# United States Patent [19]

**Cook**

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[54] **METHOD AND APPARATUS FOR CUTTING AND REMOVING ELONGATED MATERIAL**


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[52] **U.S. Cl.** .....**83/24**, 83/99, 83/913

[51] **Int. Cl.** .....**B65h 51/16**

[58] **Field of Search**.....83/913, 24, 98, 99, 83/100, 17, 18, 20, 21



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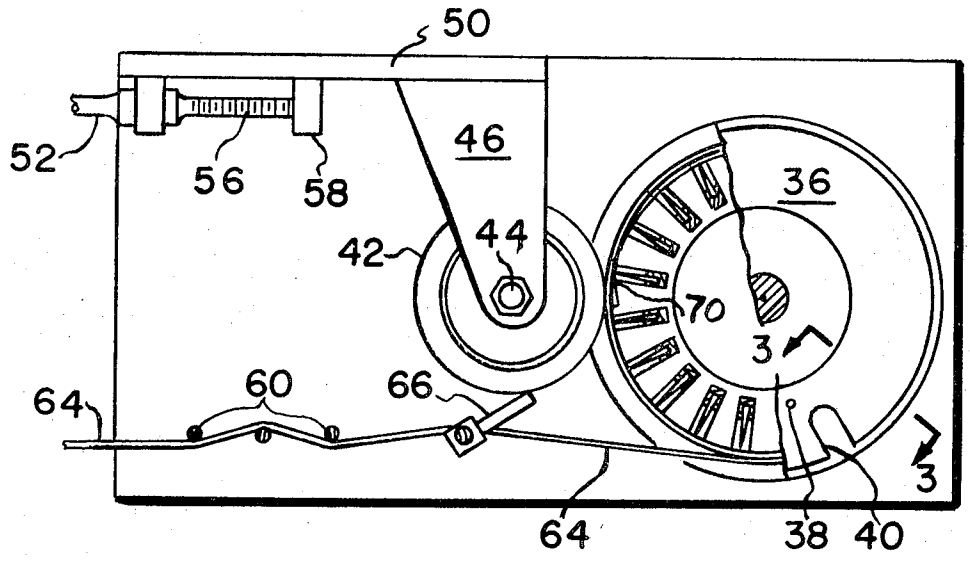
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[57] **ABSTRACT**

A method and apparatus is disclosed and claimed for cutting and removing elongated material by means of a plurality of knife edges and an overhead air jet. The cutting is achieved by applying a pressure to the inner layer of continuous filament forcing it against the knife edges and thereby cutting the filament wherein the air jet impinges downwardly upon the cut filament and causes it to be removed.


