Dec. 28, 1965 L. MISHCON 3,225,570

AUTOMATIC STITCH CONTROL

Filed June 27, 1963 5 Sheets-Sheet 1

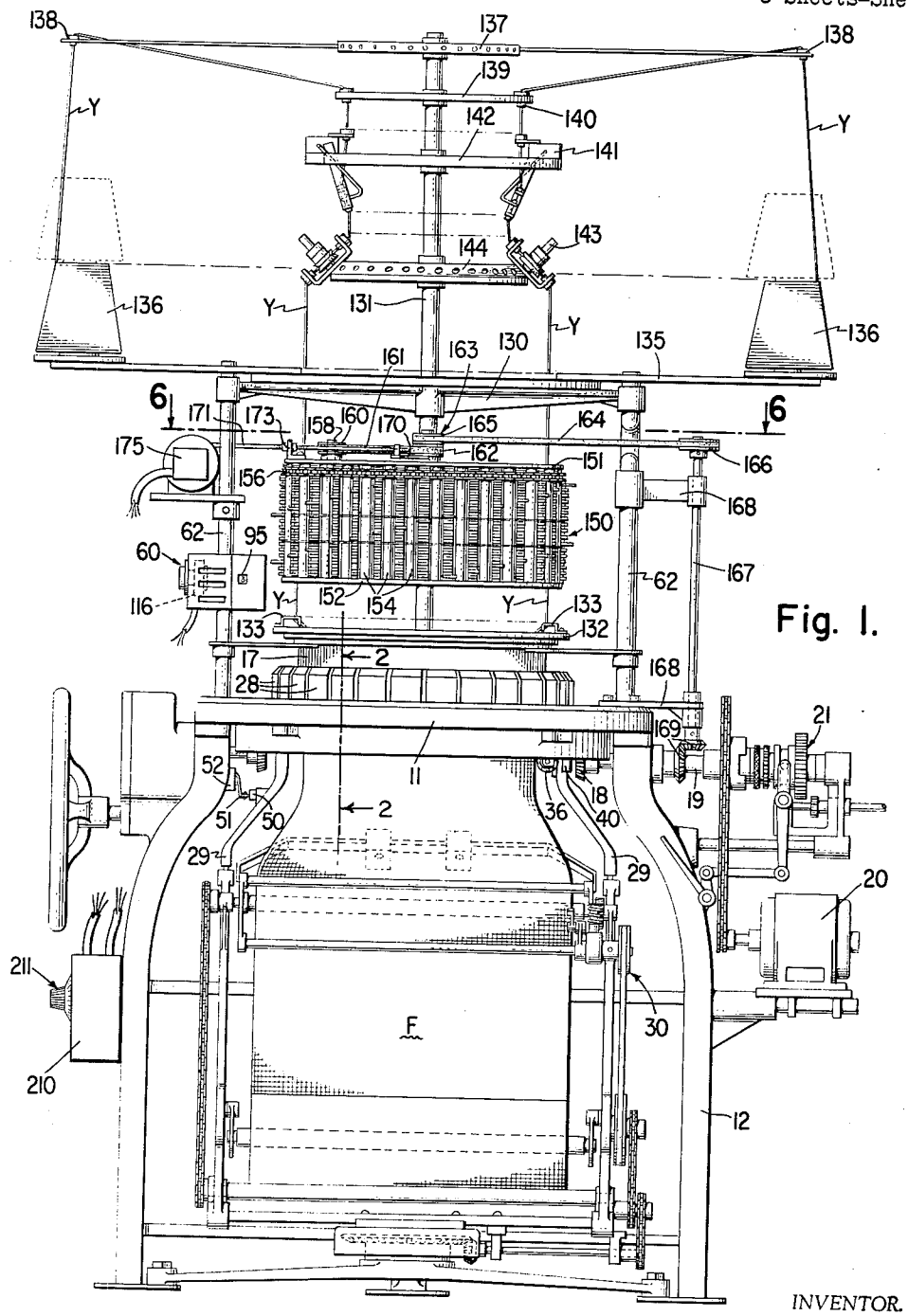

Fig. 1.

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AUTOMATIC STITCH CONTROL

Filed June 27, 1963 5 Sheets-Sheet 2

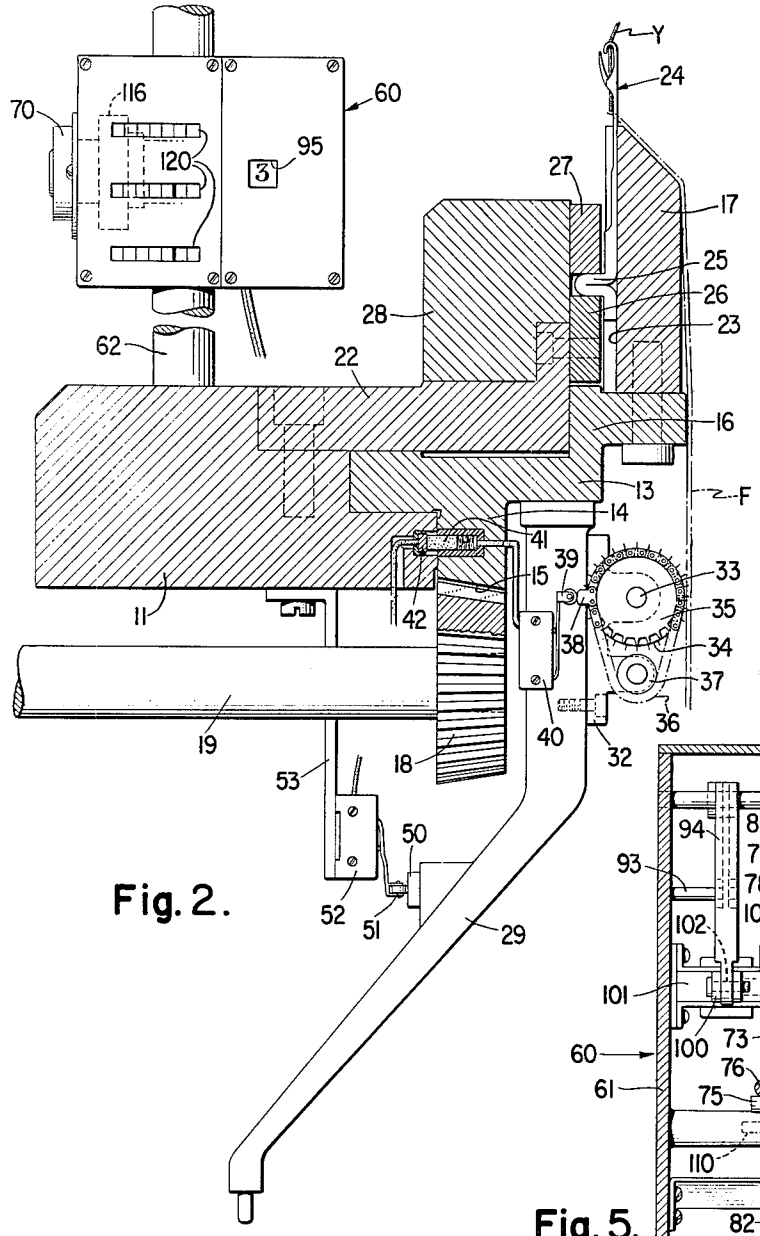

Fig. 2.

