Sept. 19, 1967 J. E. BANCROFT 3,343,008

FILAMENT TENSION MONITORING DEVICES

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FIG. 1

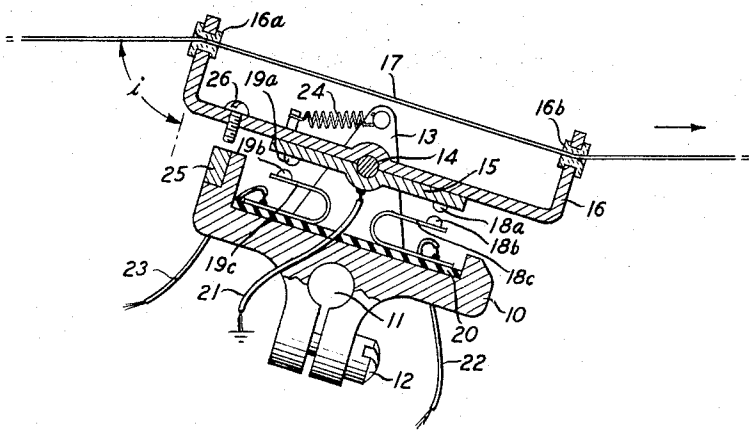
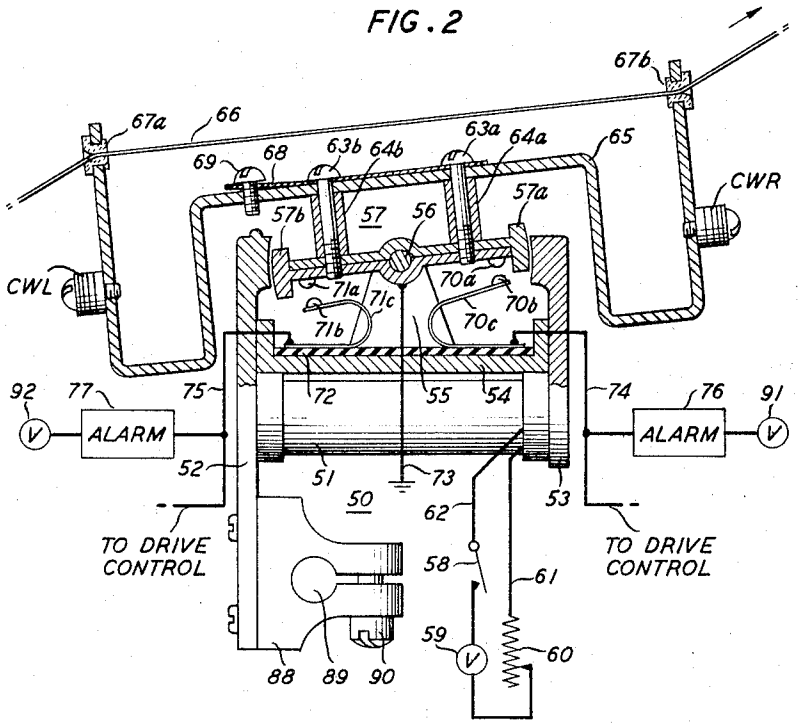


FIG. 2



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FILAMENT TENSION MONITORING DEVICES

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FIG. 3

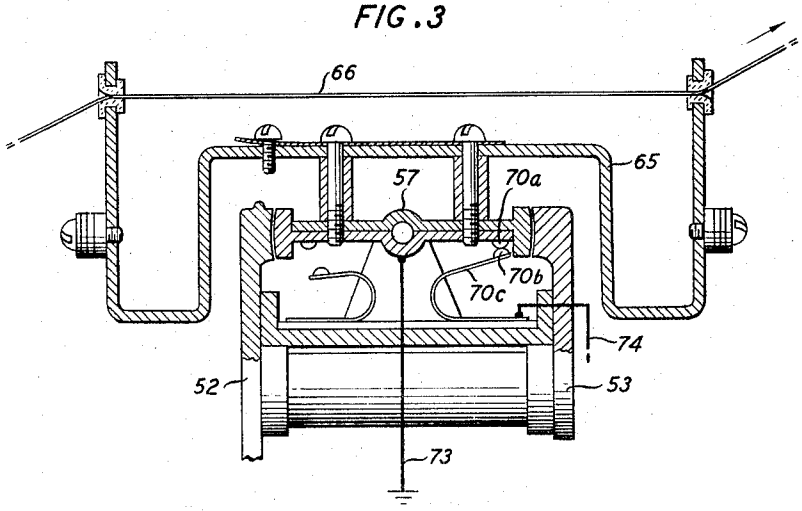


FIG. 4

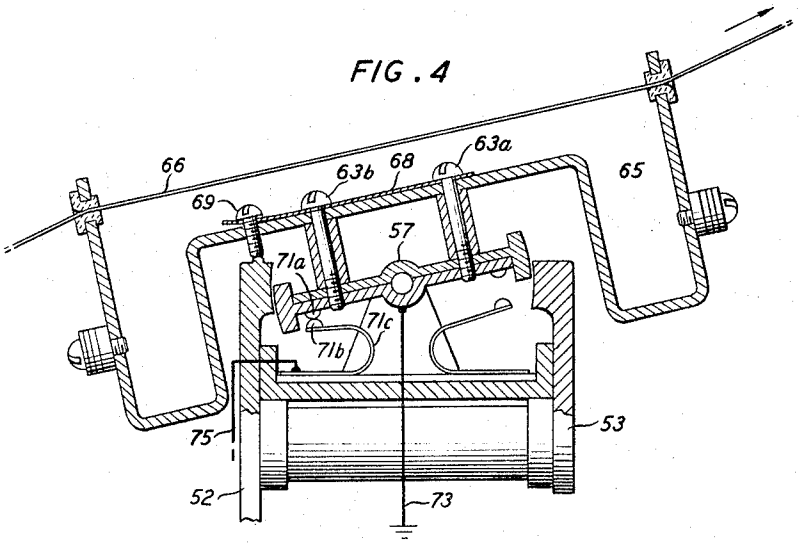
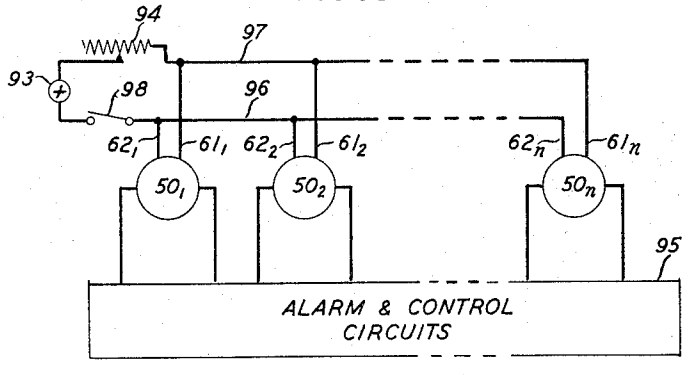


FIG. 5



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FILAMENT TENSION MONITORING DEVICES

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20 Claims. (Cl. 307—119)

ABSTRACT OF THE DISCLOSURE

A preselected component of the tension applied to a monitored filament applies a torque to a rotatable filament guide arm. An opposing force is applied to the arm by a selectable magnetic couple established between an armature attached to the guide arm and at least one pole piece. When the tension applied to the monitored filaments exceeds a predetermined value, the guide arm rotates in a first direction to close an electrical circuit which operates an alarm and/or stop motion device. Similarly, when the tension applied to the monitored filaments falls below a predetermined minimum value, the guide arm rotates in a second direction to close an electrical circuit which operates the alarm and/or stop motion device.