**7 Claims, 6 Drawing Figures**



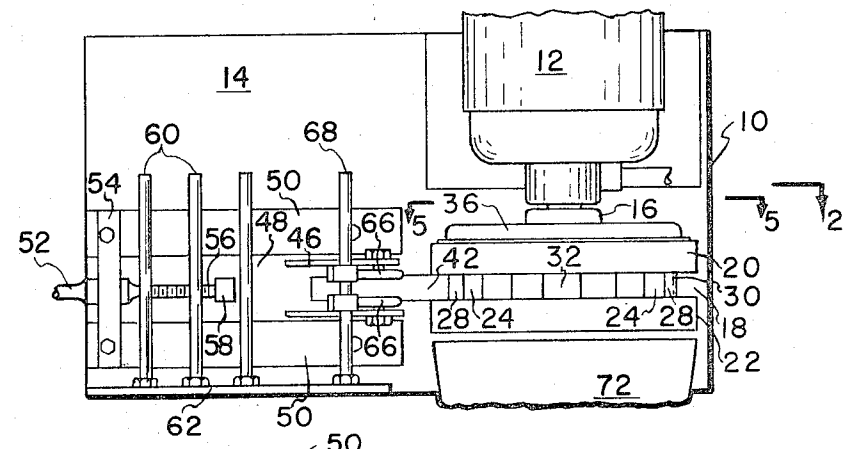



FIG. 1

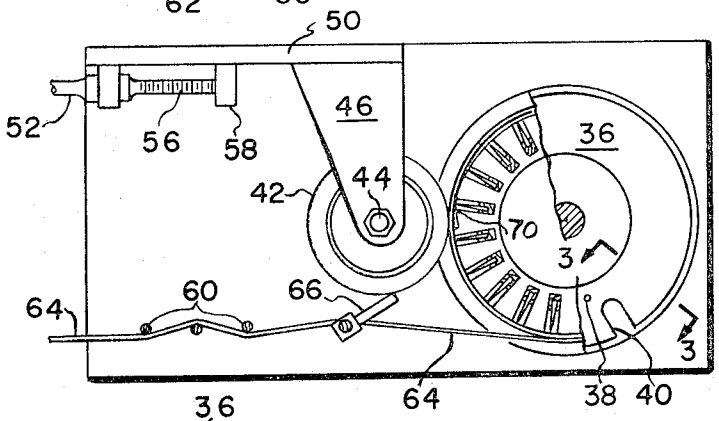



FIG. 2

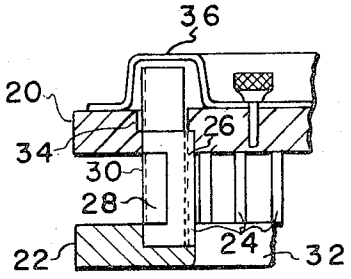



FIG. 3

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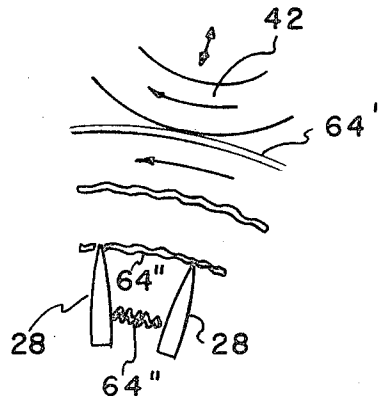



FIG. 4

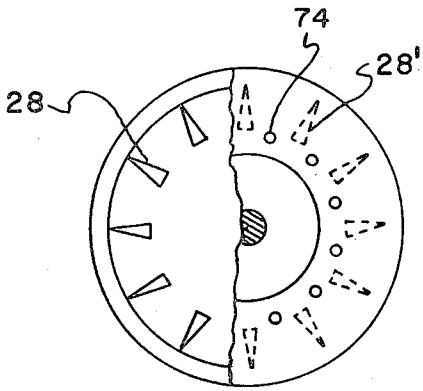



FIG. 5

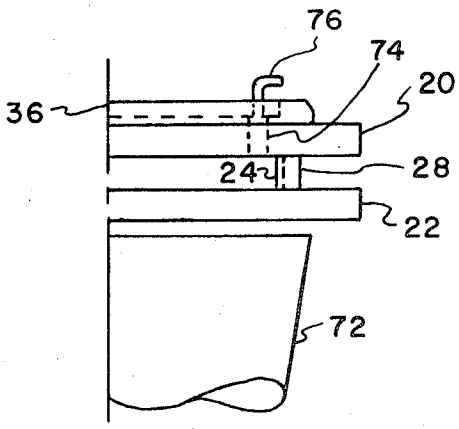



FIG. 6

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# METHOD AND APPARATUS FOR CUTTING AND REMOVING ELONGATED MATERIAL

The invention relates to an apparatus and method for cutting a continuous, elongated material into shorter lengths having predetermined dimensions and removing the same. More particularly, this invention relates to an improved method and apparatus for continually removing uniformly cut fibers from a cutting device wherein the uniformly cut fibers yield a more open, low density staple product than heretofore known.

## BACKGROUND

Many types of cutting devices and methods for dividing elongated material into shorter lengths are known. However, substantially all such cutting devices have at least one major drawback, with the major problem being a very short knife life necessitating constant change of knife edges. A major step forward was achieved in overcoming the knife edge problem with the apparatus disclosed in issued U.S. Pat. No. 3,485,120 to Garland B. Keith (hereinafter referred to as the Keith apparatus).

The Keith apparatus comprised a reel-like structure formed by a plurality of cutting blades spaced apart a distance substantially equal to the lengths to be cut and secured to a rotatable mounting member. The cutting edges of the blades formed a circular pattern around and extend radially outwardly from the axis of rotation of the mounting member. The material to be cut is fed on the reel-like structure under slight tension and is wrapped around it in touch contact with the cutting edges. The wrap, consisting generally of at least one layer, has its innermost strands of filaments forced into contact sequentially with the blade edges by a pressure applying device mounted adjacent the reel-like member. As the wrap increased in layers, the pressure on the innermost layer at the point between the pressure applying device and nearest adjacent knife edge caused the continuous material to be severed and as the reel-like structure continued to revolve, the wrap was continually cut in predetermined lengths substantially measured by the distance between knife edges. The Keith apparatus did indeed solve a perplexing problem with respect to knife life. It also, however, created a problem due to the cut fibers collecting inside the reel-like structure as opposed to fibers being cut outside a cutting device as depicted in U.S. Pat. No. 2,745,491. It was found that occasionally if the Keith apparatus was left unattended, the cut fibers became compressed by fibers being cut until either the cutting apparatus ceased cutting due to the resistance of the compressed fibers or the cut fibers built up a cake inside the cutter until the gravitational force overcame the centrifugal and fiber to fiber forces and the cake fell into the collecting chute or funnel and the resultant staple exhibited variable openness due to relatively high content of chippy fiber which is primarily caused by the fiber to fiber forces.

## THE INVENTION

According to the present invention, the above enumerated difficulties are overcome and a more open, low density staple product is produced by causing a stream of gas to impinge downwardly upon the proximity of the doffing point of the cut fiber. More particularly, this invention relates to an apparatus and method



substantially similar to the Keith apparatus with the exception that regularly spaced apertures are placed in the upper surface of the reel-like structure and a gas jet is placed pointing downwardly so that the forced gas proceeds through the apertures and impinges downwardly upon the proximity of the doffing point of the cut fiber.

This invention will be more apparent upon reference to the following specification, appended claims and drawings wherein:

FIG. 1 is a side elevational view of the cutting apparatus according to the Keith apparatus illustrating the relationship between the various elements thereof and showing a preferred cutting reel configuration;

FIG. 2 is a view taken along line 2—2 of FIG. 1 and showing in the specific relationship between the cutting reel, the pressure applicator, and the material being severed;

FIG. 3 is an enlarged detailed, fragmentary view taken along line 3—3 of FIG. 2 showing the manner in which the knife blades are secured in the cutting reel according to one embodiment of the Keith apparatus;

FIG. 4 is an enlarged, fragmentary, detail view showing the relationship between the blades, the material being severed and the pressure applicator at the point of cutting;

FIG. 5 is a view taken along line 5—5 of FIG. 1 which shows this invention, namely the apertures in the upper surface of the cutting reel;

FIG. 6 is an enlarged detailed fragmentary view partly in cross-section showing the relationship between the knife edges and the apertures in the upper surface of the cutting reel.

With reference to the accompanying figures wherein like numerals designate similar parts throughout the various views, and with initial attention directed to FIG. 1, reference numeral 10 designates generally a cutting apparatus constructed according to the Keith apparatus including a driving motor 12 mounted on a base 14 with its output shaft 16 connected in a suitable manner to a cutting reel or assembly designated generally by reference numeral 18. While the means for supplying driving power to the cutter is described as a motor it may as well consist of a gearbox receiving power from a rotating shaft common to several machines.

The cutting reel or assembly 18 consists of a mounting member including a disc 20, to which the output shaft 16 is removably connected, and a mounting ring 22 both of which are formed of generally flat plates of suitable material. As best shown in FIG. 3, the mounting disc 20 and the mounting ring 22 are secured together in spaced parallel relationship by a plurality of U-shaped connector lengths 24 which are secured in position by any of a number of well known expedients such as, for example, furnace brazing. A narrow slot 26 extends through both mounting disc 20 and mounting ring 22 as well as each connector length 24. The connector lengths24 are normally secured between the mounting disc 20 and the mounting ring 22 at equal distances radially outwardly from the shaft 16, which also defines the axis of rotation of the cutting reel 18. The circumferential spacing between connector lengths 24 is determined by the staple length desired. While the device described above is a preferred construction, a configuration in which the ring 22 is not secured to mounting disc 20 by connectors 24 can be successfully

utilized when the material to be cut is not excessively heavy wherein the clamped knife blades **28** are the sole structural tie between disc and ring.

The preferred manner of mounting the knife blades **28** is illustrated in FIGS. **1–3.** As shown therein the knife blades **28** are removably mounted or inserted in slots **26** in connector lengths **24** with the cutting edge **30** extending radially outward. Since the connector lengths are disposed radially from the output shaft **16** and the axis of rotation of the cutting assembly **18,** the knife blades **28** are likewise disposed. The width of blades **28** from cutting edge **30** to back is substantially less than the radial distance from the axis of rotation of the cutting reel **18** to the edge **30.** Thus, the mounting disc **20,** the mounting ring **22,** and connector lengths **24** in which blades **28** are supported form an open ended compartment **32** within the cutting reel **18.** The purpose and function of the compartment **32** will be described hereinafter in connection with the discussion of the mode of operation of this novel cutting apparatus.

In a preferred embodiment of the invention as specifically illustrated in FIG. **3,** the knife blades **28** are of such a length usually slightly more than twice the distance between disc **20** and ring **22** so that they will extend through a plurality of radially extending slots **34** formed in the mounting disc **20** to a point above its surface. Thus, blades **28,** which simply rest within slots **26** in connector lengths **24** are readily removable from the cutting reel **18.** An annular cap **36** protects the upper end of blades **28** as well as the operator attending the apparatus. The cap **36** is secured to the mounting disc **20** by suitable means such as thumb screws **38.** When screws **38** are removed, the cap **36** can be rotated relative to disc **20** so that individual blades **28** can be removed from the cutting reel **18** by aligning them with a slot **40** formed in the side of cap **38.** Thus, as the knife edge **30** on a blade **28** becomes dulled through usage it can be easily replaced or, if the upper end has not yet been utilized, turned end for end to present a fresh, sharp cutting surface.

As best shown in FIGS. **1** and **2,** a pressure applicator **42** of the rotatable type such as a wheel or roller is mounted on a shaft **44** secured to a bifureated bracket **46** which in turn is supported on a movable slide **48** fitted into machined ways **50** secured to the base **14.** Regulated movement of the slide **48** is accomplished by a lead screw **52** rotatably secured in a pillow block **54** fixed in position relative to machined ways **50** and thus to the base **14.** One end **56** of lead screw **52** is threaded into an appendage **58** integral with or otherwise fixed on the surface of the movable slide **48** so that rotation of screw **52** will cause slide **48** to move relative to machined ways **50** and base **14.** This structure, a lead screw actuated slide and ways assembly well known in the art, provides for movement of pressure roll **42** relative to cutting reel **18** and minute adjustment of the space between it and cutting edges **30.**

A plurality of finger guides **60** or others well known in the art extend outwardly from a plate **62** secured at right angles to the base **14.** The finger guides **60** shape the incoming filamentary tow **64** into a flattened tape or band. From the finger guides **60** the filamentary material or tow passes through rounded edge guides **66** which are pivotally mounted on an elongated rod **68** secured, as are finger guides **60,** to plate **62.** Guides **66** serve to control the width of the flattened tape band **64** so that it will wind snugly between mounting disc **20** and mounting ring **22** of the cutting reel **18.** In addition to flattening the incoming tow **64,** the finger guides **60** also serve as a friction brake to place the tow under a controlled amount of tension as it is fed into the cutting reel **18.**

In operation of this cutting apparatus, the incoming filamentary tow which has been flattened into a tape on finger guides **60** and shaped by the edge guides **66** is fed into the rotating cutting reel **18** and wrapped therearound between mounting disc **20** and mounting ring **22.** Thus, as shown in FIG. **2,** the tow is in touch contact with cutting edges **30** on knife blades **28** which form the bottom of reel **18.** The tow **64** is wrapped upon itself in layers until the distance between knife edges **20** and pressure roll **42** is filled. As the cutting reel **18** rotates under the influence of motor **12** or other drive means, the feed of filamentary tow **64** continues causing pressure to build up within a chamber defined by the pressure roll **42,** mounting disc **20,** mounting ring **22,** and the adjacent knife edge **30** which, at a point in time, is closest to the pressure roll **42.** This pressure chamber is clearly shown in FIG. **2,** and identified by reference numeral **70.** It is to be understood, however, that this pressure chamber **70** is formed with any knife edge **30** as the cutting reel **18** rotates, not just the particular chamber identified in FIG. **2.** The pressure continues to mount in magnitude until some of the filaments will be forced to escape the pressure chamber at the point where the highest unit pressure exists between the chamber confines and the filamentary pack itself. Obviously, the escape route is not through the gently radiused pressure roll surface of the flat walls of mounting disc **20** or mounting ring **22** but past the minutely small area of the cutting edge **30** itself. Hence an inward portion of the filamentary pack approximately equal to the feed of the on-coming band of tow **64** will be cut as each succeeding cutting edge **30** passes under the pressure roll **42.** The remainder of the pack formed by the several layers will be held firmly against the cutting edges **30** trapped by several tensioned outer layers, to be cut in turn as the pressure again rises in the before described chamber. As the tow is severed the staple fibers pass between the knife edges **30** into the open ended compartment **32** and pass therefrom through the aperture in mounting ring **22** into a collecting funnel **72.**

The method of cutting in the Keith apparatus is best seen by reference to FIG. **4** wherein the filamentary tow **64** is under maximum tension in the outer wrap and under substantially zero tension at **64''** in the pressure chamber **70** as previously described. Therefore, the fibers in the outermost layer are substantially devoid, temporarily, of crimp while the fibers actually in the pressure chamber **70** have recovered to the extent intended in the finished fiber. It should be understood that the tow length in the innermost wrap is the same total length as that of the outermost wrap but differs therefrom in that it has regained its original crimp completely while the tensioned filaments of the outermost wrap are substantially devoid of crimp. It is seen therefore that the length of the tensioned outermost wrap determines the total length of all wraps and therefore the length of material to be processed during one revolution of reel **18.**

The problem inherent in the Keith apparatus, again with reference to FIG. **4,** is that the cut crimped fibers

64'' collect in between the knife blades **28** and because of fiber to fiber forces and centrifugal force, the fibers 64'' also collect together outside the knife blades until gravitational forces overcome the other forces and the cut fiber having variable openness falls down a collecting chute or funnel. This point wherein gravitational forces overcomes the combined effect of fiber to fiber forces and centrifugal force is termed the doffing point and it can vary depending upon the speed of the incoming continuous filament **64** (at higher speeds the centrifugal force increases, thus compacting the cut fibers to a great extent which increases the fiber to fiber forces thus causing the doffing point to shift in the direction of the wheel spin and towards the center point of the cutting reel **18**). Accordingly, at the higher running speeds a clogging problem is very much in evidence. U.S. Pat. No. 3,485,120 indicates that the cut fiber may be removed by the urging of an air jet, vacuum, gravity or other suitable means. For reasons hereinafter discussed in detail, this invention relates to the use of a gas jet in a particular manner which not only removes the cut fiber with great efficiency but also yields a more open staple product than heretofore known.

With reference to FIG. **5** a plurality of apertures **74** are caused by drilling or otherwise in the cap **36.** The apertures **74** are preferably placed in such a manner so as to be centrally located between each clamped knife blade **28.** In view of the fact that the apertures and the knife blades are on different elevations, FIG. **5** is set forth as a cutout drawing with **28** representing the knife blades in the cut out portion and **28'** representing the hidden positioning of the knife blades vis-a-vis the apertures **74.**

The relationship of the knife edge **28,** the apertures **74** and the gas jet **76** is better seen with reference to FIG. **6.** The gas is forced through the gas jet downwardly through the aperture **74** in the upper surface of the cutting reel **20** in order that the stream of air impinges on a general area behind the knife edge referred to as the proximity of the doffing point and preferably directly at the doffing point.

Although the Keith patent indicates that an air jet, vacuum or gravity may be employed to remove the cut fiber, this is true to a certain point. If mere gravity is the means employed for removal, it is sufficient so long as the speed of the continuous filament **64** is kept to a minimum which maintains the natural doffing point quite close to the knife edge. However in commercial practice, high line speeds are desirable to increase productivity which one is unable to attain if mere gravitation is employed as a means of removal for the reasons hereinbefore discussed. Moreover, the use of gravitation does not enhance the character or quality of the cut fiber whereas this invention not only demonstrates an ease of removal of cut fiber, but a more open staple product.

The mere addition of an air jet is not the solution to the problem inherent in the Keith apparatus. Prior to attaining the present invention, an air jet was inserted at the center point of the cutting reel **18** directed outwardly so as to impinge upon the pressure roll **42.** The necessity of placing a tubing within the chute **72** to accomplish this effect resulted in a hindrance of the free fall of cut fibers, resulting in the discharge chute becoming clogged. In an attempt to overcome this deficiency the above technique was repeated except the tubing leading to the air jet was fitted along the inside wall of chute **72** and the air jet was directed in the direction of the pressure roll at the point of cut. When this method was employed (with both copper and stainless steel tubing) ballooning of the cut fiber occurred.

Additional attempts to employ an air jet were undertaken such as placing a jet at the top of chute **72** directed inwardly at the vertical axis of the cutter **10** and subsequently a plurality of jets placed around the circumferance of the top of chute **72,** all directed inwardly of the vertical axis of the cutter **10.** In both cases, the jets had little or no effect in removing the cut staple until it began to cake and sag down within the line of the air jets. Additionally, holes were inserted in the side of chute **72** and air jets were placed therein directed at the vertical axis of the cutter **10** and subsequently at a 45° angle so as to be directed upwardly towards the interior of cutting reel **18.** Although the later technique improved cut fiber removal it still did not achieve the results accomplished by this invention.

As can be seen, for one reason or another, all attempts, excepting this invention, to employ an air jet in an effort to remove cut fiber from the cutting reel resulted in adverse results.

The improvement of this invention is preferably achieved by drilling a plurality of holes in the upper surface of the cutting reel between each knife edge at a point directly above the proximity of the doffing point and preferably at the doffing point itself. However as hereinbefore described, it became readily apparent that as the line speed was increased, the doffing point progressed in the direction of the wheel spin and towards the center of the cutting reel thus passing out of the force of impinging air. Accordingly, in an effort to adapt this improved method and apparatus to varying line speeds an aperture is called for rather than a mere hole. This aperture may be circular or preferably of an elongated shape such as an oval, rectangle or slot in order that the air jet may be adapted to continually force air downwardly on the varying doffing point. The preferred apparatus would desirably have no upper mounting disc **20,** however this is virtually impossible due to the knife edges needing upper as well as lower support.

The term doffing point is a term well known in the art which refers to a natural point wherein gravitational forces overcome the combined effect of fiber to fiber forces and centrifugal force allowing the cut fiber to freely fall downwardly through a chute or other escape passage. The term doffing point as used in this invention, not only refers to the natural doffing point hereinbefore discussed, but also refers to an artificially created doffing point which would be located prior to the natural doffing point. The artificially created doffing point can be achieved by employing an air jet prior to the natural doffing point, however relatively higher volumes and/or pressures of air would be employed. In this instance, the higher air pressures or volume would combine with gravitational forces to overcome the combined effect of the fiber to fiber forces and centrifugal force at any point selected by the operator so long as it would be prior to the natural doffing point. Accordingly, it can be seen that one can accomplish the results of this invention by directing air downwardly in the proximity of the doffing point, either natural or artificial.

The amount of air flow through the air jet should be sufficient to assist in the natural doffing of the cut fiber and may vary between from about 5 standard cubic feet per minute to about 22 standard cubic feet per minute with the actual value usually depending upon the shape, size and character of the air line leading to the air jet. Preferably from about 7 to about 15 standard cubic feet per minute and most preferably from about 7 to about 10 standard cubic feet per minute are employed. It is understood however that the air jet must be of at least a size so as to assist in the natural doffing of the cut fiber as is understood by those skilled in the art. Preferably a one-fourth inch O D copper tube is employed. A smaller jet has been used successfully, however excessive noise resulted. A larger jet could be employed, but the air required to doff and open increases towards 22 standard cubic feet per minute or even higher.

Although it is preferred to employ one air jet causing air to impinge downwardly on the proximity of the natural doffing point which is usually directly adjacent to the pressure roll, this is not to say that a plurality of air jets could not be employed. Since the plurality of apertures are continually revolving as the cutting reel turns, two, three, four or more air jets could be employed at various positions around the top of the upper mounting disc **20** of the cutting reel so long as the air jets are causing air to impinge downwardly upon proximity of the doffing point of the cut fiber.

With this invention it is now possible to process large denier material of up to about 1 million total denier at speeds of about 500 feet per minute or higher, however, it is preferred to utilize filamentary material of about 850,000 or lower at speeds of about 375 feet per minute. Of course it is understood that higher speeds may be employed if lower denier filaments are employed enabling one to attain line speeds of about 500 feet per minute or higher.

Although air has been referred to as the desired medium, any inert gaseous medium may be employed so long as it does not affect the properties of the material being cut. Because of economics and ease of handling, air is the preferred gaseous medium.

The method and apparatus of this invention is particularly useful in processing polyester tow, however, the present invention may also be employed on other manufactured fibers such as for example continuous filament polyamide yarns, modacrylic yarns, acrylic yarns, polyolefin yarns and cellulose ester yarns.

A still further understanding of this invention will be had from a consideration of the following examples which are set forth to illustrate the improvement of this invention.

## EXAMPLES

The Keith apparatus as hereinbefore described was utilized by running 800,000 denier polyester tow (1.5 denier per filament) at speeds of about 375 feet per minute and a product of variable openness was produced. The product had a quantity of bundles of filaments held together by crimp geometry, finish and/or other fiber to fiber forces which are called chips. The product also had a fiber density of from 25 to about 30.

The apparatus of this invention was utilized by running 800,000 denier polyester tow (1.5 denier per filament) at speeds at about 375 feet per minute and a product of uniform openness was produced. The product had a fiber density of from 10 to about 20.

The cutter employed in this example had a radius of 8.922 inch from the center line of the cutter to the circumference of a circle defined by the plurality of knife edges. With respect to the apparatus of this invention, a jet was directed to impinge air through a plurality of holes of three-fourths inch diameter so as to contact the cut material at a point 7 ⅜ inches from the center point of the cutter, 45° from the point of cut in the direction of cut material. Since the circumference of the circle defined by the knife edges in this particular apparatus was 60 inches, the 45° specified above would translate to 7.5 inches from the point of cut.

The point defined above was the natural doffing point of this apparatus at the speed set forth. In like manner air is directed upon the proximity of the doffing point with equally good results. The proximity of this particular doffing point would translate to an area preferably defined by a circle having a 2 inch radius with the center point being the natural doffing point hereinbefore defined.

The fiber density result hereinbefore mentioned is an arbitrary test which is of assistance in measuring "openness." In the test, cut fiber is allowed to collect in a screened cylinder placed under the picking apron on a picker/opener. The screened cylinder is then placed on a scale and fiber is removed until only one pound of fiber remains in the cylinder. A standard piston weighing one pound is then allowed to free-fall from the top of the test cylinder and the level attained by the piston is recorded and reported as "fiber density." Accordingly, lower numbers correspond to lower density and relatively more uniform openness and higher numbers correspond to higher density and relatively variable openness.

Although the invention has been described in considerable detail with particular reference to certain preferred embodiments thereof, variations and modifications can be effected within the spirit and scope of the invention as described hereinabove, and as defined in the appended claims.

What is claimed is:

**1.** In the method for cutting fibrous elongated material into a number of shorter lengths comprising continuously feeding the elongated material to a plurality of knife edges and extending the inner layer of the material across and in contact with each two adjacent knife edges of the plurality of knife edges so that the inner layer is in touch, lightly tensioned contact with the knife edges, applying a pressure against the material that is outwardly of the inner layer thereby forcing said inner layer against said knife edges and while retaining the inner layer in extended manner across said adjacent knife edges cutting said inner layer into said number of shorter lengths, the improvement comprising removing the shorter lengths away from said knife edges by directing at least one stream of air downwardly upon the proximity of the doffing point of the cut fiber the cut fiber being a material of uniform openness.

**2.** The method of claim **1** wherein from about 5 to about 22 standard cubic feet per minute of air is directed downwardly by means of an air jet.

**3.** The method of claim **1** wherein said elongated material is polyester tow.

**4.** In an apparatus for cutting material into predetermined lengths comprising a cutting assembly including

a plurality of knife edges secured to a reel having an upper and a lower mounting member and having means adapted to receive successive wrappings of material to be cut in contact with said plurality of knife edges and means for forcing said material between adjacent knife edges thereby severing said material into lengths of controlled dimensions the improvement comprising means for removing the severed material, said means comprising at least one air jet causing air to flow downwardly through a plurality of apertures in said upper mounting member and impinging upon the severed material in the proximity of the doffing point of said severed material.

5. The apparatus of claim 4 wherein said material is filamentary material.

6. The apparatus of claim 5 wherein said plurality of apertures are of the same number as said plurality of knife edges and are located individually centrally between each of said knife edges and above the proximity of the doffing point of said severed material.

7. The apparatus of claim 6 wherein at least one air jet is located in such a manner so as to cause air to impinge downwardly upon the doffing point nearest said means for forcing material between adjacent knife edges.

* * * * *