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(54) **A calibrating method for controlled-tension yarn feeders in weaving lines**

(57) The calibrating method is applied to weaving lines comprising a plurality of yam feeders (D1, D2, ..., Dn) delivering respective yarns (Fl, F2, ..., Fn) to a downstream machine (MU) via respective feeding paths. The operation of each feeder is controlled by a respective tension control loop subject to the output (TO) of a respective tension sensor (SD1, SD2, ..., SDn) to maintain the tension of the unwinding yam substantially constant and equal to a desired tension (TD). A test cycle is carried out with all the feeding paths arranged at their exact operative configuration. During the test cycle, the tensions of all the yarns is subsequently measured in proximity of their respective insertion points into the machine (MU) by means of the same measuring device. For each feeder, a correction factor (K) is calculated on the basis of the ratio of the real tension (TM) measured by the measuring device (SR) to a reference tension (TR) input to the control loop. The respective correction factor (K) is applied to the control loop of each feeder to compensate for the difference between the measured real tension (TM) and the desired tension (TD).

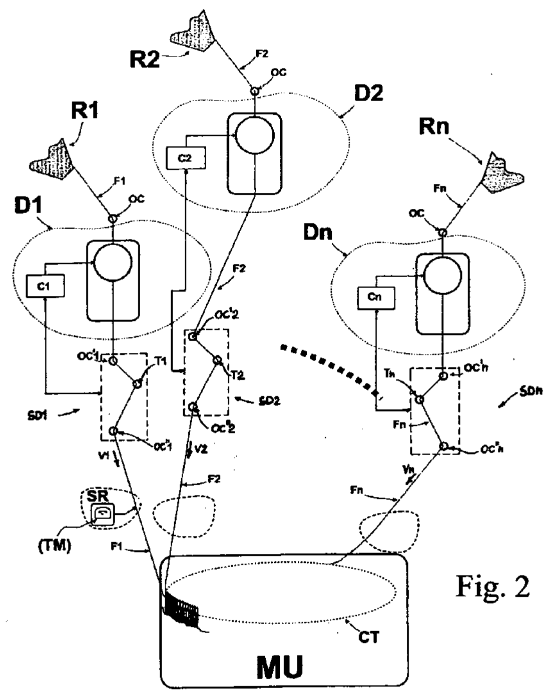

Fig. 2

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Description

[0001] The present invention relates to a calibrating method for controlled-tension yarn feeders in weaving lines, where a weaving line should be generally intended here as any yarn-processing line for production of fabric or mesh, thereby also including knitting lines and the like.

[0002] As known, a general weaving line comprises a plurality of yarn feeders associated to a single downstream machine. Such feeders can be of the so-called "positive" type, in which the yarn is wound on a motorized drum which draws it from a reel and feeds it to the downstream machine, or of the so-called "negative" type, in which the yarn is unwound from a stationary drum by the machine itself. Depending on the requirements, a line can be provided of either feeders which are all of the same type or feeders of different types.

[0003] The operation of each feeder is controlled in order to maintain the tension of the yarn fed to the machine substantially constant and equal to a predetermined value, which can be the same value for all the feeders or only for groups of feeders, depending on the pattern to be produced. In particular, as well known to the person skilled in the art, while the product is manufactured it is very important to minimize both the fluctuations of tension of each single feeder and the differences of tension between those feeders of the line which should operate at the same level of tension, in order to prevent defects in the finished products and to optimize the yield.

[0004] For the above tension control, each feeder of the line is typically provided with a respective sensor which measures the tension immediately downstream of the feeder and is usually incorporated in the feeder itself. In the positive feeders, where the tension depends on the difference between the speed of rotation of the drum of the feeder and the comsumption speed of the downstream machine, the tension is controlled by a control loop which modulates the speed of rotation of the drum on the basis of the signal received from the tension sensor. In the negative feeders, a brake is provided which comprises a hollow, frustoconical braking member which is biased against the delivery edge of the stationary drum by an electric actuator controlled on the basis of the signal received from the tension sensor, in order to brake the unwinding yarn in a controlled manner.