The present invention relates to tension monitoring devices and more particularly to such devices utilized to monitor the tension applied to filaments.

The manufacturing processes of many industries require the rapid transfer of filaments from supply spools or reels to a processing machine. In many of these operations it is imperative that the tensions applied to the moving filaments be uniformly regulated within close tolerances. In the textile industry, for example, hundreds of yarns are simultaneously drawn from individual spools located in a creel to a beaming machine to produce a warp. It is essential in such operations that the tensions applied to the individual yarns be uniform, and accordingly a tensioning device is generally associated with each of the individual yarns to regulate the tension applied thereto. If, however, these tensioning devices fail to function properly or are incorrectly operated, differences in tensions applied to the yarns may result. These differences in tension cause the production of defective warps when the looser yarns pile up and overlap the tighter yarns.

Serious difficulties are also encountered in the textile industry when the tensions on one or more of a large number of rapidly moving yarns in the beaming of a warp, for example, increase to the point where the yarns break. The resulting loose yarn ends snap and recoil and become entangled witn the other yarns, causing a serious entanglement.

In order to minimize the degree of entanglement resulting from the breakage of yarn in operations involving large numbers of rapidly moving yarns, the textile industry has in general utilized "stop motion devices" which are actuated in response to the breakage of a yarn to halt the processing machines. Many of the known stop motion devices also control the application of brakes to the supply spools to prevent an excess amount of slack yarn from being paid out and adding further to the entanglement when the processing machine is halted.

A characteristic common to many of the known stop motion devices is that they operate only on an "after the fact" basis, that is, they operate only in response to the loss or reduction in yarn tension resulting from the breakage of a yarn. When such a breakage occurs, the processing machine must be stopped, the resulting entanglement of yarns must be straightened out, and the loose ends of the broken yarns must be rejoined, all of which necessitates a costly interruption in production. Thus the known stop motion devices of this type do not prevent these difficultties but only minimize a further compounding of these and other difficulties.

The breakage of a rapidly moving filament is preceded by an increase in tension. Thus a filament tension monitoring device is needed which can detect such an increase in tension prior to its reaching the breaking point of the filament and which will operate an alarm and/or a stop motion device to halt the movement of the filament before filament breakage occurs. This will permit the cause of the tension increase to be determined and corrected before filament breakage occurs. In this manner the entanglement caused by broken filaments can be avoided and the interruption in production reduced to a minimum.

In some textile operations the same type or size of yarn is utilized year in and year out to produce the same type of fabric. Thus there is a need for a monitoring device which will monitor rapidly moving filaments for excessive as well as deficient tensions and which after an initial adjustment for the desired tension range needs no further adjustment. The primary requirements for this type of filament tensioning monitoring device are speed of actuation and reliability. Because large numbers of such monitoring devices are utilized in textile operations of this type, the cost of such a device is also a prime consideration.

Some operations in the textile industry, on the other hand, require frequent changes in the type or size of yarn utilized. Any change in the type or size of yarn generally necessitates a change in the monitored tension of the associated tension monitoring devices. Thus there is a need for a monitoring device which will monitor a rapidly moving filament for excessive as well as deficient tensions, which is fast acting, reliable, and economical, and which in addition may be adjusted from a common control simultaneously with a plurality of like devices to monitor for a different tension.

Many of the currently used tension monitoring or stop motion devices are not adjustable for the different tensions required for various types and sizes of yarn and must be replaced with a different device having the required tension rating when a different type or size of yarn is to be monitored. A disadvantage of the known stop motion devices which can be adjusted to respond to different tensions is that all require mechanical apparatus to effect such adjustments. For example, some of the known stop motion devices which utilize biasing springs to control the monitored tension require screw adjustments coupled to the spring to change the monitored tension. Other known devices utilize counterweighted lever arrangements and provision is made for shifting the position of counterweights to adjust the tension at which devices respond. All of these mechanical arrangements add significantly to the cost of the known adjustable stop motion devices. A further disadvantage of the known adjustable stop motion devices is that the devices must be individually adjusted or set and a plurality of the devices cannot be simultaneously adjusted from a common control. In operations involving hundreds of yarns this is a time consuming operation and is susceptible to errors.

The above described needs, difficulties, and problems of the textile industry are also found in the wire and cable industry. For example, in the manufacture of stranded wire or cable a plurality of strands are simultaneously fed from individual supply reels to a stranding machine. If the tensions applied to the individual strands are not uniform, imperfections in the resulting stranded cable will result. Similarly, if during the operation of a

stranding machine one or more of the rapidly moving strands should break as a result of excessive tension, the loose ends of the broken strands become seriously entangled with the remaining strands necessitating a costly halt in production. The stop motion devices utilized in the wire and cable industry to minimize these problems also have limitations and disadvantages similar to those described above. Similar needs, problems, and difficulties are also encountered in the manufacture of rope and in the winding of coils utilized in the electrical industry for inductors and for the electromagnets of relays and solenoids.

It is an object of the present invention to provide improved filament tension monitoring devices which will fulfill the above described needs and which will alleviate the above described problems and difficulties.

It is an object of the present invention to provide improved filament tension monitoring devices that are inexpensive to manufacture, fast and reliable in operation, and inexpensive to maintain.

It is another object of the present invention to provide improved filament tension monitoring devices which will detect a trouble condition or a malfunction that is evidenced by an increase in tension in a moving filament before such an increase in tension reaches the breaking point of the filament and to operate an alarm and/or a stop motion device.

It is also an object of the present invention to provide improved filament tension monitoring devices which monitor for deficient tensions and filament breakage as well as excessive tensions.

It is a further object of the present invention to provide improved filament tension monitoring devices which may readily be adjusted to monitor for both deficient and excessive tensions over the wide range of tensions required for different types and sizes of filaments.