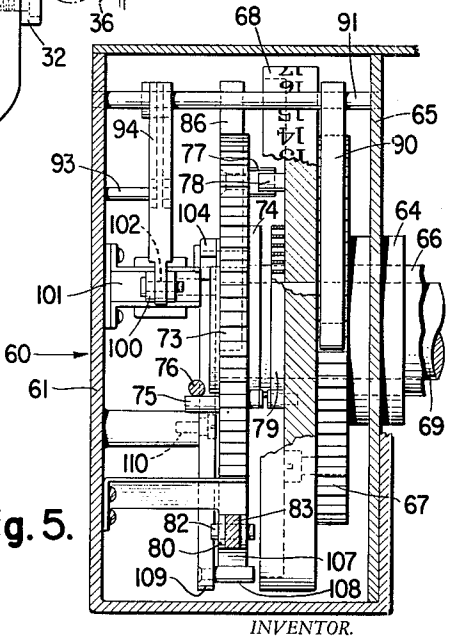

Fig. 5.

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AUTOMATIC STITCH CONTROL

Filed June 27, 1963 5 Sheets-Sheet 3

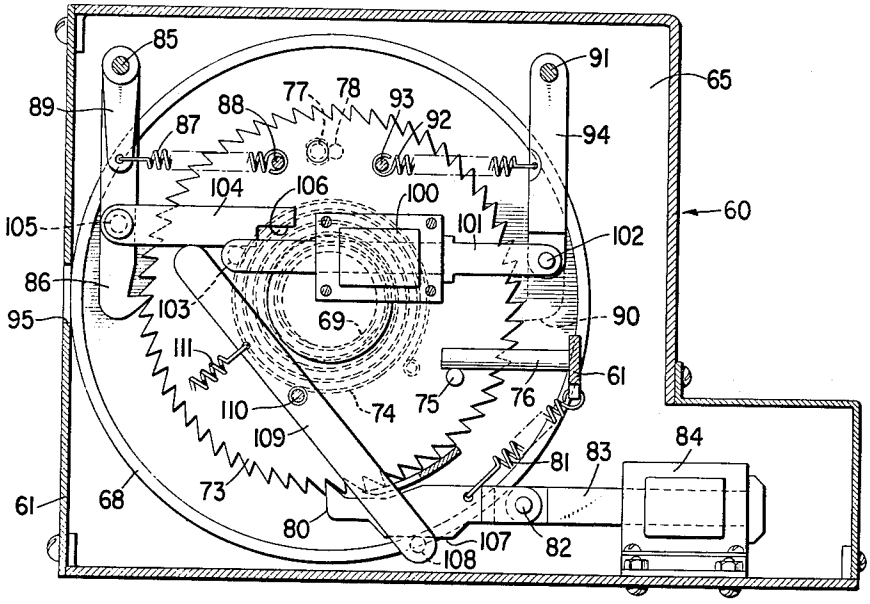

Fig. 4.

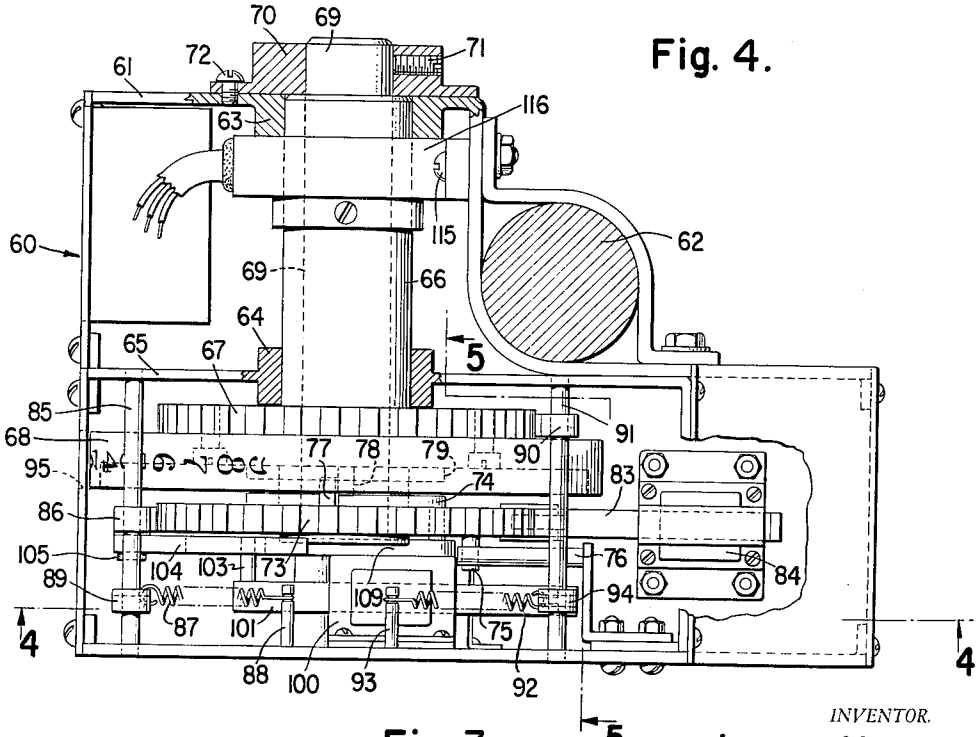

Fig. 3.

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AUTOMATIC STITCH CONTROL

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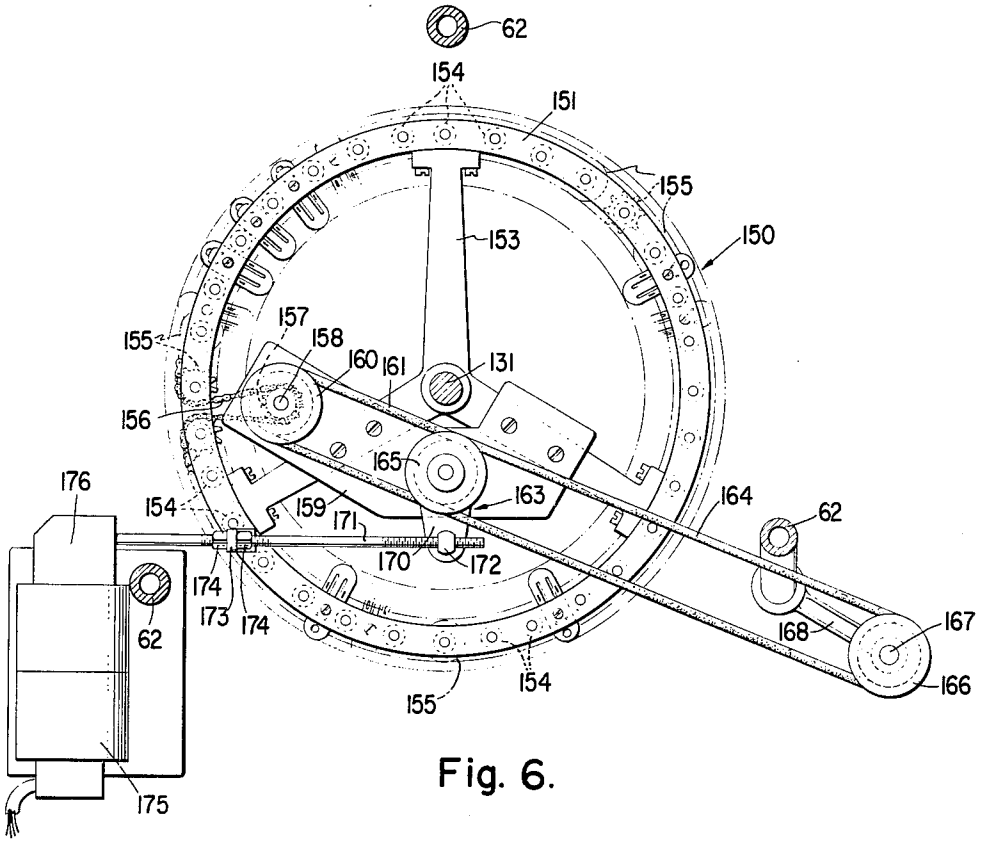

Fig. 6.

