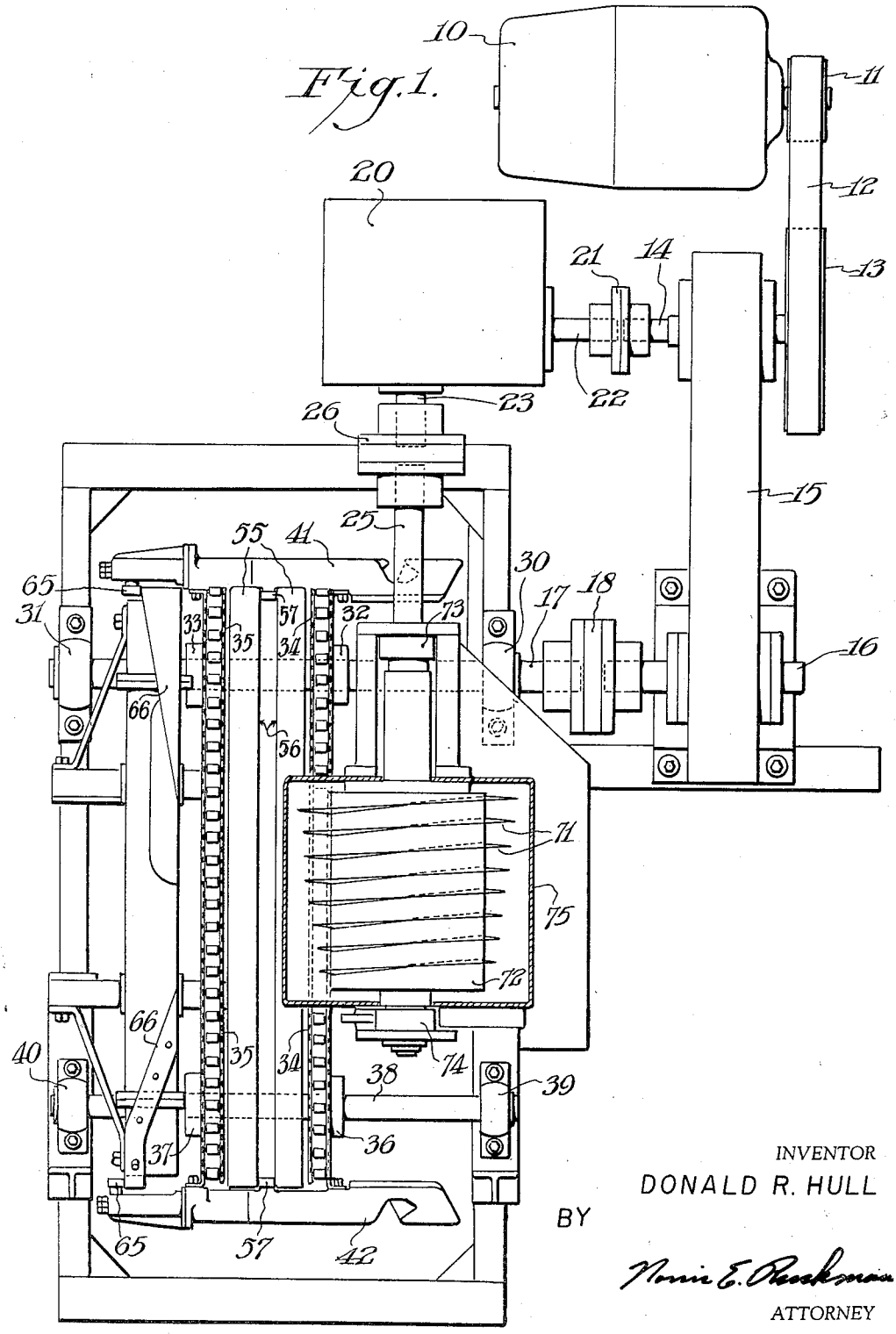
Nov. 16, 1954 D. R. HULL 2,694,447

HELICAL KNIFE APPARATUS FOR CUTTING A CONTINUOUS FILAMENT BUNDLE INTO STAPLE FIBERS OF UNIFORM LENGTH

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Fig. 1.



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Fig. 3.