It is still a further object of the present invention to provide an improved filament tension monitoring device which may be adjusted to monitor for a predetermined range of deficient and excessive tensions simultaneously with a plurality of like devices by a common control.

The foregoing and other objects are attained in illustrative embodiments of filament tension monitoring devices in accordance with the invention, each of which comprises a longitudinal arm mounted for rotation about a transverse axis intermediate the ends of the arm. Attached to the arm are two electrical contacts, one of which completes an electrical circuit when the arm is rotated a predetermined distance about its axis in a first direction and the other of which completes an electrical circuit when the arm is rotated a predetermined distance about its axis in a second direction.

Also attached to the rotatable arm is a filament guide through which the filament under tension is passed. The filament is directed through the guide such that a component of the tension of the monitored filament applies a torque to the arm tending to rotate it about its axis in a first direction. A predetermined force is applied to the arm resisting the torque applied by the filament tension. As long as the predetermined force applied to the rotatable arm is substantially equal to the torque applied to the arm by the filament tension, the arm is maintained at a neutral position where neither of the electrical contacts on the arm closes its associated electrical circuit. If the torque applied by the monitored filament exceeds the predetermined force resisting this torque, the arm will be rotated in the first direction until one of the contacts on the arm closes its associated electrical circuit. Similarly, if the torque applied by the monitored filament falls below the predetermined force resisting the torque, the arm will be rotated in a second direction until the other contact on the arm closes its associated electrical circuit. Advantageously the closure of either electrical circuit is used to operate an indicator alarm and/or a control circuit to halt the moving filament.

In a first embodiment of the filament tension monitoring device of the present invention, a simple spring of predetermined strength is utilized to apply the predetermined force to the rotatable arm to oppose the torque applied by the monitored filament. In a second embodiment of the filament tension monitoring device, in accordance with the present invention, a magnetic force of controllable strength is utilized to apply the predetermined force to the rotatable arm to oppose the torque applied by the monitored filament. In the second embodiment, the rotatable arm is an armature made of magnetizable material and is positioned between a pair of opposing pole pieces to provide a low reluctance magnetic flux path therebetween. Also positioned between the opposing pole pieces is an electromagnet which is connected to a controllable source of electrical potential. When the electromagnet is energized from the source of potential, a magnetic flux is established through the armature and between the pole pieces. This magnetic flux establishes a magnetic couple between the armature and the pole pieces which causes the armature to resist the torque applied to it by the tension of the monitored filament.

The filament tension monitoring device of the second embodiment of the invention may advantageously be adjusted simultaneously with a plurality of like devices from a common control to monitor a predetermined filament tension. This is accomplished by controlling the potential applied to the electromagnets of each of the devices such that the force of the magnetic couple between the armature and the pole pieces of each device is equal to the torque applied to the armature by a desired predetermined filament tension. As in the spring biased embodiment, as long as these forces are substantially equal, the armature is maintained at a neutral position where neither of the electrical contacts on the armature closes its associated electrical circuit. If the tension on the filament exceeds the predetermined desired tension, the force of the torque applied to the armature will be greater than the force of the magnetic couple resisting the torque and the armature will be rotated in a first direction until one of the contacts on the armature closes its associated electrical circuit. Similarly, if the tension on the monitored filament falls below the predetermined desired tension, the force of the magnetic couple between the armature and the pole pieces will be greater than the force of the torque applied to the armature by the tension of the filament and the armature will be rotated in its second direction until the other contact on the armature closes its associated electrical circuit.

When the filament tension monitoring devices of the present invention operate, as generally described above, in response to a loss or reduction in tension on a monitored filament, the arm will be held in the position to which it is rotated by the predetermined force opposing the torque applied by the monitored filament and the electrical circuit closed in response to this rotation of the arm will remain closed. One the other hand, when an excessive tension occurs on a monitored filament and the arm is rotated in the opposite direction, the electrical circuit closed in response to this rotation will remain closed only so long as the component of filament tension applied to the arm exceeds that of the opposing predetermined force. Accordingly, it is another aspect of the present invention that when the filament tension monitoring devices of the present invention operate in response to an excessive tension applied to a monitored filament the devices lock operated so as to maintain the associated electrical circuit closed although the excessive tension is transitory in nature. This advantageously permits an attendant to identify an offending filament from a large number of filaments simultaneously monitored and make the required correction to eliminate the cause of the transitory excessive tension.

The above described latching feature is attained in the first embodiment of the filament tension monitoring

device of the present invention (spring biased embodiment) by the provision of a permanent magnet on the base and an adjustable latching pole piece mounted on the rotatable arm. When the arm and attached filament guide are rotated a predetermined distance in response to an excessive tension applied to the monitored filament, the latching pole piece physically contacts the permanent magnet which holds the arm at the position to which it is rotated and thus maintains the associated electrical circuit closed. Accordingly, although the rotation of the arm and the closure of the electrical circuit may have been in response to a transitory excessive tension applied to the monitored filament the electrical circuit is maintained in its closed condition by the permanent magnet and latching pole piece. The filament tension monitoring device of this embodiment may be returned to its unoperated condition by physically displacing the arm in the opposite direction to release the latching pole piece from the permanent magnet.

The above described latching feature is attained in the second embodiment of the filament tension monitoring device of the invention by the provision of an adjustable latching pole piece and associated magnetic shunt structure mounted on the filament guide. When the armature and attached filament guide are rotated a predetermined distance in response to an excessive tension applied to the monitored filament, the latching pole piece physically contacts one of the main pole pieces and completes a low reluctance magnetic flux path shunting a portion of the main flux path between the opposing pole pieces. The latching pole piece and main pole piece are formed to obtain small opposing pole face areas and thus achieve a large magnetic holding force when the two are in physical contact and magnetic flux is established therethrough. The magnetic attraction between the latching pole piece and main pole piece holds the armature and attached filament guide at the position to which it is rotated and thus maintains the associated electrical circuit closed. Accordingly, although the rotation of the armature and closure of the electrical circuit may have been in response to a transitory excessive tension applied to the monitored filament, the electrical circuit is maintained in its closed condition by the latching structure described above. The filament tension monitoring device of this embodiment of the invention may be returned to its unoperated condition by physically displacing the armature in the opposite direction to break or open the latching flux path or by momentarily de-energizing the electromagnet.

The electrical contacts which make with the contacts attached to the rotatable arm of the filament tension monitoring devices of the present invention to close the respective electrical circuits are spaced from their associated contacts on the arm to permit the arm to rotate a predetermined distance in either direction before the respective electrical circuits are closed. This advantageously provides a predetermined allowable deviation in tension, both above and below the desired monitored tension, before either of the electrical circuits is closed. In this manner the filament tension monitoring devices in accordance with the present invention are insensitive to minor and harmless fluctuations in tension.