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AUTOMATIC STITCH CONTROL

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Fig. 7.

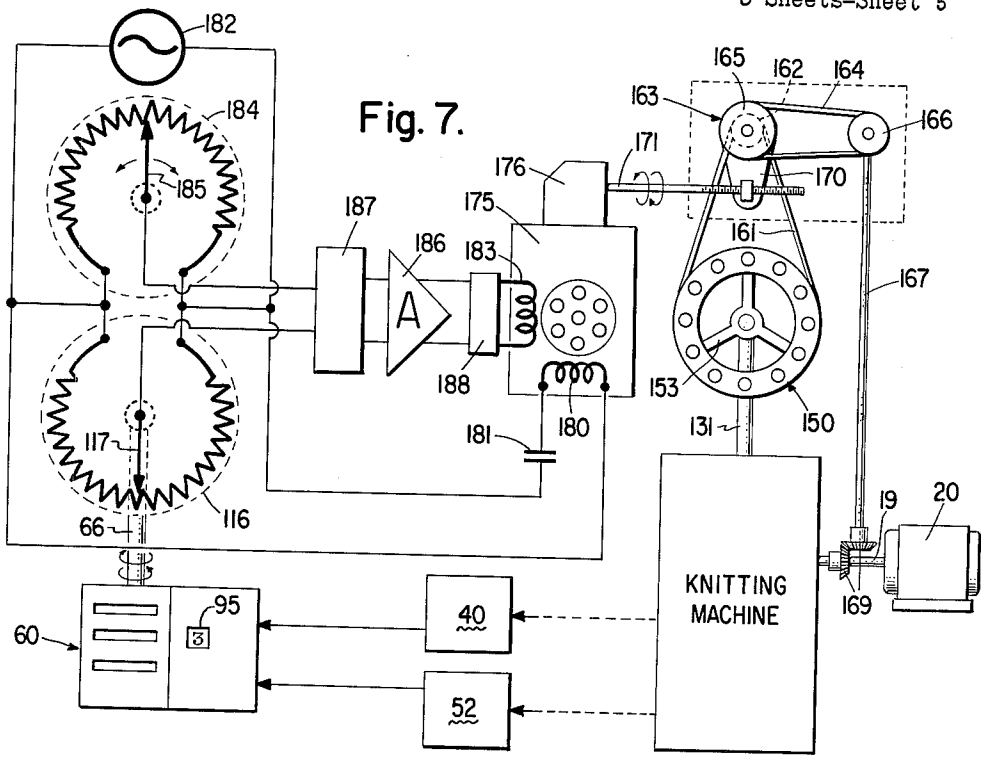
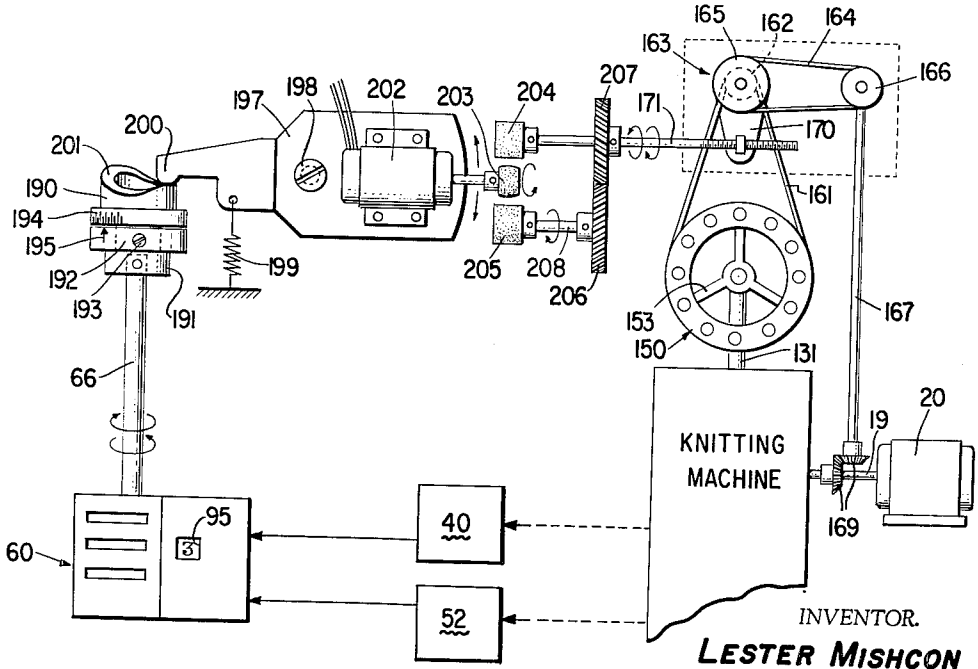


Fig. 8.



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3,225,570

Patented Dec. 28, 1965

3,225,570

AUTOMATIC STITCH CONTROL

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Filed June 27, 1963, Ser. No. 291,011
16 Claims. (Cl. 66—132)

This invention relates to the manufacture of fabric and more particularly to a control system for regulating the operation of fabric making machinery for the continuous production of fabric of uniform characteristics.

In the preferred embodiment of this invention; as illustrated in the accompanying drawings, this invention is applied to a circular knitting machine and serves to regulate the yield of the resulting knit fabric. In the manufacture of knit fabric, production of a fabric of uniform density or yield in terms of weight of the fabric per unit area is difficult because many variable factors are involved. For example, in a circular knitting machine, some of those factors include yarn tension, the condition of the yarn, the stroke of the knitting needles, frictional resistance to movement of needles, and tension applied to the fabric as it is being manufactured.

In my United States application Serial No. 278,135, filed May 6, 1963, and entitled "Yarn Controlling Device for Knitting Machines," a single yarn furnishing unit is provided which permits an operator, at his discretion, to deliver the yarns to the knitting instrumentalities in a selected one of a wide range of conditions either in measured quantities precisely meeting the demand of the knitting instrumentalities or under accurate and consistent tension. The yarn controlling device of the above referenced patent application provides for an adjustment under the influence of a knitting machine operator whereby the resulting yield of a knit fabric may be changed.

In my United States application Serial No. 160,439, filed December 19, 1961, entitled "Fabric Yield Computing Device, now United States Patent Serial No. 3,099,-142, apparatus is described for measuring and continuously indicating the yield of a fabric being produced during the operation of a fabric manufacturing machine.

While devices such as those described in the above referenced patent applications can be helpful to a machine operator, assisting him in maintaining the knitting machine in that state of adjustment which might produce fabric of substantially uniform yield, they require continuous supervision and some degree of manual adjustment by an operator. Supervision by an operator imposes a burden on the manufacturer because of the need for highly reliable personnel having well-developed skill in making manual adjustments in appropriate increments at the proper time in order to avoid spoilage of fabric. Hence, it has long been a most significant need of the fabric manufacturing industry to have a machine capable of operation without continuous supervision to produce a highly uniform yield. In meeting this need, the devices of this invention provide a measurement of the actual yield from the machine, compare that yield measurement with a desired yield, detect any difference therebetween, and effect a machine adjustment in response to any such difference to maintain the desired yield. In accordance with this invention, a knitting machine is provided for concatenating fibers to form a web having an identifiable characteristic. During operation, the knitting machine can be regulated to vary the characteristic of the web. The characteristic of the fabric web is measured during operation of the machine and a measurement

response is provided as a function of the characteristic of the fabric web. The measurement response is compared with a predetermined reference standard and the machine is regulated in response to the difference between the measurement response and the predetermined reference standard to reduce that difference.

This invention is described below with reference to particular preferred embodiments thereof shown in the attached drawings in which:

FIG. 1 represents a side elevational view of multi-feed circular knitting machine having my invention applied thereto;

FIG. 2 is an enlarged cross-sectional view of a portion of the knitting machine of FIG. 1 taken substantially along line 2—2 with certain elements thereof rearranged for convenience of illustration;

FIG. 3 represents a top plan view of a computing device with portions of the casing thereof removed and broken away;

FIG. 4 is a cross-sectional view taken substantially along line 4—4 of FIG. 3, representing a side elevation of the mechanism of the computing device within the casing;

FIG. 5 is a cross-sectional view taken substantially along line 5—5 of FIG. 3 representing a rear elevation of the mechanism of the computing device;

FIG. 6 is an enlarged cross-sectional view along line 6—6 of FIG. 1 representing a top plan view of the yarn control device of the knitting machine;

FIG. 7 is a schematic drawing of an electro-mechanical control system for regulating the fabric yield of a knitting machine in accordance with this invention;

FIG. 8 is a schematic drawing of a mechanical system for regulating the fabric yield of a knitting machine in accordance with this invention.

Referring to FIG. 1 which illustrates a knitting machine (modified in accordance with this invention), and FIG. 2, which includes an enlarged illustration of a portion of the knitting instrumentalities, the knitting machine shown is supported by a frame including a housing ring **11** and legs **12**. Journaled in the housing ring is a gear ring **13** (FIG. 2) having a depending flange **14** formed with gear teeth **15** and an upstanding flange **16** to which a needle cylinder **17** is secured. The gear teeth **15** mesh with a pinion **18** fast on a shaft **19** which is driven by an electric motor **20** by way of a clutch device **21**. The gear ring **13** is constrained rotatably in the housing ring **11** by a retaining ring **22** secured to the housing ring.

The outer wall of the needle cylinder **17** is formed with evenly spaced vertical slots **23** each slot slidably accommodating a latch needle **24** formed with a butt **25**. As the needle cylinder is rotated, the needle butts are successively influenced alternately by needle raising cams **26** carried by the retaining ring **20** and then by stitch cams **27** carried by a section block **28** on the cam retaining ring **22**. Each set of cams **26**, **27**, of which there may be many disposed outwardly of the needle cylinder, cooperate to influence endwise motion of the needles in seriatim to form a row of stitches in a fabric F by incorporation therein of loops formed from one of a plurality of yarns Y which are fed to the needles as the needles are being influenced by the cams **26** and **27**.

Fast on the gear ring **13** so as to rotate with the needle cylinder **17** are a pair of take-up driving brackets **29** which engage with and drive a fabric take-up indicated generally at **30** in FIG. 1. Secured on one of the take-up driving brackets **29** is a support frame **32** carrying a stud shaft **33** on which is journaled a fabric driven wheel **34** pro-

vided peripherally with fabric engaging pins. Secured coaxially with the wheel **34** is a sprocket wheel **35** engaging an endless chain **36** which also passes about an idler sprocket **37** journaled in the support frame. In the preferred embodiment illustrated in the drawings, one of the links **38** of the chain **36** is formed higher than the remainder of the links so as to provide a cam surface engageable with a contact arm or roller **39** of an electrical switch **40** secured on the take-up driving bracket **29** adjacent to the support frame **32**. The switch **40** is of the normally-open variety and is closed momentarily by the cam link **38** upon the passage of a predetermined quantity of fabric relatively to the fabric driven wheel **34**. Each closure of the switch **40** thus reflects the measurements of a discrete quantity of fabric produced by the knitting machine. An electrical lead from the switch **40** may be directed by way of a brush **41** in the gear ring **13** and a slip-ring **42** in the housing ring **11** to the outside of the knitting machine.

Secured on a boss on the take-up driving bracket **29** is a cam lug **50** disposed for engagement with a contact arm or roller **51** of an electrical switch **52** secured on a bracket **53** carried on the housing ring **11**. The switch **52** is of the normally-open variety and is closed momentarily by the cam lug **50** once during each revolution of the needle cylinder **17**. Each closure of the switch **52** thus reflects the measurement of the number of courses of knitting which are completed during each revolution of the knitting machine.

The leads from both switches **40** and **52** are directed to a computing device indicated generally as **60** preferably contained in a casing **61** secured to one of a plurality of vertical standards **62** rising from the housing ring **11** or in a similar position on the knitting machine where it may be viewed by the knitting machine operator. It is a function of the computing device continuously to combine the measurements of the fabric courses and of the quantity of fabric being produced to provide a response proportional to the yield of the fabric being produced and it may be used to display indicia representing fabric yield during operation of the machine.

Referring to FIGS. 3, 4 and 5 illustrating the computing device **60**, a bearing **63** on the casing **61** and a bearing **64** on a partition **65** inside the casing rotatably supports a sleeve **66** to which is fixed a retrograde ratchet wheel **67** and an indicating wheel **68** having a smooth cylindrical periphery on which indicia may be marked. A stud shaft **69** carried within the sleeve **66** is fixed to the casing **61** by means of a collar **70** and set screws **71** and **72**. Adjacent to the indicating wheel **68**, a drive ratchet wheel **73** is freely journaled on the shaft **69** and biased in a counterclockwise direction as viewed in FIG. 4 by a coil spring **74** attached to the drive ratchet wheel **73** and to the stud shaft **69**. An at rest position of the drive ratchet wheel in response to the coil spring **74** is determined by a stop pin **75** protruding from the driving ratchet wheel for engagement with an abutment pin **76** secured to the casing.

An operative connection exists between the driving ratchet wheel **73** and the sleeve **66** and the indicating wheel **68** whereby the sleeve and the indicating wheel will be driven in one direction by the driving ratchet wheel. To this end a drive lug **77** extends laterally from the driving ratchet wheel and is positioned to abut one side of a pin **78** extending laterally from the indicating wheel. As viewed in FIG. 4, clockwise movement of the driving ratchet wheel **73** will be transmitted to the sleeve **66** and the indicating wheel **68** by the drive lug **77** and pin **78**. A coil spring **79** secured at one extremity to the indicating wheel **68** and at the other extremity to the shaft **69** serves to bias the sleeve **66** and the indicating wheel **68** toward an at-rest position as determined by engagement of the pin **78** with the driving lug **77**.

