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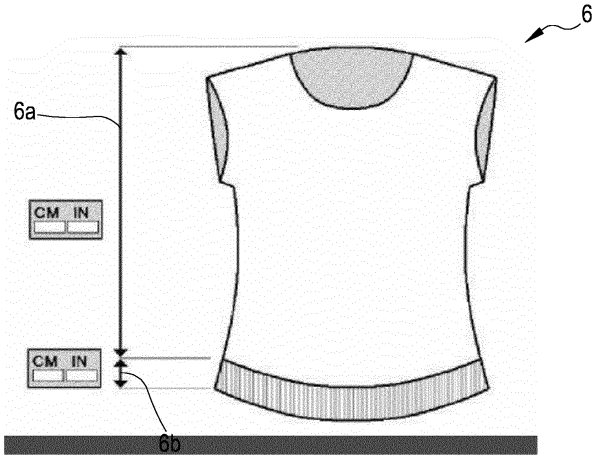
(54) A PROCESS FOR REGULATING THE SIZE OF KNITTED ARTICLES UNDER PRODUCTION IN CIRCULAR KNITTING MACHINES FOR KNITWEAR OR HOSIERY

(57) A process for regulating the size of textile articles under production on circular knitting machines for knitwear or hosiery, comprising steps of: predisposing at least a circular knitting machine (1) for knitwear or hosiery; defining a knitted article (6) to be produced on the knitting machine (1); defining at least a knitted zone or a plurality of consecutive knitted zones of the knitted article (6); activating a production program of the knitted article (6); producing the knitted zones of the knitted article (6) in sequence, maintaining a tension of the yarn (9) substantially constant; detecting a plurality of yarn consumption data (9) per knitted zone (6a, 6b) at each feeding position (10) of the machine and at the relative passive yarn feeder (8); comparing the plurality of yarn consumption data (9) per knitted zone (6a, 6b) with a respective plurality of reference values for yarn consumption (9) per knitted zone (6a, 6b), such as to obtain a respective plurality of comparable results; determining a plurality of corrective values of the position of the stitch cams (7) on the basis of the respective plurality of compared results, if the compared results are greater than respective predetermined tolerance thresholds; automatically displacing the stitch cams (7), according to the plurality of corrective values, such as to reduce the difference between the plurality of yarn consumption data (9) per knitted zone (6a, 6b) and the plurality of yarn consumption reference values (9) per knitted zone (6a, 6b).

FIG.6



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Description

[0001] The present invention relates to a process for regulating the size of knitted articles under production on circular knitting machines for knitwear or hosiery. The invention further relates to a process for regulating and balancing the stitches of the knitted fabric produced by circular knitting machines for knitwear or hosiery (i.e. for regulating and balancing the size of the stitches of the textile or the knitted article produced at the various yarn feeding positions, or drop points, of the machine). The invention further relates to a circular knitting machine for knitwear or hosiery configured to actuate the method. Modern circular knitting machines for knitwear or hosiery exhibit a high level of automation and operate together with specific knitting programs, enabling automatic production of numerous types of knitted articles, among which hosiers products, knitwear production of the seamless type, etc. As is known, the manufacturing of these products is influenced by numerous factors, such as the configuration of the knitting machine, the type of components mounted on the knitting machine, the type of yarn used, the state of wear of the various components, the environmental conditions, and more besides. It is therefore important to control the quality of the fabric of the knitwear products, by detecting the appropriate parameters, avoiding the formation of defects in the articles themselves which might lead to loss in quality and production rejects. It is therefore known to monitor certain essential parameters during the production of the knitted articles, among which typically the tension, or grammage, of the yarn which is supplied to the needles by special yarn feeders, as well as the quantity of yarn which is consumed during production, at each yarn feeding position to the needles, by means of a control of the quantity of yarn supplied by each yarn feeder. For example the prior art teaches detecting the yarn tension values and the yarn speed or consumption values, by using special sensors, and consequently manually regulating some operating parameters of the machine, such as the yarn feed velocity, the tension of the yarn or the position of the stitch cams, i.e. cams, also known as stitch cams or stitch triangles, which act on the needles of the needle cylinder in order to determine the size of the stitches produced.

[0002] Some further solutions in the prior art, which include the control and regulating of some knitting parameters in circular knitting machines, with the aim of preventing defects in the products, are illustrated for example in the patent documents indicated below: EP2186932 in the name of LGL, US5,174,133 and US5,511,392 in the name of Fukuhara, US6,832,496 in the name of Memminger-Iro, EP0452800 and EP0950742 in the name of BTSR. The known patent solution indicated above exhibit however some drawbacks. Firstly, some known solutions exhibit a certain degree of imprecision in the detecting of some operating parameters of the machine, for example in the detecting of the quantities of yarn consumed, which are often estimated on the basis of the number of rotations of a rotating organ, such as a reel or a rotating wheel, on which the yarn is wound once or more (in one or two winding spires) in a yarn feeder, with consequent possible imprecisions due to slippage between the yarn and the rotating organ or spool.

[0003] These rotary spool yarn feeders are suitable only for working some limited types of yarn, such as for example elastic yarn (such as *spandex* or *elastane*) or non-clad yarn (*bare spandex* or *bare elastane*). The rotary spool devices are suitable for feeding these types of yarn, but do not enable reliable detection of the yarn consumed by the various yarn feeding positions of the machine precisely because they are subject to slippage during the step of speed change due to the various knitting operations internally of a same manufactured product. The rotary spool devices are not suitable for feeding non-elastic yarns, such as natural fibres, artificial fibres and non-textured synthetic yarns, precisely because of the slippage due to the very rapid acceleration phases necessary for maintaining the programmed tension of the yarn feed. In these cases, if the yarn is wound about the spool with a single winding significant slippage obtains, while if there is more than one winding in order to reduce slippage, there will be an increase in the probability of breakage of the yarn and slipping thereof from the needles of the machine. In any case the detecting of the quantity of yarn absorbed is not precise and rather unreliable, so the consequent regulations will be imprecise and potentially damaging.

[0004] A further drawback of the known solutions is that they often include a contextual regulating of various reciprocally-connected parameters, with a system that is complex and at times not sufficiently reliable in the results thereof. A further drawback of the known solutions is that they enable regulating the stitches of the textile produced only partially automatically, as supervision and intervention on the part of the specialised operators are frequently necessary in order for delicate regulating operations of the operating parameters. A further drawback of the known solutions is that they require periodical performing of preliminary operations of regulation of the machine, by the carrying out of special specific regulating and balancing operations in which a sample knitted article is realised having a uniform stitch structure, and do not enable an effective control and regulation of the functioning of the machine during the production of the articles, and therefore do not enable efficient detection of the variations in production due to the environmental conditions or other parameters. Further, the known technical solutions are often complex and expensive, as they require the mounting on the machine of numerous additional components for enabling the carrying out of the control and regulation procedures. It is also important to stress that the known solutions do not enable efficient management of the production on a plurality of knitting machines present in a production centre, and that therefore each

machine has to be set manually by the operators and regulated in a substantially autonomous way. Further, with the known solutions it is generally not possible to automatically guarantee, and with sufficient precision, the uniformity of the stitches of the knitted articles realised during production.

[0005] The aim of the invention is to obviate one or more of the above-cited drawbacks. An aim of the invention is to provide a process which enables producing knitted articles of high quality and substantially without imperfections, and/or which enables reducing production waste. A further aim of the invention is to make available a process offering a control and regulation which are effective and efficient during the production of knitted articles. A further aim of the invention is to provide a process which enables regulating the fabric of knitted articles as automatically as possible, reducing operator interventions to a minimum. A further aim of the invention is to provide a process which enables obtaining highly dimensionally uniform production among the various articles produced, at different moments in time or under different operation conditions on a same machine and/or on a plurality of machines. A further aim of the invention is to provide a process which enables guaranteeing a precise and reliable control and regulation of the sizes of the knitted articles produced on one or even a plurality of knitting machines at a same time. A further aim of the invention is to provide a process which enables realising productions of knitted articles on a plurality of circular knitting machines, also having different technical characteristics, simply, rapidly and as automatically as possible. A further aim of the invention is to make available a process which is user friendly, thus facilitating the work of the operators who are controlling knitting production, especially in a case in which there is a plurality of machines carrying out the production. A further aim of the invention is to make available a process which enables reducing the number of persons required for controlling production, especially in plants where numerous knitting machines are present, thus enabling a reduced number of operators to control even a large number of knitting machines. A further aim of the invention is to provide a process and a knitting machine that are configured to perform the process and which are simple, sturdy and relatively economical to realise.A further aim of the invention is to disclose a process that guarantees high safety standards during functioning. These and other aims besides, which will more fully emerge during the course of the following description, are substantially attained by a process and a circular knitting machine according to the accompanying claims, in any combination among them and/or according to one or more of the following aspects. In a further aspect thereof, taken alone or in combination with any one of the claims or aspects indicated herein below, the invention relates to a process for regulating and balancing production of a circular knitting machine for knitwear or hosiery, comprising the step of predisposing at least a circular knitting machine for knitwear or hosiery comprising at least: a bearing structure; a needle cylinder rotatably mounted in the bearing structure; a plurality of needles supported by the cylinder and mobile parallel to a rotation axis of the cylinder for producing a knitted textile; a plurality of stitch cams operatively active on the needles and selectively and individually mobile such as each to vary a size of the stitches produced by the needles at a respective drop position of a yarn, each cam independently of another, a first plurality of passive yarn feeders, or passive fixed-drum yarn feeders, each of which is operatively active to feed the yarn, unwinding from the fixed drum, to the needles at a respective yarn feeding position and a respective cam of the stitch cams; a control device of the functioning of the knitting machine; and electric and electronic means connected to the control device and operatively active for commanding the functioning of a plurality of components of the knitting machine and for detecting a plurality of operating parameters of the functioning of the knitting machine; defining a sample portion of balancing knitted fabric to be produced on the knitting machine, the portion of balancing knitted fabric having a substantially uniform structure suitable for determining a same consumption of yarn at each yarn feeding position or drop of each device of the first plurality of fixed-drum passive yarn feeds in function for the production; producing the portion of balancing knitted fabric with a predetermined number of complete rotations of the needle cylinder, maintaining substantially constant a tension of the yarn supplied to the needles by using a braking and/or yarn tension regulation device and/or automatically maintaining the programmed grammage of the tension of the yarn; detecting, from among respective start and end signals of balancing knitted portions, a plurality of yarn consumption data of the yarn used for realising the balancing knitted portion, detecting a respective datum of yarn consumption at each yarn feeding position of the machine and/or the relative passive yarn feeder of the first plurality; comparing each yarn consumption datum, relating to a respective yarn feeding position of the machine and/or to a respective yarn feeder, or a mean of each yarn consumption data on a single complete revolution of the needle cylinder, with a single common yarn consumption reference value, such as to obtain a respective comparable result; determining, with a second algorithm, a corrective value of the position of each stitch cam on a basis of the respective comparable result of the corresponding yarn feeder, if the comparable result exceeds a predetermined tolerance threshold or if it is beyond a predetermined tolerance range; and individually displacing each stitch cam according to the relative corrective value, such as to reduce the difference between the respective yarn consumption datum of the corresponding yarn feeder and the yarn consumption reference value.In a further aspect, in combination with any one of the claims or aspects described in the following, the invention further relates to a process wherein the steps of producing a portion of knitwear, detecting a plurality of yarn consumption data, comparing each yarn

consumption datum, determining a correct value of the position of each stitch cam and individually displacing each stitch cam are cyclically carried out a plurality of times, preferably consecutively, up to when the result of the comparison is less than the predetermined tolerance threshold for all the functioning passive fixed-drum yarn feeders. In a further aspect, in combination with any one of the claims or aspects described in the following, the invention further relates to a process comprising a step of emitting an alarm signal and/or halting the knitting machine in a case in which it is not possible to obtain a balancing of the fabric produced or an achieving of a correct size of the knitted article with a predetermined number of operating cycles. In a further aspect, in combination with any one of the claims or aspects described in the following, the invention further relates to a process further comprising a step of memorising the corrective values corresponding to each knitted zone, and using the memorised corrective values to automatically displace the stitch cams before producing each corresponding knitted zone of a following corresponding knitted article on the same knitting machine or on a further knitting machine. In a further aspect, in combination with any one of the claims or aspects indicated herein below, the invention further relates to a process in which the knitting machine further comprises a needle plate, operatively cooperating with the needle cylinder, for production of knitted material and/or of the knitted article, and relative additional stitch cams operatively active on the additional needles of the needle plate, the process further comprising the step of displacing the position of the additional stitch cams, similarly and contextually to what is carried out on the stitch cams of the needle cylinder, for maintaining the relation between the stitches produced by the cylinder and the stitches produced by the plate. Further characteristics and advantage will more fully emerge from the detailed description of a preferred but not exclusive embodiment of the invention, according to the accompanying figures of the drawings, in which:

figure 1 schematically illustrates a circular knitting machine for knitwear or hosiery according to an embodiment of the present invention;

figure 2 illustrates a plurality of knitting machine of the type of figure 1, operatively connected to one another and with an external processor for a transfer of data via a cabled network and/or a wireless network;

figure 3 is a schematic view of some parts of the knitting machine of figure 1, and in particular shows a detail relating to a reel of yarn, a yarn feeder and a corresponding yarn feeding position at which yarn is supplied to the mobile needles of the cylinder of the knitting machine;

figure 4 is a detail relating to a yarn feeding position of the knitting machine, with the mobile needles vertically mobile in the cylinder according to the movements determined by the relative stitch cams or triangles;

figure 5 is a portion of knitted fabric having a regular structure;

figure 6 is an example of a knitted article subdivided into two consecutive knitted zones;

figure 7 schematically illustrates some steps of a process for regulating the size of textile articles under production on a circular knitting machine according to an embodiment of the present invention;

figure 8 is a variant of the process of figure 7;

figure 9 is a further variant of the process of figure 7;

figure 10 is an embodiment of a preliminary step of regulating and balancing the production of the circular knitting machine.

[0006] With reference to the figures of the drawings, 1 denotes in its entirety a circular knitting machine for knitwear or hosiery, which comprises at least a bearing structure 2, a needle cylinder 3 rotatably mounted in the bearing structure 2 and a plurality of needles 4 supported by the needle cylinder 3 and mobile parallel to a rotation axis of the needle cylinder 3 for producing a knitted textile and/or a knitted article 6.

[0007] In the present text, the term "circular knitting machine for knitwear or hosiery" is used for a circular knitting machine suitable for production of knitwear articles, seamless articles and/or hosiery, having a plurality of yarn feeding positions and relative stitch cams, or stitch triangles, which can be regulated automatically and individually, i.e. each cam independently of another in each predetermined knitted zone of a knitted product or article, and can be regulated also contextually, i.e. all the cams at the same time and in the same way. These knitting machines can be, for example, of a single jersey or double jersey type (i.e. with a needle plate or a double cylinder). Not included in the definition of circular knitting machine for knitwear or hosiery according to the aims of the present invention are those circular knitting machines dedicated to the production of textiles in metrage, i.e. for continuous production of textile. Continuous or metrage machines do not allow for automatic independent regulating of the stitch cams, which are regulated manually at initial set-up of the machine for production, and are then regulatable only contextually and not independently of one another. Continuous knitting machines are also provided with yarn feeders of the active (or positive) type, which all supply the same quantity of yarn at each yarn feeding position of the machine. These yarn feeders are generally activated to move directly by the rotation of the cylinder of the knitting machine with special movement means and supply all the yarn at the same speed, correlated to the rotation velocity of the cylinder. Further, these continuous knitting machines are generally large-diameter, i.e. they exhibit a diameter of the cylinder of greater than 30 inches. The circular knitting machine 1 further comprises a plurality of stitch cams 7 operatively active on the needles 4, and in particular on relative heels 4a of the needles 4, and selectively mobile such as to

vary the movement of the needles 4 and thus the size of the stitches 5a produced by the needles 4. In greater detail, the cams 7 are regulatable in height in a known way, in the direction indicated by the arrow 14 in figure 4. The circular knitting machine 1 comprises a first plurality of fixed-drum passive (or negative or stationary) yarn feeders 8, each of which is operatively active to feed a yarn 9, unwinding from the fixed drum, to the needles 4, at a respective feed 10 position and at least a respective stitch cam 7. Each yarn feeder 8 receives the yarn 9 from a respective reel 13 and supplies it to the needles 4 at a yarn feeding position 10. The passive yarn feeder 8 and the fixed drum can be for example of the type illustrated in patent documents EP0707102 and EP1335054 in the name of LGL, the content of which at least in relation to the structure of the yarn feeder 8, the braking device for maintaining the tension of the yarn 9, and the measuring modes of the quantity of yarn used is incorporated for reference in the present text. The expression "passive" is taken to mean that the yarn feeder operates in a way which is known as defile in the sector, i.e. in which the yarn unwinds from the yarn feeder following the request for yarn on the part of the knitting machine. The expression "fixed drum" is taken to mean that the drum on which the yarn is wound is immobile during the unwinding of the yarn for supplying the knitting machine (while the drum itself can be activated in rotation to take the yarn from a respective reel). The fixed-drum passive device enables carrying out the process of the invention optimally and without the slippage that happens with an innumerable number of types of yarns, for example natural yarns, artificial yarns, textured and parallel synthetic yarns and clad elastic yarns, while it is not suitable for feeding non-clad elastic yarns (*bare spandex, bare elastane*). The circular knitting machine 1 can further comprise a second plurality of passive yarn feeders with a rotary spool (not illustrated as of known type) or other types, suitable in particular for feeding a clad or elastomer elastic yarn, which can be fed to the knitting machine together with the yarn 9 for realising a knitted article having both yarn 9 and elastomer or bare yarn. The circular knitting machine 1 further comprises a control device 11 of the functioning of the knitting means 1 and electric and electronic means 12 connected to the control device 11 and operatively active such as to command the functioning of a plurality of parts of the knitting machine 1 and for detecting a plurality of operating parameters of the functioning of the knitting machine 1. The knitting machine 1 can further comprise a needle plate (not illustrated in the figures as of known type), operatively cooperating with the needle cylinder 3, for the production of the knitted textile and/or the knitted article 6, and relative additional stitch cams operatively active on the additional needles of the needle plate. In a less preferred embodiment of the present invention, instead of the fixed drum passive yarn feeders 8, other yarn feed 8 types also suitable for the aim could be used. For example passive yarn feeders could be used, of the rotary reel or other type in the first plurality of yarn feeders for carrying out a process of the invention, attaining only some of the aims of the invention and in a limited measure and very much less reliable. The above-cited components, and the further conventional components of the knitting machine 1 are not described in greater detail in the present text as they are of known type. In accordance with the present invention, a process for regulating the size of knitted articles under production on a circular knitting machine 1 for knitwear or hosiery comprises at least steps of defining (step A in figure 7) a knitted article to be produced on the knitting machine 1, subdividing (B) the article 6 to be produced, thus defining a plurality of knitted zones 6a, 6b each corresponding to a respective portion of knitted material, and activating (C) a production program of the knitted article 6 and thus of the knitted zones on the control device 11 of the knitting machine 1. Figure 6 illustrates, for example, two knitted zones 6a, 6b, but it is possible to define any number of knitted zones such as to enable a progressively more-accurate control of the size of the knitted article in its various parts. As can be seen in figure 6, each knitted zone 6a, 6b can be associated to a respective desired measurement, expressed in a determined measurement unit, for example centimetres or inches. Thereafter a measurement can be made of the knitted articles produced, concerning each knitted zone or the knitted article. The effective value of this measurement can be associated to the yarn consumption value detected for realising the corresponding knitted zone or knitted article, also such as to define a relation of correspondence between the measurement and the consumption of yarn. In this way the user can set or modify the size of the knitted article, or specific knitted zones thereof, directly by inserting the desired measurements in the selected measuring units. The process for maintaining the size of the present invention also enables maintaining the measurement of the knitted article 6 and/or each knitted zone 6a, 6b substantially uniform to the set value. The process further comprises the step of producing (D) the knitted zones of the knitted article 6 in sequence, maintaining substantially constant, by means of a braking device and/or a yarn tension regulation device (not illustrated as of known type), a yarn tension fed to the needles 4. The braking and/or yarn tension regulating device is suitable for enabling automatic maintaining of the grammage of the programmed yarn tension during production. The process further comprises the step of detecting (E) a plurality of yarn consumption data 9 per knitted zone 6a, 6b, detecting, among respective start knitting zones 6a, 6b and end knitting zones 6a, 6b, a total quantity of yarn 9 used for realising each knitted zone 6a, 6b at each yarn feeding position 10 of the machine and the relative fixed-drum passive yarn feeder 8 or for the totality of the fixed-drum passive yarn feeder 8 in function in production. The process further comprises the step of comparing (F) the plurality of yarn consumption data 9 per knitted zone 6a, 6b with a respective plurality of yarn consumption reference

values 9 per knitted zone 6a, 6b, such as to obtain a respective plurality of comparable results. The process further comprises the step of determining (G) by means of a first algorithm a plurality of corrective values of the position of the stitch cams 7 on the basis of the respective plurality of comparable results, if those comparable results exceed respective predetermined tolerance thresholds or are out of respective predetermined tolerance intervals. The first algorithm can for example comprise a calculation of a percentage displacement value, or another appropriate calculating formula. For example the corrective values can be calculated by means of a definition of single unitary displacements of the cams 7 such as to enable a progressive reduction of the differences between the plurality of yarn consumption data 9 per knitted zone 6a, 6b and a respective plurality of yarn consumption reference values 9 per knitted zone 6a, 6b, by means of a cyclical repetition of the comparisons and corrections up to a progressive reaching of an objective condition in which all the comparable results fall within the predetermined tolerance intervals. Alternatively the corrective values can be calculated by defining a plurality of unit displacements of the cams 7 in order to reach the objective condition in a single comparing cycle or a small number of cycles. In other terms, in a case of periodically and frequently performed controls several consecutive controls can be carried out up to when all the compared results fall within the tolerance intervals. Further, both in a case of several consecutive controls and in a case of periodical control, where the objective condition is not reached within a predetermined number of corrective cycles (regulation of the stitch cams 7) an alarm signal can be emitted, or the knitting machine 1 can be shut down. The process further comprises the step of automatically displacing (H) the stitch cams 7 according to the plurality of corrective values, such as to reduce the difference between the plurality of yarn consumption data 9 per knitted zone 6a, 6b and the plurality of yarn consumption reference values 9 per knitted zone 6a, 6b, with the consequent maintaining of also the assigned measurement in each zone, in centimetres or inches. In a variant, illustrated in figure 7, the step of automatically displacing (H) the yarn regulating cams 7 can be carried out before producing a following zone of the same knitted article 6, such as to regulate the stitches produced in the successive zones on the basis of what is detected in the immediately preceding zone. In a further variant, illustrated in figure 8, the step of automatically displacing (H) the stitch cams 7 can be done before producing each corresponding knitted zone 6a, 6b of a successive corresponding knitted article, such as to precisely regulate the production of each zone of a successive knitted article on the basis of what is detected in the corresponding zone of a preceding knitted article 6. In this variant, differently to the preceding one, the displacement of the cams 7 is done before each knitted zone 6a, 6b on the basis of the corrective values detected with reference to the same or corresponding zone in a preceding knitted zone 6a, 6b of the same knitted article 6. In this variant, the process can further comprise a step of memorising (I) the corrective values corresponding to each knitted zone 6a, 6b, and comprises the use of the memorised corrective values for automatically displacing the stitch cams 7 before producing each corresponding knitted zone 6a, 6b of a successive corresponding knitted article. In a further variant, illustrated in figure 9, the step of automatically displacing (H) the stitch cams 7 can be done immediately before producing a successive corresponding knitted article, such as to perform an overall correction starting from the following knitted article, for example on the basis of a mean of the corrections detected in the different zones of the preceding article. In a process according to the invention, it is further possible to detect or calculate overall yarn consumption data 9 for each knitted zone 6a, 6b corresponding to the quantity of yarn 9 used, for realising each knitted zone 6a, 6b corresponding overall to the yarn consumption 9 of the totality of fixed drum passive yarn feeders 8 in function in production. In this case the overall yarn consumption data 9 are compared with respective overall yarn consumption reference values per knitted zone 6a, 6b such as to obtain a respective plurality of comparable results and define a common corrective value for each knitted zone 6a, 6b. Further, in this case the step of displacing the stitch cams 7 is performed by contemporaneously displacing all the stitch cams 7 active in production according to a same common corrective value and/or simultaneously. The process can further comprise a preliminary regulating and balancing step (L) of the production of the circular knitting machine 1, illustrated in detail in figure 10. According to an aspect of the invention, this preliminary regulating and balancing step of the production of the circular knitting machine 1 can also be carried out on a circular knitting machine 1 of the above-described type independently of the process for regulating the size of knitted articles under production as described herein above, thus in itself defining a process for regulating and balancing the fabric produced by a circular knitting machine for knitwear or hosiery. The preliminary regulating and balancing step can be carried out before the production of the knitted articles, in order to balance the position of the stitch cams 7 in order to avoid defects or insufficient uniformity on the knitted products manufactured, and is carried out before the process steps for regulating the size of knitted articles under production as described as above. In this way the process for regulating the size of knitted articles can also enable maintaining the balance of the previously-obtained fabric. The preliminary regulating and balancing step comprises the steps of defining (M) a sample portion of balancing knitted fabric 5 to be produced on the knitting machine 1, the portion of balancing knitted fabric 5 having a substantially uniform structure suitable for determining a same consumption of yarn 9 at each device of the first plurality of fixed-drum passive yarn feeders 8 functioning for the production. A detail of the portion of balancing knitted fabric 5 is illustrated for example in figure 5, with horizontally-

placed numerals from 1 to 5 indicating the various rows or columns (or sequences of vertical stitches, each produced by a respective needle) and vertically-placed numerals from 1 to 5 indicating the successive stitch rows of the textile (each produced by a yarn feed 10 at a determined rotation of the cylinder 3). The preliminary regulating and balancing step further comprises the steps of producing (N) the portion of balancing knitted fabric 5 by means of a predetermined number of complete rotations of the needle cylinder 3, maintaining substantially constant a tension of the yarn 9 fed to the needles 4 by use of a braking and/or regulating device 9 and detecting, among respective start balancing knitted portion 5 signals and end balancing knitted portion signals, a plurality of yarn consumption 9 data used for realising the balancing knitted portion 5, detecting (O) a respective yarn consumption datum 10 at each yarn feeding position 10 of the machine and the relative fixed drum passive yarn feeder 8. The preliminary regulating and balancing step further comprises the steps of comparing (P) each yarn consumption datum 9 relative to a respective yarn feeder 8, or a mean of each yarn consumption datum 9 on a single complete revolution of the needle cylinder 3, with a single common yarn consumption reference value, in order to obtain a respective comparable result, and determining (Q), by means of a second algorithm, a corrective value of the position of each stitch cam 7 on the basis of the respective comparison result of the corresponding yarn feeder 8 if the comparison result exceeds a predetermined tolerance threshold or is out of a predetermined tolerance range. The second algorithm can comprise for example a calculation of a percentage displacement value, or another suitable calculation formula, for example the corrective value can correspond to a single *step* (minimum displacement value of the stitch cams 7) with a performing of various successive regulating cycles up to reaching the desired balance in a single cycle (and therefore up to when the comparable results are within the threshold of tolerance). Alternatively the corrective value can correspond to a plurality of steps for reaching the desired balancing in a single cycle or in a smaller number of cycles. In a case in which the corrective value is above a maximum predetermined corrective value, or in a case in which a balance is not obtainable within a predetermined number of cycles, an alarm signal can be set off, or there can be an automatic shut-down of the knitting machine 1. The preliminary regulating and balancing step further includes the step of individually displacing (R) each stitch cam 7 according to the relative corrective value, such as to reduce the difference between the respective yarn consumption datum of the corresponding yarn feeder 8 and the yarn consumption reference value 9. In all the embodiments and variants described above, the corrective value of the position of each stitch cam 7 or each corrective value of the position of each stitch cam 7 can correspond to a determined number of minimum unit displacements of the stitch cam 7 proportional to the respective value of the comparative result, or can correspond, for each comparative result, to a minimum unit displacement of the stitch cam 7. Further, at least the step of individually displacing each stitch cam 7 can be cyclically performed a plurality of times up to when the or each comparison result is below the predetermined tolerance threshold for all the fixed drum yarn feeder 8 in function. As illustrated in figure 10, the step of displacing (R) the cams 7 can be cyclically carried out by displacing the stitch cam 7 progressively with successive minimum unit displacements, or can be performed by carrying out a first displacement and then carrying out a cycle comprising the steps from the production of the knitted portion to the displacement of the cams (from step N to step R). Once all the detected values are brought to within the margin of tolerance, a stop step (S) of the preliminary step of regulating and balancing is performed and the steps of producing the knitted articles can proceed. The process of the invention can further comprise the step of emitting (T) an alarm or shut-down signal in a case in which within a predetermined number of cycles it is not possible to bring the or each comparative result below the predetermined tolerance threshold for all the fixed-drum yarn feeders 8 functioning. The process can further comprise the step of determining, on the knitting machine 1 or a second knitting machine 1', the yarn consumption reference value, the yarn consumption reference value per knitted zone 6a, 6b or the plurality of yarn consumption reference values per knitted zone 6a, 6b by means of a processing of the plurality of yarn 9 consumption data or yarn 9 consumption data per knitted zone using a third algorithm. The third algorithm can comprise, for example, performing a mean, or a maximum value, or a minimum value, of the yarn consumption data or yarn consumption data per zone, or by selecting the consumption data relative to a portion 5 of balancing knitted fabric or an approved balancing knitted article 6. The process can further comprise the step of receiving, on the knitting machine 1, the yarn consumption reference value, the yarn consumption reference value per knitted zone 6a, 6b or the plurality of yarn consumption reference values per knitted zone 6a, 6b, from a second knitting machine 1' on which the value has been detected or calculated. The process can further comprise the step of transmitting the yarn consumption reference value, the yarn consumption reference value per knitted zone 6a, 6b or the plurality of yarn consumption reference values per knitted zone 6a, 6b calculated or detected, from the textile machine 1 to at least a second knitted machine 1' or to a plurality of knitting machines 1', 1". According to the invention, as illustrated in figure 2, the steps of receiving or transmitting the reference value can be automatically carried out by means of a net 15 that can be cables and/or wireless and which can be local or connected to the internet, or by transferring a memorising device connected in successive moments to the various knitting machine 1, 1', 1" for transferring the values in question. In a variant, the process can further comprise the step of automatically modifying the size of the knitted

article 6 to enable production of a corresponding knitted article 6 having a different size on a second circular knitting machine 1' different from the above-mentioned circular knitting machine.

[0008] In a further variant, the process can further comprise the step of automatically modifying the size of the knitted article 6 such as to enable the production of a corresponding knitted article 6 having the same size on a second circular knitting machine 1' different from the above-cited circular knitting machine. In both variants, the step of automatically modifying the size can be carried out by modifying the yarn consumption reference value 9 per knitted zone 6a, 6b or the plurality of yarn consumption reference values per knitted zone 6a, 6b, detected or determined on the knitting machine according to a fourth algorithm also operating on a plurality of operating parameters of the knitting machine 1 and the second knitting machine 1' set in reciprocal relation. The operating parameters can comprise at least one or more from among the following parameters: number of needles 4 in the cylinder 3, gauge of the cylinder needles, cylinder diameter, cylinder rotation velocity, number of feeds 10 or drop positions of the yarn 9 or number of yarn feeders, types of yarn used, etc. For example the fourth algorithm can comprise a conversion of the yarn consumption reference values per knitted zone 6a, 6b in order to adapt to the second knitting machine 1', by applying a conversion formula which adapts the values proportionally to the difference, or to the percentage relation (or another) between the diameters of the two knitting machines, or between the number of needles of the two knitting machines, etc. The process can further comprise the steps of displacing the positions of the additional stitch cams, operatively active on the additional needles 4 of the needle plate, similarly and contextually to what is carried out on the stitch cams of the needle cylinder 3. The invention further relates to a process for producing knitted articles on at least a circular knitting machine for knitwear or hosiery, comprising a process for regulating a size of knitted articles according to what is described above, which is continuously performed during the production of the knitted articles or periodically, at regular intervals, predetermined or established by a user during the production of the articles. The process for regulating the size can further be carried out when at least an operating condition selected from among the following obtains: during a transitory heating period of the knitting machine after start of production; after at least a maintenance intervention on the knitting machine; after a replacing of at least one component of the knitting machine; on a variation, above a predetermined threshold, of at least an environmental condition influencing the functioning of the knitting machine, for example environmental temperature or moisture. The invention further relates to a software program for circular knitting machines for knitwear or hosiery configured such as to perform one or more steps of a process according to what is described above. The above-mentioned process steps can be realised by more than one software program, for example some steps can be carried out by a first operating software installed on the control device 11 of the knitting machine, and other steps can be carried out by a second program or design software program installed on an external processor 16 operatively connectable to the knitting machine 1 via the internet 15 or a portable memorising device. The invention further relates to a knitting machine 1 of the above-described type, which control device 11 is configured to perform at least some steps of the process of the above-described type and/or has the first software program cited above installed. The invention as it is conceived is susceptible to numerous modifications and variants, all falling within the scope of the inventive concept, and the cited components can be replaced with other technically-equivalent elements. The invention attains important advantages. Primarily the invention enables some of the drawbacks in the prior art to be obviated. The invention further enables production of high-quality knitted articles that are substantially free of drawbacks, as well as reducing production waste. The invention further enables effectively and efficiently controlling and regulating the production of the knitted articles automatically, reducing the interventions of the operators to a minimum.

[0009] The invention further enables realising productions of high dimensional uniformity, both in different temporal moments and in various operating conditions on a same machine, and also with respect to productions realised on a plurality of machines. The invention further enables precisely and reliably controlling and regulating the sizes of the knitted articles produced on one or even on a plurality of knitting machines contemporaneously. The invention further enables reducing the number of personnel required for controlling production, especially in plants in which numerous knitting machines are present. The invention is also simple, sturdy and economical to realise, and guarantees high standards of repeatability and safety.

Claims

1. A process for regulating the size of knitted articles under production on circular knitting machines for knitwear or hosiery, comprising the steps of:

   - predisposing at least a circular knitting machine (1) for knitwear or hosiery, comprising at least: a bearing structure (2); a cylinder (3) of needles (4) rotatably mounted in the bearing structure (2); a plurality of needles (4) supported by the cylinder (3) and movable parallel to a rotation axis of the cylinder (3) for producing a knitted textile; a plurality of stitch cams (7) operatively active on said needles (4) and selectively and individually movable for varying, each, the size of the stitches produced by the needles (4) themselves in correspondence of a respective yarn

feeding position (10) of a yarn (9), each stitch cam (7) independently of another, a first plurality of fixed-drum passive yarn (9) feeders (8), each of which is operatively active for feeding the yarn (9), unwinding from the fixed drum, to said needles (4) in correspondence of a respective feeding position (10) and of a respective stitch cam (7) of said stitch cams (7); a control device (11) of the functioning of the knitting machine (1); and electric and electronic means (12) connected to the control device (11) and operatively active to control a functioning of a plurality of parts of the knitting machine (1) and to detect a plurality of operating parameters of the functioning of the knitting machine (1);

- defining a knitted article (6) to be produced on the knitting machine (1), wherein for said knitted article (6) is defined at least a knitted zone (6a, 6b) of said knitted article (6) or a plurality of consecutive knitted zones (6a, 6b) of said knitted article (6), each corresponding to a respective portion of knitted fabric;
- activating a program of production of said knitted article (6) and of said at least a knitted zone or said plurality of knitted zones (6a, 6b) on said control device (11) of said knitting machine (1);
- producing said at least a knitted zone or said plurality of knitted zones (6a, 6b) of said knitted article (6) in a sequence, maintaining a tension or grammage of the yarn (9) fed to the needles (4) substantially constant, by means of a braking device and/or of a yarn (9) tension regulating device;
- detecting a plurality of data relating to yarn (9) consumption per said at least a knitted zone or said plurality of knitted zones (6a, 6b) by detecting, from among respective start and end signals of knitted zone (6a, 6b), an overall quantity of yarn (9) used for realising each knitted zone (6a, 6b) in correspondence of each yarn feeding position (10) of the machine and/or of the relative passive fixed-drum yarn feeder (8) or for a totality of the passive yarn feeders (8) of said first plurality in operation for the production;
- comparing the plurality of data for yarn (9) consumption per said at least a knitted zone or said plurality of knitted zones (6a, 6b) with a respective plurality of reference values for yarn (9) consumption per said at least a knitted zone or said plurality of knitted zones (6a, 6b), in order to obtain a respective plurality of comparison results;
- determining, by means of a first algorithm, a plurality of corrective values of the position of the stitch cams (7) on the basis of the respective plurality of comparison results, if such comparison results are greater than respective predetermined tolerance thresholds;
- automatically displacing, before producing a successive zone (6a, 6b) of the knitted article (6), and/or immediately before producing a successive corresponding knitted article (6) and/or before producing each corresponding knitted zone (6a, 6b) of a successive corresponding knitted article (6) after having temporarily memorised the corrective values corresponding to each knitted zone (6a, 6b), the stitch cams (7) in accordance with said plurality of corrective values, such as to reduce the difference between said plurality of data relating to yarn (9) consumption per said at least a knitted zone or said plurality of knitted zones (6a, 6b) and said plurality of reference values for yarn (9) consumption per said at least a knitted zone or said plurality of knitted zones (6a, 6b).

2. The process of the preceding claim, wherein overall yarn (9) consumption data for each knitted zone (6a, 6b) are detected or calculated, corresponding to the quantities of yarn (9) used, for realising each knitted zone (6a, 6b), corresponding altogether to the consumptions of yarn (9) of the totality of the yarn feeding positions (10) of the machine and/or of the yarn feeders (8) of the first plurality of yarn feeders in operation for the production, and wherein said overall yarn (9) consumption data per knitted zone (6a, 6b) are compared with respective reference values for overall yarn (9) consumption per knitted zone (6a, 6b) in order to obtain a respective plurality of overall comparison results and to define a common corrective value for each knitted zone (6a, 6b), and wherein said step of displacing the stitch cams (7) is performed by displacing all the stitch cams (7), active for the production, together in accordance with a same common corrective value and/or simultaneously.

3. The process of any one of the preceding claims, further comprising a preliminary step of regulating and balancing the knitted fabric produced by the circular knitting machine (1), which preliminary regulating and balancing step is carried out before the cited process steps and comprises the additional steps of:

- defining a portion of balancing knitted fabric (5) to be produced on the knitting machine (1), said portion of balancing knitted fabric (5) having a substantially uniform structure suitable for determining a same consumption of yarn (9) at each yarn feeding position (10) of the knitting machine (1) and/or of each yarn feeder of the first plurality of passive fixed-drum yarn feeders (8) in operation for the production;
- producing said portion of balancing knitted fabric (5), by means of a predetermined number of complete rotations of the cylinder (3) of the needles (4), maintaining a tension of the yarn (9)

fed to the needles (4) substantially constant by means of a braking device and/or of a yarn (9) tension regulating device;

- detecting, from among respective start and end portion signals of balancing knitted fabric (5), a plurality of yarn (9) consumption data of the yarn (9) used for realising the portion of balancing knitted fabric (5), detecting a respective yarn (9) consumption datum at each yarn feeding position (10) of the machine and/or of the relative passive yarn feeder (8) of said first plurality;
- comparing each yarn (9) consumption datum, relating to a respective yarn feeding position (10) of the machine and/or to a respective yarn feeder (8), or a mean of each yarn (9) consumption datum on a single complete revolution of the cylinder (3) of the needles (4), with a single common reference value for yarn (9) consumption, such as to obtain a respective comparison result;
- determining, by means of a second algorithm, a corrective value of the position of each stitch cam (7) on the basis of the respective comparison result of the corresponding yarn feeder (8), if the comparison result exceeds a predetermined tolerance threshold or if it is out of a predetermined tolerance range;
- individually displacing each stitch cam (7) in accordance with the relative corrective value, such as to reduce the difference between the respective yarn (9) consumption datum of the corresponding yarn feeder (8) and the reference value for yarn (9) consumption, in order to balance the fabric under production.

4. The process of any one of the preceding claims, wherein the, or each, corrective value of the position of each stitch cam (7) corresponds to a number of minimum unit displacements of the stitch cam (7) proportional to the respective value of the comparison result, or wherein the, or each, corrective value of the position of each stitch cam (7) corresponds for any comparison result to a minimum unit displacement value of the stitch cam (7).

5. The process of any one of the preceding claims, wherein at least said step of displacing the stitch cams (7) and/or said step of individually displacing each stitch cam (7) is carried out cyclically a plurality of times up to when the, or each, comparison result is below the predetermined tolerance threshold for all the yarn feeders (8) of the first plurality of yarn feeders (8) in operation.

6. The process of any one of the preceding claims, further comprising a step of emitting an alarm or halt signal in the case in which within a predetermined number of cycles the, or each, comparison result cannot be brought to below the predetermined tolerance threshold or within the predetermined tolerance range for all the yarn feeders (8) of the first plurality of yarn feeders (8) in operation.

7. The process of any one of the preceding claims, further comprising a step of determining, on said knitting machine (1) or on a second knitting machine (1'), the reference value for (9) yarn consumption (9), the reference value for yarn (9) consumption per knitted zone (6a, 6b), or the plurality of reference values for yarn (9) consumption per knitted zone (6a, 6b), by means of a processing of said plurality of yarn (9) consumption data or of yarn (9) consumption data per knitted zone, by means of a third algorithm, for example performing a mean, or a maximum value, or a minimum value, of said yarn (9) consumption data or the yarn (9) consumption data per zone, or by selecting said consumption data relative to a portion of balancing knitted fabric (5) or to an approved balancing knitted article.

8. The process of any one of the preceding claims, further comprising the step of receiving, in said knitting machine (1), the yarn consumption (9) reference value or the yarn consumption (9) reference value per knitted zone (6a, 6b) or the plurality of yarn consumption (9) reference values per knitted zone (6a, 6b), from a second knitting machine (1') on which it has been detected or calculated.

9. The process of any one of the preceding claims, further comprising a step of transmitting the yarn (9) consumption reference value or the yarn (9) consumption reference value per knitted zone (6a, 6b), or the plurality of yarn (9) consumption reference values per knitted zone (6a, 6b), calculated or detected by said knitting machine (1), to at least a second knitting machine (1'), said steps of receiving or transmitting said reference value being automatically carried out by means of a cabled network (15) and/or of a wireless type and/or of a local type or connected to internet or by means of transfer of a memorising device.

10. The process of any one of the preceding claims, further comprising the step of automatically modifying the size of said knitted article (6) in order to enable production of a corresponding knitted article (6) of a different size, or the production of a corresponding knitted article (6) having the same size, on a second circular knitting machine (1') different from said circular knitting machine (1), said step of automatically modifying the size being performed by modifying said yarn (9) consumption reference value per knitted zone (6a, 6b), or said plurality of yarn (9) consumption reference values per knitted zone (6a, 6b), detected or determined on the knitting machine (1),

according to a fourth algorithm operating also on a plurality of operating parameters, placed in reciprocal relation, of the knitting machine (1) and of the second knitting machine (1'), said operating parameters comprising at least one or more from among following parameters: the number of needles (4) of the cylinder (3), the gauge of the needles (4) of the cylinder, diameter of the cylinder, rotation velocity of the cylinder, number of yarn feeding positions (10) or number of yarn feeders (8) or type of yarn (9) used.

11. A process for producing knitted articles on at least a circular knitting machine (1) for knitwear or hosiery, **characterised in that** it comprises a process for regulating the size of knitted articles, according to any one of the preceding claims, which process is performed continually during production of a plurality of identical knitted articles which are distinct from one another, either periodically, at regular intervals, predetermined or established by a user, during production of the articles and/or on verifying of at least an operating condition selected from among the following: during a transitory period of heating of the knitting machine (1) after a start in production; after at least a maintenance intervention on the knitting machine; after a replacement of at least one component of the knitting machine; on varying, above a predetermined threshold, of at least an environmental condition potentially influencing the functioning of the knitting machine, for example temperature or environmental moisture level.

12. A software program for circular knitting machines for knitwear or hosiery, configured for performing a process in accordance with any one of the preceding claims.

13. A circular knitting machine for knitwear or hosiery comprising at least: a bearing structure (2); a cylinder (3) of the needles (4) rotatably mounted in the bearing structure (2); a plurality of needles (4) supported by the cylinder (3) and movable parallel to a rotation axis of the cylinder (3) in order to produce a knitted fabric; a plurality of stitch cams (7) operatively active on the needles (4) and selectively and individually movable such as each to vary a size of the stitches (5a) produced by the needles (4) at a respective yarn feeding position (10), one cam (7) independently of another, a first plurality of passive fixed-drum yarn (9) feeders (8), each of which is operatively active such as to supply the yarn (9) unwinding from the fixed drum to the needles (4) at a respective yarn feeding position (10) and a respective cam (7) of said stitch cams (7); a control device (11) of the functioning of the knitting machine (1); and electric and electronic means (11) connected to the control device (11) and operatively active such as to command the functioning of a plurality of components of the knitting machine (1) and such as to detect a plurality of operating parameters of the functioning of the knitting machine (1), the control device (11) being configured such as to perform a process as in any one of claims from 1 to 11 and/or being provided with a software program as in claim 12.

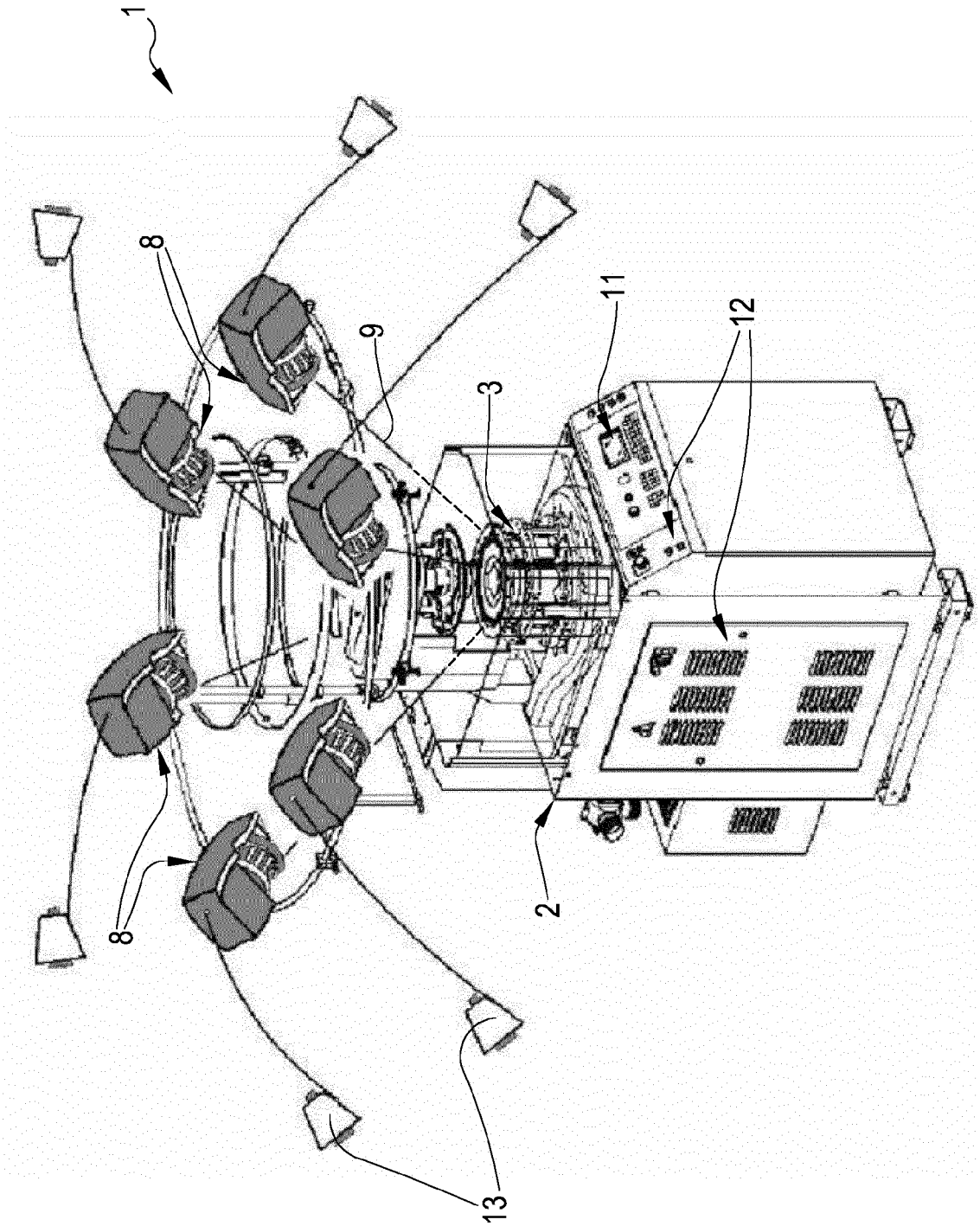


FIG.1

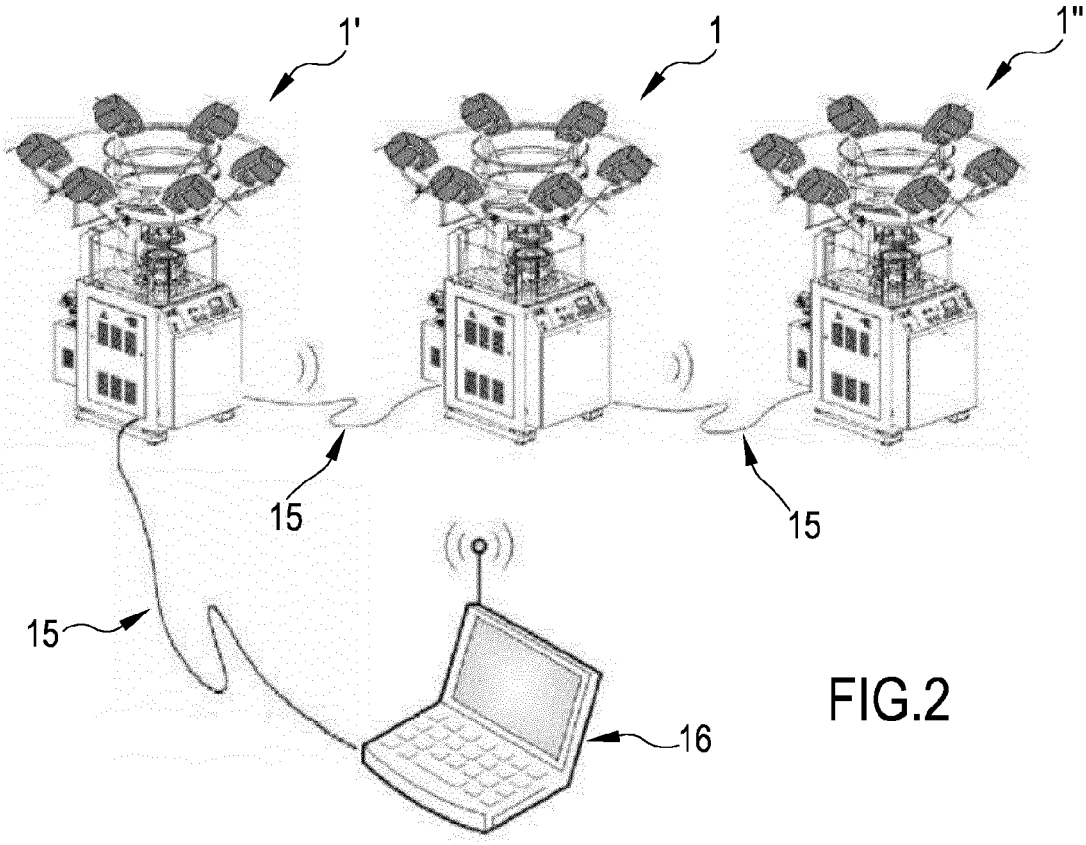


FIG.2

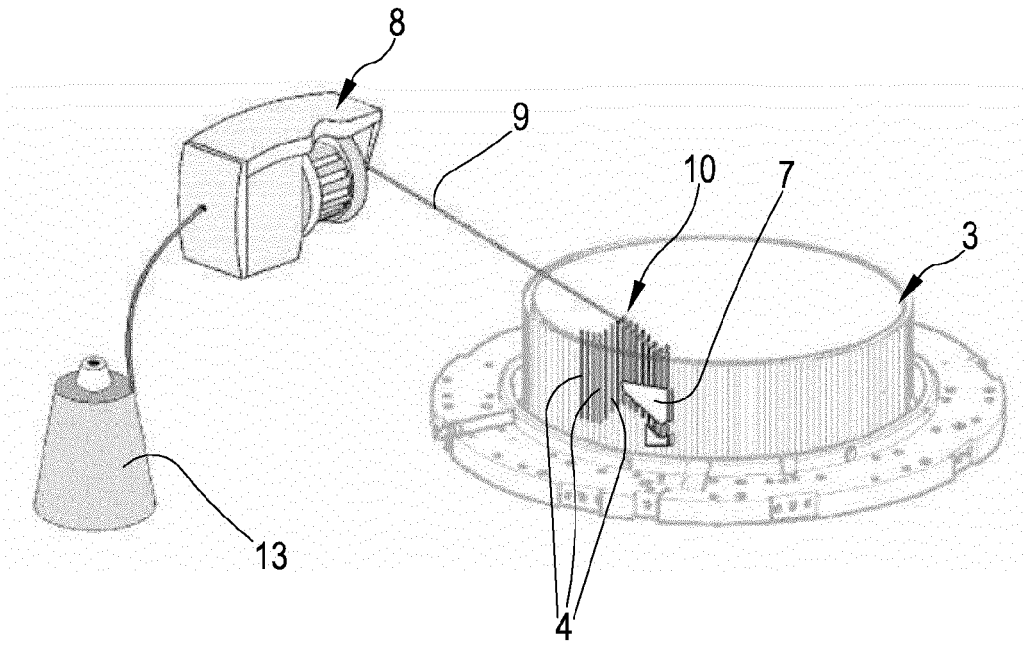


FIG.3

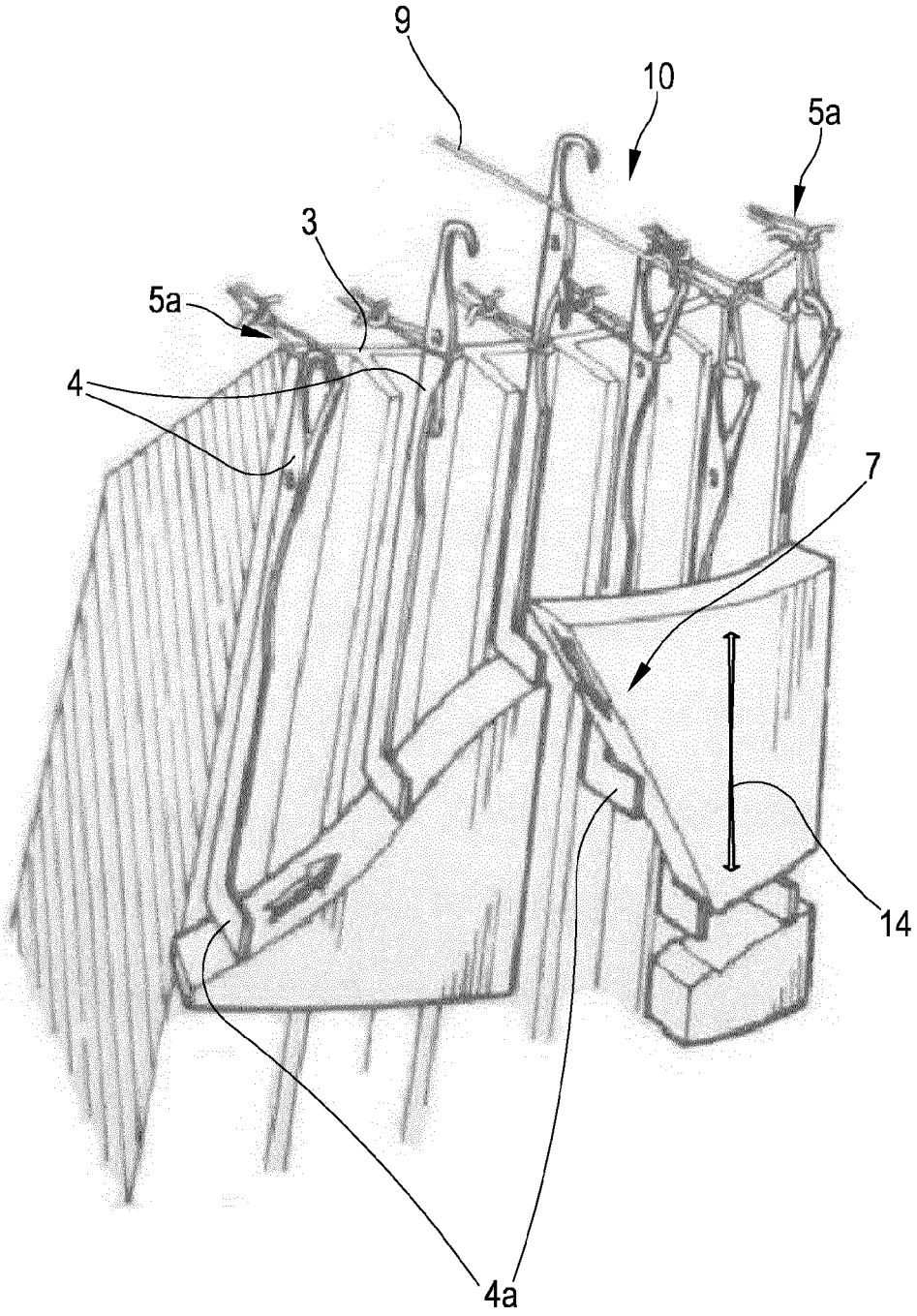


FIG.4

FIG.5

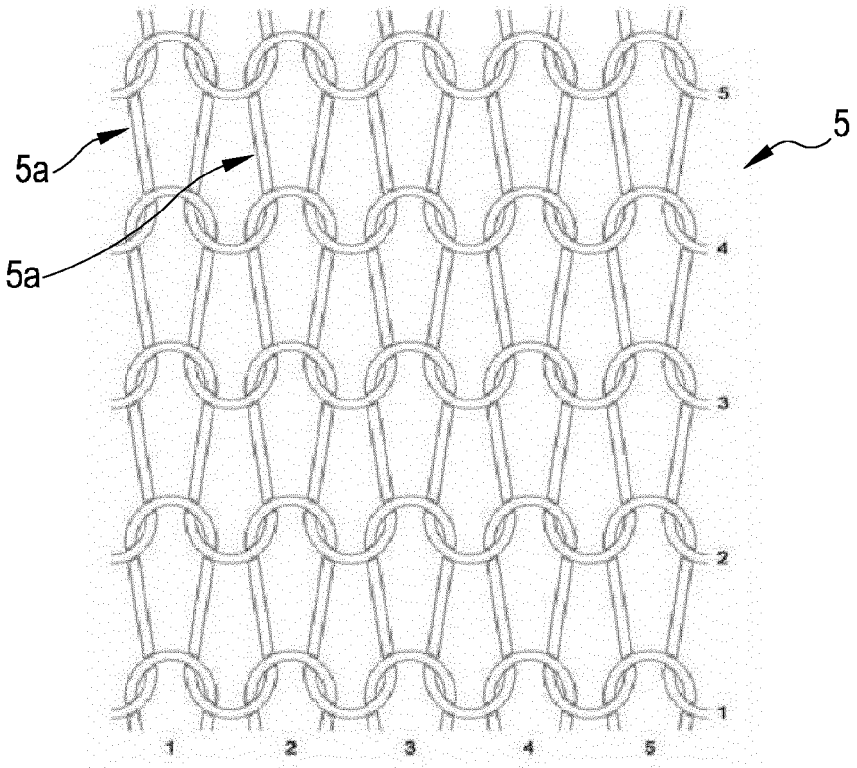


FIG.6

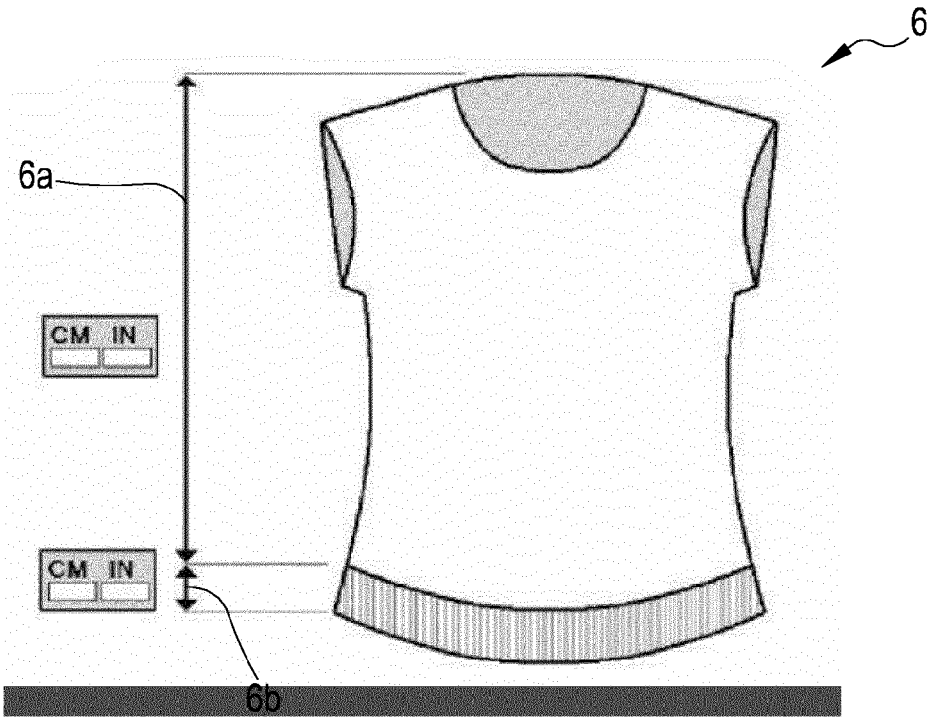


FIG.7

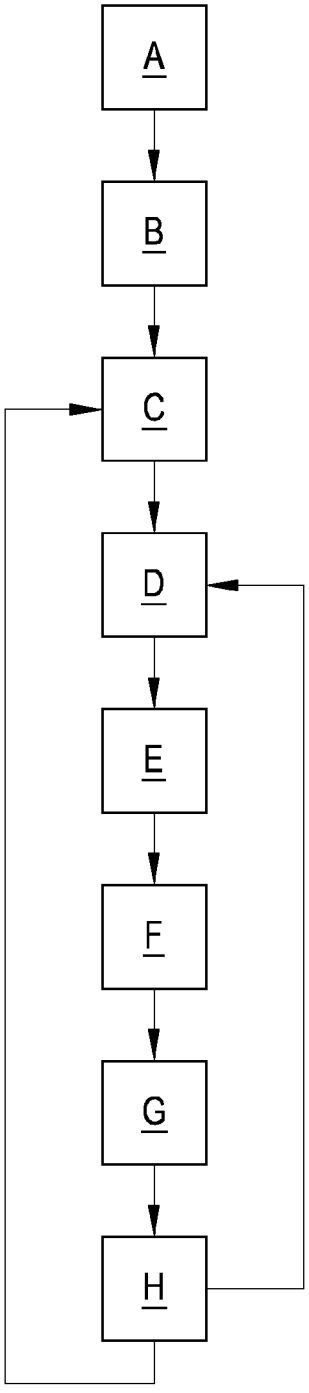


FIG.8

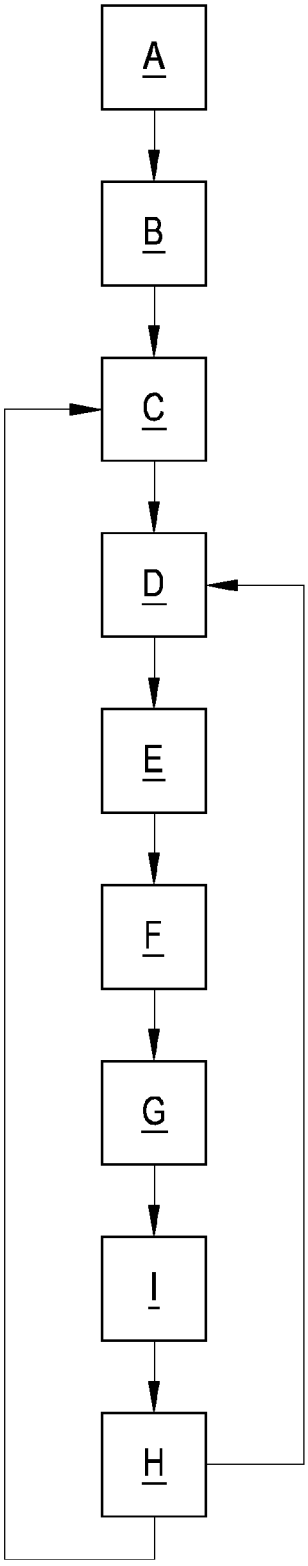


FIG.9

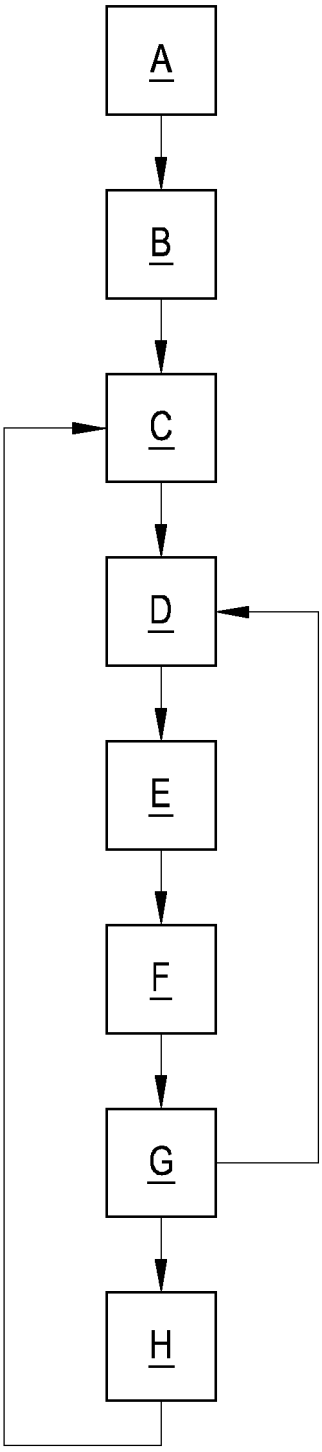
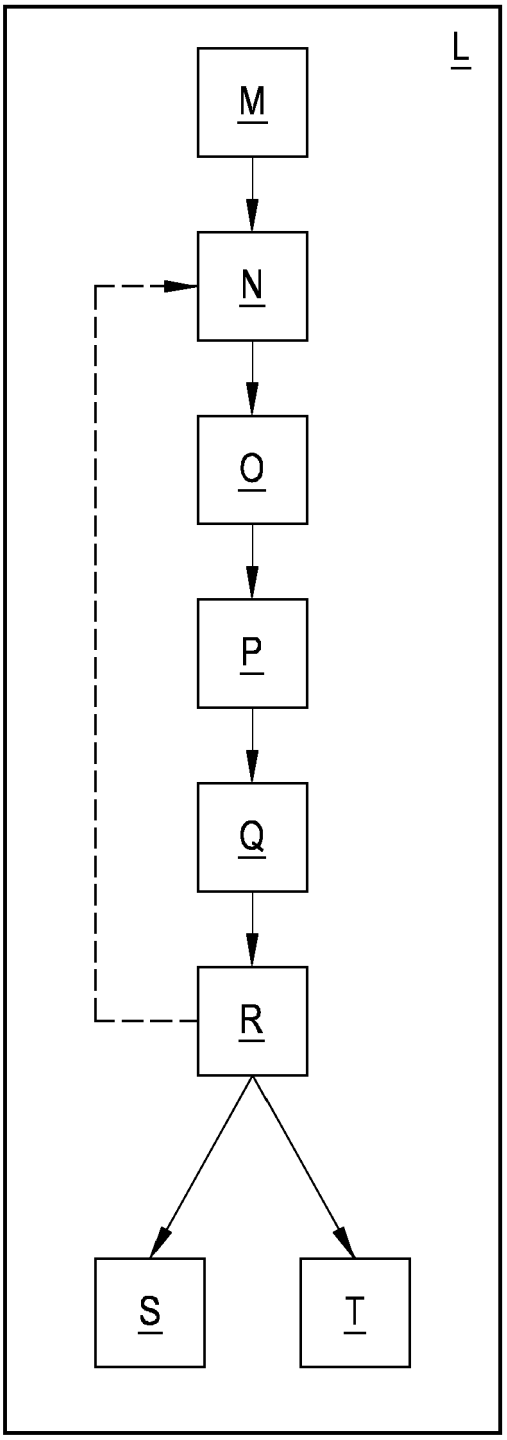


FIG.10



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EUROPEAN SEARCH REPORT

Application Number
EP 15 17 9905

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Place of search	Date of completion of the search	Examiner
Munich	11 January 2016	Uhlig, Robert

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