In accordance with another aspect of the filament tension monitoring devices of the present invention, the component of tension of the monitored filament which applies the torque to the rotatable arm is advantageously controlled to control the magnitude of the torque applied to the rotatable arm by the monitored filament. This is accomplished, in accordance with the invention, by changing the angle of incidence of the monitored filament with respect to the filament guide to thereby change the resulting component of the filament tension applied to the rotatable arm. The change in the angle of incidence is accomplished by changing the attitude of the filament tension monitoring devices of the present invention on the mounting rod upon which they are supported. This advantageously provides an adjustment in monitored tension for the devices of the present invention without the requirement for the mechanical arrangements required by the known devices of this type and hence substantially reduces the cost of the devices. This simple adjustment also advantageously permits an initial individual adjustment of a plurality of filament tension monitoring devices in accordance with the present invention to monitor simultaneously a predetermined tension applied to a plurality of filaments. As the result of this adjustment the devices of the present invention may be manufactured and assembled under less rigid requirements, thus substantially reducing the cost thereof while concomitantly providing the advantageous features described herein.

For example, in the spring biased embodiment of the present invention, this adjustment will permit a plurality of the devices to monitor a predetermined filament tension even though the strength of the springs which oppose the torques applied by the monitored filaments to the respective devices may vary from device to device. Similarly, in the second embodiment of the invention, the armature, pole pieces, and electromagnet which provide the magnetic force to oppose the torque applied by the monitored filament to the rotating armature may be manufactured and assembled under relaxed tolerances because a plurality of the devices, even though having different electrical and magnetic characteristics, may be adjusted in the manner indicated above to monitor for a uniform predetermined filament tension.

It is a feature of the present invention that a filament, monitored for excessive as well as deficient tensions, apply a torque to a rotatable arm to oppose a predetermined force also applied to the rotatable arm and that indicator circuits operate in response to the rotation of the arm when the torque exceeds or falls below the predetermined force by a predetermined amount.

It is another feature of the present invention that a latching arrangement hold the indicator circuit operated when the arm is rotated a predetermined distance in response to a transitory excessive tension applied to a monitored filament.

It is also a feature of the filament tension monitoring devices of the present invention that the component of tension of the monitored filament applying the torque to the rotatable arm be controlled by changing the attitude of the device on its mounting rod to effect a change in the angle of incidence of the monitored filament with respect to the filament guide attached to the rotatable arm and to thereby change the resulting component of the filament tension applied to the rotatable arm.

It is further a feature of one embodiment of the present invention that the tension of the monitored filament apply a torque to a rotatable armature, that an electromagnet establish a controllable magnetic couple between the armature and a pair of associated pole pieces to oppose the torque applied to the armature, and that an indicator circuit operate when the force of the torque and the force of the magnetic couple differ by a predetermined value.

It is also a feature of the aforementioned embodiment of the present invention that a low reluctance magnetic flux path, shunting a portion at least of the main flux path establishing the magnetic couple between the armature and the pole pieces, be completed to hold the indicator circuit operated when the force of the torque exceeds the force of the magnetic couple.

It is a further feature of the aforementioned embodiment of the present invention that the desired tension for which a filament is to be monitored may be preselected by the operation of a simple remote electrical control.

It is an additional feature of the invention that a plurality of filament tension monitoring devices in accordance with the aforementioned embodiment of the invention may be simultaneously controlled by a simple remote

electrical control to preselect the desired tension for which each of a plurality of filaments is to be monitored.

In furtherance of the above feature and in accordance with another aspect thereof, the rotatable armature and the attached filament guide of the aforementioned embodiment of the present invention are balanced with respect to gravity for all positions of rotation. Accordingly, there will be no component of force due to gravity to either oppose or assist the force of the magnetic couple established between the rotatable armature and the associated pole pieces. Thus a plurality of the devices of this embodiment of the invention will advantageously respond uniformly to changes in current flow through the electromagnets thereof which are connected in a common circuit with a common current control device.

It is also a feature of the present invention that it is insensitive to minor fluctuations in tension applied to a monitored filament, both above and below the predetermined desired tension.

The foregoing and other objects, features, and advantages of the present invention will be readily understood from the following description of illustrative embodiments thereof when read in reference to the accompanying drawings in which:

FIG. 1 is a side elevation and partial vertical cross-sectional view of an illustrative embodiment of a filament tension monitoring device in accordance with the present invention;

FIG. 2 is a side elevation and partial vertical cross-sectional view of a second illustrative embodiment of a filament tension monitoring device in accordance with the present invention;

FIG. 3 is a partial vertical cross-sectional view of the filament tension monitoring device of FIG. 2 when actuated in response to a deficient tension applied to a monitored filament;

FIG. 4 is a partial vertical cross-sectional view of the filament tension monitoring device of FIG. 2 when actuated in response to an excessive tension applied to a monitored filament; and

FIG. 4 is a schematic drawing illustrating the manner in which a plurality of filament tension monitoring devices of the embodiment of FIG. 2 may be simultaneously adjusted to monitor a plurality of filaments for a predetermined tension.

Referring now to the drawing, illustrative embodiments of filament tension monitoring devices in accordance with the present invention will be described in detail. FIG. 1 shows one such embodiment which comprises a base **10** of nonmagnetic material and adapted to be secured to a mounting rod inserted through hole **11** by means of a screw **12** in the manner shown. Projecting upwardly from base **10** and secured thereto by any suitable means are a pair of spaced apart supports **13** (only one of which is visible in the cross-sectional view) which provide support for pin **14** in a manner known in the art. Rotatably mounted on pin **14** is arm **15**, made of electrically conducting materials, and filament guide **16**, made of nonmagnetic material, which are clamped together with a suitable bearing (not shown) on opposite sides of pin **14** to permit free rotation thereabout.

Filament **17**, the tension of which is to be monitored, is threaded through trumpet-shaped eyelets **16***a* and **16***b* in filament guide **16** and moves from left to right as shown in FIG. 1. Mounted at the opposite ends of arm **15** are two electrical contacts **18***a* and **19***a*. The respective mating contacts **18***b* and **19***b* are mounted on respective contact springs **18***c* and **19***c* which are in turn mounted on base **10** and electrically insulated therefrom by insulating member **20**. Electrical conductor **21** is connected between a suitable source of ground potential and the midpoint of arm **15**. Electrical conductors **22** and **23** connect respectively to contact springs **18***c* and **19***c*.