The driving ratchet wheel **73** is indexed during the operation of the knitting machine by means of a drive pawl **80** biased into engagement with the driving ratchet wheel by a spring **81** and pivoted as at **82** to the armature or plunger **83** of an electric solenoid **84**. The solenoid is connected electrically with the switch **52** so as to actuate the drive pawl **80** upon each revolution of the knitting machine sensed by the switch **52**.

Secured on a rock shaft **85** journaled between the casing **61** of computer **60** and the partition **65** is a retrograde pawl **86** biased into engagement with the teeth of the driving ratchet wheel **73** by means of a spring **87** which extends between an anchor pin **88** secured to the casing and a rock arm **89** secured on the rock shaft **85**. The retrograde ratchet wheel **67** and sleeve **66** secured to the indicating wheel **68** similarly cooperate with a retrograde pawl **90** secured on a second rock shaft **91** journaled between the computer casing and the partition **65**. A spring **92** extending between an anchor pin **93** on the casing and a rock arm **94** fast on the second rock shaft **91** serves to bias the retrograde pawl **90** into engagement with the retrograde ratchet wheel **68**.

Both the retrograde pawl **90** and the drive lug **77** when in engagement with the pin **78** serve to prevent the sleeve **66** and the indicating wheel **68** from partaking of retrograde movement as the indicating wheel **68** is indexed by the driving ratchet wheel **73**. The indicia on the indicating wheel are thus indexed past a window **95** (FIGS. 1 and 2) formed in the computer casing a predetermined increment for each revolution of the knitting machine, or in other words, a given increment upon each completion of that number of courses made by the machine in each revolution.

Secured on the computer casing **61** is an electrical solenoid **100** of which the armature or plunger **101** is pivoted as at **102** to rock arm **94** associated with the retrograde pawl **90**. The solenoid **100** is connected electrically with the switch **40** and is arranged when activated by closure of the switch **40** to shift the plunger **101** to the right as viewed in FIG. 4 to release the retrograde pawl **90**. Since the switch **40** is closed only momentarily upon the measurement of each predetermined quantity of fabric, the solenoid **100** will be activated only momentarily after which the retrograde pawl **90** under the action of the spring **92** will be returned into engagement with the retrograde ratchet wheel **67** and the armature **101** will be shifted to the left as viewed in FIG. 4.

A pin **103** protruding from the armature **101** slides beneath a link **104** pivoted at **105** on the retrograde pawl **86** which engages the driving ratchet wheel **73**. The undersurface of the link **104** is formed with a notch **106** which falls into engagement with the pin **103** when the armature **101** is shifted to the right as viewed in FIG. 4 upon actuation of the solenoid **100**. When the spring **92** returns the armature **101** to the left as viewed in FIG. 4, the pin **103** in engagement with the notch **106** will shift the retrograde pawl **86** out of engagement with the driving ratchet wheel **73** thus releasing the driving ratchet wheel to be returned at the at-rest position by the coil spring **74**.

Since the retrograde pawl **90** will have re-engaged the retrograde ratchet wheel **67** associated with the sleeve **66** and the indicating wheel **68** prior to release of the driving ratchet wheel **73**, the indicating wheel **68** and sleeve **66** will be maintained in the final position to which they have been indexed by the driving ratchet wheel **73** and the positions of the sleeve **66** and the indicium on the indicating wheel **68** corresponding to such indexed position will be maintained.

Upon the first actuation of the drive pawl **80** after each release of the driving ratchet wheel **73**, a cam surface **107** formed beneath the drive pawl **80** will engage a pin **108** carried by a release lever **109** fulcrumed at **110** on the computer casing, and shift the release lever against the action of a light spring **111** upwardly beneath the link **104**. The notch **106** in the link will thus

be raised out of engagement with the pin **103** and the retrograde pawl **86** will be returned by the spring **87** into engagement with the driving ratchet wheel **73**.

The cycle of operation above described will be repeated continually during the operation of the machine with a plurality of indexing pulses being imparted to the driving ratchet wheel until culminated by the alternate release of the retrograted motion pawls **90** and **86**. If the fabric being manufactured by the machine is of uniform yield the number of courses produced during the measurement of any discrete quantity of fabric will remain the same and the drive lug **77** will be in engagement with the pin **78** whenever the retrograde pawl **90** is released. With uniform conditions, therefore, the positions of sleeve **66** remain unchanged and the same indicium will remain in view through the window **95**.

If, however, the fabric should gradually become more dense, i.e., comprise a greater number of courses and hence the number of stitches per unit length of fabric, a greater number of indexing pulses will occur by way of the driving pawl **80** during each interval of fabric measurement. As a result, the lug **77** will engage and advance the pin **78** and, therefore, the sleeve **66**, and the indicating wheel **68** so as to change the indicia displayed through the window **95**.

Should the fabric decrease in weight i.e. contain fewer courses per unit length, the lug **77** will be indexed short of engagement with the pin **78** and upon release of the retrograde pawl **90**, the sleeve **66** and the indicating wheel **68** will be returned by the coil spring **79** until the pin **78** engages the lug **77** thus changing the sleeve position and the indicium displayed through the window **95**.

Referring to FIG. 3, there is secured as by fastening screw **115** to the casing **61** of the computer **60** adjacent the sleeve bearing **63** an adjustable potentiometer **116**. The potentiometer **116**, as is conventional, includes a movable contact arm **117** (see FIG. 7) which is attached to the sleeve **66** to be turned thereby.

The measurements which result in a position of the contact arm **117** representative of fabric yield are derived from the fabric F as it is being knit and while the fabric is under the influence of a take-up device. This is advantageous, as pointed out above, in providing practically immediate corrective adjustments of the contact arm **117** of the potentiometer. Preferably, the fabric yield measuring devices is located closely adjacent to the point at which the fabric is being manufactured. This was stated in my above cited United States Patent No. 3,099,-142, col. 2, lines 3–11 and it is shown in FIGS. 1 and 2, herein, insofar as element **36** is closely adjacent to the point at which fabric is being produced. In other words the measurement is made closely adjacent to the needles **24** relative to the fabric take-up **30**, with the resulting advantage that there is a reduction of the time lag between the time of occurrence of a variation in fabric yield and the time of correction of that variation. The yield of a fabric, however, may change when it passes from the influence of the take-up device. Moreover, different yarns recover at different rates from the tensions applied during fabric manufacture. The difference between the condition of the fabric as it is being knit and its condition after it has reached an equilbrium is, for any given fabric substantially a constant, the value of which once determined either by measurement or by experience may be included in the adjustment and design of the potentiometer and the calibration of the indicating wheel.

As illustrated in FIG. 2, the casing of the computing device **60** may also include conventional counting devices **120** for recording and displaying, for instances, the total machine revolutions, or the total fabric yardage produced. These conventional counting devices may be operated by the solenoids or by other means if desired. Since such counting devices are conventional in the art, the operating means therefore are not illustrated in the accompanying drawings.

