the surface of cylinder 14. The flow in this respect can be considered as laminar, and parallel to the cylinder surface. Thus any fiber which is inclined forwardly (with respect to a radius) as it inclines inwardly will at its inner end experience a greater force due to the air than at its outer end. Thus the fiber will tend to become parallel to the surface of cylinder 14, and the fibers tend to settle in planes similar to the laminar flow. Secondly, the duct is converging. Hence the fibers in each plane will tend to become end-on to the nip between cylinders 14 and 16, and at right angles to the axis of cylinder 14. On the other side of the nip the duct is diverging so that the fibers in the planes tend to become parallel to the axis of the cylinder 16 while the radially decreasing airflow tends to keep or further move the fibers to the planes parallel to the surface of the cylinder 16.

The fibers moving on cylinder 16 towards consolidating or twisting location 24 are held against the cylinder surface by suction in the cylinder, the airflow being generally radial into the cylinder. The fibers are twisted by the act of being drawn off as a strand at location 24. This drawing off in effect provides a substantially fixed (but of course temporary in the sense that the strand is continuously being formed) hold at one end of the fibers at location 24 enabling the effects of the contact with the moving surfaces and the airflow to be a twisting of the fibers.

11. Apparatus according to claim 10, in which said preceding surface is that of a taker-in cylinder, and said one of said two surfaces is that of a perforate cylinder, said means for transferring the fibrous material from one cylinder to the other being a fluid.

12. Apparatus according to claim 11, in which the peripheries of the two cylinders approach closely to each other, said fluid being air which entrains the material struck down by the taker-in cylinder and carries the material to the region where the cylinder peripheries approach each other for transfer of the material to the surface of the perforate cylinder, the air passing away through the perforations.

13. Apparatus according to claim 12, in which the fluid flow is controlled in a manner to produce the desired orientation of fibers of the material deposited on said perforate cylinder.

14. Apparatus according to claim 10, including a cross conveyor adapted to move in a direction transverse to the direction of movement of said preceding movable surface where the material is drawn off, the fibrous material being fed over said cross conveyor whereby the fibrous material is moved transversely during feeding.

15. Apparatus according to claim 9, including means for

consolidating the yarn or fiber assembly after same has been drawn off.

16. Apparatus according to claim 15, wherein the consolidating means comprises cooperating endless conveyors which move at the same speed in the direction of yarn travel and are simultaneously oscillated transversely relative to one another.

17. Apparatus as claimed in claim 9, in which one of the two surfaces forming said nip is a roller arranged to prevent movement of the fibers over the other of the two surfaces.

18. Apparatus for making a yarn or like fiber assembly comprising a cylinder having a perforate surface, a roller having a surface arranged to define a nip with the perforate surface, means for feeding fibers to the nip for engagement by the surfaces with the fiber axes substantially parallel to the axes of the cylinder and roller, means for rotating the cylinder and roller surfaces in opposite senses at the nip, means for providing a fluid flow in the region of the nip to assist twisting together of the fibers, and means for drawing off the twisted fibers as a continuous strand of twisted fibers transversely to the direction of rotation of the cylinder surface at said nip.

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