Spring **24** is secured between upright **13** and filament guide **16** as shown in FIG. 1 and provides a predetermined force tending to rotate the arm **15** and attached filament guide **16** in a clockwise direction. A component of the tension of monitored filament **17** is applied to arm **15** through filament guide **16** to apply a torque tending to rotate arm **15** and attached filament guide **16** in a counterclockwise direction. As long as the force applied to arm **15** by spring **24** is substantially equal and opposite to the torque applied to arm **15** by the component of the tension of filament **17**, arm **15** will be maintained at a neutral position as depicted in FIG. 1 where neither of the electrical contact pairs **18***a* and **18***b* or **19***a* and **19***b* are closed.

When the tension on monitored filament **17** increases such that the torque applied to arm **15** is greater than opposing force applied thereto by spring **24**, arm **15** will be rotated in a counterclockwise direction until contact **19***a* and contact **19***b* make. When this occurs an electrical circuit is completed from ground via conductor **21** through arm **15**, closed contacts **19***a* and **19***b*, contact springs **19***c*, and conductor **23**. This electrical circuit may advantageously be utilized to control an indicator alarm and/or to operate drive control circuits to halt the movement of filament **17** through filament guide **16**, in the same manner as the corresponding circuit of the embodiment of FIG. 2 described hereafter. Similarly, if the tension on monitored filament **17** decreases such that the torque applied to arm **15** is less than the opposing force applied to arm **15** by spring **24**, arm **15** will be rotated in a clockwise direction until contacts **18***a* and **18***b* are closed. When this occurs an electrical circuit is completed from ground through conductor **21**, arm **15**, closed contacts **18***a* and **18***b*, contact spring **18***c*, and conductor **22**. This electrical circuit is similarly used to control an indicator alarm and/or to operate drive control circuits to halt the movement of filament **17** through filament guide **16**.

Arm **15** and attached filament guide **16** will be held, at the clockwise position of rotation where electrical contacts **18***a* and **18***b* are closed, by the force applied thereto by spring **24** as long as this force exceeds the force applied to the monitored filament. Thus, in the case of the breakage of a filament or in the case of the loss of filament tension, the electrical circuit completed from ground via conductor **21** through contacts **18***a* and **18***b* and lead **22** will remain closed to notify an attendant of a trouble condition.

On the other hand arm **15** and attached filament guide **16** will be held at the counterclockwise position of rotation where electrical contacts **19***a* and **19***b* are closed only so long as there is an excessive tension applied to filament **17**. To maintain contacts **19***a* and **19***b* closed when a transistory excessive filament condition has occurred on a monitored filament **17**, a permanent magnet **25** is attached, by any manner known in the art, to the left-hand end of base **10** as shown in FIG. 1. Threaded through the left-hand end of filament guide **16** as shown in FIG. 1 is an adjustable latching pole piece **26**. Latching pole piece **26** is an adjustable screw made of magnetic material and is adapted to make contact with permanent magnet **25** when arm **15** and attached filament guide **16** are rotated a predetermined distance in a counterclockwise direction in response to an excessive tension applied to a monitored filament. When latching pole piece **26** contacts permanent magnet **25**, arm **15** and attached fiilament guide **16** will be held at the position to which they are rotated by the magnetic attraction between permanent magnet **25** and latching pole piece **26**, and thus contacts **19***a* and **19***b* which complete the electrical circuit from ground via conductor **21** through conductor **23** will be held in a closed condition. Accordingly, although the increase in tension applied to monitored filament **17** may be transitory in nature the filament tension monitoring device of the embodiment of FIG. 1 will operate and hold in the operated condition to indicate to an attendant a trouble condition on the monitored

filament. After the attendant determines and corrects the cause of the excessive tension, the device may be returned to its unoperated condition by physically displacing arm **15** and attached filament guide **16** in a clockwise direction to release latching pole piece **26** from permanent magnet **25**.

In accordance with an aspect of the present invention, the component of the tension of the monitored filament **17** which applies the torque to rotatable arm **15** tending to rotate it in a counterclockwise direction is advantageously controlled simply by changing the attitude of the filament tension monitoring device on the mounting rod inserted through hole **11**. This is accomplished by loosening screw **12** and rotating base **10** on the mounting rod inserted through hole **11** such that the angle of incidence *i* shown in FIG. 1 between filament **17** and filament guide **16** is increased or decreased. For example, if it is desired to increase the torque applied to arm **15** by filament **17**, screw **12** is loosened and base **10** is rotated in a clockwise direction to decrease the angle of incidence *i*. A decrease in the angle of incidence *i* between filament **17** and filament guide **16** causes a corresponding increase in the component of the force resulting from the tension of filament **17** which applies a torque to rotate arm **15** in a counterclockwise direction. Conversely, an increase in the angle of incidence *i* causes a corresponding decrease in the component of the force resulting from the tension of filament **17** which applies a torque to rotate arm **15** in a counterclockwise direction.

This simple adjustment advantageously enables the embodiment of the filament tension monitoring device of FIG. 1 to monitor for different filament tensions without the necessity for the mechanical adjustment arrangements required by the presently known stop motion devices. It also advantageously enables a plurality of these devices to be balanced uniformly to monitor tensions applied to a plurality of filaments although the strength of the springs **24** in the respective devices may not be identical.

In accordance with another aspect of the invention, the filament tension monitoring device of the embodiment of FIG. 1 is insensitive to minor and harmless fluctuations in tension applied to the monitored filament. This is accomplished, in accordance with this aspect of the invention, by adjusting, i.e., depressing or expanding, contact springs **18***c* and **19***c* such that the corresponding contacts **18***b* and **19***b* are spaced predetermined distances from their mating contacts **18***a* and **19***a*. For example, by spacing contact **19***b* a predetermined distance from contact **19***a*, the force of the torque applied to arm **15** by the component of the tension of monitored filament **17** must exceed the opposing force applied to arm **15** by spring **24** by a predetermined amount before arm **15** will be rotated in a counterclockwise direction to a position where contacts **19***a* and **19***b* are closed, thus closing the above described electrical circuit. The adjustment in spacing between contacts **19***a* and **19***b* will necessitate a corresponding adjustment of latching pole piece **26** such that latching pole piece **26** contacts permanent magnet **25** at substantially the same instant that contact **19***a* makes electrical contact with contact **19***b*. Similarly, contact **18***b* may be positioned a predetermined distance from contact **18***a* such that the force of the torque applied to arm **15** by the component of the tension of monitored filament **17** must fall below the opposing force applied to arm **15** by spring **24** by a predetermined amount before arm **15** is rotated in a clockwise direction to close contacts **18***a* and **18***b* and the associated electrical circuit.

The illustrative embodiment of the filament tension monitoring device shown in FIG. 1 and described above may advantageously be utilized in operations involving large numbers of filaments where the desired tension to be monitored is infrequently changed. It will monitor for both excessive as well as deficient filament tensions and a plurality of the devices can be balanced by initial adjustment to uniformly monitor a predetermined tension applied to a large number of filaments. The desired filament tension to be monitored may also be changed by individually adjusting the devices if desired. The device is simple, inexpensive to manufacture, reliable, and hence may advantageously be utilized where thousands of filaments must be monitored.

It is obvious, however, that the filament tension monitoring device shown in FIG. 1 may not be simultaneously controlled from a common control with a plurality of similar devices when it is desired to change the monitored tension as is required in some types of operations. An embodiment of a filament tension monitoring device in accordance with this invention which will meet this further requirement is disclosed in FIGS. 2 through 5 of the drawing and will now be described in detail.

As shown in FIG. 2, this embodiment of a filament tension monitoring device in accordance with the present invention, indicated generally by the reference numeral **50**, includes an electromagnet **51** positioned between a pair of opposing pole pieces **52** and **53**. Also positioned between the opposing pole pieces is an armature bracket **54** fabricated of nonmagnetic material such as brass. Armature bracket **54** has a pair of spaced apart armature supports **55** projecting upwardly from the armature bracket **54** (only one armature support **55** is shown in the cross-sectional view). Armature supports **55** provide support for a pin **56** in a manner known in the art. Rotatably mounted on pin **56** is armature **57** which is fabricated of magnetizable material and comprises two sections. The upper section **57***a* and the lower section **57***b* of armature **57** are clamped together with a suitable bearing (not shown) on opposite sides of pin **56** to permit free rotation thereabout. Armature **57** provides a low reluctance magnetic flux path between pole pieces **52** and **53** when electromagnet **51** is energized.

When switch **58** is closed, electromagnet **51** is energized by current flowing from voltage source **59** through potentiometer **60** over electrical conductors **61** and **62**. This energization of electromagnet **51** generates a magnetic flux which extends between pole pieces **52** and **53** through armature **57**. This magnetic flux establishes a magnetic couple between armature **57** and pole pieces **52** and **53** which resists any torque tending to rotate armature **57**. The strength of the magnetic couple is controlled by adjustment of potentiometer **60** to control the current flow through electromagnet **51**.

Secured to armature **57** with screws **63***a* and **63***b* made of magnetic material and spacers **64***a* and **64***b*, in the manner shown in FIG. 2, is a filament guide **65** made of non-magnetic material. Filament **66**, the tension of which is to be monitored, is threaded through trumpet-shaped eyelets **67***a* and **67***b* in filament guide **65** and moves from left to right as shown in FIG. 2. Mounted on filament guide **65** by the screws **63***a* and **63***b* is a magnetic shunt plate **68** and a latching pole piece **69** both made of magnetic material. Latching pole piece **69** is, as shown in FIG. 2, an adjustable screw extending through filament guide **65** and is adapted to make contact with pole piece **52** when the armature **57** and attached filament guide **65** are rotated in a counterclockwise direction. Magnetic screws **63***a* and **63***b*, which are threaded into armature **57** in conjunction with magnetic shunt plate **68** and magnetic latching pole piece **69**, provide a low reluctance magnetic path shunting a portion of the main magnetic flux path existing between pole pieces **52** and **53** when the armature **57** and attached filament guide **65** are rotated in a counterclockwise direction so that latching pole piece **69** physically contacts pole piece **52**.

Mounted on the opposite ends of the lower section **57***b* of armature **57** are electrical contacts **70***a* and **71***a*. The respective mating contacts **70***b* and **71***b* are mounted on respective contact springs **70***c* and **71***c* which in turn are mounted on armature bracket **54** and insulated therefrom by insulating member **72**. Electrical conductor **73**

is connected between a suitable source of ground potential and the midpoint of armature **57** as shown in FIG. 2. Electrical conductors **74** and **75** connect respectively to contact springs **70***c* and **71***c*. Conductors **74** and **75** extend to alarm indicator circuits **76** and **77**, respectively, and, as indicated hereinbefore, may also extend to drive control circuits which are utilized to halt the movement of monitored filament **66** through the tension monitoring device of the embodiment of FIG. 2 when an excessive or deficient tension is detected.

In accordance with an aspect of the embodiment of the invention shown in FIG. 2, the rotatable assemblage comprising armature **57** and attached filament guide **65** is balanced with respect to gravity for all positions of rotation by the appropriate selection of counterweights CWL and CWR secured to filament guide **65** in the manner shown. This advantageously eliminates any component of force due to gravity to either oppose or assist the force of the magnetic couple established between armature **57** and pole pieces **52** and **53**.

As shown in FIG. 2, pole piece **52** is attached to a clamp member **88** by suitable screws. Clamp member **88** is in turn adapted to be secured to a mounting rod inserted through hole **89** by means of screw **90** in the manner shown. Thus the component of tension of the monitored filament **66** which applies a torque tending to rotate armature **57** and attached filament guide **65** in a counterclockwise direction may advantageously be adjusted in the manner described hereinbefore in connection with the embodiment of FIG. 1. Screw **90** may be loosened and the filament tension monitoring device of the FIG. 2 embodiment shifted either clockwise or counterclockwise to decrease or increase respectively the angle of incidence which filament **66** makes with filament guide **65**, and in this manner the component of tension applying the torque to the armature **57** may be increased or decreased respectively.

The embodiment of the filament tension monitoring device of FIG. 2 is also advantageously insensitive to minor and harmless fluctuations in tension applied to monitored filament **66**. This is accomplished in the same manner as described hereinbefore in connection with the embodiment of FIG. 1 by adjusting, i.e., depressing and expanding, contact springs **70***c* and **71***c* to provide predetermined spacing between the associated contact pairs **70***a* and **70***b* or **71***a* and **71***b*. The adjustment in spacing between contacts **71***a* and **71***b* will necessitate a corresponding adjustment of the latching pole piece **69** such that latching pole piece **69** contacts the top of pole piece **52** substantially at the same instant that contact **71***a* makes electrical contact with contact **71***b*. As shown in FIG. 2, the left-hand end of shunt plate **68** is slightly offset in the upward direction from filament guide **65** to provide a spring action working against latching pole piece **69**. This provides a locking action on latching pole piece **69** to hold it in the desired position.