[0005] A typical tension sensor comprises a pair of aligned yarn-guide eyelets having a detecting finger arranged therebetween which deviates the yarn running between the eyelets and, therefore, is subject to the tension of the yarn.

[0006] A known drawback of the above tension control system is that, although all the sensor installed on the line are considered to be substantially identical, small differences actually exist among them due to the manufacturing tolerances. These differences may affect the measuring accuracy of the sensor and, even worse, affect it in a variable manner from a feeder to another in the same line.

[0007] Moreover, even if all the sensor are assumed to be ideally identical to one another, the real conditions in which each of them operates, once installed on the line, can be very different from both the controlled, nominal conditions in which it was calibrated in the factory, and the conditions in which the other sensors operate. This circumstance may cause the real yarn tension downstream of the sensor to be altered and, even worse, to be altered in a variable manner from a feeder to another in the same line, which feeders, on the contrary, should operate at the same level of tension. As well known to the person skilled in the art, some factors which can alter the tension downstream of the the sensor depend on the positioning of the feeder which incorporates the sensor and are, e.g., the exit angle of the yarn from the tension sensor, the angle of entry of the yarn into the respective yarn-guide eyelet of the machine, the distance between the feeder and - the point of insertion of the yarn into the product, and the like.

[0008] In addition, it should be considered that the yarns downstream of the respective feeders may follow different paths. In fact, some yarns could follow a rectilinear path to the yarn-guide eyelet of the machine, other yarns could be deviated by various yarn-guide eyelets, resulting in the real tension under which the yarn enters the machine being further altered.

[0009] It is also well known to the person skilled in the art that different yarn-guide eyelets, even if made of a same material (typically, ceramics), may have slightly different rugosities. Other factors which can affect the yarn tension downstream of the feeder in a different manner from a feeder to another are, e.g., the running speed of the yarn, the type of yarn, etc.

[0010] For all the above reasons and other, it has been found that, during the weaving process, the real tensions of the yarns fed to the machine not only differ from the desired tension on which the feeders are set but, even worse, those feeders which should theoretically operate at the same level of tension often operate at levels of tension which actually differ from one another of a non-negligible amount, thereby causing defects and undesired distorsions in the product.

[0011] It has been found in practice that the real tension of the yarn measured at the point of insertion into the machine may differ by 20% to 25% from the tension measured by the sensor, to different levels within that range from a feeder to another.

[0012] EP 1 901 984 discloses a feeding apparatus, in which each feeder has a second sensor associated thereto which measures the yarn tension near the downstream machine and, in operation, corrects the measurement performed by the first sensor in real time as a function of the difference between the two measured values.

[0013] Although the system of EP 1 901 984 improves the accuracy of the tension control on the single feeder, however it is not completely satisfactory, both because it increases the cost of the apparatus, since a second sensor must be provided for each feeder, and because the second sensors, in turn, though nominally identical, will inevitably differ from one another and will have different behaviours depending on their positioning. In general terms, also the second sensors will generate alterations which will be variable from a feeder to another.

[0014] Therefore, it is a main object of the invention to provide a calibrating method for controlled-tension yarn feeders in weaving lines, which allows the differences to be minimized between the real tensions of the yarns which are desired to be fed at the same level of tension, while compensating for both the unevenness due to the intrinsic differences between the various sensors and the differences deriving from the different conditions in which the various feeders operate.

[0015] The above object and other advantages, which will better appear from the following description, are achieved by the calibrating method having the feature recited in claim 1, while the dependent claims state other advantageous, though secondary, features of the invention.

[0016] The invention will be now described in more detail with reference to a few preferred, non-exclusive embodiments, shown by way of non limiting example in the attached drawings, wherein:

- Fig. 1 is a diagrammatical plan view showing an angular portion of a circular knitting line to which the calibrating method of the invention is appliable;
- Fig. 2 is a block diagram of the knitting line of Fig. 1;
- Fig. 3 is a circuit diagram of a tension control loop associated to one feeder of the line of Fig. 2, which has been calibrated on the basis of a first embodiment of the method according to the invention;
- Fig. 4 is a circuit diagram of a tension control loop associated to one feeder of the line of Fig. 2, which has been calibrated on the basis of a second embodiment of the method according to the invention;
- Fig. 5 is a flowchart showing a few steps of the calibrating method according to the invention.

