Dec. 30, 1969 C. A. LEE ET AL 3,486,956

METHOD AND APPARATUS FOR THE CONTINUOUS MANUFACTURE OF SEWN MESH FABRIC

Filed April 29, 1966 2 Sheets-Sheet 1

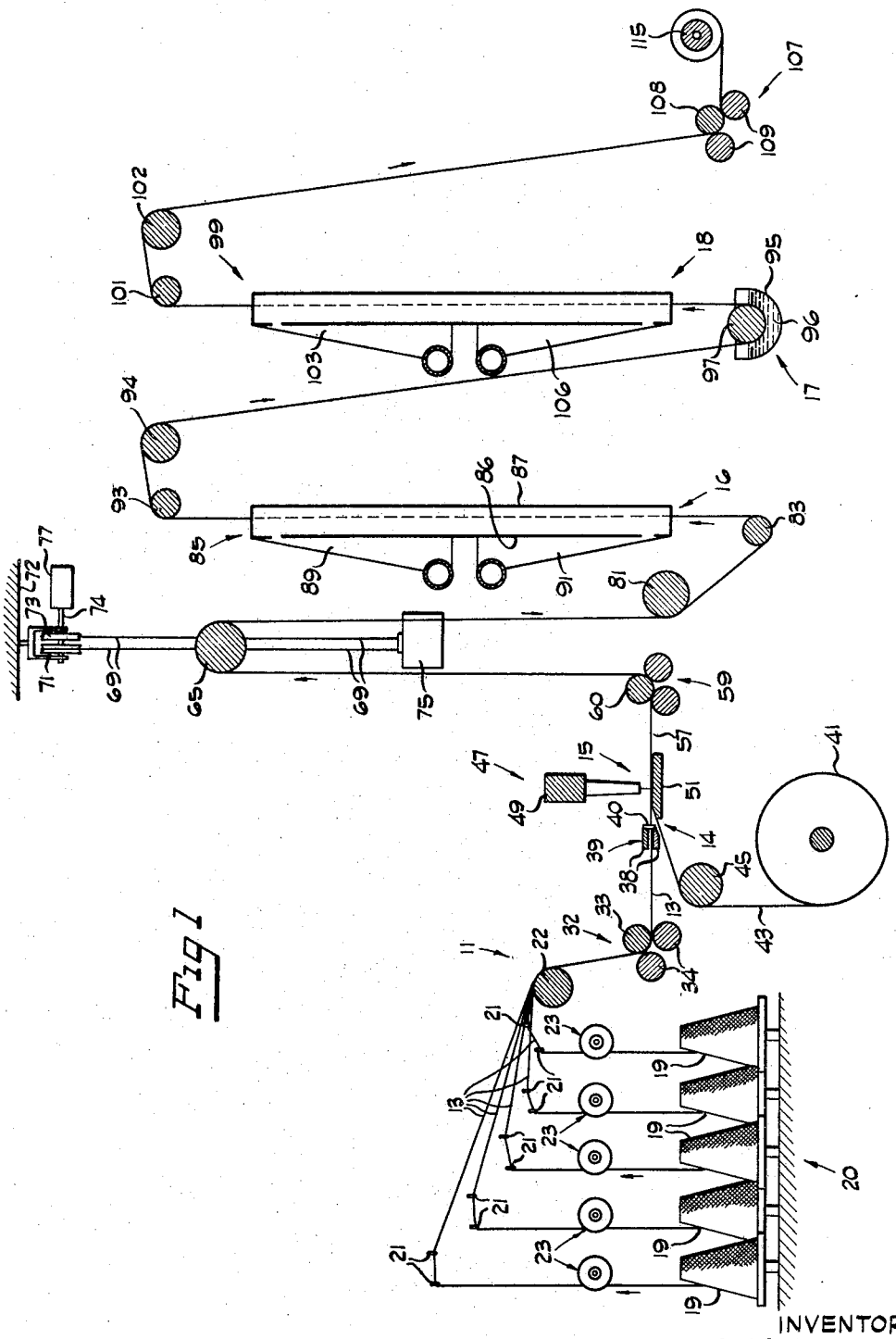


Fig 1

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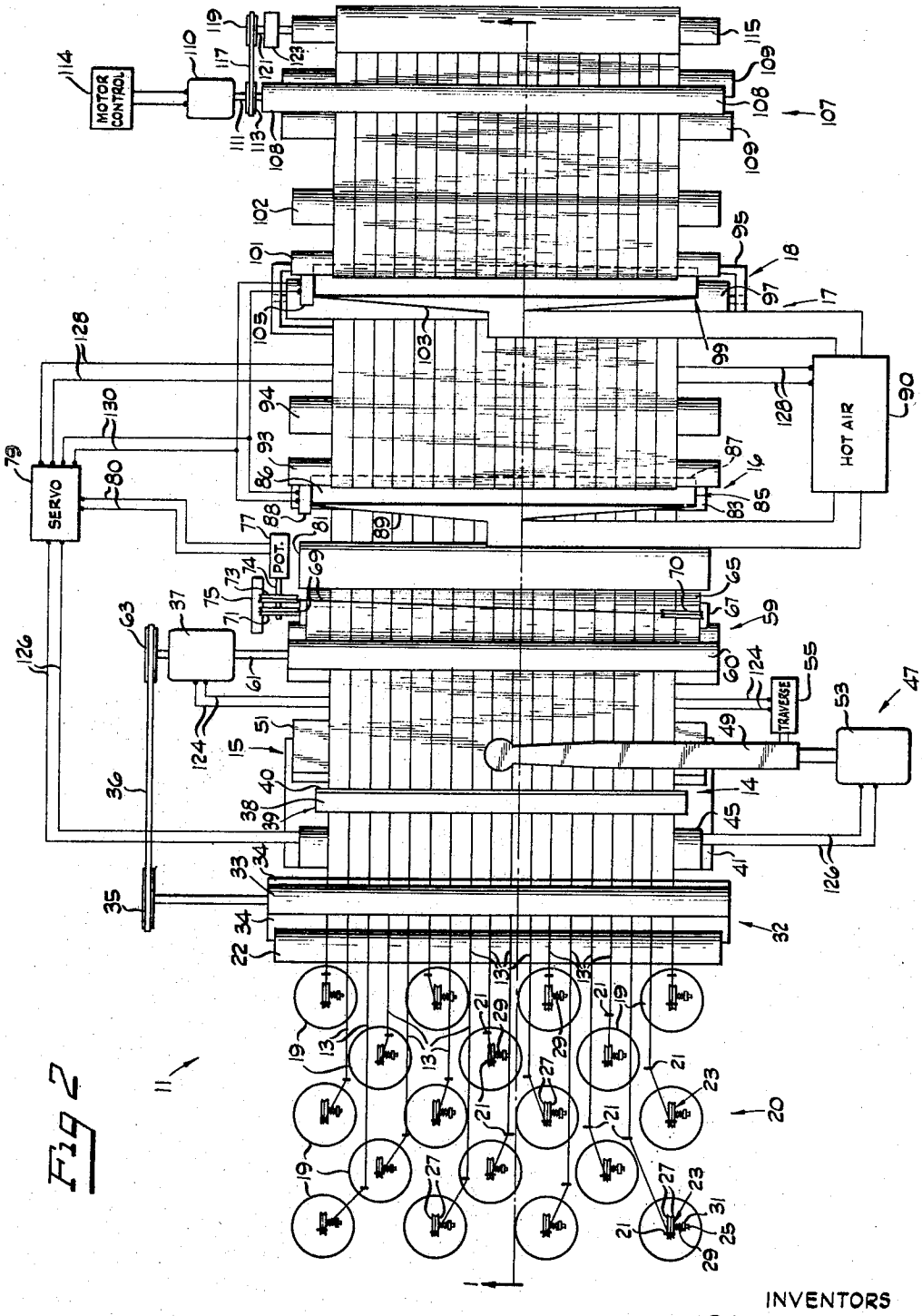


Fig 2

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METHOD AND APPARATUS FOR THE CONTINUOUS MANUFACTURE OF SEWN MESH FABRIC

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U.S. Cl. 156—84 23 Claims

ABSTRACT OF THE DISCLOSURE

Sewn fabric is formed and finished in a continuous process. A sewn fabric is formed by moving a plurality of continuous laterally independent rack filaments in spaced parallel relation over a continuous path past successive stations. At a first station nonwoven filler filaments are disposed on the rack filaments. Sewn filaments are stitched transversely of the rack filaments as successive portions of the rack filaments are moved past the sewing station thereby sewing the rack filaments together and to the filler filaments to form a continuous mesh sewn fabric. The sewn fabric is subsequently moved continuously past a stabilizing station where successive portitons of the fabric are heated and stabilized. Subsequently, bonding agent may be added as the fabric moves past a subsequent station, the bonding agent being subsequently cured at a later station.

This invention relates to a method and apparatus for forming fabrics by sewing. More particularly, it relates to a method and apparatus for making continuous fabrics continuously in which sewn filaments are sewn in one direction across continuous rack filaments running along a continuous path in another direction.

This invention is directed to a method and apparatus for making fabrics such as the fabrics described in the copending application of Charles A. Lee, Ser. No. 431,030, filed Feb. 8, 1965, for "Sewn Fabric and Method of Manufacture," now abandoned. Such fabrics are formed by stitching sewn filaments across a plurality of rack filaments, preferably with nonwoven filler filaments therebetween. The present invention is particularly directed to a method and apparatus for making such fabrics continuously and more particularly to such method and apparatus wherein the entire fabrication is performed as a continuous process where the rack filaments are advanced along a continuous path past one operational station after another.

In the preferred form of the invention, the rack filaments are drawn along a predetermined continuous path defined by a plurality of parallel rolls disposed in predetermined relative position to form a rack. The rack filaments are drawn from a creel and deposited in predetermined laterally spaced relation upon the rack. Individual adjustments are provided for each filament leaving the creel to make the tension in each filament the same. The filaments may then be moved longitudinally to the sewing operation, although prior to the sewing, non-woven filler filaments may be deposited upon the rack filaments so that the sewn filaments may sew the filler filaments to the rack filament.

The sewing operation is performed at a sewing station disposed along the predetermined path along which the rack filaments are moved. The sewing operation may be performed automatically by sewing back and forth transversely of the rack filaments and advancing the rack filaments a predetermined amount after each traverse.

Preferably the rack filaments are supported for sewing between members maintaining a predetermined tension in the rack filaments. These members may form a pair of three-roll nips driven differentially to advance the rack filaments along the predetermined path past the sewing station. A continuous mesh fabric is thus formed as the rack filaments are moved along the predetermined path past the sewing station.

For most applications of the sewn fabric, it is necessary that it then be stabilized. Stabilization may be effected in various ways depending upon the materials of which the fabric is made and upon the particular use to which it is to be put. The stabilization may usually be effected by heat treatment or by adding a bonding agent or by both. The sewn fabric thus formed may be stabilized on the same rack by continuing to advance the fabric along the predetermined path past at least one other station. At a subsequent station on the path, the fabric passes through an oven. The temperature gradient in this oven provides a gradually rising temperature, finally reaching a predetermined temperature, as the fabric passes continuously through it. It is preferred that the heat treatment be gradual, for the heat treatment may shrink the fabric, and it is preferable that this shrinking be gradual in order that it may be uniform and not place great local stresses upon the fabric in the process.

In one embodiment of the present invention the fabric is advanced continuously through the oven at a predetermined uniform rate. Inasmuch as the sewing operation is preferably intermittent, the apparatus for driving the fabric through the oven is independent of the apparatus for driving the rack filaments past the sewing station. At the same time the operation of the two drive means must be related in some manner, for the sewing operation must deliver sewn fabric fast enough for the later operation to be carried out at the predetermined speed, yet not so fast as to accumulate unfinished fabric. It is a further feature of the invention that the fabric be kept in predetermined tension during the heating process in order to prevent uneven shrinking. To this end, a third three-roll nip may be used to advance the fabric through the oven at the predetermined rate and a stretch roll may be used to maintain constant tension in the fabric between this third three-roll nip and the preceding filament drive.

This stretch roll is made movable to take up any slack and more importantly to provide a storage loop to permit the fabric to move continuously through the oven even though the filament drive is intermittent. At the same time the movement of the stretch roll is used to control the sewing speed so that there is never too much slack or too little sewn fabric for processing. By providing a relatively long storage loop over the stretch roll, there is sufficient slack to permit the sewing operation to be halted momentarily, as when the sewing thread breaks or must be replaced, without having to stop the finishing process, which might damage the fabric.

It is ordinarily undesirable to stop the continuous movement through the oven, for the fabric may become overheated and damaged, if not actually melted, by standing too long at one place in the oven. Provision is made for turning off the oven and opening it up, should the slack be entirely used up. This may result in some damage, but it will localize the damage and avoid having to restoring the entire machine.

The temperature to which the fabric is heated depends upon the particular materials of which the fabric is made. It is desirable that it be heated to a temperature as high as the fabric is likely to experience in use in order that it not shrink further in use. Preferably, the fabric

is heated to a temperature just below that which would damage the fabric, as by melting it, for it is then certain that it will never be used at a hotter temperature, since any hotter temperature would destroy the fabric anyway.

For most purposes, it is desirable that the fabric be chemically stabilized as well as heat stabilized. To this end, some bonding agent is applied to the fabric, which bonding agent is then cured, preferably by running the fabric through a succeeding oven like that used in the heat treating.

It is therefore a primary object of the present invention to provide a method and apparatus for making fabric by sewing rack filaments together with sewn filaments to form a continuous mesh fabric. Another object of the invention is to provide method and apparatus for making such a fabric in which non-woven filler filaments are sewn to the rack filaments by sewn filaments. Still another object of the invention is to provide a method and apparatus for disposing a plurality of rack filaments upon a rack, advancing the rack filaments along a continuous path defined by the rack, sewing the rack filaments together with sewn filaments transversely of the rack filaments as the rack filaments are advanced along the continuous path and thereafter stabilizing the sewn fabric thus produced as the fabric is advanced along the path. It is still another object to provide a method and apparatus for advancing the fabric continuously through the stabilizing operation while advancing the rack filaments intermittently during sewing. Further objects and advantages of the present invention will become apparent from consideration of the following description taken in conjunction with the following drawings wherein:

FIGURE 1 is a sectional view of apparatus for the continuous manufacture of sewn fabrics, taken along line 1—1 of FIGURE 2; and

FIGURE 2 is a partly diagrammatic plan view of the apparatus illustrated in FIGURE 1.

Briefly, the apparatus includes a rack **11** for supporting a plurality of rack filaments **13** in predetermined parallel spaced relation and moving the rack filaments along a predetermined continuous path, defined by the members comprising the rack, past a number of successive stations **14**, **15**, **16**, **17**, **18** at each of which is performed one of a plurality of processing operations. In the particular embodiment illustrated, as the rack filaments **13** are moved along the path defined by the rack **11**, filler filaments are deposited thereon at the first station **14** and are sewed thereto at the second station **15**, and the sewn fabric is subjected to various stabilizing operations at succeeding stations **16**, **17** and **18**.

More particularly, the apparatus illustrated in FIGURE 1 includes a plurality of cones or spools **19** from which the rack filaments **13** are payed out. The number of cones **19** required is dependent upon the width of the fabric and the density of the rack filaments desired; however, for clarity of illustration only five rows of cones are illustrated in detail in FIGURES 1 and 2. Normally, the filaments **13** are disposed more closely together. The cones **19** are positioned upon a creel **20** in a pattern corresponding generally to the relation which the filaments **13** will assume as they pass through the rack **11**. The free end of each of the filaments **13** is fed from the respective cone **19** and directed through positioning eyes **21** and then over a guide roll **22**. The eyes are spaced so that the filaments **13** passing over the roll **22** will be arranged in a generally parallel spaced relationship.

To provide a means for individually adjusting the tension in each of the rack filaments **13** a tension means **23** is mounted on the creel **20** for each of the filaments. Each tension means **23** may comprise a horizontally disposed screw **25** upon which are placed two washer-like members **27** biased together by means of a spring **29**. The washers **27** and spring **29** are maintained upon the screw **25** by a nut **31** which may be adjusted by hand to adjust the compression of the spring **29** and hence the tension in the respective filament **13** occasioned by the friction force exerted by the members **27** between which it is drawn. The rack filaments **13** are shown drawn from the creel **20** by a three-roll nip **32** including a driving roll **33** and idler rolls **34**. The three-roll nip **32** is a conventional means for driving elongated flexible members, such as the filaments **13**, in their longitudinal direction. The idler rolls **34** are pressed against the driving roll **33** with the filaments therebetween, thereby wrapping the filaments **13** part way around the driving roll **33** and holding the filaments **13** tightly against the driving roll **33** so that any movement of the driving roll **33** moves the filaments **13** correspondingly. As shown, the driving roll **33** is is driven by a pulley **35**. The pulley **35** is shown coupled by a belt **36** to a drive motor **37** in a manner to be hereinafter more fully described.

To position and align the filaments **13** in the spacial relationship desired for processing, guide bars **38** comprising a comb **39** are positioned to engage the filaments **13** after they pass from the nip **32**. The comb **39** is mounted with teeth **40** disposed to separate and guide the rack filaments **13** as they pass from the nip **32**. Positioned below the rack filaments **13** at the first station **14** and approximately midway between the nip **32** and the comb **39** is a roll **41** of filler **43**, which is preferably comprised of non-woven filler filaments. The filler **43** is fed from the roll **41** and about a positioning roll **45** for deposition upon the rack filaments **13** as shown in FIGURE 1.

To secure the filaments of filler **43** to the rack filaments **13**, a sewing means **47** is mounted at the station **15** for reciprocation transversely of the rack filaments **13**. The sewing means **47** comprises a sewing machine **49** mounted for movement upon a bed **51** along a path transverse to the rack filaments **13**. The relative disposition of the guide bars **38** and the bed **51** directs the filaments **13** and the filler **43** so that the filler **43** is disposed upon the filaments **13** when the latter reach the sewing station **15**. The sewing machine **49** is actuated by a suitable motor **53**. Traversing drive means **55** are provided for moving the machine **49** reciprocally across the filaments **13**. These means automatically reverse the direction of sewing after each traversal of the rack filaments **13** and thus sew the filler filaments to the rack filaments with the filaments from the sewing machine, which may be called the sewn filaments. The construction and operation of the machine **49** may be as described in greater detail in the copending application of Charles A. Lee and Warren R. Furbeck, Ser. No. 546,251, filed Apr. 29, 1966 for "Sewing Method and Apparatus for Making Sewn Fabric," now U.S. Patent No. 3,395,658.

After the filaments **13** have been sewn to the filler **43** to form a sewn mesh fabric **57**, the fabric is preferably passed through a second three-roll nip **59** operating like the nip **32** and cooperating with the nip **32** to drive the rack filaments **13** and the fabric **57** while maintaining them in tension therebetween. The nip **59** includes a drive roll **60** rotated by a drive shaft **61** secured to the motor **37**. A pulley **63** is secured to the motor **37** and coupled by the belt **36** to the pulley **35** for driving the nip **32**. As shown in FIGURE 2, the diameter of the pulley **35** is slightly larger than the diameter of the pulley **63** so that the nip **59** will be driven slightly faster than the nip **32** thereby stretching the rack filaments **13** therebetween while they pass the sewing means **47** at the second station **15**. As will be described in greater detail below, the operation of the motor **37** is controlled by the traversal of the sewing machine **49** so as to advance the fabric a predetermined amount after each traversal and thus provide rows of sewn filaments back and forth across the rack filaments and filler filaments.

Following the sewing, the fabric may be stabilized. To this end, the rack **11** further includes a stretch roll **65** disposed to receive the sewn fabric **57** after it leaves the nip **59** and to form a storage loop. The stretch roll **65** is rotat-

ably mounted at each end in a bearing **67**. The bearings **67** are suspended by cables **69** from pulleys **70, 71**, which are secured to a fixed member **72**, such as the ceiling of the room housing the rack **11**. From the pulley **70** the cable **69** is passed over a pulley **73** suspended from the member **72** and mounted for rotation on a shaft **74**, on which the pulley **71** is also fixed. The free ends of the cables **69** are secured to a suitable weight **75** as shown in FIGURE 1. The shaft **74** is coupled to a multiturn potentiometer **77** which serves as the sensing device for a servo means **79** of conventional construction, the coupling thereto being made by conductors **80**.

If the paths of the fabric **57** to and from the stretch roll **65** are parallel, the tension force in the fabric **57** is equal to half the weight of the weight **75**. With paths of other relative disposition, the relationship is different and changes as the stretch roll **65** moves up and down. It is therefore preferred to move the fabric over vertical paths to and from the stretch roll **65**. To direct the mesh fabric **57** over a generally vertical path to and from the stretch roll **65**, the stretch roll is mounted directly above the nip **59**, and a guide roll **81** is provided following the stretch roll **65**. Under these conditions, a predetermined tension is maintained in the fabric **57** by maintaining a fixed weight **75** pulling on the cables **69** to maintain predetermined tension therein.

Following the storage loop at the stretch roll **65**, the fabric **57** is directed past the stations **16, 17** and **18** where it is stabilized. The particular stabilizing operations performed depend, as stated above, upon the particular materials used and upon the particular application to which the fabric **57** is to be put. As illustrated, heat treating is performed at the station **16**. The mesh fabric **57** is directed about a second guide roll **83** and upwardly through an oven **85** located at the station **16**. The oven is preferably constructed in two concave sections **86, 87** hinged together along a mating edge. Thus, the oven **85** may be readily opened for inserting the fabric **57** for passage therethrough. To permit a rapid means of reducing the heat applied to the fabric **57**, such as might be necessary if the fabric stopped moving for any reason, the oven is shown provided with a solenoid actuated latch **88** of conventional construction, the operation of the latch being controlled by the servo means **79** in a manner to be described below. Heated air is introduced into the oven near the upper end thereof by means of ductwork **89** connected to a source of hot air **90** which may comprise a blower and a heater. The air is exhausted from the oven through an exhaust ductwork **91** located near the lower end of the oven **85**.

The hot air is introduced at the top in order that the flow of air through the oven is in a direction counter to the direction of movement of the fabric **57**. The oven is necessarily hottest where the hot air is introduced. The oven is cooler in the direction of motion of the air, which is cooled by conduction and radiation as it moves. Thus, the oven is cooler where the fabric **57** enters at the bottom, and there is a temperature gradient up to the point where the hot air enters. In the steady state operation with the fabric in motion upward and the air flowing the counter direction, the air may be introduced at the hottest temperature the fabric is to be exposed to. The fabric thus first contacts the cooler air in the oven and is gradually heated to a predetermined temperature which is slightly less than the temperature of the entering air because of the thermal inertia of the fabric **57**.

It is usually desirable to heat the fabric **57** gradually to as high a temperature as it can stand without damage; however, other temperatures may be utilized to control the amount of shrinkage. In any event any heat sensitive fabric should be heated to a temperature above that which it will likely be subjected to in use. Most fabrics, and particularly those made of synthetic fibers, shrink when heated. The heat treatment thus preshrinks the fabric and thus stabilizes its dimensions when placed in use. The amount of shrinkage is dependent to some extent upon the tension applied to the fabric during the heat treatment. This is controlled by adjustment of the weight **75**. In order that the shrinkage be uniform, it is important that the fabric be vertically disposed during heating. This avoids differential shrinkage occasioned by the sagging or catenary action of a horizontally disposed fabric.

After the controlled heat treatment, further stabilization may be desirable, as by applying a bonding agent to hold the rack filaments, filler filaments and sewn filaments in their relative positions. It may also be desirable to control the permeability or other property of the fabric. For such purposes, the fabric **57** upon leaving the oven **85** is directed over guide rolls **93** and **94** serving to reverse the direction of the fabric for passage to the station **17** and a subsequent operation. At the station **17**, the mesh fabric enters a tank **95** containing a treating fluid **96**, which may be a bonding agent of epoxy resin appropriately diluted by acetone. The sewn fabric **57** is passed over a tank roll **97** which is partially submerged in the fluid **96** within the tank **95** as shown in FIGURE 1 and is thus saturated with the fluid **96**. To prevent the fluid **96** from adhering to the roll **97**, it is preferred that the roll **97** be coated with phobic material, such as the polymer of tetrafluoroethylene sold under the trademark Teflon.

Upon leaving the fluid at the station **17**, the fabric **57** is directed vertically upward toward the station **18** and there through a vertically disposed oven **99** similar to the oven **85** and then about guide rolls **101** and **102**. The vertical disposition of the fabric upon leaving the roll **97** causes the excess fluid **96** to drip back into the tank **95** without contaminating the surrounding apparatus. Further it travels vertically through the oven **99** so that the fluid **96** does not drip on the oven. The vertical travel also avoids permanent deformation of the fabric as might otherwise occur upon heating while permitting catenary sagging of a horizontally suspended fabric.

Heat is introduced into the oven **99** by means of ductwork **103**, serving to force heated air into the oven from a source of heated air, which may be the same source **90** that supplies hot air to the oven **85**, although a separate source may be used as well. Air is removed from the lower end of the oven **99** by means of ductwork **106** which may be connected by suitable tubing to the atmosphere. The oven is provided with a solenoid latch **105** actuated by the servo means **79** so that the oven may be readily opened in the event an emergency arises. The functions of the oven **99** and the heated air introduced therein are to dry and cure the treating fluid **96**, including driving off a solvent. The evaporated solvent is preferably vented to the atmosphere. The dried mesh fabric **57** is then passed over the guide rolls **101** and **102** and through a three-roll nip **107** comprising a drive roll **108** and idler rolls **109**. The drive roll **108** is rotated by means of a constant speed motor **110** through a drive shaft **111** having a pulley **113** secured thereto. The speed of the motor may be controlled by a motor control **114**. The mesh fabric **57** is then wound about a takeup roll **115** which is rotated by the motor **110** through a suitable belt **117** driving a pulley **119**. The pulley **119** is coupled to a drive shaft **121** by means of a slip clutch **123** for imparting rotary movement to the takeup roll **115**.

In accordance with the illustrated embodiment, the mesh fabric **57** is processed in the following manner: The ends of the filaments **13** supplied from the cones **19** of the creel **20** are passed through the eyes **21** thereby aligning the filaments in the relative disposition they will maintain within the sewn fabric. The filaments **13** are held in tension by the tension means **23** which are adjusted to equalize the tension of the filaments **13** between the tension means **23** and the nip **32**. The filaments **13** then pass through the positioning comb **39**, over the sewing machine bed **51**, and through the nip **59**. As previously mentioned, the motor **37** actuates the driving members **33** and **60** of the nips

32 and 59, respectively. However, since the pulley 35 is of a larger diameter than the pulley 63, the nip 32 will be operated at a slightly slower speed than the nip 59, thereby applying a uniform tension to the filaments as they pass between the nips. The maintenance of the filaments in uniform tension as they pass between the nips 32 and 59 is particularly desirable if a uniform product is to be attained.

As previously mentioned, the filler 43 is fed about the guide roll 45 and is deposited upon the rack filaments 13 at station 14. The sewing means 47 is caused to move transversely across the filaments 13 by traversing drive means 55, thereby sewing the filaments 13 to the filler 43 at the station 15. As noted above, the traversing drive means 55 includes means for reversing its direction of drive after each traverse. At the same time, the drive means 55 applies a signal over conductors 124 to actuate the motor 53 for a predetermined period, thereby causing the three-roll nips 32 and 59 to advance the filaments 13 incrementally by a predetermined amount. Thus, as each traverse of the sewing means 47 is completed, the filaments will be advanced through the nips 32 and 59 an incremental distance. The movement of the sewing means 47 is thereupon reversed and the procedure repeated, thus producing a sewn mesh fabric.

The sewn fabric is then passed over the stretch roll 65 to form the storage loop and then over the guide rolls 81 and 83. As previously mentioned, the path of the mesh fabric 57, to and from the stretch roll 65, is generally vertical to provide constant tension on the fabric, even upon movement of the stretch roll. Because of the different operations to which the fabric 57 is subject in the course of its fabrication and due to speed variations within the system, there is slack in the fabric that is taken up by the movement of the stretch roll 65. For example, in the illustrated embodiment the filaments are passed by the stations 14 and 15 incrementally, whereas the fabric is passed continuously by the remaining stations 16, 17 and 18.

The rate at which the fabric is advanced through the ovens 85 and 99 is relatively critical. It is desired to operate with the ovens as hot as possible without damaging the fabric. The maximum temperature depends in part upon the speed of the fabric, partly because of the thermal inertia of the fabric. Therefore the motor 110 is caused to advance the fabric 57 at a constant predetermined rate. The speed of the sewing operation is relatively uncritical and is therefore controlled to accommodate the rate of the stabilizing operation.

As previously mentioned, the stretch roll 65 is provided with a multiturn potentiometer 77 which functions as the sensing means for a servo means 79. The servo means 79, in turn, regulates the speed of the motor 53, the servo means 79 being coupled to the motor 53 by conductors 126. This regulates the speed of sewing of the sewing means 47, and since the fabric is advanced incrementally as the sewing means 47 reaches its limit of travel, the rate of feed of the rack filaments 13 through the sewing operation is correspondingly regulated. For example, if the average rate of advance past the station 15 is greater than the rate of advance past the station 16, slack accumulates therebetween, and the stretch roll 65 is raised to take up the slack; similarly, the stretch roll 65 is lowered upon a decrease in fabric slack within the process, all the while maintaining a constant tension in the fabric because of the constant force exerted by the weight 75.

The movement of the roll 65 up and down is transmitted by the cables 69 to the pulleys 71 and 73 and hence to the potentiometer 77. The position of the potentiometer 77 is therefore indicative of the condition of the amount of fabric in the storage loop and hence of the relative rates of travel past stations 15 and 16. If there is too little fabric stored, the potentiometer 77 will be displaced in a first direction from its normal position, sending a signal to the servo means 79 which operates in a conventional manner to develop a control signal which is used to control the speed of the motor 53 to cause the sewing means to accelerate. Thus, the speed of the sewing means 47 will increase, causing it to traverse the filaments more quickly, resulting in an increase in the average rate at which the fabric is discharged from the nip 59, in turn providing greater slack within the system and causing the stretch roll 65 to rise. As the stretch roll 65 rises, a constant tension will be maintained in the sewn fabric, since the stretch roll 65 is biased a fixed amount by the weight 75. As the roll 65 rises, the potentiometer is caused to rotate in the direction opposite to the first direction. This movement of the potentiometer 77 will be sensed by the servo means 79, causing the sewing means 47 to decrease in speed thereby decreasing the rate at which the sewn fabric passes through the nip 59. The rate at which slack is produced is thus decreased, and the amount of fabric in the storage loop will gradually reach some predetermined amount, depending upon the control set point of the servo means 79. If the storage loop becomes too great, the servo means 79 will signal the motor 53 to slow down still further, thus slowing the sewing means 47, resulting in a decrease of slack fabric .

The servo means 79 operates in a manner well-known in the art to keep the amount of fabric in the storage loop relatively constant. The time constant of servo control will permit some change in the amount, as may be required by the intermittent operation of the motor 57. However, the sewing rate will otherwise be adjusted relatively promptly so that the average rate of advance past the sewing station 15 is just equal to the rate of advance past the stabilizing station 16.

It may be noted that the stretch roll 65 is shown near the top of its travel. This is the normal operating position, as it is desired to have a substantial amount of fabric in the storage loop, thus providing a substantial amount of sewn fabric for the continuous stabilizing operation in the event the sewing operation is shut down for a short period, as for replacing a broken or exhausted filament at the sewing machine, replacing a broken sewing machine needle, or adding a new roll 41 of filler 43. The fabric in the storage loop permits the stabilizing operation to continue uninterrupted for a short time. After the repair has been effected, the servo means 79 causes the sewing operation to proceed at a fast rate to accumulate more fabric in the storage loop and return the stretch roll 65 to its normal operating range.

Should there be a failure in the sewing operation that cannot be corrected in the time in which fabric is available for processing, the stretch roll 65 will approach the end of its downward travel. Such movement of the roll 65 to this extreme position will be sensed by the potentiometer 77, which will send an appropriate signal to the servo means 79. The servo means 79 then transmits control signals over conductors 128 to shut off the source of hot air 90 as by turning off the blower and heater. At the same time control signals are transmitted by the servo means 79 over conductors 130 to release the solenoid latches 88 and 105 provided upon the covers of the ovens 85 and 99. These covers are preferably spring biased, thus causing them to open upon release of the latches.

Alternatively, should the stretch roll 65 approach the upper end of its travel, the potentiometer 77 will supply a corresponding signal to the servo means 79, causing it to send out a control signal to the motor 53 to stop the sewing operation. Since this condition exists only when something has failed, as by a jamming of the stabilizing operation, the servo means 79 may be programmed, if desired, to shut down the stabilizing operation in the same manner as in the case of too little fabric, as described above.

As the sewn fabric 57 passes through the furnace 85, the fabric is heated causing it to shrink. Shrinkage in

the longitudinal direction is controlled by the constant tension under which the mesh fabric **57** is maintained by the stretch roll **65** as the fabric passes through the stabilizing operation. As previously mentioned, heat is introduced into the furnace at its uppermost end; thus the mesh fabric is subjected to the maximum heat just prior to being withdrawn from the oven. In this manner, the heat to which the mesh fabric is subjected is progressively increased as it passes through the furnace, thereby shrinking the fabric in a gradual uniform manner.

After the heat treatment, the mesh fabric is passed about the guide rolls **93** and **94** and about the tank roll **97** thereby coating the mesh fabric with the treating fluid **96**. The coated fabric is then passed through the oven **99**. Passage through the oven **99** serves to dry the coated fabric in a uniform gradual manner and cure the stabilizing agent. The dried mesh fabric passes from the oven about the guide rolls **101** and **102** and through the nip **107**. The nip **107** operates at a constant uniform speed so that the speed of the fabric through the shrinking oven **85** and fluid bath **95** and the drying oven **99** will be relatively constant and uniform, thereby affording uniform finishing treatment. The constant speed at which the motor **110** drives the nip **107** is controlled by the motor control **114**. The desired speed depends upon the particular fabric being made. It depends upon the material of which the filaments **13** and the sewn filaments are made as well as upon the material of the filler **43**. It depends upon the particular stabilizing fluid **96** and the desired properties of the finished fabric, such as porosity, permeability and stiffness. The stabilizing treatment may be as described in greater detail in the co-pending application of Charles A. Lee and Warren R. Furbeck, Ser. No. 546,381, filed Apr. 29, 1966, for "Method and Apparatus for Stabilizing Sewn Fabric."

After the fabric is thus finished, it is wound upon a takeup roll **115** which, as previously mentioned, is connected through a slip clutch **123** to the motor **110**. The roll **115** is coupled to the motor through a slip clutch **123** to compensate for the change in roll diameter as the fabric is rolled thereupon. That is, the takeup roll **115** must be driven at a rate just fast enough to take up all of the finished fabric as it leaves the nip **107**. The fabric leaves the nip **107** at a constant speed, but since the effective diameter of the roll changes as the fabric accumulates thereon, it cannot be driven at a constant speed. The belt **117** therefore is used to drive the pulley **119** at a greater rate than necessary to take up slack, but the clutch **123** slips to permit the roll **115** to advance at the proper rate. The clutch **123** is caused to slip by the tension in the fabric **57** between the nip **107** and the roll **115**.

Although certain specific embodiments of this invention have been shown and described, it will be understood that the details of the construction shown may be altered without departing from the spirit of this invention, as defined by the following claims. For example, in the illustrated embodiment the filaments pass through the sewing means incrementally; however, if desired the filament may be advanced continuously during the sewing process, thus producing non-parallel rows of stitches.

It may be noted that the continuous movement of the fabric **57** past the stabilizing stations **16**, **17** and **18** includes the periodic movement of the fabric by uniform increments. In this case, the motor control **114** may actuate the motor **110** periodically for time intervals of uniform duration. This drives the fabric at a substantially uniform rate, as the term is used herein. A further control on the amount of fluid **96** added to the fabric **57** may be achieved by adding blowers between the stations **17** and **18** and blowing off excess fluid. This also serves to keep the fabric open and of relatively uniform permeability.

It should also be noted that the method and apparatus of this invention are useful in making a number of different products from a number of different materials. In particular, they may be used in making the products disclosed in the aforesaid copending Lee application Ser. No. 431,030, now abandoned, from the materials disclosed therein.

We claim:

1. A method of manufacturing a continuous mesh fabric comprising the steps of supporting a plurality of continuous laterally independent rack filaments in spaced parallel relation upon a plurality of elongated support members mounted in fixed spaced relations to form a rack, moving said rack filaments between first and second points along a predetermined continuous path defined by said members to move successive portions of said rack filaments past first and second stations located successively between said first and second points, at said first station sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments together to form a continuous mesh fabric, and at said second station gradually heating said fabric to a predetermined temperature as successive portions thereof are moved past to heat-shrink said fabric.

2. A method of manufacturing a continuous mesh fabric comprising the steps of supporting a plurality of continuous laterally independent rack filaments in spaced parallel relation upon a plurality of elongated support members mounted in fixed spaced relations to form a rack, moving said rack filaments between first and second points along a predetermined continuous path defined by said members to move successive portions of said rack filaments past first and second stations located successively between said first and second points, applying tension to said rack filaments on said rack, at said first station sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments together to form a continuous mesh fabric while maintaining said rack filaments in tension on said rack, and at said second station stabilizing successive portions of said fabric as they are moved past.

3. A method of manufacturing a continuous mesh fabric comprising the steps of supporting a plurality of continuous laterally independent rack filaments in spaced parallel relation upon a plurality of elongated support members mounted in fixed spaced relations to form a rack, moving said rack filaments between first and second points along a predetermined continuous path defined by said members to move successive portions of said rack filaments past first, second, third and fourth stations located successively between said first and second points, sewing transversely of said rack filaments as successive portions thereof are moved past said first station to sew said rack filaments together to form a continuous mesh fabric, thereafter gradually heating successive portions of said fabric to a predetermined temperature as they are moved past said second station to heat-shrink said fabric, adding bonding agent to successive portions of said fabric as they are moved past said third station, and curing said bonding agent on successive portions of said fabric as they are moved past said fourth station.

4. A method of manufacturing a continuous mesh fabric comprising the steps of supporting a plurality of continuous laterally independent rack filaments in spaced parallel relation upon a plurality of elongated support members mounted in fixed spaced relations to form a rack, moving said rack filaments past first, second, third, fourth and fifth stations located successively between said first and second points, at said first station depositing nonwoven filler filaments on said rack filaments, sewing transversely of said rack filaments as successive portions thereof are moved past said second station to sew said rack filaments to said filler filaments to form a continuous mesh fabric, gradually heating successive portions of said fabric to a predetermined temperature as they are moved past said third station to heat-shrink said fabric, adding bonding agent to successive portions of said fabric as they are moved past said fourth station, and curing said bonding

agent on successive portions of said fabric as they are moved past said fifth station.

5. A method of manufacturing a continuous pre-shrunk mesh fabric comprising the steps of positioning a plurality of laterally independent continuous rack filaments in spaced parallel relation upon a rack, applying tension to said rack filaments on said rack, moving said rack filaments along a predetermined continuous path defined by said rack, sewing transversely of said rack filaments to sew said rack filaments together to form a continuous mesh fabric while maintaining said rack filaments in tension on said rack, and thereafter applying heat to said fabric to cause shrinkage thereof while maintaining said loops in tension on said rack to limit shrinkage in the direction of said rack filaments.

6. A method of manufacturing a continuous mesh fabric comprising the steps of supporting a plurality of continuous laterally independent rack filaments in spaced parallel relation upon a plurality of elongated support members mounted in fixed spaced relations to form a rack, moving said rack filaments between first and second points along a predetermined continuous path defined by said members to move successive portions of said rack filaments past first and second stations located successively between said first and second points, applying substantially equal tension to each of said rack filaments in said rack, at said first station sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments together to form a continuous mesh fabric while maintaining said rack filaments in tension on said rack, and at said second station stabilizing successive portions of said fabric as they are moved past.

7. A method of manufacturing a continuous mesh fabric comprising the steps of supporting a plurality of continuous laterally independent rack filaments in spaced parallel relation upon a plurality of elongated support members mounted in fixed spaced relations to form a rack, moving said rack filaments between first and second points along a predetermined continuous path defined by said members to move successive portions of said rack filaments past first, second and third stations located successively between said first and second points, at said first station depositing non-woven filler filaments on said rack filaments, at said second station sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments to said filler filaments to form a continuous mesh fabric, and at said third station stabilizing successive portions of said fabric as they are moved past.

8. A method according to claim 7 wherein a storage loop is provided in said sewn fabric between said first and second stations, said fabric being moved past said second station at a substantially uniform rate, and said rack filaments being moved intermittently past said first station at an average rate maintaining the length of said storage loop substantially constant.

9. A method of manufacturing a continuous mesh fabric comprising the steps of supporting a plurality of continuous laterally independent rack filaments in spaced parallel relation upon a plurality of elongated support members mounted in fixed spaced relations to form a rack, moving said rack filaments between first and second points along a predetermined continuous path defined by said members to move successive portions of said rack filaments past first and second stations located successively between said first and second points, at said first station sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments together to form a continuous mesh fabric, and at said second station stabilizing successive portions of said fabric as they are moved past.

10. A method according to claim 9 wherein a storage loop is provided in said sewn fabric between said first and second stations, said fabric being moved past said second station at a substantially uniform rate, and said rack filaments being moved intermittently past said first station at an average rate maintaining the length of said storage loop substantially constant.

11. A method according to claim 10 wherein said rack filaments are moved intermittently past said first station in substantially equal increments, said sewing being performed while said rack filaments are stopped between movements.

12. A method according to claim 11 wherein substantially constant tension is applied to said rack filaments at said first station, and substantially constant tension is applied to said sewn fabric at said second station.

13. An apparatus for the manufacture of continuous mesh fabric comprising a rack including a plurality of elongated members mounted in fixed relationship to each other for receiving a plurality of laterally independent continuous rack filaments in spaced parallel relation thereupon and supporting said rack filaments for movement transversely of said members along a predetermined continuous path between first and second points, means for moving the rack filaments along said path from said first point to said second point to move successive portions of said rack filaments past first, second and third stations located successively between said first and second points, means at said first station for depositing non-woven filler filaments on said rack filaments, sewing means at said second station for sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments to said filler filaments to form a continuous mesh fabric, and means at said third station for stabilizing successive portions of said sewn fabric as they are moved past.

14. An apparatus for the manufacture of continuous mesh fabric comprising a rack including a plurality of elongated members mounted in fixed relationship to each other for receiving a plurality of continuous laterally independent rack filaments in spaced parallel relation thereupon and supporting said rack filaments for movement transversely of said members along a predetermined continuous path between first and second points, means for moving the rack filaments along said path from said first point to said second point to move successive portions of said rack filaments past first, second and third stations located successively between said first and second points, sewing means at said first station for sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments together to form a continuous mesh fabric, heating means at said second station for gradually heating successive portions of said sewn fabric as they are moved past, and means at said third station for applying bonding agent to successive portions of said fabric as they are moved past.

15. An apparatus for the manufacture of continuous mesh fabric comprising a rack including a plurality of elongated members mounted in fixed relationship to each other for receiving a plurality of continuous laterally independent rack filaments in spaced parallel relation thereupon and supporting said rack filaments for movement transversely of said members along a predetermined continuous path between first and second points, means for moving the rack filaments along said path from said first point to said second point to move successive portions of said rack filaments past first, second, third, and fourth stations located successively between said first and second points, means at said first station for depositing non-woven filler filaments on said rack filaments, sewing means at said second station for sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments to said filler filaments to form a continuous mesh fabric, means at said third station for gradually heating successive portions of said sewn fabric as they are moved past, and means at said fourth station for applying bonding agent to successive portions of said fabric as they are moved past.

16. An apparatus for the manufacture of continuous mesh fabric comprising a rack including a plurality of elongated members mounted in fixed relationship to each other for receiving a plurality of laterally independent continuous rack filaments in spaced parallel relation thereupon and supporting said rack filaments for movement transversely of said members along a predetermined continuous path between first and second points, means for moving the rack filaments along said path from said first point to said second point to move successive portions of said rack filaments past first and second stations located successively between said first and second points, sewing means at said first station for sewing transversely of said rack filaments as successive portions thereof are moved past to sew said rack filaments together to form a continuous mesh fabric, and means at said second station for stabilizing successive portions of said sewn fabric as they are moved past.

17. Apparatus according to claim 16 including first tensioning means for applying substantially constant tension to said rack filaments at said first station, and second tensioning means for applying substantially constant tension to said fabric at said second station.

18. Apparatus according to claim 16 wherein said means for moving includes a first motive means for moving said fabric at a substantially uniform rate past said second station, and a second motive means for moving said rack filaments intermittently past said first station.

19. Apparatus according to claim 18 including means for operating said second motive means to move said rack filaments a predetermined increment after each traverse of said sewing means across said rack filaments.

20. Apparatus according to claim 18 including means for maintaining a storage loop in said fabric intermediate said first and second stations.

21. Apparatus according to claim 20 wherein said means for maintaining a storage loop includes a stretch roll for maintaining a substantially constant tension in said fabric.

22. Apparatus according to claim 20 including means responsive to the amount of fabric in said storage loop for controlling the operation of said second motive means to maintain said amount substantially constant.

23. Apparatus according to claim 22 wherein said means responsive to the amount of fabric is coupled to said sewing means to control the speed thereof and including means for operating said second motive means to move said rack filaments a predetermined increment after each traverse of said sewing means across said rack filaments.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,486,956 Dated December 30, 1969

Inventor(s) Charles A. Lee and Warren R. Furbeck

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 22, "the sewing" should read -- a sewing --;
line 26, "portitons" should read -- portions --;
line 65, "filament" should read -- filaments --.
Column 2, line 66, "restoring" should read -- restring --.
Column 3, line 15, after "provide" insert -- a --.
Column 11, line 5, change "laterally independent continuous" to -- continuous laterally independent --;
line 13, change "loops" to -- rack filaments --;
line 50, change "first" to -- second --;
line 51, change "second" to -- third --;
line 54, change "station" to -- and second stations --.
Column 12, line 16 - 17, change "laterally independent continuous" to -- continuous laterally independent --.
Column 13, lines 4 - 5, change "laterally independent continuous" to -- continuous laterally independent --.

SIGNED AND
SEALED
OCT 13 1970

(SEAL)
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