The operation of the filament tension monitoring device of the embodiment of FIG. 2 will now be described with reference to FIGS. 2, 3, and 4. FIG. 2 shows the position of armature **57** with respect to pole pieces **52** and **53** and when the tension of the monitored filament **66** is correct and within the predetermined allowable range. FIG. 3 shows the position of armature **57** with respect to pole pieces **52** and **53** when a deficient tension on the monitored filament **66** is detected, and FIG. 4 shows the position of armature **57** with respect to pole pieces **52** and **53** when an excessive tension on monitored filament **66** is detected. As described hereinbefore, a component of the tension on monitored filament **66** applies a torque to armature **57** and attached filament guide **65** tending to rotate them in a counterclockwise direction. With switch **58** closed, potentiometer **60** is adjusted until a magnetic couple is established between armature **57** and pole pieces **52** and **53**, the force of which is equal and opposite to the torque applied by the monitored filament. Thus, as long as the tension of the monitored filament remains substantially constant, the armature will be maintained in the position shown in FIG. 2 where neither of the electrical contact pairs **70***a* and **70***b* or **71***a* and **71***b* are closed. Slight variations in this predetermined tension are permissible, as indicated hereinbefore, and armature **57** may rotate slightly in either a clockwise or a counterclockwise direction without closure of either of the contact pairs. In this way the device is insensitive to harmless variations in tension.

If it is desired to change the tension to be monitored by the device, it is only necessary, in accordance with the invention, to adjust the potentiometer **60** to increase or decrease the strength of the magnetic couple established between armature **57** and pole pieces **52** and **53**.

If, through some malfunction, the tension applied to monitored filament **66** is reduced below the desired predetermined value, the force of the magnetic couple established between armature **57** and pole pieces **52** and **53** will be greater than the force of the torque applied to the armature **57** by the monitored filament and the armature will be rotated in a clockwise direction by the force of the magnetic couple to the position shown in FIG. 3. When this occurs an electrical circuit is closed from ground through conductor **73**, armature **57**, closed contact pair **70***a* and **70***b*, contact spring **70***c*, conductor **74**, and through alarm indicator circuit **76**, to a suitable source of potential **91**. This circuit may also extend via conductor **74**, as indicated in FIG. 2, to drive control circuits which will halt the movement of filament **66**.

Armature **57** will be held in the position shown in FIG. 3 by the force of the magnetic couple existing between armature **57** and pole pieces **52** and **53** as long as the force of the magnetic couple exceeds the force applied to the monitored filament. Thus, in the case of a breakage of a filament or in a case of a loss of filament tension, the alarm indicator circuit **76** will operate and remain operated to notify an attendant of a trouble condition.

On the other hand, if the tension applied to the monitored filament **66** exceeds the desired predetermined tension as the result of a snag or other malfunction, the torque applied to armature **57** by the monitored filament will exceed the force of the magnetic couple established between armature **57** and pole pieces **52** and **53**. This will cause armature **57** and attached filament guide **65** to be rotated in a counterclockwise direction to the position shown in FIG. 4. When this occurs an electrical circuit is closed from ground through conductor **73**, armature **57**, closed contact pair **71***a* and **71***b*, contact spring **71***c*, conductor **75**, and through alarm indicator circuit **77**, to a suitable source of potential **92**. This circuit, as shown in FIG. 2, may also extend via conductor **75** to the drive control circuits which will halt the movement of filament **66**.

As indicated hereinbefore and in accordance with an aspect of the present invention, when armature **57** is rotated to the position shown in FIG. 4, latching pole piece **69** makes physical contact with the top of pole piece **52** and this completes a low reluctance magnetic flux path shunting a portion of the main flux path between pole pieces **52** and **53**. This shunting flux path extends from pole piece **53** through armature **57**, magnetic screws **63***a* and **63***b*, shunt plate **68**, and through latching pole piece **69** to pole piece **52**. Latching pole piece **69** and pole piece **52** are formed to obtain small opposing pole face areas and thus provide a large magnetic holding force between the two when the two are in physical contact and the magnetic flux is established therethrough. The magnetic attraction between latching pole piece **69** and pole piece **52** holds the armature **57** and attached filament guide **65** in the position to which it is rotated as shown in FIG. 4 and thus maintains the associated electrical contact pair **71***a* and **71***b* closed.

Accordingly, although the increase in tension applied to monitored filament **66** may have been transitory in na-

ture, the filament tension monitoring device of the embodiment of FIG. 2 will operate and hold in the operated condition, operating the alarm **77** to indicate to the attendant a trouble condition on the monitored filament. After the attendant determines and corrects the cause of the excessive tension, the device may be returned to its unoperated position by physically displacing the armature in a clockwise direction until the locking shunt flux path is broken or, alternatively, switch **58** may be momentarily opened to de-energize electromagnet **51** to remove the magnetic flux established through the shunting flux path to permit the release of latching pole piece **69** from pole piece **52**.

Although individual alarm indicator circuits **76** and **77** are shown in FIG. 2 of the drawing to indicate deficient and excessive tensions respectively, it is understood that a single alarm circuit may be utilized and that leads **74** and **75** may advantageously extend to this single alarm circuit.

Because the embodiment of the filament tension monitoring device shown in FIG. 2 may be electrically controlled from a control such as potentiometer **60**, the device may advantageously be simultaneously controlled with a plurality of like devices from a remote electrical control to preselect the desired tension for which each of a plurality of filaments is to be monitored. FIG. 5 is a schematic drawing illustrating one way in which a plurality of filament tension monitoring devices **50** of the type shown in FIG. 2 may be controlled from a remote common electrical control. As shown in FIG. 5, filament tension monitoring devices 50_1, 50_2 . . . 50_n are connected in parallel to a source of potential supplied from voltage source **93** through potentiometer **94** and switch **98** to conductors **96** and **97**. Each of the leads **61** and **62** connected to the electromagnets **51** of the respective filament tension monitoring devices 50_1 through 50_n is connected in parallel to leads **96** and **97** as shown. Each of the alarm leads **74** and **75** from the respective devices **50** is connected to an alarm and control circuit **95** which may advantageously include signal indicator lights, an audible alarm, and appropriate control circuitry to control the drive circuits of a plurality of monitored filaments. By adjusting the angle of incidence each monitored filament makes with its associated device in the manner described hereinbefore, and by balancing the armature **57** and attached filament guide **65** with respect to gravity for all positions of rotation also as described hereinbefore the component of tension applying the torque to the armature **57** of each of the devices **50** and the opposing force resulting from the magnetic couple between armature **57** and pole pieces **52** and **53** for each of the devices may be made uniform so that a uniform change in current through the electromagnet **51** of the respective devices will make a corresponding uniform change in the magnetic couple between the armature **57** and pole pieces **52** and **53** of the respective devices. In this manner a plurality of filament tension monitoring devices **50** in accordance with the invention may be simultaneously controlled by adjusting potentiometer **94** to uniformly monitor different predetermined tensions applied simultaneously to a plurality of monitored filaments.