[0017] With initial reference to Fig. 1, a general yarn processing line comprises a machine MU, which in the example of Fig. 1 is a circular knitting machine, which is surrounded by a plurality of yarn feeders D1, D2, ..., D8. The feeders deliver respective yarns F1, F2, ..., F8 from respective reels R1, R2, ..., R8 to respective inlet eyelets OM1, OM2, ..., OM8 of the machine MU. In the example of Fig. 1, the line is provided with a first series of so-called "negative" feeders D1, D3, D5, D7 which are arranged on an outer circumference, and with a second series of so-called "positive" yarn feeders D2, D4, D6, D8 which are arranged on an inner circumference.

[0018] As shown in the Figures, with the positive feeders the yarn is wound on a motorized rotary drum RD2, RD4, RD6, RD8, which draws the yarn from the respective reel R2, R4, R6, R8 and feeds it to the downstream machine MU; with the negative feeders, the yarn is unwound from a stationary drum S1, S3, S5, S7 by the machine MU itself.

[0019] The operation of each feeder is controlled in such a way as to maintain the tension of the yarn fed to the machine MU substantially constant and equal to a predetermined value which, in the example described herein, for simplicity is assumed to be the same for all the feeders, but could also be the same only for groups of feeders (e.g., the positive feeders could operate at a first level of tension and the negative feeders at a second level of tension).

[0020] To this purpose, having now reference also to Fig. 2, each feeder is provided with a respective tension sensor SD1, SD2, ..., SDn which is arranged near the delivery end of the feeder. As shown diagrammatically in Fig. 2, each sensor conventionally comprises a pair of aligned yarn-guide eyelets OC'1, OC"1, OC'2, OC"2, ..., OC'n, OC"n having a detecting finger T1, T2, ..., Tn arranged therebetween, which deviates the yarn running through the eyelets and, therefore, is subject to the tension of the yarn.

[0021] With the positive feeders, in which the tension depends on the difference between the speed of rotation of the drum and the comsumption speed of the downstream machine, the tension is controlled by a control loop which modulates the speed of rotation of the drum on the basis of the signal received from the tension sensor. The negative feeders make use of a brake provided with a hollow, frustoconical braking member B1, B3, B5, B7 (Fig. 1) biased against the delivery edge of the stationary drum by an electric actuator (not shown) which is driven on the basis of the signal of the tension sensor, so that the unwinding yarn is braked in a controlled manner.

[0022] The measurements of the various sensors may be affected in a variable manner by the inevitable, small manufacturing differences between the sensors. Accordingly, these differences may alter the accuracy of measurement of the sensor and, even worse, may alter it in a variable manner from a sensor to another in the same line.

[0023] Furthermore, there are other factors which may alter the real tension of the yarn downstream of the sensors before entering the machine, in a variable manner from a feeding path to another. For example, as shown in Figs. 1 and 2, the exit angles of the yarn from the respective sensors, as well as the angles of entry of the yarns into the eyelets of the machine, are usually different from one feeder to another. Moreover, the yarns downstream of the respective feeders could follow different paths through a variable number of deviating yarn-guide eyelets (not shown). Other factors which may affect the tension in a different manner from one feeder to another are, e.g., different yarn-feeding speeds v1, v2, ..., vn (Fig. 2), different types of yarn, etc.

[0024] All the above differences may cause the real tensions of the various yarns fed to the machine to be typically different both from the desired tension and from one another. This circumstance, as mentioned above, may cause defects and distorsions in the product.

[0025] In order to minimize the above differences, a preliminary calibration according to the invention is carried out, which comprises the steps of:

- carrying out a test cycle, resulting in the production of a sample CT (Fig. 2), with all the feeding paths arranged in their exact operative configuration;

- during the test cycle, subsequently measuring the real tensions TM of all the yarns in proximity of their respective insertion points into the machine by means of the same tension-measuring instrument SR;

- for each feeder, calculating a correction factor K on the basis of the ratio of the real tension TM measured by the measuring instrument SR to the reference tension TR input to the control loop; and

- applying the respective correction factor K to the control loop of each feeder to compensate for the difference between the measured tension TM and the desired tension TD.

[0026] Advantageously, in the examples described herein the correction factor K is equal to the ratio of the measured tension TM to the reference tension TR input to the control loop, according to the formula:

$$K = TM/TR.$$

[0027] According to a first embodiment of the invention, as shown in Fig. 3, the compensation is carried out by multiplying the value of the tension signal TO detected by the tension sensor SD1, SD2, ..., SDn by the correction factor K, thereby obtaining a compensated feedback tension TF = TO x K as an input to the adder node of the control loop. In the diagram of Fig. 3, ET indicates the tension error calculated by the control loop on the basis of the difference between the compensated feedback tension TF and the reference tension TR, A indicates the adjusting block which includes both the control unit and the adjusting device (brake or motor depending on the type of feeder), and DT represents all the factors which may affect the yarn tension dowstream of the feeder.

[0028] In practice, the correction is carried out by programming the software which controls the feeder in such a way that a correction factor K can be set, by using programming techniques which fall within the normal knowledge of the person skilled in the art and therefore are not disclosed in detail herein. The steps of the method are diagrammatically shown in the flowchart of Fig. 5.

[0029] During the test cycle, the user first sets reference tension TR to the desired tension TD, then measures the tension at the entry to machine TM by the instrument SR and inputs it to the control unit C1, C2, ..., Cn (Fig. 2) associated to the feeder. Now, the control unit C1, C2, ..., Cn automatically calculates the value of correction factor K as the ratio TM/TR(=TD) and inputs it to the feedback branch of the control loop, as described above.

[0030] Alternatively, during the test cycle the user can first modify the reference tension TR input to the control loop by repeated attempts until the measuring instrument SR exactly measures the desired tension, and than input the resulting value to the control unit, which will consequently calculate the value of the correction factor K as a ratio TM(=TD)/TR.

[0031] It has been found in practice that the values of the correction factor calculated according to the two above-mentioned criteria can be applied independently. However, it is preferable that the same criteria is used with all the feeders which must operate at the same level of tension.

[0032] In a second embodiment of the method according to the invention, which is shown diagrammatically in Fig. 4, the compensation is carried out by multiplying the desired tension TD by 1/K, thereby obtaining a compensated reference tension TR = TD x 1/K as an input to the adding node of the control loop.

[0033] In practice, the user can perform the test cycle in a way similar to the first embodiment and, once the value of K has been calculated by the control unit, this value is input to the control loop so that the reference value is changed from the desired value TD (set by the user) to TR, according to what described above.

[0034] Also in this case, the user can alternatively adjust the reference tension TR input to the control loop by repeated attempts until the measuring instrument SR exactly indicates the desired tension, and than input the resulting value to the control unit which will calculate the value of K accordingly as a ratio TM(=TD)/TR.

[0035] Of course, it is preferable to perform the measurement, by instrument SR, as close as possible to the point of entry of the yarn into the machine, depending on the limits of encumbrance deriving from the configuration of the machine, in order to minimize the influence of any other altering factors downstream of the instrument. However, it is very important that the point chosen for the measurement is the same for all the feeding paths.

[0036] The calibrating method according to the described embodiments has many advantages because it allows the real tensions of the yarns feeding the machine to be levelled to a desired value, regardless of the possible differences between the various sensors and the different feeding conditions. To this purpose, the person skilled in the art will appreciate that any inaccuracies of the measuring instrument used for the calibration will be compensated because will affect all the feeding paths in the same manner. However, as the person skilled in the art will understand, reference tension TR could also be corrected by a factor, e.g., an empirically calculated factor, in order to take into account possible errors of the measuring instrument.

[0037] In addition, the line calibrated by using the method according to the invention has the advantage that, if the operative tension is set to a different value with respect to the value used during the calibration, it will not be necessary to perform a new calibration because the system will apply the same correction factor to the control loop adjusted on the new reference value.

[0038] A few preferred embodiments have been described herein, but of course many changes can be made by the person skilled within the scope of the claims. In particular, although in the described embodiments the method has been applied to a line employing a circular knitting machine, of course the same method can be applied to textile lines using rectilinear machines or other types of machines.

Claims

1. A calibrating method for weaving lines comprising a plurality of yarn feeders (D1, D2, ..., Dn) delivering respective yarns (F1, F2, ..., Fn) to a downstream machine (MU) via respective feeding paths, the operation of each of said feeders being controlled by a respective tension control loop subject to the output (TO) of a respective tension sensor (SD1, SD2, ..., SDn) to maintain the tension of the unwinding yarn substantially constant and equal to a desired tension (TD), **characterized in that** it comprises the steps of:

   - carrying out a test cycle with all the feeding paths arranged at their exact operative configuration;
   - during said test cycle, measuring subsequently the tensions of all the yarns in proximity of their respective insertion points into the machine (MU) by means of the same measuring device;
   - for each feeder, calculating a correction factor (K) on the basis of the ratio of the real tension (TM) measured by the measuring device (SR) to a reference tension (TR) input to the control loop;
   - applying the respective correction factor (K) to the control loop of each feeder to compensate for the difference between said measured real tension (TM) and said desired tension (TD).

2. The calibrating method of claim 1, **characterized in that** said correction factor (K) is given by the formula:

$$K = TM/TR,$$

where K is said correction factor, TM is the real tension measured by said measuring device (SR), and TR is said reference tension input to the control loop.

3. The calibrating method of claim 1 or 2, **characterized in that** said compensation is obtained by multiplying said output signal (TO) by said correction factor (K) to obtain, as an input to the adder node of the control loop, a compensated feedback tension (TF) according to the formula:

$$TF = TO \times K,$$

where TF is said compensated feedback tension (TF) and TO is said output signal.

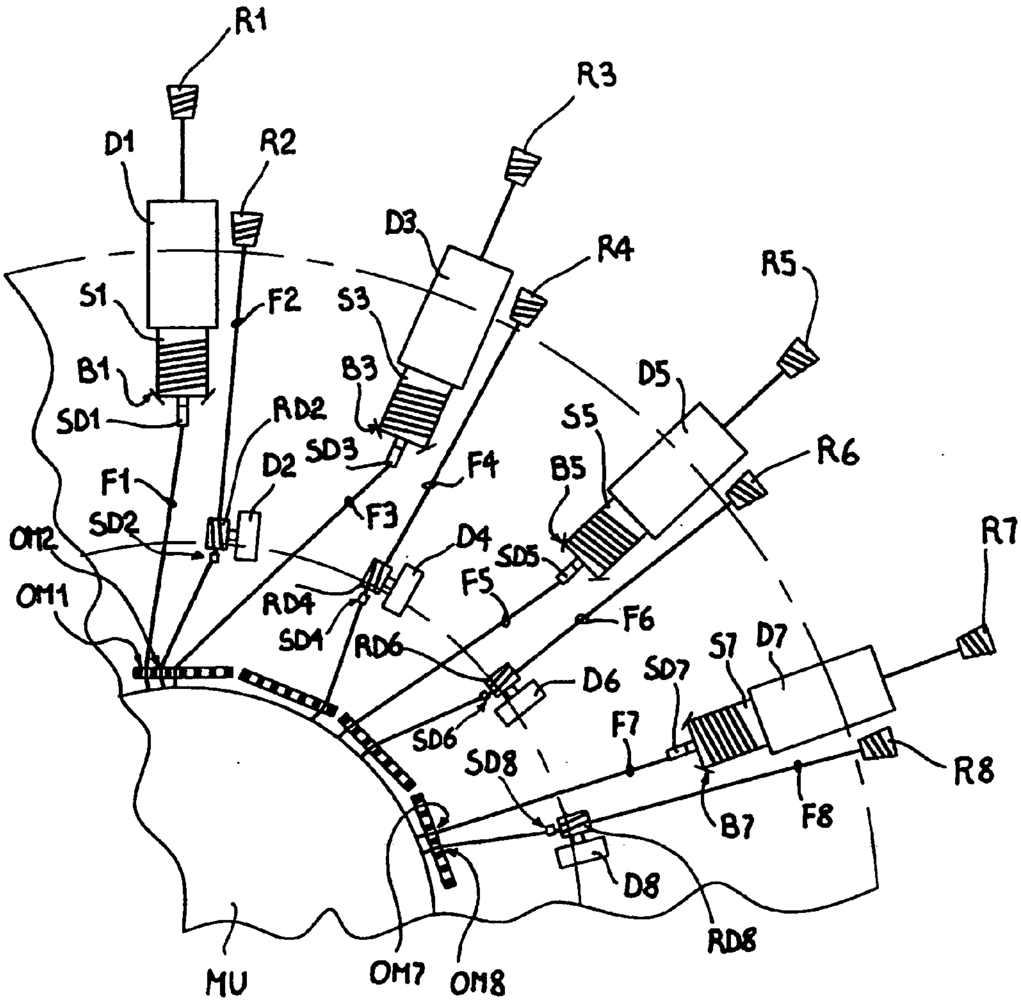
4. The calibrating method of claim 1 or 2, **characterized in that** said compensation is obtained by multiplying said desired tension (TD) by the inverse of said correction factor (1/K) to obtain, as an input to the adder node of the control loop, said reference tension (TR) on the basis of the formula:

$$TR = TD \times 1/K,$$

where TR is said reference tension (TR).

5. The method of any of claims 1 to 4, **characterized in that**, in order to calculate the correctiuon factor (K), during said test cycle the reference tension (TR) is set to the desired tension (TD).

6. The method of any of claims 1 to 4, **characterized in that**, in order to calculate the correctiuon factor (K), during said test cycle the reference tension (TR) is progressively adjusted until the measured real tension (TM) becomes equal to the desired tension (TD).


R1
R2
R3
R4
R5
R6
R7
R8
D1
D2
D3
D4
D5
D6
D7
D8
S1
S3
S5
S7
B1
B3
B5
B7
SD1
SD2
SD3
SD4
SD5
SD6
SD7
SD8
RD2
RD4
RD6
RD8
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F4
F5
F6
F7
F8
OM1
OM2
OM7
OM8
MU

Fig. 1

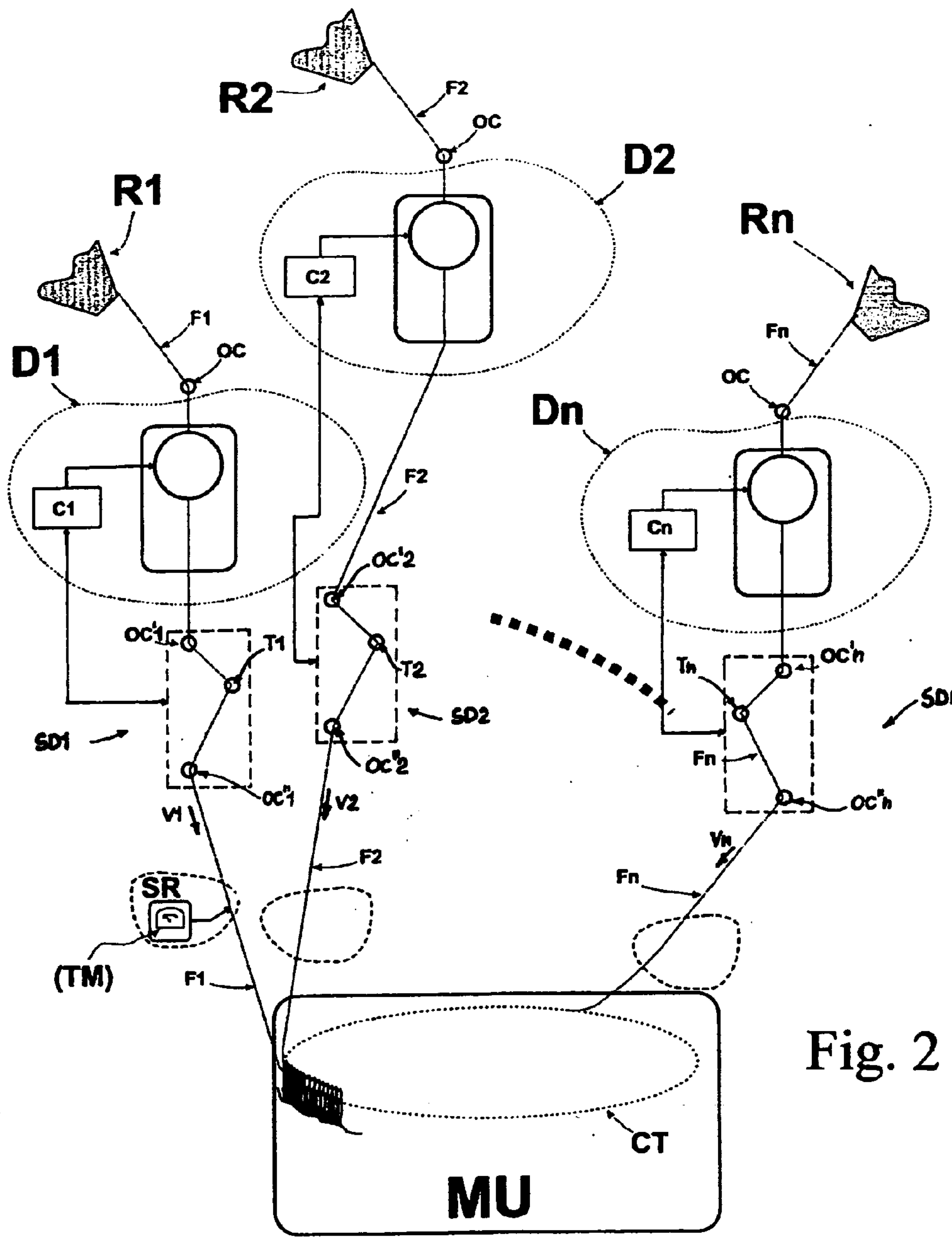

Fig. 2

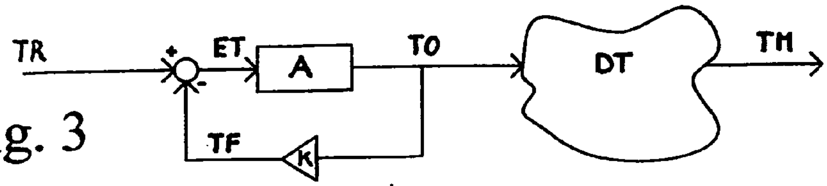

Fig. 3

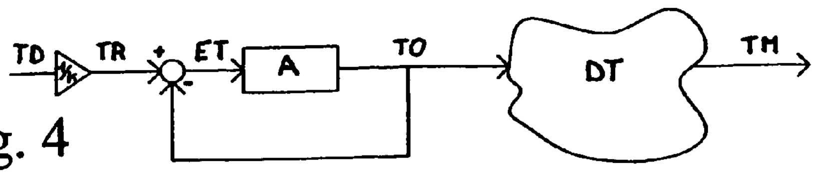

Fig. 4

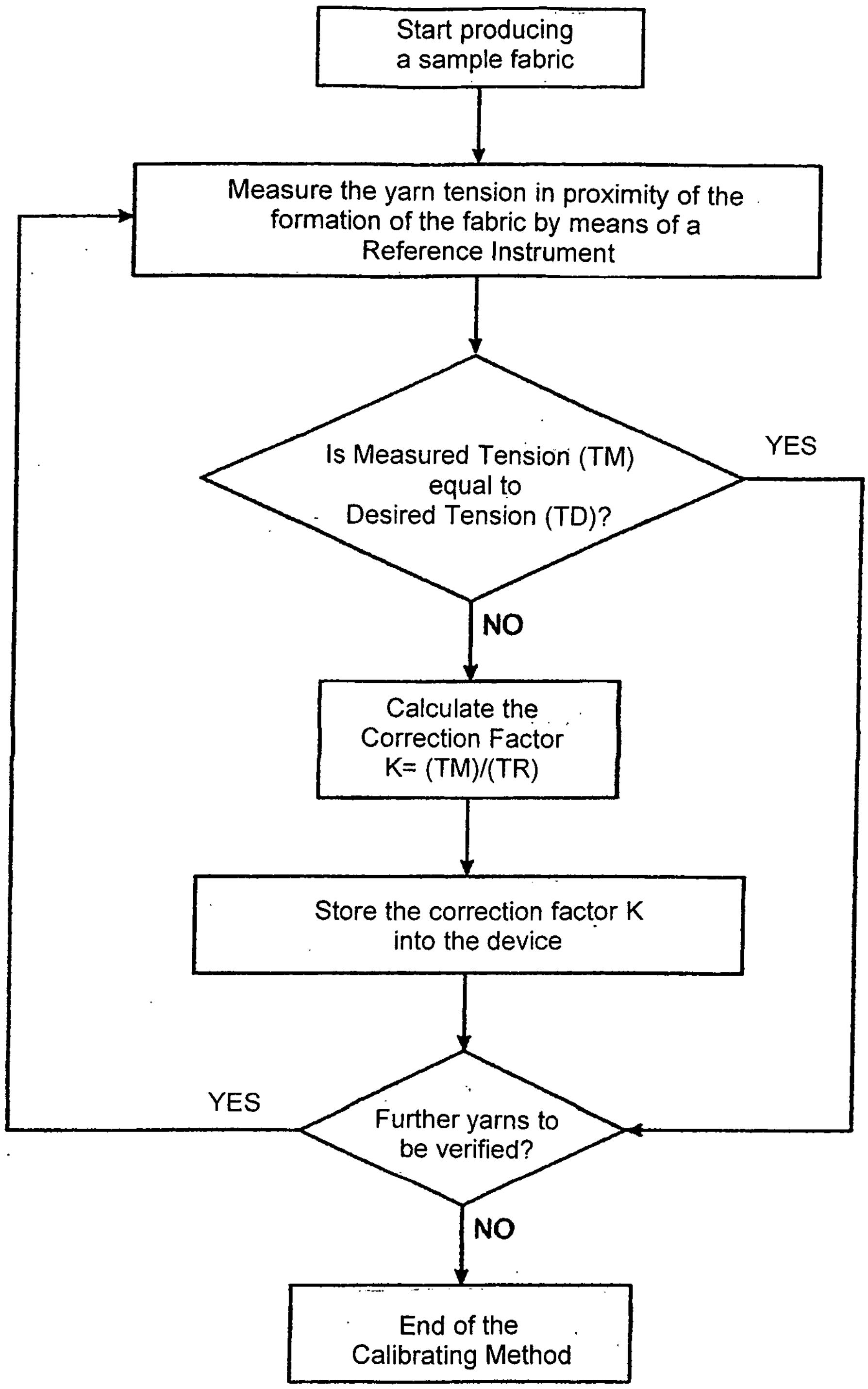
Start producing
a sample fabric
Measure the yarn tension in proximity of the formation of the fabric by means of a Reference Instrument
Is Measured Tension (TM) equal to Desired Tension (TD)?
YES
NO
Calculate the Correction Factor K= (TM)/(TR)
Store the correction factor K into the device
YES
Further yarns to be verified?
NO
End of the Calibrating Method

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 12 00 4518

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

B65H
D04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	23 January 2013	Pussemier, Bart

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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