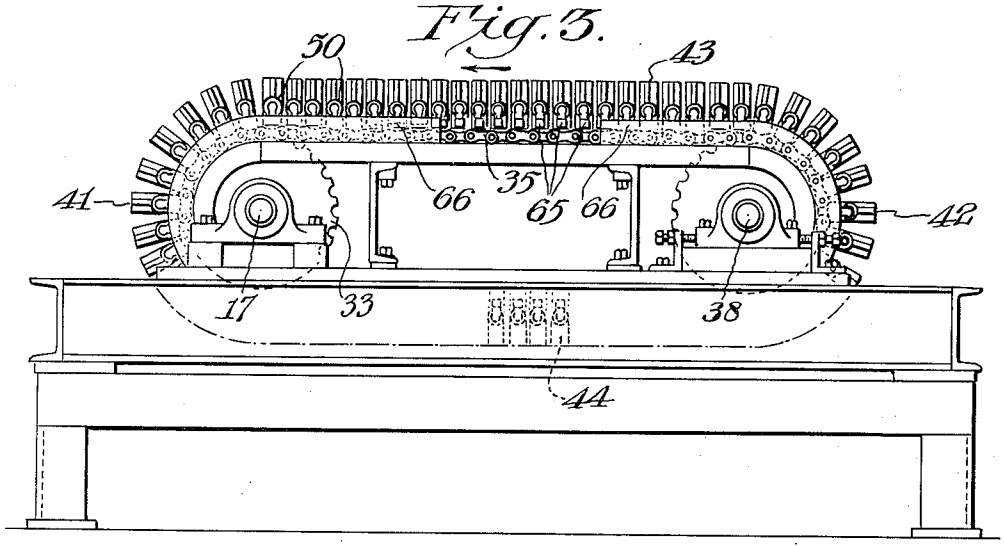
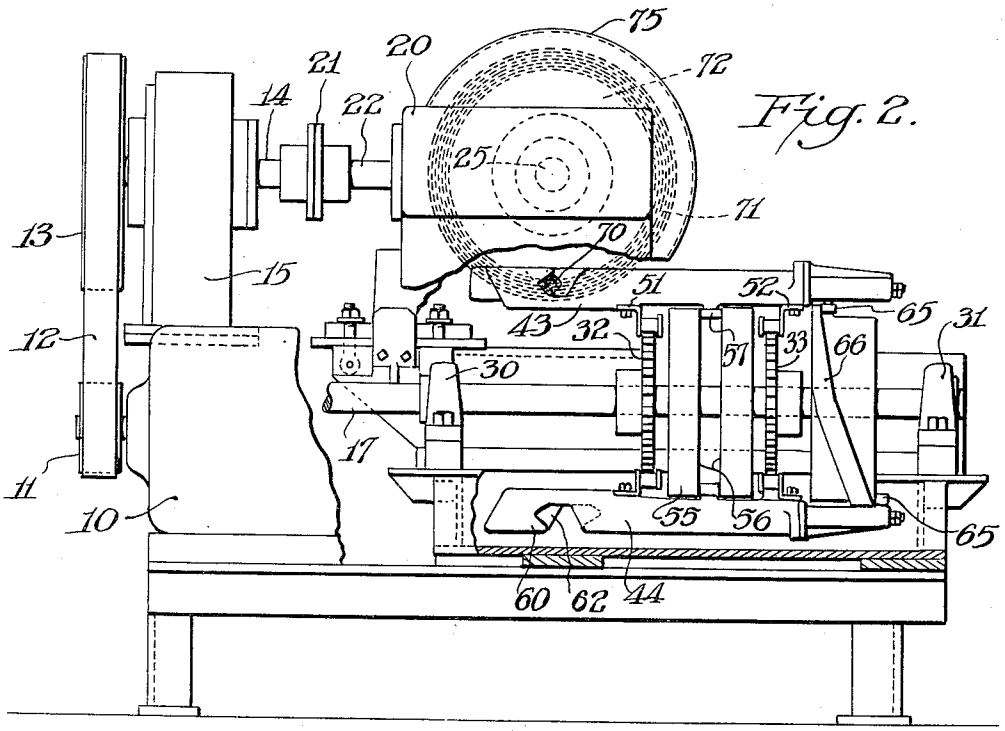


Fig. 2.



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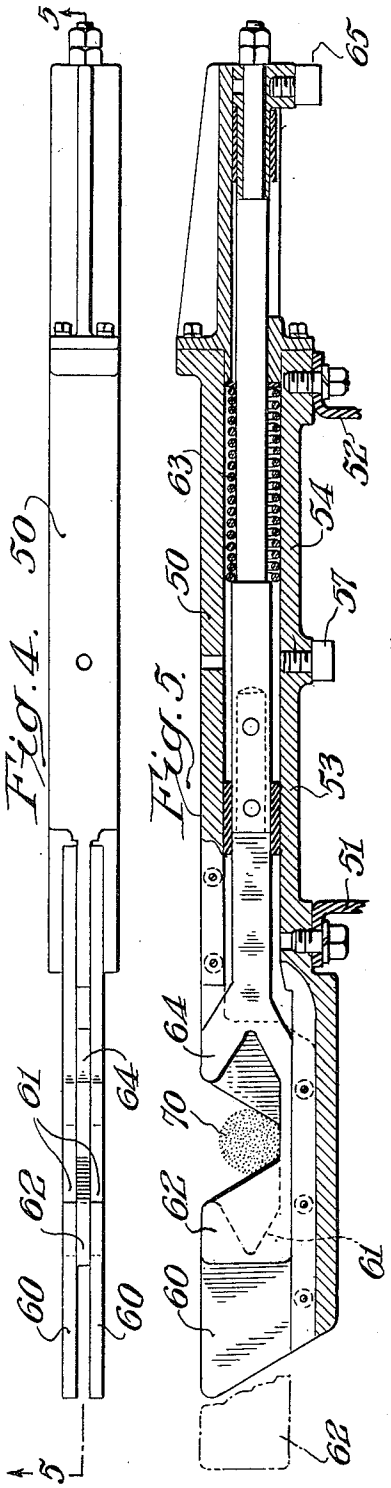
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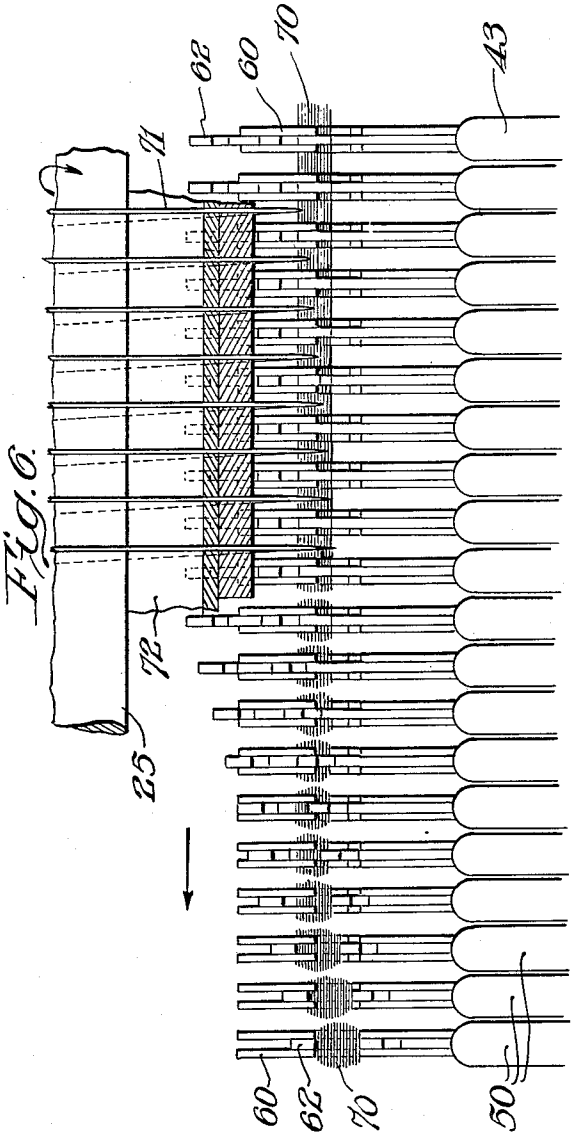
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HELICAL KNIFE APPARATUS FOR CUTTING A CONTINUOUS FILAMENT BUNDLE INTO STAPLE FIBERS OF UNIFORM LENGTH

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7 Claims. (Cl. 164—61)

This invention relates to apparatus for cutting elongated objects, such as ropes, rods or tubes, into uniform lengths, and is particularly concerned with apparatus for cutting bundles or tows of substantially continuous filaments into staple fiber of uniform length.

Artificial fibers are spun in continuous lengths, whereas most natural fibers are produced in short lengths. In order to blend the two types of fibers it is necessary to cut the artificial fibers into corresponding short lengths or staple. Also, staple is frequently desirable so that the artificial fibers can be processed like wool or cotton, and so that similar effects can be achieved in the products. Various devices have been used to cut continuous filaments into staple. These have all had disadvantages, especially when applied to cutting strong, tough polyamide or polyester fibers.

One type of prior art cutter will be referred to as a centrifugally fed cutter. The bundle of fibers is fed into the center of a device which is rotating at high speed. Passing outward under centrifugal force, the fibers are whirled at high speed against a stationary cutting edge. It has been found that the twisting action on the fiber bundle causes the outside fibers to be cut into longer lengths than the inside fibers. This becomes serious as the size of the bundle is increased. Another type of cutter is the flying knife cutter. Here the problem is to feed the fiber bundle at uniform speed in proper synchronism with the moving knife. With both of the above types the impact between the fiber bundle and the cutting edge produces rapid wear; this is particularly objectionable when cutting tough, highly delustered fibers.

Another type of cutter utilizes the slicing action of a helical knife cutter. Since there is no impact between the fibers and the cutting edge, and the cutting action is distributed over a considerable length of the cutting edge, wear is greatly reduced. Furthermore, the fiber bundle is positively fed to the knife and held while it is cut, so greater uniformity of staple length should be possible. Nevertheless, the helical knife cutter has not been used to any extent in this industry. The manner of gripping the fiber bundle between two wheels or cylinders has not been sufficiently firm to prevent slippage of the inner fibers, particularly when cutting large bundles, resulting in uneven lengths of staple. Also the fibers are fed around a curve so that the fibers nearest the circumferences of the feed wheels travel through a longer arc and are cut into longer lengths than the fibers nearer the axes of the wheels.

It is an object of the present invention to provide an industrially practical staple cutter of the helical knife type. A further object is to provide such a cutter which will efficiently cut a large bundle of continuous filaments into staple fiber of uniform length. Other objects will become apparent from the following description, the drawings, and the claims.

These objects are accomplished with an apparatus which comprises a conveyor belt for feeding a filament bundle or tow to a cutter, a plurality of filament clamping members for holding the bundle mounted at uniform intervals along the belt, a rotatable cutter having a helical cutting edge adapted to pass between said clamping members and sever a filament bundle held by the clamping members, driving means for advancing the belt and rotating the cutter in synchronism, and clamp-actuating means for closing the clamping members on the filament bundle and for opening the clamping members to release the cut staple.

In the drawings, which illustrate a preferred embodiment of the invention,

Figure 1 is a plan view of an apparatus in accordance with this invention,

Figure 2 is an end view of the apparatus shown in Figure 1.

Figure 3 is a side elevation of the apparatus with certain of the parts removed to show the conveyor belt and clamping members,

Figure 4 is a detailed plan view of one of the clamping members shown in the above figures,

Figure 5 is a cross-sectional elevation of the clamping member taken on the line 5—5 of Figure 4, and

Figure 6 is a perspective detail showing how the helical knife cutter and clamping members cooperate in cutting a tow.

Referring to Figure 1, electric motor **10** provides the driving power for the apparatus. Motor pulley **11**, operating through belt **12**, turns pulley **13** on drive shaft **14**. Shaft **14**, through speed reducer **15**, drives shaft **16** which transmits power to conveyor belt shaft **17**. The ends of shafts **16** and **17** are united through flexible coupling **18**. Drive shaft **14** also supplies power to the cutting mechanism through a second speed reducer **20**, which is coupled to drive shaft **14** by flexible coupling **21** and shaft **22**. The output shaft **23** of this speed reducer engages cutter shaft **25** through flexible coupling **26**.

Conveyor belt shaft **17** is supported at the ends by bearings **30** and **31**. Mounted on the shaft are drive sprocket wheels **32** and **33** which support and drive continuous link belts **34** and **35**, respectively. The link belts comprise the conveyor belt for feeding the bundle of filaments to the cutter. They also run over idler sprocket wheels **36** and **37** which support the belts so that they run through a horizontal path from the drive sprocket wheels. The idler sprockets are mounted on shaft **38** which turns in bearings **39** and **40**. These belts support clamping members for holding the filament bundle. For the purposes of clarity only two such clamping members **41** and **42** are shown in Figure 1, in positions at the extreme ends of the travel of the belts. In Figure 2 the clamping members **43** and **44** are shown at top and bottom positions, respectively. Actually these clamping members are mounted at closely spaced intervals all the way along the belts as shown in Figure 3. These clamping members are identical in construction.

The construction of an individual clamping member is shown in Figures 4 and 5. The clamping member comprises a hollow frame member **50** which is bolted to the link belts by means of angle irons **51** and **52**. Frame member **50** slides on surfaces **53** and **54** over a guide track **55**, best seen in Figure 2, which conforms to the path of the belts. A groove **56** is cut into the track to receive roller **57**, mounted on the clamp frame to prevent longitudinal displacement. A slotted frame extension **60** is arranged at one end of frame **50** and is cut out to form a stationary jaw **61**. A spring-loaded finger member **62** slides back and forth in the slot of frame member **50**, being urged in one direction by spring **63**. One end of sliding member **62** is cut into a movable jaw **64** arranged to cooperate with stationary jaw **61**, and the other end of the member is provided with a cam roller **65** for pulling the member back against the action of the spring. This cam roller rides against cam surface **66**, as shown in Figure 2. During the upper horizontal pass of the clamping member the cam surface is shaped to permit the spring **63** to push the sliding member **62** to the left as seen at the top in Figure 2. But, as the clamping member travels around shaft **17** at one end of its path, the cam surface causes the cam follower or roller **65** to move to the right and pull the member **62** to the position shown at the bottom of Figure 2 and in solid lines in Figure 5. The member **62** remains in this position until it has completed its lower horizontal travel and passed around shaft **38**, as is evident from the position shown at the bottom of Figure 1.

A filament bundle, indicated by **70** in Figure 5, is laid in the jaws of the clamping member as the member starts on its upper horizontal path of travel. The jaws are open to their fullest extent at this point as shown in Figure 5. The cam surface then releases the roller **65** and the filament bundle is gripped between the V-shaped portions of

the jaws under pressure of the spring **63**. The position of the jaws is then as shown at **43** in Figure 2. The spring closing makes it possible for the clamping member to grip a variety of bundle sizes securely. After the filaments are cut the cam action operates to open the jaws and release the bundle. The surfaces of the jaws now bearing against the bundle slope outward to positively expel the bundle. This shape provides a self-cleaning feature, as will be apparent from Figure 5.

The cutting mechanism shown in Figures 1 and 2 comprises a helical cutter **71** mounted in head **72** on cutter shaft **25**. This shaft is suitably driven as previously described and is supported on each side of the cutter head by bearings **73** and **74**. A cover **75** surrounds the cutter except at the bottom. The cutter head may suitably be constructed of a number of sleeves machined to the desired helix angle and adapted to be bolted in proper position to hold the cutter. The cutter may be built up of a series of annular disk blades made discontinuous by a radial cut. Alternate sleeves and blades are then assembled on the head and bolted together to form a continuous multiple-turn helical cutter. The blades are ground to provide a cutter of gradually increasing radius as shown in Figure 1. The cutter is supported with shaft **25** directly over and parallel to the path of the filament bundle so that the first portion of the cutting edge barely touches the bundle and the last portion of the edge cuts completely through the bundle.

The cutter must cooperate with the clamping members so that the blades extend between them and rotate at a rate which will keep each portion of the blades doing the cutting midway between adjacent clamping members. This action is shown in Figure 6. The filament bundle **70** has been engaged by the clamping member **43** and is being conveyed to the left toward the cutter **71**. The cutting edges of the cutter are spaced apart at a distance equal to the length of staple desired and slice through the bundle to gradually increasing depths as the cutter is revolved by the rotation of shaft **25**. The clamping members are spaced a corresponding distance apart and are moved to the left at the proper rate to remain midway between cutting edges, i. e., so that a clamping member will remain at the same distance from the adjacent operating portion of the revolving cutting edge.

By the time the filaments have passed beyond the cutter they have been cut into bundles of staple which are still held by the clamping members as shown. The cam now begins to operate and the clamping jaws gradually open. When the end of the travel is reached the jaws have opened and the staple is dumped. The clamping members are continuously returned to the original position to grip the filament bundles and repeat the cycle as described.

The multiple-turn helical cutter has been shown and described, but usually a one-turn helical cutter blade can be used satisfactorily. Preferably the cutter blade increases gradually in radius, as disclosed, to gradually slice through the filaments and thereby distribute the work along the length of the cutting edge. However, a similar result may be achieved in a less satisfactory manner with blades of uniform radius by mounting the cutter shaft **25** at a slight angle to the travelling filaments, instead of parallel as shown. When assembling the cutter, cracking of the knife blades can be avoided by providing them with radial slots which increase in length as the radius increases. In this way a one-turn blade can be made sufficiently flexible to pull out to any lead up to 5 inches without preforming.

The required synchronism between the rotation of the cutter and the movement of the clamping members is obtained by the speed reducers **15** and **20** discussed in connection with the driving mechanism. A given cutting unit may be converted to cut lengths which are multiples of the spacing of the clamping members by using cutters having a pitch of 2, 3 or more times that shown. The cuts will then include a corresponding number of clamping members between cuts instead of a cut being made between each clamping member. For other staple lengths both the pitch of the cutter and the spacing of the clamping members will need to be changed. Proper synchronization of the two will, of course, be obtained by changes in the speed reducers as necessary.

The cut staple may be removed from the machine by

any conventional means, such as a gravity chute or a suction duct located at the point of release by the clamping members. Removal of material from the members can be facilitated if necessary by an auxiliary jet of fluid or by mechanical means such as a moving rubber-bladed paddle, a rotating rubber disk or a bristled disk, so arranged as to dislodge the material when the clamping jaws open.

The helical cutting apparatus of this invention is of particular value in assuring uniform lengths of staple. It is well known in the art that the presence of lengths ¼" or more longer than the normal length is detrimental to the quality of the yarn spun, especially when processing on the cotton system, and the greater the difference between the long cuts and the short cuts, the greater becomes the bad effect. The bad effect shows up as nonuniformity in the fiber roving and yarn but chiefly as ends broken down in spinning or as cockles (very thick places of high twist) in the yarn. Results showing the marked improvement obtained by using the helical cutting apparatus of this invention is shown in Table I.

Table I

Cutter Used	Helical Knife	Centrifugally fed
Count Spun (cotton system)	30/1	30/1
Denier per Filament	3	3
Staple Length, Inches	1½	1½
Ends Down per 1,000 Spindle Hours	107	132
Cockles Due to Long Ends, per 1,000 Spindle Hours	438	3,690

Another advantage of the helical knife cutting apparatus of this invention is the large production rate which can be achieved even when cutting relatively short lengths of staple fibers, e. g., see the comparison between the centrifugally fed and the helical cutter in Table II.

Table II

Cutter Used	Helical Knife	Centrifugally fed
Length Cut, inches	1½	1½
Total Tow Denier	2,000,000	170,000
Throughput, yds./min	60	143
Production, lbs./hr	1,700	330

In the table the tow denier was taken as 2,000,000. Actually, there appears to be no obvious limit to the number of ends which can be cut simultaneously on the helical cutter and it probably depends only on the size and effectiveness of the clamping jaws and the size of the knife blades. In contrast, the centrifugally fed cutter is limited by the twist imparted to the tow by the rotation of the rotor. When large tows are used the outer filaments are appreciably longer than the center ones (one turn per cut) when any given tuft is untwisted. This becomes noticeable for tows ⅜" in diameter and serious when cutting a million and a half denier (¾" dia. rope).

In the preferred mode of operation for the apparatus of this invention the speed of the clamp chain is maintained constant, e. g., 60 yds./min., as shown in Table II, to simplify the changes necessary when going from the cutting of one staple length to the cutting of a different length staple. Thus, when holding the speed of this clamp chain constant, the staple length depends only upon the pitch of the helical knife. The forward linear speed at which any point on the helix of the knife advances must, of course, be equal to the speed of the clamp chain and this is achieved by using the appropriate change gears in speed reducer **20** so as to mesh the knife with the proper clamp chain assembly. Another particular advantage of the apparatus of this invention is the easy interchangeability which permits the changing over from one staple length to a different staple length in a matter of only a few minutes. The cutter and conveyor sub-assemblies can easily be changed and properly located on the main base. Hard steel locating pads may be provided to precisely locate the knife unit on the base or the clamp chain sub-assembly on its base. Hinged swing bolts may be used to make the units fast. Power may be delivered to the knife unit

and to the chain unit through block-type or other suitable couplings which are quickly and easily separated by lifting apart. Both the knife and the chain subassemblies may be equipped with locating pads and pins which pre-position the mechanism so that they match with the proper couplings and mesh properly the one with the other.

As many different embodiments of the present invention may be made without departing from the spirit or the scope thereof, it is to be understood that the invention is not limited to the specific embodiments disclosed except to the extent as defined in the appended claims.

What is claimed is:

1. Apparatus for cutting a continuous filament bundle into staple of uniform length which comprises a helical knife cutter provided with a cutting edge having a helix pitch equal to the desired staple length, said helical cutter being mounted for rotation about the helix axis, driving means for rotating said cutter, a conveyor belt arranged to advance past said cutter along an adjacent straight path substantially parallel to said axis of rotation, a plurality of clamping members for holding a filament bundle mounted at uniform intervals along said belt in position for said cutting edge to pass between adjacent members during cutting of the filament bundle, said members having clamping jaws adapted to close on a filament bundle with a positive gripping pressure to hold the bundle together in position for cutting, clamp-actuating means for successively closing the jaws of said clamping members on a filament bundle as each member reaches a given point in the advance toward said cutter and for successively opening the jaws of said clamping members as each member reaches a given point beyond said cutter, and driving means for advancing said belt in synchronism with rotation of said cutter so that a clamping member will remain at the same distance from the adjacent operating portion of said cutting edge during cutting of filaments held by that member.

2. Apparatus as defined in claim 1 in which each of said clamping members is adapted to hold a filament bundle between a movable spring-loaded finger and an opposing fixed jaw.

3. Apparatus as defined in claim 1 in which said cutter has a helical cutting edge of gradually increasing radius from the portion where cutting is initiated and is arranged to sever the filaments of an advancing bundle with a saw-like motion.

4. Apparatus as defined in claim 1 in which said driving means operate to advance said belt and to rotate said cutter continuously to provide for continuous cutting of filaments into staple.

5. Apparatus as defined in claim 1 in which said clamp-actuating means comprises cam followers attached to movable portions of each of said clamping members, each of said arms being movable to open the jaws of the clamping member against the action of a spring, and a cam surface arranged to press against said arms to open the jaws for releasing cut staple, and arranged to release said arms when the jaws are again in position to grip the filament bundle being fed to the cutter.

6. Apparatus for cutting a continuous filament bundle into staple of uniform length which comprises a rotatable knife cutter having a helical cutting edge of gradually increasing radius and a pitch equal to the length of staple to be cut, conveyor means for transporting a filament bundle along a path substantially parallel to the axis of rotation of said cutter in position to be cut when said cutter is rotated said conveyor means including a plurality of filament clamping members provided with jaws shaped for gripping a filament bundle mounted at uniform intervals along said conveyor corresponding to the pitch of said cutting edge, driving means for advancing said conveyor and rotating said cutter in proper synchronism to sever filaments between said clamping members, cam-actuated means for holding said jaws open at positions removed from the cutter, and spring-actuated means for closing said jaws while in proximity to the cutter to grip a filament bundle during severing of the filaments by the cutter.

7. In an apparatus for cutting a continuous filament bundle into staple, the combination of a rotatable knife cutter having a helical cutting edge, a conveyor belt passing through a path substantially parallel to the axis of rotation of said cutter and adjacent to said cutting edge, a plurality of filament clamping members provided with jaws adapted to close on and grip a filament bundle mounted at uniform intervals along said belt in position to hold a filament bundle against said cutting edge, clamp-actuating means for closing said jaws on a filament bundle prior to the cutter and for opening the jaws after the cutter to release the cut filaments, and driving means for rotating said cutter and moving said belt past the cutter in proper synchronism to feed a filament bundle continuously to the cutter, cut the filaments into staple, and release the cut staple.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,510,729	Weisner	Oct. 7, 1924
2,187,791	Lipps	Jan. 23, 1940
2,547,157	Gibbons	Apr. 3, 1951

FOREIGN PATENTS

Number	Country	Date
639,466	Great Britain	June 28, 1950