It is to be understood that the above described embodiments are but illustrative of the principles of the present invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a filament tension monitoring device the combination comprising a movable member, means responsive to the desired tension of a monitored filament for applying a first predetermined force to said member, means comprising an electromagnet and at least one pole piece juxtaposed thereto for applying a second predetermined force, equal but opposite to said first predetermined force, to said member, means for changing the angle of incidence said monitored filament makes with said filament tension monitoring device to change the value of said first predetermined force, means responsive to the movement of said member and operative when the tension of said monitored filament exceeds said desired tension by a predetermined amount, and means responsive to the movement of said member and operative when the tension of said monitored filament falls below said desired tension by a predetermined amount.

2. In a filament tension monitoring device the combination comprising a longitudinal arm mounted for rotation about a transverse axis intermediate the ends of said arm, means responsive to a predetermined component of the tension of a monitored filament for applying a torque to said arm tending to rotate said arm in a first direction, eletromagnetic means for applying a predetermined opposing force to said arm to resist said torque, first control means operative when said torque exceeds said opposing force by a predetermined amount, in response to the rotation and a second control means operative in response to the rotation of said arm a predetermined distance in a direction opposite said first direction.

3. The combination defined in claim **2** further comprising means for selectively changing said predetermined component of tension to change the force of said torque applied to said arm.

4. The combination defined in claim **3** wherein said means for selectively changing said predetermined component of said tension comprises means for changing the angle of incidence of said filament with respect to said arm.

5. In a filament tension monitoring device, the combination comprising a movable magnetizable member, means responsive to the tension of a monitored filament for applying a first force to said member tending to move it in a first direction, magnetic means comprising at least one pole piece of magnetizable material and means for establishing a magnetic couple between said pole piece and said movable member for applying a second force to said movable member tending to move it in a second direction, first control means operative in response to the movement of said member a predetermined distance in said first direction, second control means operative in response to the movement of said member a predetermined distance in said second direction, and means for selectively controlling the force of said magnetic couple.

6. The combination defined in claim **5** wherein said means for establishing a magnetic couple between said pole piece and said movable member comprises an electromagnet and wherein said means for selectively controlling the force of said magnetic couple comprises means for selectively controlling the flow of electrical current through said electromagnet.

7. The combination defined in claim **6** further comprising means controlled by said electromagnet and operative when said member has moved said predetermined distance in said first or second direction for holding said member at the position to which it has been moved.

8. A filament tension monitoring device comprising in combination a pair of spaced pole pieces of magnetizable material, a movable armature positioned adjacent said pole pieces to provide a low reluctance magnetic flux path therebetween, means connected to said armature and responsive to a predetermined component of the tension of a monitored filament for applying a first force to said armature tending to move it away from said pole pieces, means for establishing a magnetic couple between said armature and said pole pieces to resist said first force, means for selectively controlling the strength of said magnetic couple, and control means responsive to the movement of said armature and operative when said first force and the force of said magnetic couple differ by a predetermined value.

9. The combination defined in claim **8** further comprising magnetic means operative when said armature

moves a predetermined distance for holding said armature at the position to which it is moved.

10. The combination defined in claim **9** wherein said magnetic means operative when said armature moves a predetermined distance comprises means operative when said armature moves said predetermined distance for establishing a low reluctance magnetic flux path in shunt with a portion at least of said magnetic flux path between said pole pieces and said armature.

11. The combination defined in claim **10** wherein said means for establishing said low reluctance magnetic flux path comprises a shunt plate of magnetic material attached to said armature and a latching pole piece of magnetic material attached to said shunt plate, said latching pole piece being adapted to contact one of said pole pieces to complete said low reluctance magnetic flux path when said armature is moved said predetermined distance.

12. The combination defined in claim **18** further comprising means for changing the predetermined value that said first force must differ from the force of said magnetic couple for said control means to be operative in response to the movement of said armature.

13. A device for monitoring the tension applied to a moving filament comprising in combination a longitudinal armature of magnetic material mounted for rotation about a midpoint transverse axis, a pair of pole pieces of magnetic material juxtapositioned at opposite ends of said armature, said armature providing a low reluctance magnetic flux path between said pole pieces, a filament guide attached to said armature and adapted to rotate therewith, said filament guide having a pair of spaced trumpet-shaped eyelets for directing said monitored filament along an axis substantially parallel to the longitudinal axis of said armature, means including said filament guide for applying a selectable component of the tension applied to said filament as a counterclockwise torque to said armature, means for establishing a magnetic couple of selectable force between said armature and said pole pieces to resist said torque, a first control circuit, a second control circuit, first means controlled by said armature and operative when the force of said torque exceeds the force of said magnetic couple by a predetermined value for energizing said first control circuit, and second means controlled by said armature and operative when the force of said torque falls below the force of said magnetic couple by a predetermined value for energizing said second control circuit.

14. The combination defined in claim **13** wherein said first means controlled by said armature comprises a first pair of electrical contacts which close in response to a predetermined counterclockwise rotation of said armature when said torque exceeds the force of said magnetic couple by a predetermined value, and wherein said second means controlled by said armature comprises a second pair of electrical contacts which close in response to a predetermined clockwise rotation of said armature when the force of said torque falls below the force of said magnetic couple by a predetermined value.

15. The combination defined in claim **14** further comprising means for holding said first pair of electrical contacts closed after an initial closure when the force of said torque momentarily exceeds the force of said magnetic couple.

16. The combination defined in claim **15** wherein said means for holding said first pair of electrical contacts closed comprises magnetic means operative in response to said predetermined counterclockwise rotation of said armature for holding said armature at the predetermined counterclockwise position whereby said first pair of contacts remain closed.

17. The combination defined in claim **16** wherein said magnetic means comprises a plate of magnetic material attached to said armature to provide a partial low reluctance magnetic flux path in shunt with said path between said pole pieces provided by said armature, a latching pole piece of magnetic material attached to said plate and adapted physically to contact one of said pole pieces to complete said partial shunt path when said armature is rotated to said predetermined counterclockwise position.

18. The combination defined in claim **13** wherein said means including said filament guide for supplying a selectable component of the tension applied to said filament as a counterclockwise torque to said armature comprises means for changing the angle of incidence of said monitored filament with respect to said filament guide.

19. The combination defined in claim **13** wherein said means for establishing a magnetic couple of selectable force between said armature and said pole pieces to resist said torque comprises an electromagnet and means for controlling the flow of current in said electromagnet.

20. The combination defined in claim **13** further comprising means for balancing the assemblage comprising said armature and said attached filament guide with respect to gravity for all positions of rotation whereby no component of force due to gravity will either oppose or assist the force of said magnetic couple.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,343,008 September 19, 1967

James E. Bancroft

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 14, lines 19 and 20, strike out "in response to the rotation".

Signed and sealed this 1st day of October 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents