Jan. 31, 1967 J. A. HANCOCK 3,301,974

DEFECT SENSING DEVICE

Filed Dec. 14, 1964

Fig. 1.

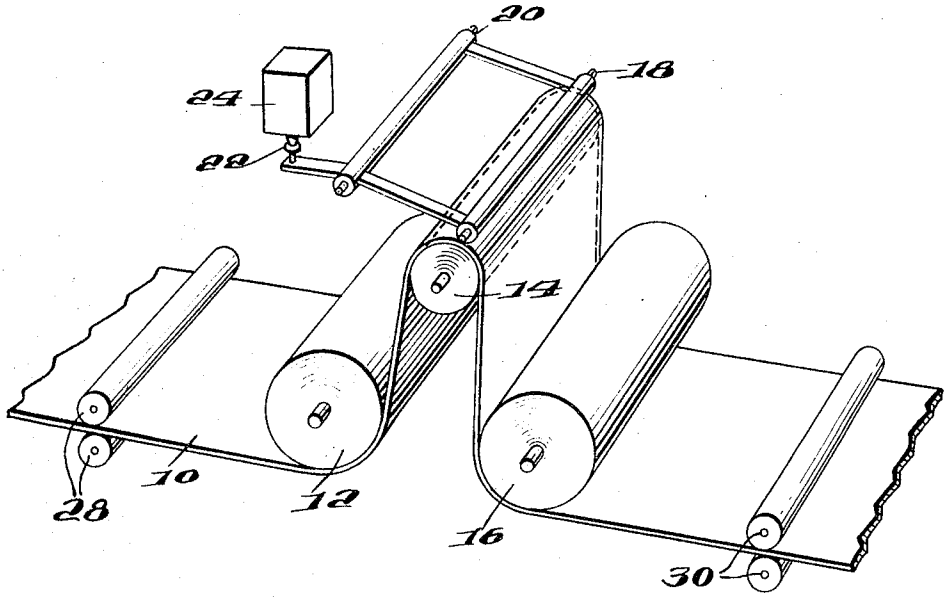


Fig. 2.

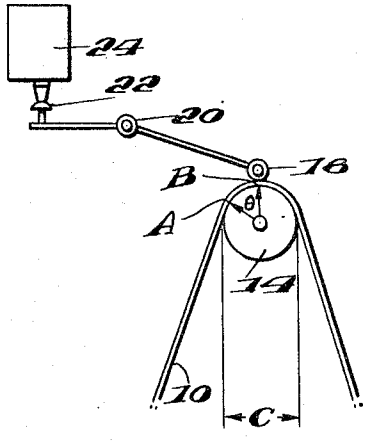
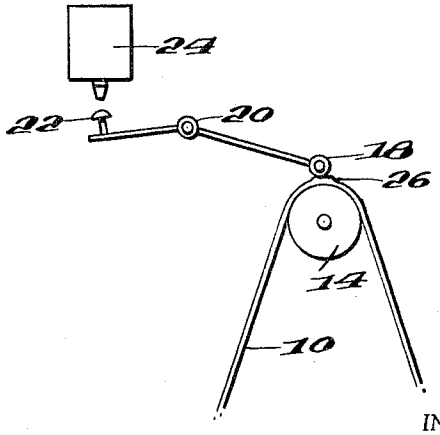


Fig. 3.



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DEFECT SENSING DEVICE

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This invention relates to improved means for detecting non-uniformities and defects in filamentary tow.

Advantageous use of continuous filamentary tow in processes adapted to convert tow into sliver and yarns requires a very high degree of uniformity in the tow. The processes for tow manufacture offer many opportunities for non-uniformities to develop and even the best attainable process control will not be successful in removing every significant non-uniformity.

Devices to detect non-uniformities in a moving tow are known and generally employ a roller across which the tow is drawn and a second, dancer roller which rides on top of the tow so as to provide a measurement of tow thickness as a function of the separation of the two rollers as the tow passes therebetween. None of these devices has been completely satisfactory in detecting the smaller defects, resulting from a minor knot or crimper damage, for example, without such extreme sensitivity that non-existent defects were frequently indicated. The prior art devices are either completely insensitive to these defects or are so unstable when adjusted to high sensitivity as to indicate defects where none are present. A particular inadequacy of these devices is their inability to detect non-uniformities which result in the stiffening of the tow without any appreciable effect on thickness. These stiffened portions may result from the fusion of several filaments and their detection is important.

An object of this invention is to provide improved means for detecting non-uniformities in filamentary tow. A further object is to provide a means for positive detection of non-uniformities which result in stiffening of the tow without any appreciable effect on thickness. Other objects will appear hereinafter.

The objects of this invention are accomplished by apparatus which comprises, in general, roll means having a diameter of no more than about 1½ inches, means to forward a filamentary tow around the roll means at no less than about a 45° advance wrap angle and sensing means operably disposed a predetermined distance from the roll means, the sensing means being capable of signaling a response when a non-uniformity contacts the sensing means. The term "advance wrap" is meant to define the angle between (1) the radius drawn from the point where the filamentary tow initially contacts the roll means and (2) the radius bisecting the sensing means at the point where the sensing means is a predetermined distance from the roll means.

The present invention includes the discovery of the major difficulties in the devices available heretofore. These devices are not able to provide, at the point of defect detection, an accurate representation of the tow i.e., the tow is distorted in such a manner as to hide defects and/or movements of the tow ("flutter") at the point of defect detection result in instability. A further difficulty exists due to the fact that the large-diameter rolls, usually employed, permit close compliance to the curvature thereof of small, stiff segments of tow.

The present invention's combination of large advance angle and small roll-diameter cooperate to overcome these deficiencies.

For a given level of tow tension, the tow is more firmly compressed against the roll with a larger advance angle of wrap. This more firm contact with the roller serves several desirable purposes. First, because many defects are relatively incompressible, the compressed tow of generally reduced thickness emphasizes the unreduced defects. Second, the tow is in firmer contact with the roll and does not "flutter" (i.e., the uniform tow does not move away from the roll at point of defect detection). The use of an advance wrap angle of no less than about 45° has been found to be essential to achieve these desired results.

The small roll diameter (i.e., less than about 1½ inches) has been found to be essential to the detection of the stiff segments of tow. Since they fail to conform to the greater curvature of these small diameter rolls, the leading end of such a defect rises somewhat above the roll surface. Although "flutter" of uniform tow is undesirable, the movement of the leading end of these stiff segments advantageously exaggerates the thickness of the tow and allows detection of this type of non-uniformity. The cojoint use of a small roll diameter and the advance wrap angle greater than about 45° is necessary (e.g. there would be no appreciable raising of the leading end of a stiffened defect if the advance wrap angle was very small) to accomplish the desired results of the present invention.

In the preferred embodiment, the filamentary tow is subjected to a tension of about 0.002 to about 0.006 gm./denier with about 0.004 gm./denier being preferred.

For a clearer understanding of the invention, reference can be had to the accompanying drawings in which:

FIGURE 1 is a schematic of one embodiment of this invention,

FIGURE 2 is a side elevation of part of the embodiment illustrated in FIGURE 1, and

FIGURE 3 is a side elevation illustrating the passage of a non-uniformity.

With reference to FIGURE 1, filamentary tow **10** from supply means **28** (illustrated as a pair of feed rolls) is led under approach roll **12**, over roll **14** and under follower roll **16** and to forwarding means **30** (illustrated as a pair of draw rolls). These roll pairs (**28** and **30**) combine to provide a means to place the desired tension on the filamentary tow. Floating shoe **18**, pivoted around line **20**, is positioned above roll **14** and the clearance therebetween is adjusted to the precise value required by means of adjusting screw **22**. In this embodiment, the weight of floating shoe **18** is such that switch **24** is normally kept closed by contact with adjusting screw **22**. FIGURE 2 is a side elevation illustrating the "normal" position of floating shoe **18**. Floating shoe **18** is operably disposed above roll **14** at a distance preferably equivalent to the thickness of filamentary tow **10**. The advance wrap angle θ is the angle between the radius drawn from the point A where the filamentary tow **10** initially contacts the roller **14** and the radius bisecting the floating shoe **18** at the point B. Advance wrap angle θ is no less than about 45°. The diameter C of roller **14** is less than about 1½ inches. Adjusting screw **22** is in contact with switch **24**. Referring to FIGURE 3, there is shown the passage of a non-uniformity **26**. As non-uniformity **26** contacts floating shoe **18** the contact between adjusting screw **22** and switch **24** is broken.

The operation of the apparatus of this invention should be readily apparent from the description hereinbefore. The distance between floating shoe **18** and roll **14** is adjusted to the thickness of filamentary tow **10** by means of adjusting screw **22**. The weight of floating shoe **18** maintains adjusting screw **22** in contact with switch **24** in the normal position. When a non-uniformity or a defect passes through the embodiment, the non-uniformity contacts floating shoe **18** thereby breaking the contact between adjusting screw **22** and switch **24**.

Sensitivity of the apparatus of this invention can be easily adjusted. Obviously, the closer the distance between floating shoe **18** and roll **14** approaches the actual thickness of filamentary tow **10**, the smaller will become the limiting size of non-uniformities detected. Thus, ex-

tremely minor defects which are without consequence to subsequent operations can be "tuned out."

A simple application of this invention would involve connection of switch **24** to a relay which controls the power fed to the forwarding means. In this case the process would be stopped and the defect found a certain reliable distance downstream from the apparatus. Where extremely small defects must be removed, detection by eye may pose a problem. It is within the scope of this invention to employ a marking device to provide a very precise pinpointing of the defect. The marker may, for example, consist of a pen, brush, or pressure spray can mounted in such a manner as to be urged into contact with the tow or to have a valve opened momentarily when the defect passes, as signaled by the opening of switch **24** by the defect. With such an arrangement, interruption of the process might be avoided and removal of the clearly identified defect postponed until a later stage of processing.

In a direct comparison, the apparatus of this invention pinpointed 10 defects in 10,500 yards of filamentary tow while the same apparatus having an advance wrap angle of only 10° detected but one, very noticeable defect.

The tension placed on the filamentary tow must only be such as to enable an approach to the approximate theoretical thickness but should not be so large as to accomplish any orienting or stretching.

It should be obvious that defects other than those having a difference in thickness in relation to the filamentary tow can be measured. For example, non-uniformities which are stiffer than the remainder of the filamentary tow do not bend around the wide wrap as fast as the more pliable tow and thereby contact the floating shoe. Also, it should be apparent that approach roll **12** becomes unnecessary if the tow supply means is arranged to provide the minimum required advance wrap angle around roll **14**.

It should be pointed out that the floating shoe can be of any convenient design. It does not have to be in the form of a roller since the floating shoe is not riding on the filamentary tow but is disposed adjacent thereto.

As hereinbefore indicated, the advance wrap angle should be at least about 45°. The exact angle which is selected depends upon the sensitivity which is desired. Additionally, since only the advance wrap angle is critical, it should be apparent that follower roll **16** is not essential, but is a mere matter of choice.

It will be obvious that many variations in the specific embodiment illustrated may be employed without departing from the spirit and scope of this invention and it is to be understood that the invention is not to be limited except to the extent defined in the following claim.

What is claimed is:

An apparatus for detecting stiff segments in filamentary tow of substantially uniform thickness which comprises:

(1) roll means having a diameter of no more than about 1½ inches,

(2) means to place a tension of from about 0.002 gm./denier to about 0.006 gm./denier on said filamentary tow,

(3) means to forward the tensioned filamentary tow around said roll means at above a 45° advance wrap angle,

(4) a floating shoe operably disposed a predetermined distance from the outer periphery of said roll means to signal a response when a leading edge of a stiff segment of filamentary tow rises away from the surface of said roll means, and

(5) switch means positioned relative to said floating shoe and actuated thereby.

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R. N. ENVALL, JR., *Assistant Examiner.*