The standards **62** rising from housing ring **11** sustain a webbed ring **130** above needle cylinder **17**. From the ring **130** extends a central post **131** supporting various parts of the yarn stand as is described below. Fixed relatively to the machine frame is a sinker carrier ring **132** which encompasses the top of the needle cylinder **17**. The sinker carrier ring **132** has formed or secured thereto surfaces which support sinkers (not shown) which cooperate with the needles in knitting fabric and sinker actuating cams (not shown). Further description of this portion of the sinker mechanism which is conventional is set forth in United States Patent application Serial No. 278,135 referred to hereinabove. Secured on the sinker carrier ring **132** are a multiplicity of yarn carriers **133** arranged about the needle cylinder with one corresponding to each set of needle raising and stitch cams **26**, **27**. Each yarn carrier **133** together with the appropriate sinker cams and needle cams **26**, **27** for actuating the sinkers and needles to cooperate with the yarn carrier and to incorporate the delivered yarn into the knit fabric are referred to collectively as a "feed." A multifeed knitting machine refers to an arrangement as illustrated in FIG. 1 in which many feeds are arranged about the needle cylinder.

Secured on post **131** is a ring **135** holding yarn packages **136**. At the top of post **131** is a bracket **137** having radial arms adapted to be fitted with unwinding eyelets **138** for the yarn through each of which a single yarn passes from its package. A bracket **139** on the post **131** has similar eyelets **140** for guiding yarn to respective stop motion devices **141** supported on a bracket **142** on the post **131**. Beneath the stop motion devices are yarn tensioning devices **143** supported on a bracket **144** on the post **131** with one for each of the yarns, which tensioning devices may be of the conventional type.

A variable yarn conditioning device **150** shown in FIGS. 1 and 6 is supported on post **131**. A pair of support rings **151** and **152** are affixed in spaced coaxial relation by brackets **153** secured on the post **131**. Extending between and journaled on the rings **151** and **152** are identical cylindrical yarn feed rollers **154**. Each roller **154** is attached to one of a set of identical sprocket wheels **155**. A link chain **156** is directed about the sprocket wheels **155** in mesh therewith. The chain is directed between two of the sprocket wheels **155** in mesh with a drive sprocket wheel **157** fast on a stud shaft **158** journaled in a plate **159** on the bracket **153** for the upper support ring **151**. Also fast on the stud shaft **158** is a V-belt pulley **160**. A conventional V-belt **161** is entrained on pulley **160** and also entrained on one of the companion sheaves **162** of a variable speed V-belt pulley unit **163** carried on the plate **159**. A second V-belt **164** is entrained on the other companion sheave **165** of the pulley unit **163** and extends to a pulley **166** fast on a shaft **167** journaled in brackets **168** on one of the vertical frame standards **62**. By means of bevel gears **169** on the shaft **167** and on the knitting machine drive shaft **19**, a drive is completed from the knitting machine motor **20** to the yarn feed rollers **154**.

The variable speed V-belt pulley unit **163** illustrated in the drawings is designed so that the effective pitch diameters of the companion sheaves **162**, **165** may be varied inversely by angular adjustment of a regulating arm **170**. A threaded shaft **171** threadedly engages a stud **172** on the arm **170**. The shaft **171** is constrained in a bearing bracket **173** on the support ring **151** by collars **174** on the shaft. A servo-motor **175** and gear box **176** are connected to adjust the shaft **171**. It will be understood that by means of the motor **175**, gear box **176**, and the pulley unit **163**, the speed of rotation of rollers **154** may be adjusted relatively to the speed of rotation of the needle cylinder **17**. Further description of the details of operation of apparatus designed in accordance with variable yarn conditioning device **150** may be found by reference to United States application Serial No. 278,135

referred to hereinabove. In general, the yarn conditioning device **150** may be used to apply consistent and uniform tension to yarns Y delivered to the needles. By a turning movement applied to the shaft **171** by the motor **175**, the tension applied to all the yarns may be varied alike so as to influence the stitch configuration and stitch count in the resulting knit fabric during regular operation of the knitting machine to provide the desired fabric yield from the knitting machine.

The automatic control system of this invention may be an electrical system such as that shown in FIG. 7 or a mechanical system such as that shown in FIG. 8.

Referring to FIG. 7 the contact arm **117** of the adjustable potentiometer **116** is shown attached to the sleeve **66** of the computing device **60**. Switches **40** and **52** are shown in block form connected electrically to the computing device **60** and connected mechanically as described above to the knitting machine also shown in block form for convenience of illustration. Central post **131** is shown supporting the variable yarn conditioning device **150** including the bracket **153** supporting the yarn conditioning device **150** and the belt **161** connected to drive the yarn conditioning device. The motor **20** is directly connected to the knitting machine drive shaft **19** connected by bevel gears **169** to the shaft **167** driving the pulley **166** which drives belt **164** which drives the companion sheaves **165**. The companion sheave **162** is connected to drive belt **161**. The regulating arm **170** for the variable speed drive **163** is adjusted by the threaded shaft **171** connected to be driven by servo motor **175** through gear box **176**.

The servo motor **175** is a conventional two phase A.C. servo motor having a first winding **180** connected through a capacitor **181** to an A.C. power source **182**. The capacitor **181** provides a phase shift of about 90° in the potential applied to the winding **180** from power source **182**. An error signal winding **183** is connected to receive an error signal when it exists from an electrical signal comparison circuit, providing excitation of the winding **183** with the power from source **182**. In the absence of excitation of winding **183**, the motor **175** will remain at rest. The phase of the potential applied to winding **183** may lead or lag the potential applied to winding **180** and depending on the lead or lag condition will drive shaft **171** in opposite angular directions about its axis.

To provide an error signal, a second adjustable potentiometer **184** having a contact arm **185** adapted to be adjusted manually has the ends of its windings connected to the terminals of the A.C. power source **182**. The contact arm **185** is adjusted to a position providing a reference potential which may be calibrated with an index thereon and indicia on a fixed plate to indicate a predetermined desired fabric yield for each position of contact arm **185**. The actual yield is indicated by the position of sleeve **66**, and contact arm **117** of potentiometer **116** which likewise has the ends of its windings connected to the terminals of the A.C. power source **182**. The contact arms **185** and **117** are connected as inputs to an amplifier **186**, preferably through a minimum potential signal circuit **187**. The signal supplied to the circuit **187** is an error signal indicating the present difference between the actual fabric yield represented by the signal on contact **117** and the desired yield or reference signal on contact **185**. The relative phase of the signal applied to the circuit **187** with respect to the phase on winding **180** depends upon which one of the signals on contacts **117**, **185** exceeds the other with respect to a reference potential for instance, at the junction of source **182** and capacitor **181**. The minimum signal circuit **187** is preferably included in the circuit to prevent very small error signals from causing response of the system and attendant hunting by the servo motor **175** in an attempt to reduce the error signal exactly to zero. This minimum potential signal circuit may be omitted if desired. The output of amplifier **186** is applied to the winding **183** of the servo motor **175** preferably through a maximum time delay circuit **188** permitting servo motor **175** to be adjusted incrementally and thereby eliminating sharp readjustments in fabric yield which might cause striations in the fabric. However, the maximum time delay circuit **188** may be omitted from the system if desired. The maximum-time delay circuit may comprise a conventional time-delay relay or the like.

In operation, if the fabric yield increases, the computing device **60** is driven to a higher position rotating shaft **66** further clockwise as viewed from FIG. 4 or will move contact arm **117** counterclockwise as viewed in FIG. 7. Assuming that no difference in potential had existed between arm **117** and arm **185** prior to that time, there will be an error signal produced. In response thereto, the motor **175** will be driven in such a direction as to adjust the shaft **171**, the variable speed drive, and the yarn conditioning device **150** to reduce the yield, thereby restoring the fabric yield computing device **60**, sleeve **66** and arm **117** to their original positions. At such time, the error signal will be reduced to zero or to such a small value that the motor **175** will stop.

If the fabric yield decreases, the arm **117** will be driven clockwise as viewed in FIG. 7 producing an error signal of opposite phase to that for counterclockwise rotation, and the motor **175** will be rotated in the opposite direction, to reduce yarn tension until arm **117** is returned to provide minimum or zero error signal, when the desired fabric yield is obtained.

The second potentiometer **184** providing the reference potential together with the minimum potential error circuit **187**, the amplifier **186** and the minimum time delay circuit **188** may be housed in a casing **210** attached to a leg **12** of the knitting machine as illustrated in FIG. 1. The casing **210** is preferably located a convenient height for operator influence of a knob **211** thereon by which the potentiometer contact arm **185** may be adjusted.

If desired, the knob **211** can be adjusted continuously to provide a programmed variation in yield or it can be changed at various intervals as desired. The overall operation of the system when a constant yield is desired can be obtained without any supervision of the fabric yield or manual adjustment of the mechanisms controlling the formation of the stitches after the machine has been initially adjusted for operation.

Referring to FIG. 8, a control system similar in result to that described in connection with FIG. 7 is shown but employing a mechanical system of error detection. As can be seen, the elements of the system from shaft **171** through the knitting machine to the sleeve **66** are identical to those shown in FIG. 7. In the modification illustrated in FIG. 8, however, a cam **190** is adjustably attached to the end of sleeve **66** by means of a collar **191** fitting over the end of sleeve **66** and pinned thereto and a hollow portion **192** of the upper end of collar **191** adapted to receive and mate with the lower end of the cam **190** adjustably affixed thereto by means of set screw **193**.

The position of the cam **190** on the sleeve **66** may be adjusted by releasing set screw **193** and rotating the cam **190** in the hollow portion **192**. Indicia **194**, **195** are preferably provided on the cam **190** and on the collar **191** to indicate the relative angular position of the cam **190** with respect to the sleeve **66**.

A plate **197** is rotatably supported relatively to the knitting machine by a fulcrum screw **198** and is biased by spring **199** to hold a cam follower surface **200** on one end thereof in contact with the camming surface **201** of the cam **190**. A motor **202** having a single direction of rotation is affixed to plate **197** at the opposite end thereof. A friction drive wheel **203** is attached to the shaft of the motor **202** and is engageable with friction driven wheels **204**, **205** for respective angular positions of plate **197** about support screw **198**.

The friction driven wheel 204 is directly connected to the shaft 171 permitting adjustment of the position of regulating arm 170 in one direction when the friction drive wheel 203 engages the friction driven wheel 204. Friction driven wheel 205 is connected to the shaft 171 by way of gear wheels 206 and 207 and a countershaft 208 so as to drive shaft 171 and shift the regulating arm 170 in the opposite direction when the friction drive wheel 203 engages the friction driven wheel 205. The cam surface 201 is designed to control the position of the friction drive wheel with respect to the friction driven wheels 204, 205 in response to rotation of sleeve 66. When the cam surface 201 raises the cam follower surface 200 a predetermined amount, the driven friction wheel 205 will be driven by friction drive wheel 203 and when cam surface 201 lowers the cam follower surface 200 a predetermined amount, driven friction wheel 204 will be driven by friction drive wheel 203. For intermediate positions of the cam follower surface 201 the friction drive wheel 203 will remain out of engagement with both driven wheels 204 and 205 and the shaft 171 will be at rest maintaining adjustment of the yarn conditioning device 150 until such time as rotation of sleeve 66 causes the system to readjust in response to variations in the fabric yield of the knitting machine.

Having thus described the nature of this invention what I claim herein is:

1. In a circular independent needle knitting machine adapted to concatenate yarn into a knit fabric having an identifiable characteristic, the combination which includes yarn conditioning means associated with said knitting machine for varying said characteristic of the knit fabric during operation of the machine, means for measuring said characteristic of the knit fabric during operation of the knitting machine and providing a measurement output varying in quantity as a function of said characteristic of the knit fabric, and control means operable in response to deviation of said measurement output from a selected norm for providing adjustment of said yarn conditioning means in proportion to the quantity of said deviation in a manner tending to reduce said deviation from said norm.

2. In a circular knitting machine having a plurality of feeds, the combination which includes, yarn conditioning means associated with said knitting machine for delivering yarn to each of said feeds in a manner influencing a characteristic of the resulting knit fabric, means for measuring said characteristic of the knit fabric during operation of the knitting machine and providing a measurement output varying in quantity as a function of said characteristic of the knit fabric and control means operable in response to deviation of said measurement output from a selected norm for providing adjustment of said yarn conditioning means in proportion to the quantity of said deviation in a manner tending to reduce said deviation from said norm.

3. In a circular knitting machine, means for measuring the angular displacement of said circular knitting machine during operation thereof, means for simultaneously measuring the linear quantity of fabric produced on said knitting machine, a fabric yield computing device operated by said measuring means and providing an output as a function of the computed yield, and a control means operable in response to deviation of said output from a selected norm for influencing the operation of said knitting machine in a manner tending to produce a knit fabric having a uniform yield.

4. In a circular independent needle knitting machine adapted to concatenate yarn into a knit fabric having an identifiable characteristic, the combination which includes means for measuring said characteristic of the knit fabric during operation of the knitting machine and providing a measurement output varying in quantity as a function of said characteristic of the knit fabric, and a reversible knitting machine corrective motor operable in one direction in response to deviation of said measurement output above a selected norm and in the opposite direction in response to deviation of said measurement output below said selected norm said motor being regulated by an input varying as a function of the quantity of said deviation from said selected norm.

5. In a circular independent needle knitting machine adapted to concatenate yarn into a knit fabric having an identifiable characteristic, the combination which includes yarn conditioning means associated with said knitting machine for varying said characteristic of the knit fabric during operation of the machine, means for measuring said characteristic of the knit fabric during operation of the knitting machine and providing a measurement output as a function of said characteristic of the knit fabric, means providing a reference output, control means operable in response to deviation of said measurement output from said reference output for providing adjustment of said yarn conditioning means in a manner tending to reduce the deviation from said norm, and means for varying said reference output during operation of said knitting machine.

6. In a circular knitting machine having a plurality of feeds, the combination which includes, yarn conditioning means associated with said knitting machine for delivering yarn to each of said feeds in a manner influencing a characteristic of the resulting knit fabric, means for measuring said characteristic of the knit fabric during operation of the knitting machine and providing a measurement output as a function of said characteristic of the knit fabric, means providing a reference output, control means operable in response to deviation of said measurement output from said reference output for providing adjustment of said yarn conditioning means in a manner tending to reduce the deviation from said norm, and means for varying said reference output during operation of said knitting machine.

7. In a circular knitting machine, means for measuring the angular displacement of said circular knitting machine during operation thereof, means for simultaneously measuring the linear quantity of fabric produced on said knitting machine, a fabric yield computing device operated by said measuring means and providing a computed output as a function of the computed yield, means providing a reference output, a control means operable in response to deviation of said computed output from said reference output for influencing the operation of said knitting machine in a manner tending to produce a knit fabric having a predetermined yield, and means for varying said reference output during operation of said knitting machine to provide for a predetermined yield variation along the length of the resulting knit fabric.

