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[54] APPARATUS FOR CUTTING SLIVERS OF CONTINUOUS TEXTILE FILAMENTS BY MEANS OF FOCALIZED LASER RAYS

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[52] **U.S. Cl.** .... **219/121 L,** 19/3, 19/6

[51] **Int. Cl.** **B23k 27/00**

[58] **Field of Search** .... 219/121 L, 121 EB, 219/69, 384; 83/325, 913; 19/3, 6; 57/2

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[57] **ABSTRACT**

A method and equipment for cutting slivers of continuous filaments of textile material into tuft fibres adapted for further spinning and twisting operations, wherein a continuous sliver formed by said filaments is advanced at a high speed in a plane and laser ray pulses are focalized on said plane in the form of a narrow window having a length greater than the width of said sliver, in order to cut the same into a plurality of tuft fibres having a predetermined length.

6 Claims, 2 Drawing Figures

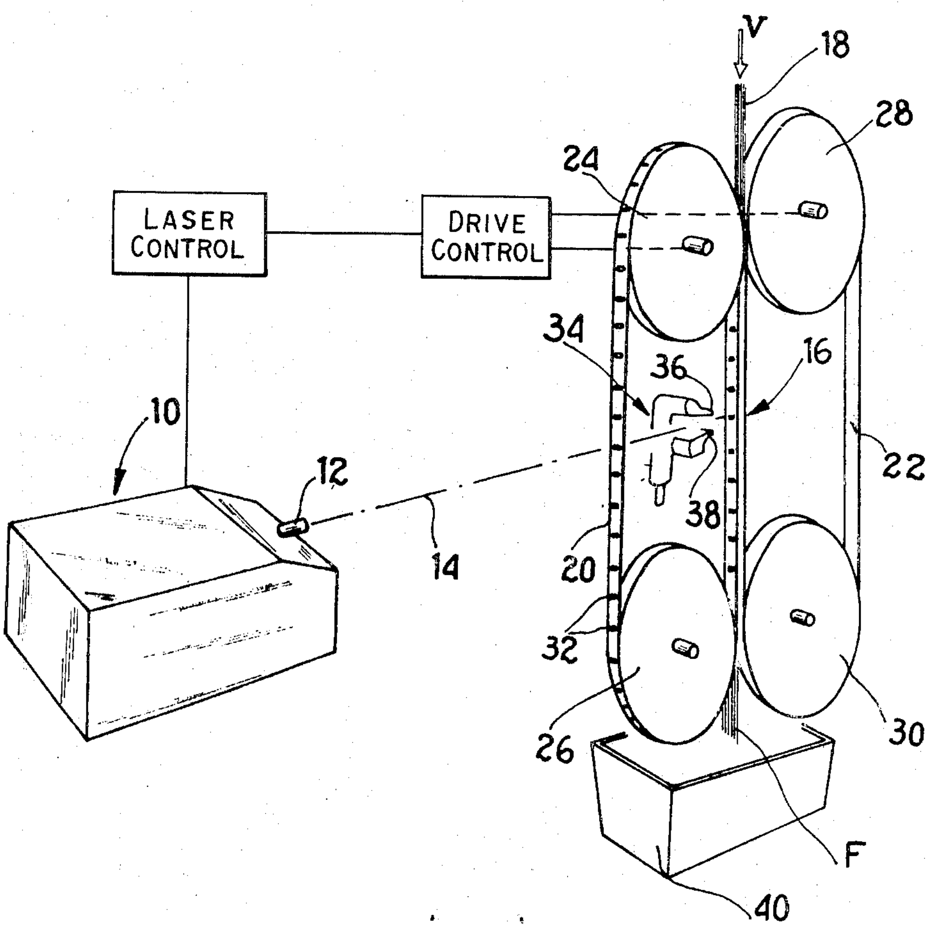

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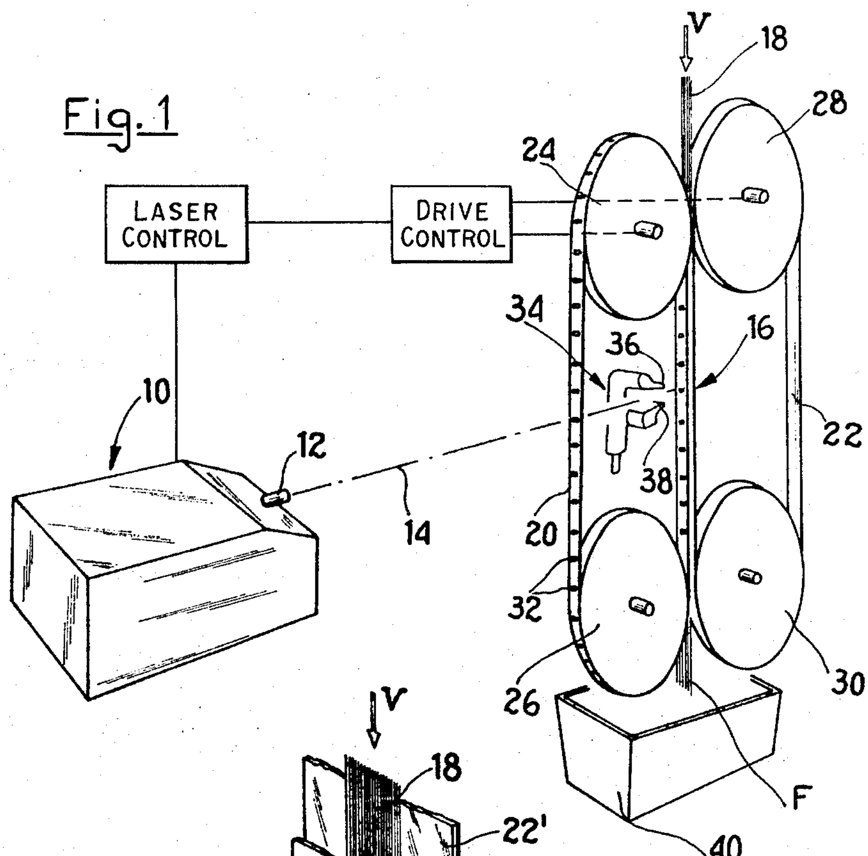
Fig. 1



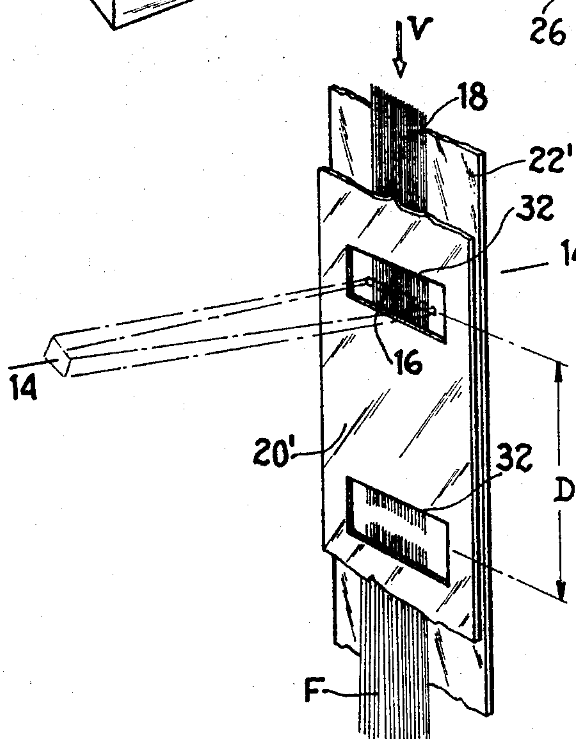


Fig. 2

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APPARATUS FOR CUTTING SLIVERS OF CONTINUOUS TEXTILE FILAMENTS BY MEANS OF FOCALIZED LASER RAYS

BACKGROUND

This invention generally relates to the problem of cutting textile and in particular synthetic continuous filaments into more or less short fibres in order to obtain so called tuft fibres adapted for further spinning and twisting operations, as required for producing fibrous textile yarns.

As well known, all artificial and synthetic fibres are produced in the form of continuous filaments extruded through spinnerets and then suitably drawn or otherwise processed, said filaments being gathered and advanced in the form of slivers (wherein said filaments are arranged parallel and close to, but not connected with each other), consisting of a very large number (usually many thousand) of filaments. Such slivers, or more exactly all filaments thereof are cut into pre-established lengths to form said tuft fibres which are then forwarded to conventional processes in order to obtain a rove whereon spinning and twisting operations are carried out.

The most modern techniques for producing artificial and synthetic filaments allow the attainment of very high sliver feeding speeds, of the order of several hundred meters per minute, and a trend to further increase said speeds can also be noticed. Since the filaments to be converted into tuft fibres are to be cut into very short lengths (of about 40 mms for a so called "cotton cut," and about 70–90 mms for a "woollen cut"), the cutting frequency may attain very high values, of the order of several thousand cuts per minute and therefore of many hundred cuts per second.

According to the known art, a cutting operation is carried-out on filament slivers by mechanical means and in particular by suitable shear blades or knives that act on the sliver in a point intermediate between two points thereof wherein the filaments are retained or "anchored." Such action is usually performed by engaging and advancing the sliver between counter-rotating members, generally in the form of suitably grooved rollers, metal chains or the like. The filaments are thus engaged between the sharp corners of slots or grooves of said rotary members, one or both of which may comprise edges of a resilient material in order to ensure the adherence and detainment of filaments. Downstream of the cutting point, an air stream or other suitable means draws away the thus obtained tuft fibres.

Such mechanical systems are rather complicated and the high speeds and cutting frequencies as required in the actual production of said fibres are hardly attained. In addition, the artificial filaments and in particular the synthetic ones as e.g. polyester filaments, may be rather hard and then cause a very quick wear of blade or knive cutting edges, which results in a necessity to frequently replace the cutting tools and thus to stop the cutting equipment.

In addition, said blades or knives may become further worn due to the possible presence of acidic components in the filaments, when obtained from spinning rayon or regenerated cellulose.

In addition to said increase in the silver linear speed, the most modern technique trends to gather an ever increasing number of filaments into a single sliver, until

obtaining slivers formed of filaments individually having a very small count (e.g. 1 or 2 deniers) but showing on the whole very big counts, of the order of a few millions of deniers (weight in grams of 9,000 meters of textile material).

An object of this invention is to provide, in the field of cutting slivers consisting of a very high number of single filaments and advancing at very high linear speeds, a method by which already known drawbacks and restrictions of prior art mechanical cutting systems are wholly overcome. A more specific object of this invention is to find and industrially carry-out the scientific principle of obtaining a very high and strictly localized thermal action by means of focalized laser rays (coherent monochromatic light energy).

In the textile industry it is well known to use laser rays to cut fabrics, carpets and similar laminar-shaped textile products, but this cutting operation is carried-out over a great fabric length and then at a reduced speed.

Under these conditions the thermoplastic filament ends may stick with each other and this occurrence is not considered as harmful; on the contrary, at least from certain viewpoints said sticking action may be considered as suitable in that it stabilizes the cut fabric edges.

However the problem to cut filament slivers into short fibres differs from above in that the filament feeding speeds are very high and the cutting time is consequently reduced; further, a filament end sticking action would be very harmful.

SUMMARY

According to this invention, it has been surprisingly ascertained that a laser radiation, when focalized in an essentially rectangular window having a major side directed crosswise to the sliver feeding direction and longer than the sliver width, as well as a minor side of a few microns only, and when said radiation is applied in the form of pulses having a pulse duration of a few millionth of second, is able to sharply and thoroughly cut all filaments in the sliver, with a complete removal of material in front of said window and without causing undesirable melting phenomena in the zones adjacent to the cut as well as welding phenomena on the fibres closely contacting with one another during said cutting operation.

In particular, the method according to this invention consists in feeding a filament sliver at a required linear speed, between two counter-rotating feeding elements, and in particular between parallel and closely adjacent lengths of two endless chain tracks, at least one of which is formed with windows uniformly spaced at intervals equal to the length or to a submultiple of the length of fibres into which the filaments are to be cut, and in directing on said sliver a pulsed laser ray focalized toward the plane wherein the sliver is lying, in synchronism with the passage of said windows across the point wherein the sliver feeding direction intersects the direction of said laser ray.

Laser pulses synchronized with the passage of said windows can be obtained by placing a suitable intercepting device, e.g. in the form of a suitably perforated rotating disk, in the path of rays continuously emitted by a generator, or preferably by providing a pulse generator having a frequency synchronized with that of said cutting cycle, and more precisely a frequency as follows:

f = sliver feeding speed/cut length (or fibre length)

said synchronism being obviously pre-set in such a manner that said focalized ray pulses strike the sliver at the moment wherein it appears uncovered through a window of said feeding track system.

According to a preferred embodiment of this invention a laser ray source is used that emits a radiation having a wavelength corresponding to one of the absorption bands of the polymer forming the filaments to be cut, and preferably corresponding to the more relevant absorption band. Said absorption bands are generally very narrow and it has been ascertained that changes in the laser ray wavelength, even of fractions of microns, may considerably affect the cut efficiency. On the contrary, when a laser ray having a wavelength corresponding to the more relevant polymer absorption band is provided, the cut operation may be performed at a high speed and without any harmful fibre sticking.

According to a further feature of this invention, said method also comprises to blow an inert gas and in particular nitrogen against sliver points directly upstream and downstream the cut line, in order to ensure an instantaneous heat removal from the filament and fibre zones directly adjacent to said cut (wherein the filament material is melted or more exactly volatilized), as well as to ensure that the cutting operation be made in an environment wherein no oxidation phenomena due to the presence of atmospheric oxygen may occur.

DRAWING

FIG. 1 is a perspective view of the whole equipment, and

FIG. 2 is an enlarged detailed view of the cutting zone of said equipment.

PREFERRED EMBODIMENT

The shown equipment comprises a laser generator, generally designated by the numeral **10** and operating to emit a ray through a window **12**, having a few millimeter's light diameter, in a direction as indicated by the dot and dash line **14**. Said generator comprises suitable focalizing systems well known in the art and therefore not shown, by which said laser ray is focalized or concentrated at a pre-established focal length in the form of a flat and lengthened beam, directed toward a rectangular window **16** (see FIG. **2**), having a major side slightly longer than the width of the sliver **18** to be cut.

The sliver **18** is fed at a linear speed V between two counter-rotating endless chain tracks **20** and **22** having parallely fitted sections located at a right angle in respect to the laser ray direction **14**. Said endless chain tracks are guided at a linear speed V by pairs of pulleys **24, 26** and **28** and **30**, respectively, at least one pulley of each pair being suitably driven. Said tracks **20** and **22** may be in the form of metal bands or non-metallic material bands, and are supported in such a manner as to show parallel and approached lengths **20'** and respectively **22'**, leaving a space therebetween to ensure the engagement of sliver **18** in a suitable planar arrangement for cutting operations thereon.

At least the track **20** is formed with a plurality of windows **32**, having a width and a height greater than the corresponding dimensions of window **16** wherein said laser ray is focalized, said windows **32** being spaced at intervals D equal to the greatest common factor between the lengths of tuft fibres into which the filaments of sliver **18** are to be cut.

The whole equipment is assembled in such a way that the vertical lengths of track **20**, which obviously run in opposite directions, show aligned windows **32** when crossing the laser ray. Similarly, said laser ray is pulsed (or pulsatorily intercepted) in synchronism with the passage of said windows **32** in alignment relationship with said ray direction **14.**

Moreover, the whole equipment is obviously assembled and pre-set in such a manner that the plane wherein said sliver **18** lies, between said approached track lengths, is coincident with the plane wherein the laser ray is focalized within said essentially rectilinear window **16.**

Thus, when the equipment is operated under said alignment, focalization and synchronism conditions, the sliver portions that are left uncovered by said windows **32** are struck by the laser ray, as focalized in **16** and are accurately and sharply sheared across a minimum height, owing to very small height of window **16** wherein the ray is focalized, as well as to very short pulse duration.

Obviously, when said laser pulses are synchronized at a frequency corresponding to the passage of windows **32**, the filaments of sliver **18** are cut into tuft fibres having a length D. When fibres having a length equal to a multiple of D are required, said pulses shall be synchronized at a frequency such as to operate only when a corresponding multiple of windows **32** is passed across said direction **14.**

The laser ray energy in excess to that absorbed for the volatilization of filaments may be taken-up by the downstream located track length **22.** However, in order to prevent any damage to said track length **22,** it can be formed with windows and a suitably cooled screen is then fitted behind the same and in the laser ray direction **14** to take-up said residual energy.

The equipment comprises further a device **34**, that is connected to a suitable source of pressurized nitrogen and is formed with slit nozzles **36** and **38** through which blade-shaped nitrogen jets are directed against the sliver **18,** above and below the striking point of said laser ray.

Moreover, the equipment comprises also means wherein the tuft fibres are collected when discharged in a direction F from said feeding tracks, such means being diagrammatically exemplified by a collecting container **40**; as well as means for cooling said tracks, safety and protection means for the zone traversed by said laser ray, and so on.

As an example of an equipment built and operated according to this invention, a sliver formed by 10,000 polyester filaments each having a count of 1.5 deniers and thus with a total sliver count of 15,000 deniers was cut in tuft fibres. Said sliver was fed at a speed of 500 m/min. and cotton-cut sheared. The track **20** was formed with windows at intervals D or 40 mms, and laser pulses having a wavelength of about **8** microns and focalized as in **16** over a width of 20 mms were sent therethrough at a frequency of about 208 pulses per second in such a manner that the sliver **18** was struck approximately at the center of each window **32.** Another sliver was similarly sheared into woolen-cut tuft fibres 80 mm and 120 mm long by means of laser rays having a frequency equal to a half and respectively to a third of the above stated one. A sharp and constant cutting action was obtained, with a very small portion of welded fibres that is due to faults in the previously carried-out filament drawing and thermosetting operations.

A similar experiment was conducted on a sliver of polyamidic filaments (Nylon 6) which was cut by following the above procedure except that laser pulses having a wavelength of about 6.1 microns were used. The results were similarly favourable.

We claim:

1. Apparatus for cutting a sliver of textile filaments into textile tufts comprising first and second endless track means, means mounting said track means for rotation, at least a portion of said first track means being positioned in a plane parallel to and adjacent at least a portion of said second track means for holding a length of sliver therebetween, means for rotating said track means, said means for rotating said track means moving said portions of said track means in the same direction, whereby said length of sliver is also moved in said same direction in a plane parallel to said first mentioned plane; said first track having a plurality of windows therein for exposing a portion of said sliver, each of said windows having a width larger than that of said sliver and a height of a few microns so that the entire width of said portion of said sliver can be exposed in said windows; means for generating a beam of laser radiation positioned adjacent said track means; and means for focusing said beam onto a part of said first track means where said portion of said track means is adjacent said portion of said second track means and in the path of said moving windows, said means for focusing said laser beam directing said beam onto said first track means in a form having an elongated rectangular cross-section; and means for interrupting said beam when a window having a portion of said sliver exposed therein is not positioned at the part of said first track means where said beam is focused.

2. Apparatus as claimed in claim 1 including means for emitting said beam of laser radiation in pulses having a pulse duration shorter than one thousandth of a second.

3. Apparatus as claimed in claim 1 wherein said track means comprise counter-rotating tracks and said means for rotating rotates said tracks at a speed equal to the sliver feeding speed, said windows having a length and a width greater than that of said laser beam focused on said first track and spaced at intervals equal to the length of textile tufts to be obtained.

4. Apparatus as claimed in claim 1 wherein said track means comprise counter-rotating tracks and said means for rotating rotates said track at a speed equal to the sliver feeding speed, said windows having a length and a width greater than that of said laser beam focused on said first track and spaced at intervals a submultiple of the length of the textile tufts to be obtained.

5. Apparatus as claimed in claim 3 wherein said means for generating said beam of laser radiation and said track are mutually located so that the direction of said laser beam is coincident with an alignment of positions simultaneously taken by said track windows that are present in both lengths of said first track means.

6. Apparatus as claimed in claim 3 comprising means for blowing a jet of an oxidation preventing gas towards points located directly upstream and downstream of the part of said first track struck by said laser beam.

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