8. In a machine for concatenating fibers to form a fabric web having an identifiable characteristic, the combination which includes regulating means associated with said machine for varying said characteristic of the fabric web during operation of the machine, means for measuring said characteristic of the fabric during operation of the machine and providing a measurement output varying in quantity as a function of said characteristic of the fabric web, and control means operable in response to deviation of said measurement output from a selected norm for providing adjustment of said regulating means in proportion to the quantity of said deviation in a manner tending to reduce said deviation from said norm.

9. In a machine for concatenating fibers to form a fabric web having an identifiable characteristic, in combination regulating means associated with said machine for varying said characteristic of the fabric web during the operation of the machine, means for measuring said characteristic of the fabric web during operation of the machine and providing a measurement output varying in quantity as a function of said characteristic of the fabric web formed on said machine, means for providing a selected refer-

ence relatively to said measurement output, and means responsive to differences between said measurement output and said reference for operating said regulating means in proportion to the corresponding quantity of each of said differences in a manner tending to reduce the said differences.

10. In a machine for concatenating fibers to produce a fabric, a first means for measuring the fiber courses being incorporated into said fabric during operation of the machine, a second means for measuring the linear quantity of fabric produced during the operation of the machine, a fabric yield computing device operated by said first and second measuring means, means for providing an electrical reference signal, means operated by said computer to provide an electrical indicator signal, means for comparison between said indicator and reference signals, and trically to produce an error signal in response to the comparision between said indicator and reference sginals, and means operated in response to said error signal for adjusting said machine to reduce the amplitude of said error signal.

11. In a machine for concatenating fibers to produce a fabric, means for measuring a characteristic of the fabric produced during operation of the machine, said means producing an output in response thereto, control means responsive to the output of said measuring means providing a signal for predetermined outputs from said measuring means, means operating in response to said signal for adjusting said machine to provide substantially a predetermined output from said measuring means.

12. In a machine for concatenating fibers to produce a fabric, means for computing a characteristic of the fabric produced during the operation of the machine, means for providing a first electrical signal, means responsive to said computer for providing a second electrical signal, means for providing a third electrical signal in response to said first and second electrical signals, and means operable in response to said third signal for adjusting the condition of operation of said machine in such manner as to vary the magnitude of said second signal in a direction tending to reduce said third signal.

13. A multi-feed knitting machine having knitting instrumentalities, actuating means for operating said knitting instrumentalities, means for supporting a plurality of yarn supplies relatively to said knitting machine, means for furnishing yarns from said yarn supplies to said knitting instrumentalities comprising a plurality of cylindrical yarn feed rollers of equal diameter, means for directing yarn between each of said yarn supplies and said knitting instrumentalities into engagement with each of said yarn feeding rollers in seriatim, means for imparting turning movement to each of said yarn feeding rollers including a common drive element operatively engaging each of said yarn feed rollers, drive means operatively connecting said common drive element with said actuating means for said knitting instrumentalities, speed control means in said drive means adjustable for selectively varying the turning movement of said yarn feed rollers relatively to the operation of said knitting instrumentalities, means for measuring the angular displacement of said circular knitting machine during operation thereof, means for simultaneously measuring the linear quantity of fabric produced on said knitting machine, a fabric yield computing device operated by said measuring means and providing an output as a function of the computed yield, and a control means operable in response to deviation of said output from a selected norm for influencing the operation of said means for adjusting said speed control means of said yarn furnishing means in a manner tending to produce a knit fabric having a uniform yield.

14. In a circular knitting machine having a plurality of feeds, the combination which includes, yarn conditioning means associated with said knitting machine for delivering yarn to each of said feeds in a manner influencing a characteristic of the resulting knit fabric, measuring means for providing response to the formation of each predetermined number of courses of knitting by said machine, measuring means for providing response to each predetermined length of fabric knit by said machine, a fabric yield computing device comprising a shiftable indexing member, means for defining an at-rest position of said indexing member, means for biasing said indexing member towards said at-rest position, a ratchet associated with said indexing member, pawl means cooperating with said ratchet for imparting successive increments of movement to said indexing member in one direction from said at-rest position one increment upon each response of one of said measuring means, a retrograde pawl cooperating with said ratchet, a fabric yield output member shiftably supported adjacent to said indexing member for movement towards and away from the at-rest position of said indexing member, means for biasing said output member toward said at-rest position, an abutment on said indexing member engageable with said output member in a predetermined relative position of said members and effective to shift said output member along with said indexing member in said one direction from said at-rest position, retrograde brake means associated with said output member, means effective upon each response of said other measuring means for effecting in seriatim release of the retrograde brake means of said output member, reengagement of said retrograde brake means, and release of the retrograde pawl of said indexing member, and means responsive to the position of said output member for providing adjustment of said yarn conditioning means in a manner tending to produce a knit fabric having a uniform yield.

15. A multi-feed knitting machine having knitting instrumentalities, actuating means for operating said knitting instrumentalities, means for supporting a plurality of yarn supplies relatively to said knitting machine, means for furnishing yarns from said yarn supplies to said knitting instrumentalities comprising a plurality of cylindrical yarn feed rollers of equal diameter, means for directing yarn between each of said yarn supplies and said knitting instrumentalities into engagement with each of said yarn feeding rollers in seriatim, means for imparting turning movement to each of said yarn feeding rollers including a common drive element operatively engaging each of said yarn feed rollers, drive means operatively connecting said common drive element with said actuating means for said knitting instrumentalities, speed control means in said drive means adjustable for selectively varying the turning movement of said yarn feed rollers relatively to the operation of said knitting instrumentalities, measuring means for providing response to the formation of each predetermined number of courses of knitting by said machine, measuring means for providing response to each predetermined length of fabric knit by said machine, a fabric yield computing device comprising a shiftable indexing member, means for defining an at-rest position of said indexing member, means for biasing said indexing member towards said at-rest position, a ratchet associated with said indexing member, pawl means cooperating with said ratched for imparting successive increments of movement to said indexing member in one direction from said at-rest position one increment upon each response of one of said measuring means, a retrograde pawl cooperating with said ratchet, a fabric yield output member shiftably supported adjacent to said indexing member for movement towards and away from the at-rest position of said indexing member, means for biasing said output member toward said at-rest position, an abutment on said indexing member engageable with said output member in a predetermined relative position of said members and effective to shift said output member along with said indexing member in said one direction from said at-rest position, retrograde brake means associated with said output member, means effective upon each response of said other measuring means for effecting in seriatim re-

lease of the retrograde brake means of said output member reengagement of said retrograde brake means, and release of the retrograde pawl of said indexing member, means for adjusting said speed control means, and means responsive in a predetermined manner to the position of said output member for providing actuation of said means for adjusting said speed control means in a manner tending to produce knit fabric having a uniform yield.

16. Apparatus in accordance with claim **3**, wherein said means for measuring the linear quantity of fabric produced on said knitting machine measures the linear quantity of fabric produced at a point closely adjacent to the point at which said fabric is being produced.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,225,570 December 28, 1965

Lester Mishcon

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 11, lines 15 to 17, strike out "comparison between said indicator and reference signals, and trically" and insert instead -- comparing said reference signal and said indicator signal electrically --; same column 11, line 18, for "sginals" read -- signals --.

Signed and sealed this 6th day of December 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents