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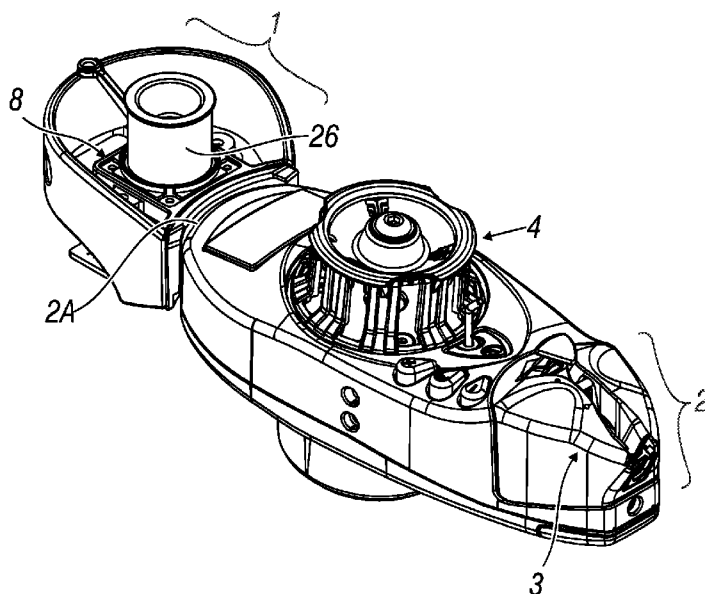


Fig. 3

(57) Abstract: A method and a system according to the invention comprise the use of a device (2) for feeding yarn (F) to a textile machine (T), operating discontinuously or with alternating motion, and a device (1) compensating for changes in the conditions for feeding or taking up the yarn (F) by the textile machine (T), said compensator device (1) including a movable compensating means (13) that performs this compensation to maintain a constant tension in the yarn (F) even when the aforementioned change in the conditions for feeding or taking up the yarn occurs, said compensating means (13) being rigid and connected to an electric actuator, a control unit of this actuator being capable of detecting displacement of said compensating means (13) from a predetermined resting position when there is a change in take-up or feeding of the yarn and being capable of returning said compensating means (13) to the resting position



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after such a change. Provision is made for continuously detecting the yarn tension and operating the electric actuator to maintain this tension at a constant value.

METHOD AND IMPROVED YARN FEEDER SYSTEM AND DEVICE FOR
OPTIMISING YARN FEED TO A TEXTILE MACHINE OPERATING
5 HIGHLY DISCONTINUOUSLY OR WITH ALTERNATING MOTION

DESCRIPTION

The object of the present invention is a method for feeding yarn to a machine that processes it according to
10 the precharacterising clause of the principal claim. A system and a compensator device according to the precharacterising clause of the corresponding independent claims are also the object of the invention.

Constant tension yarn feeders have long been known
15 for feeding a yarn or wire to a textile machine, either to produce a finished manufactured article (e.g. a knitted article or a sock) or to process that yarn, possibly in combination with other yarns (e.g. machines for preparing yarn for subsequent uses).

20 In particular, known devices for feeding yarn of the type capable of feeding yarns (including metal wires) or (textile/technical) yarns at constant tension are known. Said devices operate according to a known closed-loop control principle implemented through a known constant
25 tension yarn feeder. The method of control ensures that a yarn or wire is regularly fed at constant tension regardless of the rate of feed of said yarn and also regardless of changes in the tension of the yarn at the intake to said constant tension yarn feeder; all this
30 whether the changes in tension are due to gradual emptying of the yarn bobbins or whether such changes are due to tears or additional tensions deriving from irregular unwinding of said yarns.

A known constant tension yarn feeder of the type mentioned above is, for example, the object of EP1492911 in the name of the same Applicant; this prior text describes a feeder comprising a tension sensor, an actuator or motor acting on a feed wheel or pulley and a control unit (or electronics) capable of assessing the tension in the yarn measured by the aforementioned sensor by comparing it with a desired working tension (or SET POINT). On the basis of this comparison the control unit acts on the motor so as to act on the pulley connected to it by braking or feeding the yarn so as to modify or maintain the tension in yarn fed to a textile machine constant (for the production of a manufactured article or for processing the yarn itself).

Also known are devices and systems (and the methods they implement) intended to feed yarn to a textile machine discontinuously or in a manner according to which the yarn moves with at least one first and at least one second condition for feeding to or taking up by the textile machine which differ from each other. Such different feed conditions follow one another over time.

By way of example, a constant tension yarn feeder comprising means, for example a load cell, capable of measuring the tension of the controlled yarn in real time, a pulley on which the yarn is wound with one or more turns, an electric motor which drives the pulley in rotation and control electronics which, depending on the tension of the measured yarn, regulate the rotation speed of the motor and consequently of the pulley to keep the measured tension in line with a predetermined and programmable value, possibly a function of the operating stage of the textile machine, is known. Rotation of the motor is generally controlled in two directions, the

first to deliver yarn to the machine, the second to recover it from the machine during stages of stopping or reversal to prevent yarn from becoming slack and to maintain it always at the desired tension.

5 With feeders of this type the yarn is picked up from a bobbin directly from the device and wound onto the pulley. Obviously, to ensure constant good quality of the controlled tension there must be no slip between the yarn and the pulley; only in this situation can the control
10 electronics in fact precisely calculate the speed to be set for the motor associated with the pulley to keep the tension at the desired value.

 In applications where the rate of take-up by the machine is constant or is without major discontinuities,
15 this type of feeder device is able to keep the measured tension constant as the feed conditions change (variable yarn tension at the feeder intake, changes in rate of feed, etc.). Obviously, since there is no slip, under these working conditions the feeder is able to keep the
20 measured tension perfectly in line with the set value and at the same time accurately measure the quantity of yarn fed, this being another fundamental parameter to ensure the quality of the finished manufactured article.

 Known solutions of the type mentioned above do
25 however have operating limitations when the rate of take-up by the textile machine changes suddenly. In applications of this type the rate at which the yarn is taken up by the textile machine varies very quickly, for example when following the selection of needles in a
30 knitting machine; in this case, if the motor that rotates the pulley does not have the necessary output dynamics to follow these changes in take-up, tension peaks occur in the yarn when take-up increases, and slackening occurs

when take-up falls.

Both these defects in tension control (peaks and slackening) can cause quality problems in the garment produced (the presence of stop marks due to incorrect
5 tension during processing) or lead to the yarn breaking (due to a tension peak) or to the yarn being dropped from the operating means (such as the needle) of the textile machine (due to slackening).

Obviously the problem is the greater the lesser the
10 elasticity of the yarn that helps to compensate for the lack of dynamics in the motor response.

Various solutions for this type of problem are known: for example, a feeder system including a compensator device which is connected upstream of the feed (of the
15 type described above) and which by acting together with the yarn helps to overcome the limitations described above is known from EP2262940, in the name of the same Applicant. After the yarn has been wound onto the pulley of the feeder, this system requires that it be routed to
20 a movable arm of the compensator device and then redirected to the load cell of the feeder. In this way the compensator device lies within a control loop (tension measured with respect to the speed of the feed pulley) to ensure that the yarn tension remains constant
25 as the position of the movable arm varies.

In other words, according to the aforesaid prior document the movable arm acts as a compensator device located between the pulley (on which the yarn accumulates) and the tension detection means (load cell)
30 and is capable of compensating for changes in the conditions under which yarn is fed or taken up as it passes through each condition in which it is taken up by the textile machine. This is to maintain the yarn tension

at a constant predetermined value even during any changes in the conditions under which it is fed to the textile machine.

The movable arm of the known solution is constructed with a spring (for example a spiral spring), whose terminal part comprises an eye (for example of ceramic) for passage of the yarn, to allow the arm to perform its compensating function.

When the compensator device is in use, an operator adjusts the spring force (manually or electronically) so that its terminal part through which the yarn runs during the working stages is on average in the centre of an angular working sector. In this way, if changes in take-up by the textile machine occur one of the following situations may arise:

- during a sharp increase in take-up which the pulley motor cannot follow (compensate for) because of its limited dynamics, the compensating arm will fall, allowing the motor time to accelerate and reducing the tension peak leaving the feeder; or
- during a sharp reduction in take-up which the motor cannot follow because of its limited dynamics, the compensating arm will rise, allowing the motor time to decelerate and reducing slackening of the tension leaving the feeder.

Obviously the ability to compensate for tension peaks and yarn slackening is closely related to the dynamics of the system (spring force) and the amplitude of the angular sector within which the arm can move.

It should also be noted that the aforesaid prior document provides for the possibility of measuring the position of the compensating arm used by the control electronics of the feeder to increase or decrease the

pulley speed, as well as the possibility of adjusting the force of the spring through an electric actuator to make it work automatically, without requiring the operator to adjust the force manually.

5 This known solution, while operating extremely well, still has limitations, as indicated below.

 The compensator device of the known system in practice operates as a balance and the force of the spring is adjusted manually or automatically to ensure
10 that its force is able to compensate for the tension in the fed yarn to keep its terminal part at the centre of the angular sector of movement. The lighter the spring (in terms of weight), the more its force will be correctly calculated and the more it will increase the
15 responsiveness of the system. However it is clear that the force of the spring is also associated with the working tension limits within which the device can work effectively.

 For example, if the spring is calibrated for medium-
20 high tensions for a specific application (e.g. 10 g), its force must be calculated accordingly; when instead the working tension is lower, the chosen force will constitute an operating limit for the device.

 The known compensator device thus has the great
25 limitation that the spring must be dimensioned according to the desired working tension, making the system inflexible, or that the spring must be differently dimensioned by the operator, or that the entire compensator device must be differently dimensioned as the
30 working tension varies, which of course is not always possible.

 In addition, because the terminal part of the compensating arm is part of the spring, it too undergoes

bending due to the force of the yarn and this makes reading of its position inaccurate and therefore difficult to use as a predictive signal for anticipating any compensating action by the device to vary the
5 conditions under which the yarn is taken up; it is also difficult to keep the spring in a specific position, as it is flexible.

Finally, ability to compensate, particularly during the slackening stage, is closely related to the length of
10 the arm and the amplitude of the angular sector; this ability is therefore limited.

US4752044 relates to a yarn feeder apparatus with electronic tension control. The apparatus comprises a housing on one side of which is located rotating means on
15 which yarn directed towards a textile machine is wound, said yarn having previously acted together with braking means associated with such housing. At the outlet from the rotating means the yarn passes through a fixed eye and then through an eye located at the end of a movable
20 guide arm forming an integral part of the known yarn feeder apparatus; at the outlet from the eye of this guide arm the yarn acts together with another fixed eye before leaving the apparatus.

The yarn guide arm is intended to form a reserve of
25 yarn F on the outlet side of the rotating means and therefore downstream of it when yarn feed slows down due to a change in yarn take-up by the textile machine.

The yarn guide arm can be directly attached to a permanent magnet direct current electric motor contained
30 in the housing of the apparatus or it can act together with a lever which is in turn an integral part of the apparatus and is moved by an electric motor within said housing. In both embodiments an electro-optical signal

transducer detects the angular position of the guide arm and emits a signal that represents the tension of the fed yarn and at the same time represents the angular position of such arm and therefore the size of the reserve of yarn
5 created downstream of the rotating means.

The (direct current) electric motor forms an electromagnetic control transducer that exerts a carefully predetermined and adjustable control force on the guide arm. The force is equal to the tension the yarn
10 exerts on the eye of the guide arm.

This force can be adjusted by means of a potentiometer in an electric circuit comprising a power supply unit powering the direct current motor. In this circuit a compensation signal that is imposed on the
15 control input to the aforesaid power supply is defined, said signal being set (and therefore of constant value) so as to correspond to a specific yarn tension.

In this way the power supply unit controls the direct current motor to define an equilibrium position of the
20 guide arm which it is able to maintain when subjected to the force of the yarn.

More specifically, under normal operating conditions the guide arm takes up the particular equilibrium angular position between two stop pins between which the arm can
25 only move angularly. The force exerted by the yarn passing through the eye attached to the arm is balanced by the force of the direct current motor acting on the lever or on the arm itself.

In the event of a change in yarn feed conditions,
30 such as reduced use of the yarn by the textile machine, the guide arm moves angularly with respect to the initial equilibrium position so as to generate an electrical signal corresponding to the change in position through

the transducer mentioned above. The signal is passed to means controlling the apparatus. This means acts on the feed of an actuator that controls the rotating means so as to act on the yarn feed rate until the guide arm
5 returns to the predetermined equilibrium position in which the yarn tension is compensated for by the control force exerted by the lever acting on the aforesaid arm generated by the electric motor connected to that lever or is in equilibrium with the force generated directly on
10 the movable arm by the motor which acts together with it.

Thus through the movement of the guide arm the known solution is able to detect a change in the feed conditions for the yarn that is compensated for by corresponding action on the rotating feeder device. In
15 this solution the guide arm is directly or indirectly subjected to the action of an electric motor whose function is only to counterbalance the change in tension of the yarn to keep the guide arm in the resting position. However the guide arm, and the actuator
20 directly or indirectly acting together with it, have a wholly passive function because it is only the action on the actuator of the rotating means that enables this arm to stay in the balance position or return to it after the arm has moved angularly between the fixed pins (attached
25 to the housing of the apparatus). Such a guide arm is always subject to a predetermined force and can only compensate for limited changes in yarn tension because of its limited movement between these fixed pins.

WO2005/111287 describes a yarn feeder device
30 comprising a sensor capable of reading the tension of yarn fed to a textile machine and rotating feeding means subject to the control of an electric motor. The movement of this means is controlled by a microprocessor unit

which regulates the speed of this means according to the tension of the yarn detected by the tension sensor. This sensor is located at the free end of a rigid arm which can move against a resistant element when the yarn
5 changes its tension at the outlet from the rotating means and passes over an idling roller or pulley associated with the free end of the movable arm. Opposition to the movement of this arm can be achieved by means of a spring or a carriage moving along a rail associated with the
10 feeder device.

The rotating means and the movable rigid arm are an integral part of the known feeder device.

Under working conditions the yarn is wound at least once onto the rotating means before passing through the
15 pulley at the end of the rigid arm. Movement of the yarn causes the arm to rotate in a direction that follows yarn feed direction and this rotation is counteracted by the opposing elements (spring or carriage), an action regulated by an operator. The tension sensor detects the
20 yarn tension, compares it with a fixed value and then adjusts the speed of the rotating means so as to keep the yarn tension close to the required value. Movement of the rigid arm prevents any excessively rapid increase in yarn tension by moving back, thus preventing the yarn from
25 breaking.

Again, movement of the rigid arm is limited within a predetermined angular sector.

In both the known solutions of the two prior documents described above, the apparatus in US4752044 or
30 the device in WO2005/111287 are elements incorporated into the compensation devices and are not separable or capable of being constructed independently. The result is a high level of complexity in implementation of the known

solutions, and great difficulty when performing any maintenance work, as well as a high cost.

WO 2013/064879, in the name of the applicant, describes a method and a system according to the precharacterising parts of the corresponding independent
5 claims of the present document.

The aforesaid prior document describes a metal wire feeder device comprising a body with wire-braking means, one or more pulleys controlled by their respective motors
10 on which the wire is wound, a wire which passes through a compensator member and a tension sensor before reaching an operating machine. Control electronics are able to measure the wire tension continuously so as to match it to a predetermined value by acting on a first control
15 loop acting on the motors and a second control loop acting on the compensator member.

This compensator member also comprises a compensating arm having a free end acting together with the wire and in turn free to rotate about a pin fixed on a bracket
20 associated with body. This arm can then move within the body of a predetermined angular sector by approaching or moving away from the tension sensor (defined by a load cell).

The compensating arm is associated with a spring
25 connected on one side to a support fixed to the body of the device and on the other to the compensating arm by a movable carriage which is moved, through an Archimedes or endless screw, by an electric stepper motor.

Thus the compensating arm is not directly connected
30 to the electric motor, but the latter drives and moves this compensating arm through the interposition of other components, each with its own inertia.

The compensating arm is associated with a position

sensor connected to the control unit which is thus able to measure the position of that arm within a predetermined angular sector.

The compensating arm is thus able to oppose slip of
5 the wire not in a static but in a dynamic way: the control unit can in fact vary the position of the carriage (acting on the electric motor) to which the spring is attached, bringing about a change in the force exerted by the latter on the arm and bringing it to the
10 desired position within the predetermined angular sector. In this way the compensating arm keeps the wire always perfectly tensioned on the load cell or tension sensor, especially during the stages when the wire is not fed to the textile machine.

15 The compensating arm also creates a reserve of metal wire from which the machine can draw during unforeseen speed changes.

The prior document in question then describes a feeder device equipped, as an integral and inseparable
20 component, with a compensating arm which is free to move within a predetermined angular sector.

The control system for the device knows the position of the arm and through an electric motor and a system of (one or more) springs is able to define the force to be
25 applied, according to the measured tension or the read position, thus closing two possible control loops, a second loop relating to the tension (the first is the one relating to the motors connected to the pulleys) and a possible second one for the position of the arm.

30 It should however be noted that the force applied to the arm is managed through a system of springs and a movable carriage, driven by an electric stepper motor, which is used to change the fulcrum of the lever and

therefore the force that it exerts on the wire.

Even in this prior document the problems pointed out for the system described in EP 2262940 mentioned above still apply.

5 In fact the ability to compensate for tension peaks and slackening of the wire of the device which is the object of WO 2013/064879 is closely related to the dynamics of the system (spring force, the moving carriage and motor) and the amplitude of the angular sector within
10 which the compensating arm can move.

Furthermore, even in this prior document the compensating arm in practice operates as a balance and the force of the spring is adjusted automatically so that its force is able to compensate for the tension of the
15 fed wire to keep its terminal part at the centre of the angular sector of movement.

Finally, compensating capacity, particularly during the slackening stage, is closely linked to the length of the compensating arm and the amplitude of the angular
20 sector; this capacity is therefore limited.

In addition, the known feeder device inseparably incorporates the compensator member. The result is a heavy assembly of not insignificant dimensions.

The object of the present invention is to provide an
25 improved method and system for controlling the feeding of discontinuously fed yarn which comprises a yarn feeder associated with a device compensating for changes in yarn take-up by the textile machine.

In particular, the object of the present invention is
30 to provide a system of the type mentioned with a compensator device which is to be inserted into a control loop (tension measured with respect to the speed of the feed pulley) when feeding yarn to a textile machine that

overcomes the limitations of existing solutions.

Another object is to provide a method of the type mentioned above that can actively or dynamically compensate for any change in tension undergone by the yarn during the aforementioned discontinuous feeding to the textile machine, during the stages of both feeding the yarn to the textile machine and removing yarn from the latter during the stages in which such feeding is interrupted.

10 A further object of the invention is to provide an independent compensator device suitable for use in a system of the type mentioned above that does not vary its dynamic characteristics in relation to the set working tension, making the device flexible and easy to use.

15 Another object is to provide a compensator device of the type mentioned above that allows for precise measurement of the position of the compensating means and can also operate in a predictive manner when the yarn begins to undergo tension changes at the start of a different stage in the discontinuous feed to the textile machine.

20 A further object is to provide a compact compensator device that can also be applied as an additional element to a feeder device that enables the system to which it belongs to recover more yarn during the stages of slackening or reversal of the textile machine in comparison with how much can be recovered by known systems.

25 These and other objects which will be evident to those skilled in the art are accomplished through a method, a feeder system and a compensator device according to the appended claims.

For a better understanding of the present invention

the following drawings are attached, purely by way of a non-limiting example, in which:

Figure 1 shows a front view of a compensator device according to the invention associated with a known feeder device for controlling the tension of a yarn fed to a textile machine;

Figure 2 shows a side view of the devices shown in Figure 1;

Figure 3 shows a perspective view of the compensator device according to the invention and the feeder device in Figure 1;

Figure 4 shows a front perspective view of the compensator device according to the invention;

Figure 5 shows a side view of the compensator device according to the invention;

Figures 6 to 8 show the compensator device from above and in three different positions of use;

Figure 9 shows a view from beneath of the compensator device according to the invention; and

Figures 10A-10C show different block diagrams relating to use of the system according to the invention;

Figures 11A-11C show graphs of the tension of the yarn directed to the textile machine in situations where the device which is the object of the invention is not operational (Figure 11A) and in two situations where the system according to the invention operates in passive-dynamic mode (Figure 11B) and in active-predictive mode (Figure 11C) respectively.

With reference to the aforesaid figures (where corresponding parts have identical numerical references), and Figure 1 in particular, a compensator device according to the invention is generically indicated by 1 and is associated with an end 2A (or is located on a

side) of a feeder device or simply a feeder 2, which is in itself known, to feed a yarn F (shown as a dashed line in Figure 1) at constant tension to a textile machine T. Yarn F can also be a metal wire and can be delivered to an operating machine such as a winder. Device 1 is a complete and clearly identifiable element, in terms of both construction and use, in comparison with feeder 2.

Feeder 2 has a tension sensor 3, a pulley 4 (or equivalent yarn accumulation means) driven by its own electric motor (not shown) and a control unit or electronics 60, preferably with microprocessor (see Figure 10A-10C), which is in itself known. This control unit or electronics is able to assess the tension in a yarn detected by sensor 3 as it is fed to the textile machine, compare the detected tension with a predetermined value (or SET POINT value) and check and adjust the tension of the yarn (if it differs from the desired value) through acting on the aforesaid electric motor and therefore on pulley 4. This feeder 2 and its parts 3, 4 are of a type and operation which are known and therefore will not be further described.

The feeder, as mentioned, allows the yarn to be fed to the textile machine at constant tension, said textile machine being a production unit for manufactured products or a machine for processing the yarn.

Device 1 and feeder 2 define a feeding system for yarn F according to the invention.

Compensator device 1 according to the invention is able to act together with the yarn after it has passed over pulley 4. This compensator device is therefore within the yarn tension control loop, as may be seen from Figure 1 and as will be clear from the description of the method according to the invention. Thanks to the present

invention it is possible to increase the dynamic performance of the feeder system so that it will be able to compensate instantly for sudden changes in yarn take-up (positive and negative), enabling the pulley motor to
5 change to the new speed to feed the yarn as required by the new take-up situation without causing positive or negative tension peaks in the final yarn tension.

The presence of compensator device 1 within the control loop always ensures that the tension of the yarn
10 leaving feeder 2 is always the same as the one set.

Compensator 1 is an independent device in comparison with feeder 2 and comprises an electric motor 8, for example a direct current brush motor, preferably with very low inertia to increase its dynamics. In the
15 embodiment of the invention provided by way of example motor 8 directly moves a drive shaft having two parts projecting from opposite sides of the motor itself. In the figures the first part of the drive shaft is indicated by 7 (see Figures 7-9), and the second part
20 indicated by 10 may be seen in Figure 9; the motor is also inserted within a body 11 of the device. A rigid arm 13 (which is thus attached to the drive shaft itself) is mechanically attached to the first part of the drive shaft. At end 14 of arm 13 there is also an annular body
25 (or one of another shape) of ceramic (or other material) 16 over which the yarn runs.

Electric motor 8, as mentioned, is preferably of very low inertia to allow rapid movement of arm 13 under the force of the yarn and therefore rapid compensation for
30 this movement without it causing tension peaks in the yarn itself.

Arm 13 can however freely rotate (causing the motor to rotate) about an axis M (or drive shaft axis) if drawn

by yarn F, both when the motor has very low inertia (preferred) and when it has limited inertia; in every case this arm has a zero or initial resting position (for example that seen in Figure 6) that is adopted when yarn
5 F is taken up by textile machine T without changes in tension and without interruptions. This arm may also adopt other compensation positions, as described below.

The assembly of arm 13 and motor 8 (i.e. substantially device 1) can operate in two different
10 modes: passive-dynamic mode or active-predictive mode.

In passive-dynamic mode the motor enables arm 13 (attached to the drive shaft) to be pulled by the yarn and moved from its resting position also causing the motor itself to rotate. However, this motor acts after
15 said movement to return arm 13 to the resting position. In this mode or operating mode the motor substantially operates as a "dynamic" spring whose force (with which it acts on arm 13) can be programmed by programming and/or controlling the motor torque.

20 This force is not however predetermined and fixed (as in the solution in US4752044), but can vary in that it automatically adjusts to changes in the set value of the yarn tension in the various stages of the production process so as to always maintain the arm in its
25 predetermined position whatever the set operating tension of the yarn for each particular stage in the production of a manufactured article. This enables motor 8 to oppose an equal and opposite force to that which moves arm 13 (to which it is always directly connected) from the
30 resting position to maintain this arm in its equilibrium position (for example that at "3 o'clock" in Figure 6).

The variability of the opposing force or the action of the motor on arm 13 will be described below.

In active-predictive mode, motor 8 is able to act in advance (in "predictive" mode) as soon as it detects a change in the yarn tension (detected by sensor 3) due to a change in the operating stage of the machine. In this case motor 8 moves arm 13 carried by the drive shaft to the compensating position capable of compensating for the change in tension: if this tends to increase, motor 8 moves the arm to the compensating position at "6 o'clock" in Figure 7, if the change tends to a decrease in yarn tension (because the textile machine has stopped or slowed down yarn take-up), the motor moves arm 13 to the compensating position at "12 o'clock" in Figure 8. This enables the yarn tension to be kept constant regardless of the operating and production stage of textile machine T.

Figures 11A-11C show the tension curves in situations where motor-arm assembly or device 1 is disabled (Figure 11A), in passive-dynamic mode (Figure 11B) or in active-predictive mode (Figure 11C).

In the figures, curves or lines F, K, W and Y respectively define the set yarn tension (in a production operating stage, curve F), the measured yarn tension (curve K), the set point position for arm 13 (curve W) and the actual position of arm 13 (curve Y). In the figures, time is the abscissa, the ordinate is the tension measured for F and K, as well as a position value for W and Y.

As may be seen from comparing the figures, when device 1 is disabled the measured yarn tension has significant peaks and variations in comparison with the other situations in Figures 11B, 11C. From comparing Figures 11B and 11C it can also be seen that the yarn tension has more limited variations in the situation

where device 1 acts in active-predictive mode. Finally, in Figure 11C it can be seen that the resting position of arm 13 (curve W) is not predetermined, but follows the change in the yarn tension; this resting position is also
5 "followed" by the "present" position of the arm during the compensation performed by device 1.

Second part 10 of the drive shaft supports a magnet 18, which, together with arm 13 associated with motor 8, is free to rotate about its axis M within a specific
10 circular sector (causing the drive shaft to rotate). Alternatively, the assembly comprising arm 13 and magnet 18 can rotate freely, making a complete revolution about axis of rotation M (the axis of the drive shaft); in other words, both arm 13 and magnet 18 are splined onto
15 the drive shaft with the result that both rotate about axis M in the same way, freely or within an angular sector. This enables the position of arm 13 to be immediately known by detecting the position of the magnet.

20 For this purpose there are position detectors 19 around the magnet, for example one or more linear Hall sensors 20, capable of generating a position signal addressed, for example, to a control unit 70 of compensator device 1. Thanks to the Hall sensor data this
25 unit 70 is able to transform the motor rotation into two sinusoids offset by 90° (Sine and Cosine) from which it is possible to obtain the absolute position of the shaft and therefore of arm 13 that acts together with the yarn, arm 13 being rigidly attached to the shaft and to magnet
30 18, in real time.

In one embodiment, the control unit also advantageously comprises systems (in themselves known) to drive the electric motor to control its rotation speed

and applied torque.

Preferably, provision is also made for real-time data exchange between control electronics 60 of feeder 2 and control unit 70 of compensator device 1 so as to be able to set the desired torque for the motor of this device 1 and then control its rotation and read its position (and consequently, in a direct and immediate way, that of arm 13). The torque setting is dynamic and not fixed as it depends on the set yarn tension or that detected by sensor 3.

Information exchange may take place in one of the following ways: through any serial bus, through digital or PWM signals, or through analog signals.

It is therefore clear that feeder 2 (through its control electronics), which acts together with said compensator device 1, is able to know the position of arm 13 in real time, in a secure and immediate way, and adjust the torque/shift/speed applied to the motor of compensator device 1. This is because of the direct connection between the drive shaft and said arm or because of the direct action of this motor on the arm.

By appropriately managing the received position signal for arm 13 and by appropriately controlling the motor acting on this arm, the feeder system for yarn F according to the invention is therefore able to close a second control loop for the position of arm 13 in an almost immediate way to keep it in the desired position, for example in its central position ("3 o'clock"), as the set tension varies. This is to compensate for movement of the yarn and changes in its tension linked to the various operating stages of the textile machine.

With reference to Figures 10A, 10B, the system can be implemented in different ways:

1. Compensator device 1 has its own control unit 70 which is intended to receive from control electronics 60 of feeder 2 a resting position reference (indicated by block 80 in Figures 10A and 10B) which the arm must maintain as the set or detected tension of yarn F varies. Control unit 70 acts together with the means (magnet 18) for measuring the position of arm 13 and driving motor 8 (blocks 81 and 82). The control unit thus closes the control loop for the position of arm 13.
2. Alternatively, and preferably, it is control electronics 60 of feeder 2 that receive the data relating to the position of arm 13 from magnet 18 and consequently set a torque value for motor 8 to close the control loop for that position (on the basis of the set or detected yarn tension). In this case, the drive means for motor 8 may be located in control unit 70 of compensator device 1 (to which a reference is passed by the feeder) or in the electronics 60 of feeder 2 (as described below). This solution is preferable because control electronics 60 of feeder 2 not only know the position of the arm, but also know directly the measured tension of the yarn (being connected to tension sensor 3) and can then use the two items of information to optimise the performance of the system. For example, if such electronics detect that the yarn tension is increasing due to a sudden request for yarn from textile machine T, they may decide to automatically change the position set point for arm 13, for example by moving it from "3 o'clock" to "6 o'clock". This is in accordance with the active-predictive operating mode of the assembly of motor 8 and arm 13 indicated above.

This function also allows for further reduction in the peak tension because use is made of not only the low inertia of motor 8 but also its dynamics to compensate for the situation. The same obviously applies to the stage of a sudden slowdown in take-up. All this may in fact be seen from Figure 11C and comparison with Figure 11B previously mentioned.

The electronics of the feeder system (i.e. control unit 70 of compensator device 1 or control electronics 60 of feeder 2, as described above), by continuing to read the position of arm 13 (depending on the tension detected in yarn F) and by suitably controlling the torque of the motor acting together with arm 13, are able to hold the position of compensating arm 13 at the desired value. This torque value will therefore allow arm 13 to be kept in equilibrium in its resting position, for example at 3 o'clock, by applying a force equal and contrary to the feed tension of the yarn to the arm, directly through the drive shaft. This is without any delay in the action on arm 13, as instead happens in the solution in WO 2013/064879.

Thus an increase or decrease in yarn tension will cause arm 13 to move from its balanced position, always keeping the yarn at the set working tension, as for example indicated below:

a) in the case where the set yarn tension needs to be increased during processing, arm 13 will obviously tend to fall (moving towards the "6 o'clock" position in Figure 7) and the system electronics (i.e. control unit 70 of device 1 or control electronics 60 of feeder 2) reading this change in position will calculate the new torque to be applied to motor 8 to bring arm 13 back to the resting position;

b) in the case where the set tension needs to be decreased during processing, arm 13 will obviously tend to rise (moving towards the "12 o'clock" position in Figure 8) and the control unit or the electronics of the feeder reading this change in position will calculate the new torque to be applied to motor 8 to bring arm 13 back to the resting position.

The feeder electronics will therefore be able to control the position of compensating arm 13, automatically and quickly, precisely because the arm is attached to the drive shaft, thus enabling the operator to modify the working tension at will during processing, for example, to make graduations in tension during the production cycle for a manufactured article (for example graduated compression on medical socks, etc.). Each change in tension involves a change in the motor torque applied to arm 13 that will always adopt the resting position (for example "3 o'clock") or will be brought back to it to keep constant the "present" tension of the yarn or the tension that the yarn takes up during the particular feed stage required for that particular production stage.

In other words, the feeder system is provided with a control unit (device 1 or feeder 2), incorporating for example a microprocessor, which controls operation of the motor that directly moves arm 13. However this arm, together with the drive shaft to which it is connected, can initially move freely about axis M (causing the motor to rotate) when the textile machine's take-up or feed conditions vary with consequent change in the tension of the yarn passing through annular body 16 supported by arm 13.

Any change in the position of arm 13 (with respect to

a predetermined reference or resting position, e.g. "3 o'clock") is detected by the control unit of the feeder system through signals coming from position detection means 19. These data are supplied to said electronic control unit (60, 70) for the feeder system to close the control loop.

Control unit 70 of device 1, in particular, is able to detect by how much (angularly) arm 13 has moved from the reference position and on the basis of this value control electronics 60 of feeder 2 can monitor, change and control the power supply to the motor of pulley 4 so that it changes its rotation speed to compensate for the angular movement of arm 13 with respect to the reference position. In this way feeder 2 makes use of information on the position of arm 13 to anticipate the change (acceleration/deceleration of pulley 4), further improving the quality of the delivery tension. This is in accordance with the "active-predictive" operating mode described above.

Also in this case, (as in the case of EP2262940) compensator device 1 therefore acts as a "balance" and the electronics of the feeder system will in real time calculate the torque to be applied to motor 8 that acts together with arm 13 to keep it always in balance in a wholly automatic way. This depends on the "present" tension of yarn F (obviously to maintain the predetermined tension).

Controlling the position of arm 13 in this way will also have a compensating effect on the delivery tension, which will lead to total elimination or drastic reduction in tension peaks and slackening of the yarn itself. In fact when textile machine T increases its demand for yarn F suddenly and the dynamics of the motor driving pulley 4

is insufficient to compensate for such change, arm 13 will tend to fall (moving towards the "6 o'clock" position) increasing the quantity of yarn F sent to machine T; this until the motor of pulley 4 reaches the
5 necessary rotation speed to eliminate or reduce the tension peak. At this point the arm will return to its initial or resting position automatically.

On the contrary, when the textile machine decreases its demand for yarn suddenly and the dynamics of the
10 motor driving pulley 4 is insufficient to compensate for such change, arm 13 will tend to rise (moving towards the "12 o'clock" position in Figure 8) decreasing the quantity of yarn F sent to machine T, until the motor of pulley 4 reaches the necessary rotation speed to
15 eliminate or reduce slackening of the yarn. At this point the arm will return to its initial or resting position automatically (Figure 6).

In its first embodiment the resting position of arm 13 lies within a range of movement of compensating means
20 or arm 13 which has two limiting positions (that is 6 o'clock and 12 o'clock).

Also, knowing the position of compensating arm 13 precisely and in real time the electronics of feeder 2 can use this information to accelerate or slow the
25 rotation of pulley 4 to minimize the time for settling into the new ideal speed to obtain a constant preset value of the tension of yarn F and maintain it, further limiting the amplitude of the tension peak or slackening in yarn F.

30 Also, knowing the position of compensating arm 13 and the value of the tension measured through sensor 3 precisely and in real time during transients (changes in take-up), the feeder system can change the drive of motor

8 that acts together with arm 13 to reduce the change in the delivery tension of feeder 2 even more; for example:

i) during the sudden acceleration stage, arm 13 will tend to fall (moving towards the "6 o'clock" compensation position in Figure 7) and the measured yarn tension will tend to rise; in this case the electronics of the feeder system may decide to:

1) interrupt closing of the loop controlling the position of arm 13 or reduce its effect so that the yarn can lower arm 13 until the yarn tension is within the predetermined limits, thus using this interval to move from 3 o'clock to 6 o'clock as a stock of yarn F to be fed;

2) automatically set a working set point for arm 13 to a lower position to provide more yarn F to textile machine T until the critical condition is overcome.

(ii) during the sudden deceleration stage, arm 13 will tend to rise (moving to the "12 o'clock" compensation position in Figure 8) and the measured tension will tend to fall; in this case the feeder system may decide to:

1) interrupt closing of the position control loop or reduce its effect so that arm 13 can recover yarn F until its tension lies within the predetermined limits, thus using the interval to move from 3 o'clock to 12 o'clock, acting to recover the excess fed yarn;

2) automatically set a working set point or resting position for arm 13 to a higher position to provide less yarn F to textile machine T until the critical condition is overcome.

The set point or reference value for the position control loop for compensating arm 13, hitherto considered for example to be the "3 o'clock" value (Figure 6), may instead be variable and suitably dynamically managed by

the feeder electronics in order (for example) to provide for a possible subsequent feeding stage; for example, during the stage in which the yarn is slowed down and then stopped by the textile machine the set point could
5 automatically pass to the 12 o'clock position so that there is a greater stock of yarn F to provide for the next acceleration on restarting, further reducing the next peak.

In a further embodiment of the invention (already
10 included in the figures), there is also associated with compensating arm 13 a drum or cylinder 26 on which yarn is deposited during the recovery stage, thus increasing the quantity of yarn F stored, because the amplitude of the angular rotation sector has increased, and in this
15 case will no longer be restricted to between 6 o'clock and 12 o'clock but will be able to rotate freely about axis of rotation M.

The drum where the yarn is deposited may be attached to arm 13 or free to rotate on bearings that make its
20 rotation independent. The diameter of the drum determines the maximum quantity of yarn F that can be recovered from the device 1 / feeder 2 system. This drum may therefore have different dimensions depending on the quantity of yarn F that is desired to be recovered on it. This drum
25 may be cylindrical, semicylindrical or have a shape with a variable cross-section.

The compensator device may work without mechanical stops preventing it from rotating beyond the 6 o'clock to 12 o'clock arc, allowing arm 13 to rotate without
30 restriction about the axis during the recovery stage. In this case arm 13 is free to deposit a much larger quantity of yarn stored during the recovery stage on drum 26, which will then be fed back to the textile machine at

the next restart.

This brings about a double "reservoir" of yarn, that is drum 26 in addition to pulley 4.

Thanks to the present invention a single "system" is
5 able to work at even very different feed tensions,
without the need for any action by the operator. This
system is able to compensate for sudden changes in feed
without giving rise to tension peaks or slackening of the
yarn, as well as, to a small extent, to recover greater
10 quantities of yarn F than in the solutions previously
described in the state of the art.

Various embodiments of the invention have been
described. Of course yet others are possible. For
example, the annular ceramic body on arm 13 may be
15 replaced by a body made of any other material having slip
characteristics appropriate to the application. In
addition, the text describes the use of a direct current
motor with brushes, but it is obvious that any type of
electric motor or actuator (brushless, stepper, etc.) and
20 also pneumatic could be used.

The use of an encoder with Hall sensors to detect
rotation of the drive shaft has been described, but any
encoder on the market may also be used or a Hall sensor
may be incorporated in the motor; in this case there is
25 no need to have the drive shaft projecting on both sides.

In addition, arm 13 is rigid, although it may have
its own minimal flexibility, so as to further cushion the
compensating effect, such flexibility deriving from the
material or cross-section with which the arm is made.
30 Furthermore, this compensating arm is described as
rotating, but it may be replaced by an arm that follows a
linear motion using a linear actuator or motor moving
longitudinally through positions equivalent to 6, 3 and

12 o'clock.

Finally, the existence of a control unit for device 1 acting together with the control electronics for feeder 2 has been described. Obviously this control unit may be
5 the one for feeder 2 (that is it may be part of its control electronics) and act automatically when body 11 of device 1 is attached to feeder 2, automatically recognising the presence of device 1 (the presence of body 11 being detected by suitable connectors, not shown,
10 through which the control unit acts together with the motor of device 1 and the encoder or position sensor means for the drive shaft associated with arm 13). This solution is shown in Figure 10C.

The invention applies to the feeding of textile
15 yarns, but also metal wires.

These variants are also to be regarded as being included within the scope of the invention as defined by the following claims.

CLAIMS

1. Method for feeding yarns or threads including metal wires to a textile machine (T) at a constant tension, or to a machine processing the metal wire, said feeding taking place discontinuously, that is with sequences of stages in which the yarn (F) moves with at least a first and at least a second condition of feeding or take-up by the machine which differ from each other, said conditions following each other in time, said feeding being performed by a yarn feeder device (2) having tension detection means (3), yarn accumulator means (4) driven by its own electric motor and control means (60) connected to such tension detection means (3) and accumulator means (4) and capable of acting on such accumulator means (4) on the basis of a tension value obtained from said tension detection means (3), provision being made for a compensator device (1) associated with said feeder device (2) acting together with the yarn (F) coming from said accumulator means (4) before acting together with said tension detection means (3), said compensator device (1) being able to compensate for changes in the feed or take-up conditions of the yarn (F) at the transition between each first and each second feed or take-up condition following upon the first, this enabling the control means (60) for the feeder device to act on the accumulator means (4) to alter its action on the yarn and maintain the value of the tension detected by the tension detection means (3) constant over time and equal to a set value, said constant tension also being maintained during the stage of changing the feed conditions thanks to the interaction between said yarn and said compensator device (1), the compensator device (1) including movable compensating means (13) supporting

a body (16) capable of acting together with the yarn (F) at one free end, said movable compensating means being able to move from a predetermined resting position in the feed direction of yarn (F) when the yarn passes from a condition of lesser take-up to a condition of greater
5 take-up, but moving in the opposite direction when the yarn (F) passes from a condition of greater take-up to a condition of lesser take-up, said compensating means (13) returning to the resting position at the end of such
10 change in take-up, characterised in that provision is made to control the movement of said compensating means (13) through its own corresponding electric motor (8) directly and rigidly attached to said compensating means (13) and capable of directly controlling the movement of
15 said arm, the compensating arm (13) being controlled according to the set or detected tension of the yarn (F) and the position measured during each stage in which it is fed to the textile machine, said compensating means (13) being rigid.

20 2. Method according to claim 1, characterised in that the compensating means (13) and its electric motor (8) that controls it directly and strictly in movement operate in a passive-dynamic mode, said compensating means (13) being able to move freely, together with the
25 motor, under the force of the yarn (F) but being brought back to the resting position after such movement by the electric motor (8), said motor (8) generating a torque capable of maintaining said compensating means for yarn (F) in the resting position as yarn is fed to the textile
30 machine.

3. Method according to claim 1, characterised in that the compensating means (13) and the relative electric motor (8) which controls it in motion operate in an active-

predictive mode, said motor (8) moving the compensating means (13) from the resting position to a compensating position corresponding to change in the tension of yarn (F) as soon as such change is detected.

5 4. Method according to claim 1, characterised in that it provides for continuous control of the electric motor (8) of the compensator device by a control unit (60, 70) connected directly or indirectly to the tension detection means (3).

10 5. Method according to claim 1, characterised in that provision is alternatively made for said compensating means (13) to rotate about a fixed axis (M) of a drive shaft leaving the electric motor to which said compensating means is rigidly attached, or moves along
15 the compensator device (1).

 6. Method according to claim 1, characterised in that provision is made for a further accumulation of yarn (F) on the compensator device (1) in addition to the accumulation of yarn on the accumulator means (4) of the
20 feeder device (2).

 7. Method according to claims 1 and 5, characterised in that movement of the compensating means (13) is alternatively angularly limited or unlimited.

 8. System for feeding yarn, including metal wires or
25 threads, at constant tension to a textile machine (T) or to a metal wire processing machine, said feeding being performed discontinuously or with sequences of stages in which the yarn (F) moves with at least a first and at least a second condition of feeding or take-up by the
30 machine which differ from each other, said conditions following one another in time, said feeding system operating according to the method in claim 1 and including a feeder device (2) for the yarn having tension

detection means (3), yarn accumulator means (4) driven by its own electric motor and control means (60) connected to such tension detection means (3) and accumulator means (4) and capable of acting on said accumulator yarn (4) on the basis of a tension obtained from such tension detection means (3), provision being made for a compensator device (1) associated with said feeder device (2) acting together with the yarn (F) leaving said accumulator means (4) before it acts together with said tension detection means (3), said compensator device being able to compensate for changes in the feeding or take-up conditions for the yarn (F) at the transition between each first and each second feeding or take-up condition consecutive upon the first, this enabling the control means (60) for the feeder device to act on the accumulator means (4) to alter their action on the yarn and maintain the value of the tension detected by the tension detection means (3) constant over time and equal to a set value, said constant tension being maintained even during the stages of changes in the feeding conditions thanks to the interaction between said yarn and said compensator device (1), the compensator device (1) including movable compensating means (13) capable of moving from a predetermined resting position in the feed direction for the yarn (F) when the yarn passes from a condition of lesser take-up by the machine to a condition of greater take-up, but moving in the opposite direction when the yarn (F) passes from a condition of greater take-up to a condition of lesser take-up, said compensating means (13) returning to the resting position at the end of this change in take-up, characterised in that said compensating means (13) is a rigid arm carrying a terminal body (16) able to act together with the yarn

(F), said rigid arm (13) being directly and rigidly connected to its own electric motor (8) which directly controls it in movement according to the set or detected tension in the yarn (F), said rigid arm being located
5 between said yarn accumulator means (4) and said tension detection means (3), but being separate from the latter.

9. System according to claim 8, characterised in that alternatively the resting position of the compensating means (13) lies within a range of movement of such
10 compensating means having two limiting positions or is defined within a circular path of such means about an axis (M), said path not being restricted angularly.

10. System according to claim 8, characterised in that position detector means (19) are provided to
15 determine the spatial position of the rigid arm (13), said position detector means (19) being associated with the drive shaft of said electric motor also rigidly carrying said rigid arm.

11. System according to claim 10, characterised in
20 that provision is made for a control unit (60, 70) for the electric motor (8) of the compensator device (1) connected to the position detector means (19) and capable of detecting movement of the compensating means (13) from the predetermined resting position through said position
25 detector means (19) and of returning said compensating means (13) to the predetermined resting position through control of the electric motor to which the compensating means (13) is rigidly and directly attached, said control unit (60, 70) being directly or indirectly connected to
30 the yarn tension detection means (3), said control unit controlling the electric motor on the basis of the tension in the yarn (F) detected while said yarn (F) is fed to the machine.

12. System according to claim 11, characterised in that said control unit (60, 70) is alternatively associated with the compensator device (1) and connected to the control means of the feeder device (2) or said control unit is part of the control means for the feeder device (2).

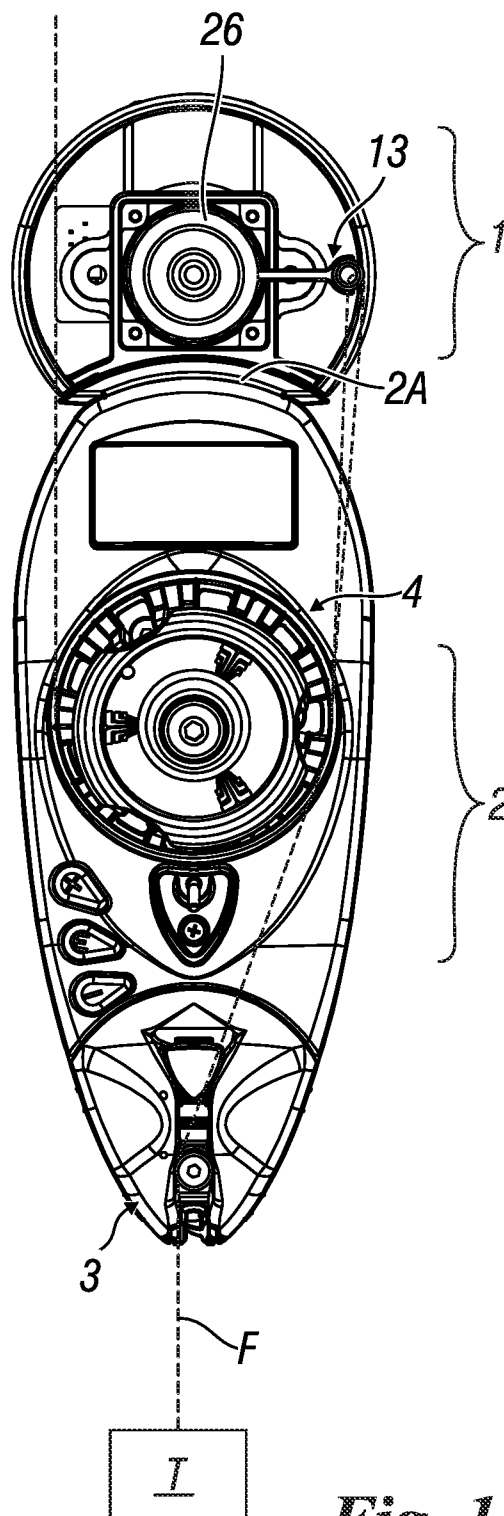
13. System according to claim 8, characterised in that said compensator device (1) is a component independent of the feeder device (2), said compensator device (1) being removably attached to the feeder device (2) and being located at one end (2A) or on one side of said feeder device, said compensator device (1) being fully automatic with respect to said feeder device (2) but being intimately connected to said feeder device when it is connected to it.

14. System according to claim 8, characterised in that the compensator device (1) has means (26) rotating about its own axis and capable of receiving, when wound, the yarn (F) in at least one of said machine feeding or take-up conditions.

15. Compensator device suitable for use with a feeder device (2) for yarns including metal wires or threads (F), at a constant tension to a textile machine (T) or to a wire processing machine, said feeder device (2) including tension detection means (3) for said yarn (F), and accumulator means (4) for said yarn, said machine operating discontinuously, said compensator device (1) and said feeder device (2) defining a feeding system according to claim 8 operating according to the method in claim 1, said compensator device (1) having movable compensating means (13) capable of acting together with said yarn (F) before it leaves said feeder device (2), characterised in that said compensating means (13) is

defined by a rigid arm rigidly associated with means for actuating its movement, said rigid arm acting together movably with the yarn (F) and being located between said accumulator means (4) and said tension detection means (3) for the feeder device (2), said tension detection means (3) being separate from said rigid arm (13) and in that the accumulator means (4) for the yarn, the rigid arm being able to move from a predetermined resting position in the feed direction of the yarn (F) when the yarn passes from a condition of lesser take-up by the machine to a condition of greater take-up, but moving in the opposite direction when the yarn (F) passes from a condition of greater take-up to a condition of lesser take-up, provision being made for position detector means (19) capable of detecting movement from said resting position, said position detector means (19) being connected to a control unit capable of directly or indirectly detecting the tension in the yarn (F) and to control said actuator means on the basis of the set or detected tension to return said rigid arm to the resting position after the movement therefrom.

16. Compensator device according to claim 15, characterised in that it comprises a rotating means (26) capable of receiving the yarn upon it when the machine is stopped or when in the stage of returning the yarn to the feeding process.

*Fig. 1*

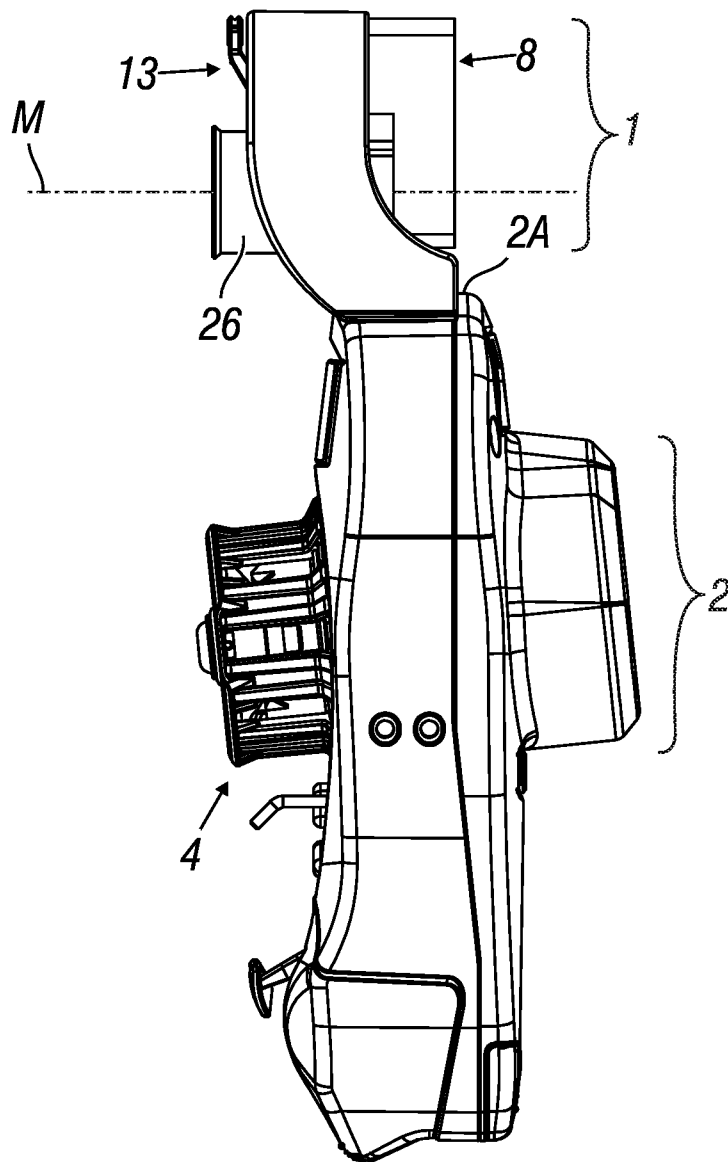


Fig. 2

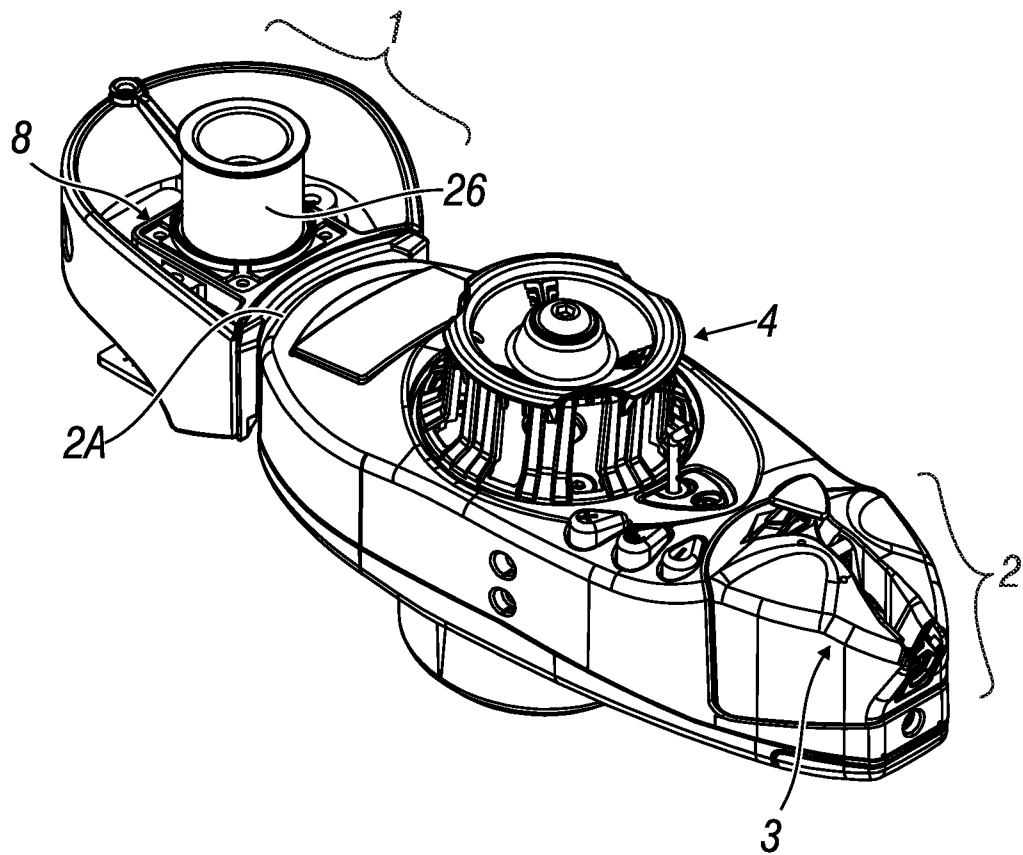
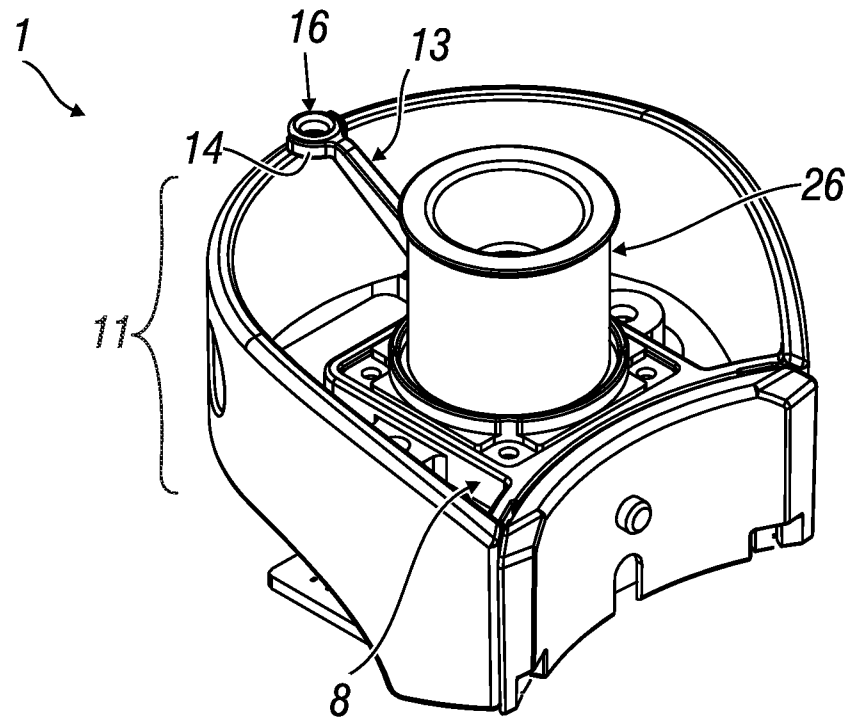
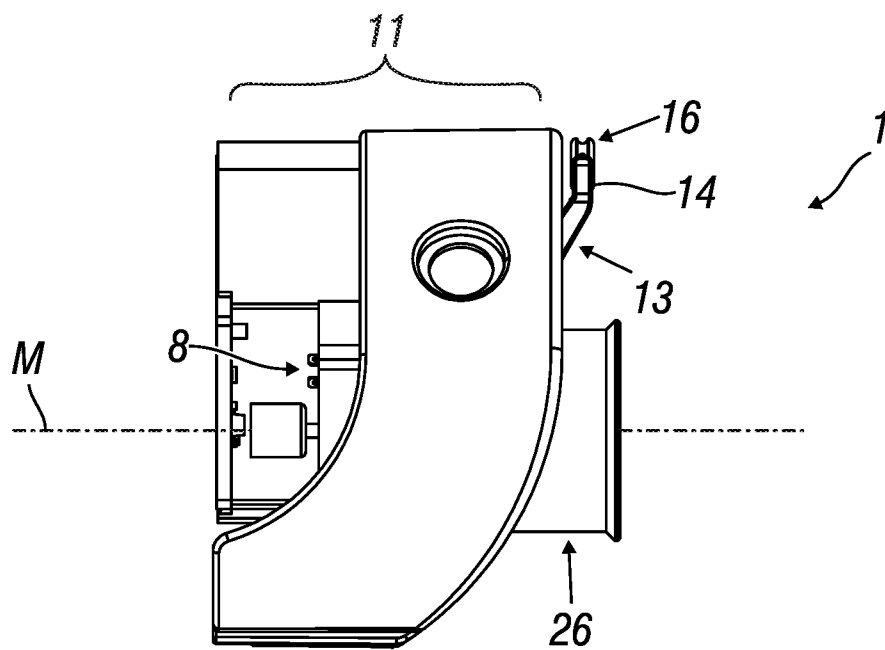


Fig. 3

*Fig. 4**Fig. 5*

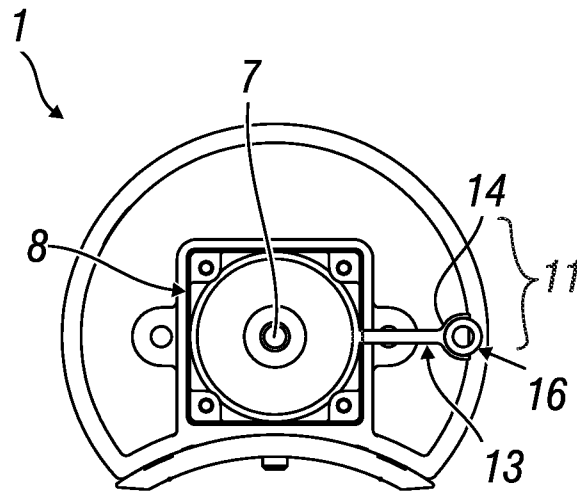


Fig. 6

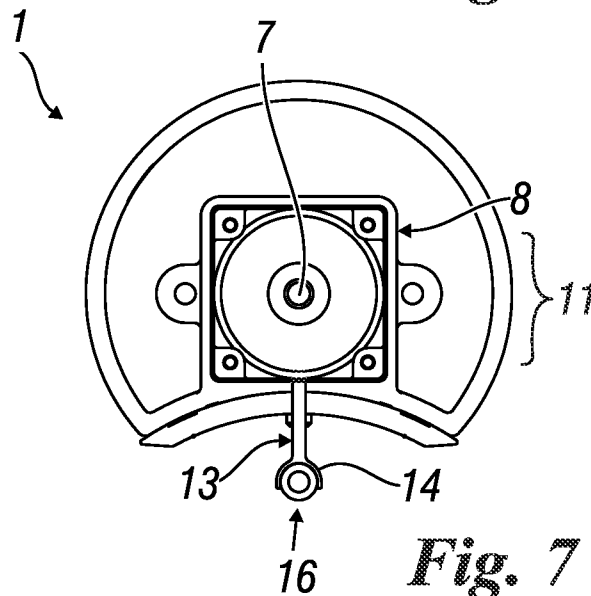


Fig. 7

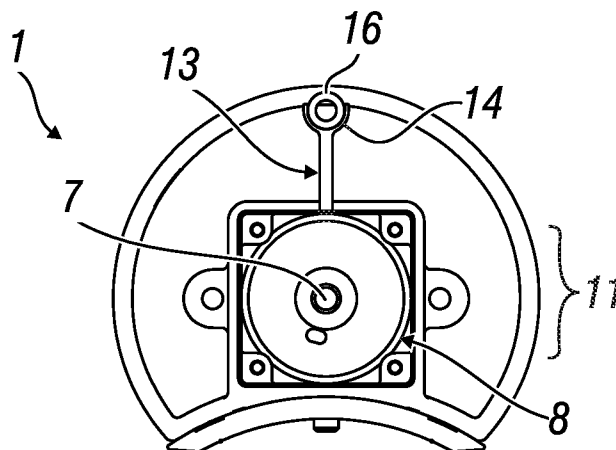


Fig. 8

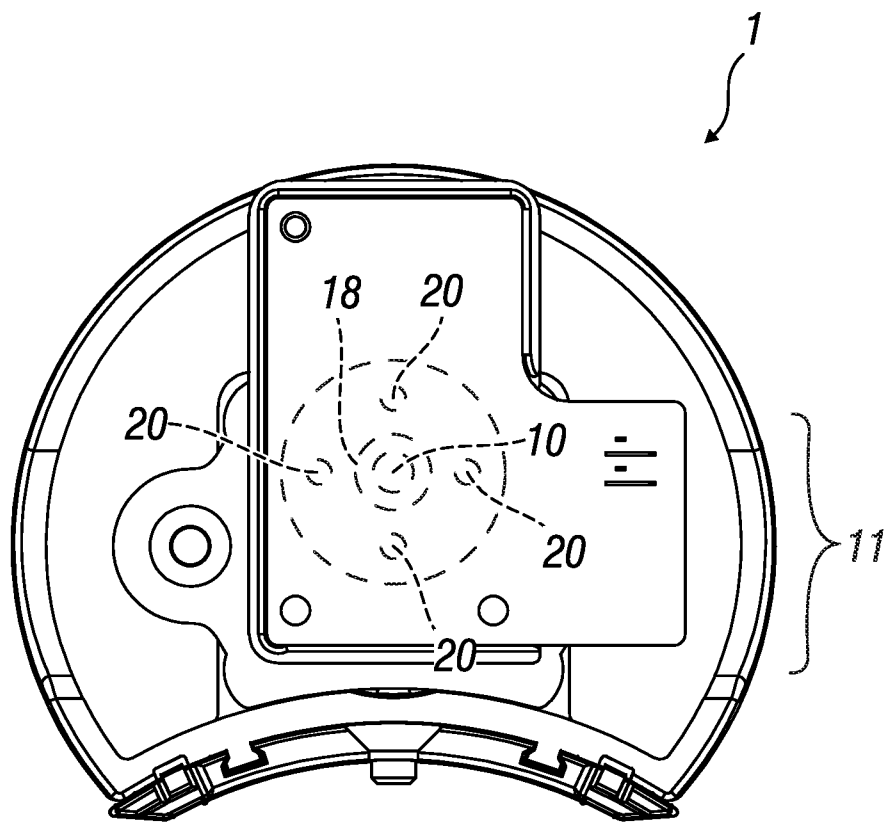
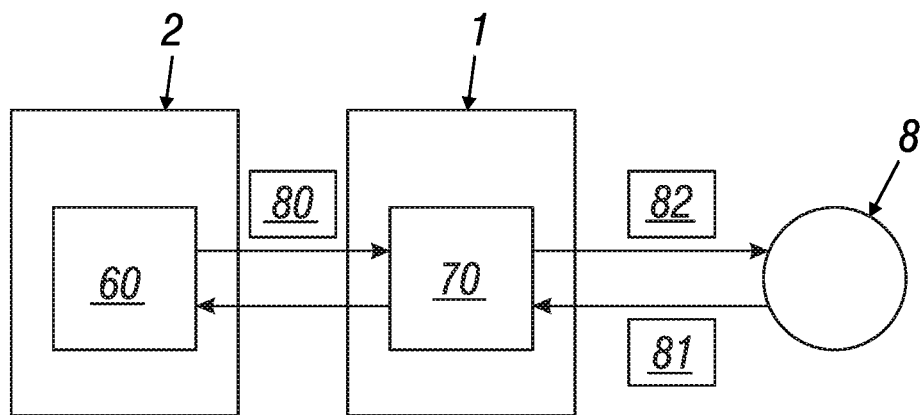
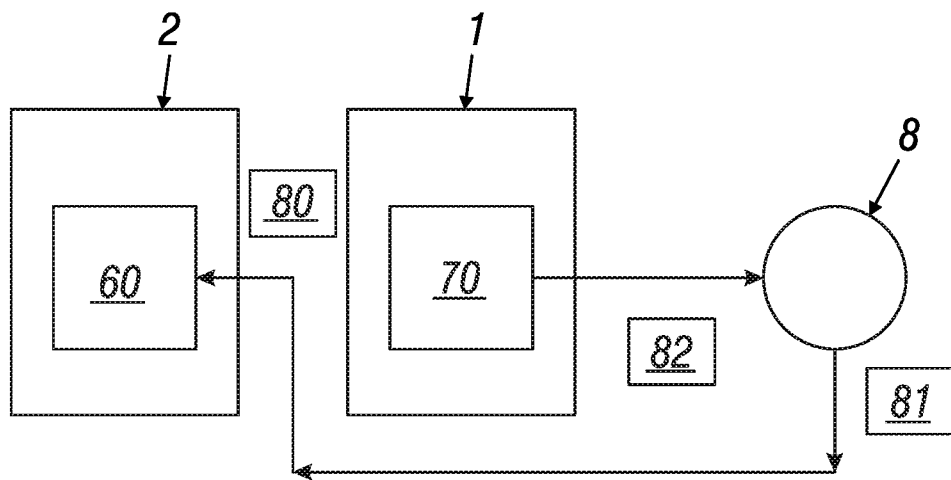
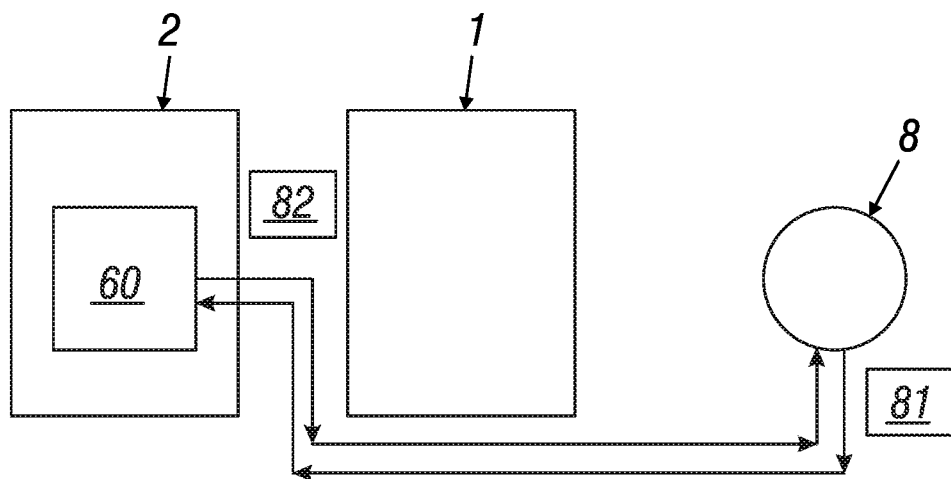


Fig. 9

*Fig. 10A**Fig. 10B**Fig. 10C*

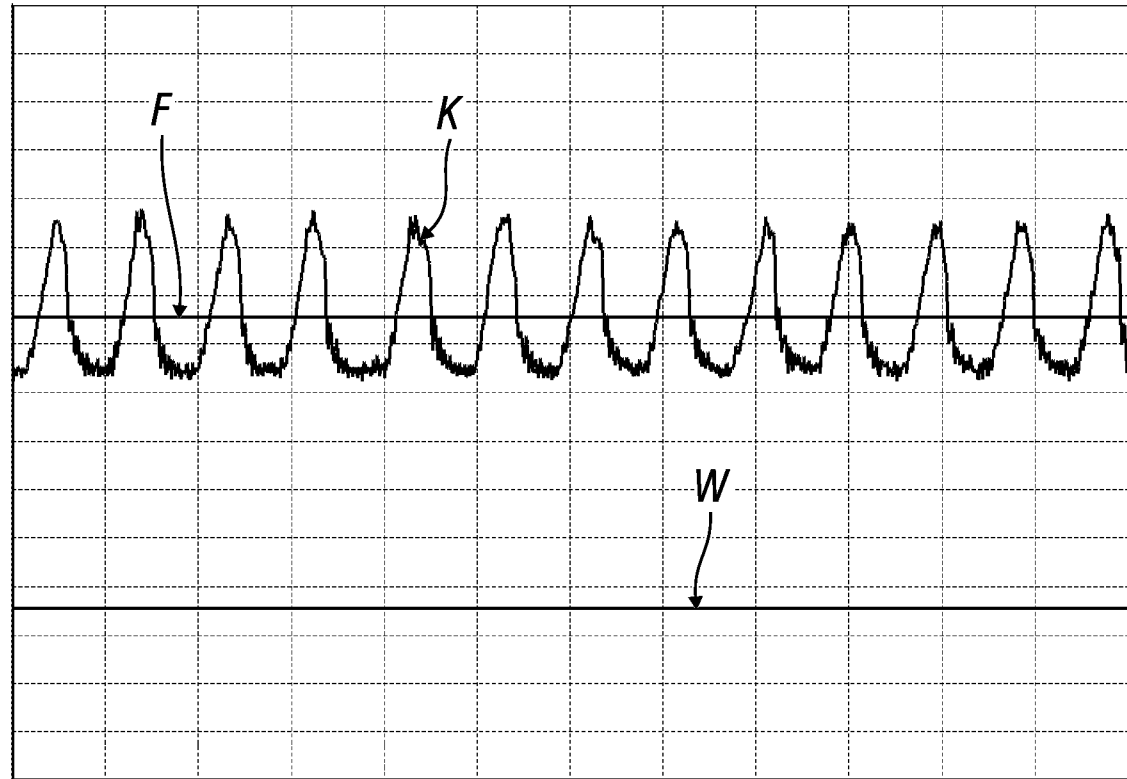


Fig. 11A

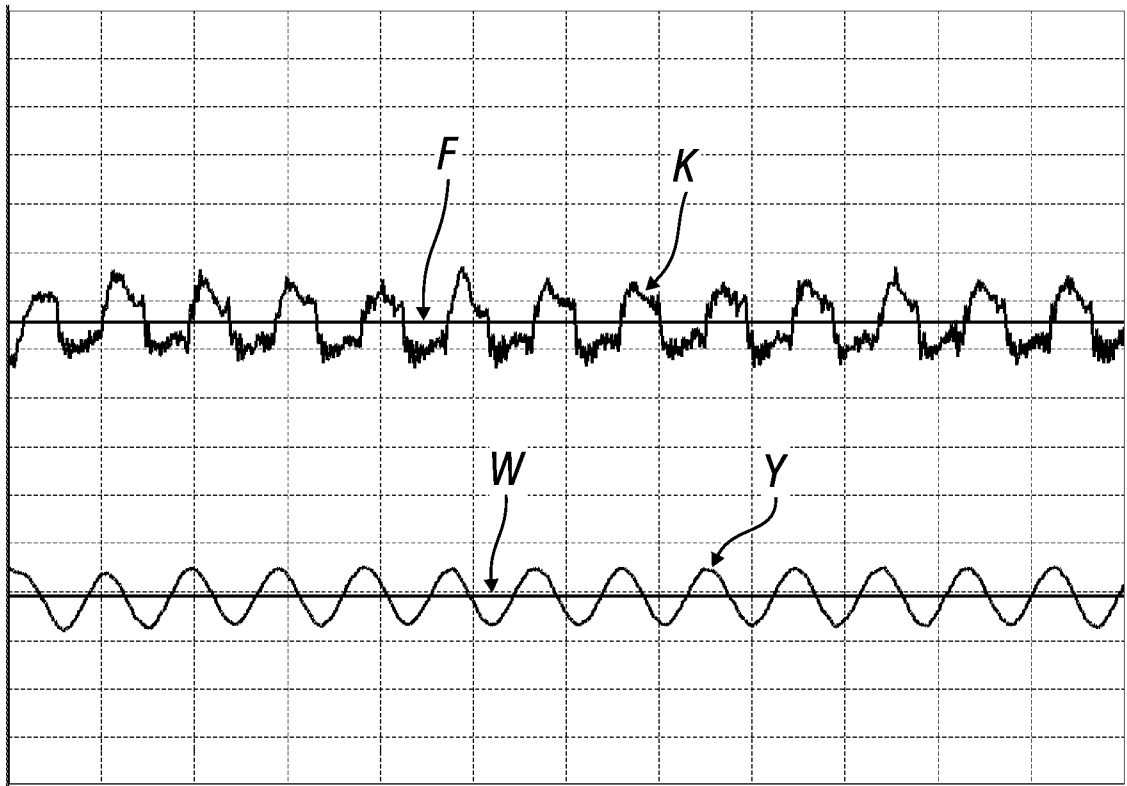


Fig. 11B

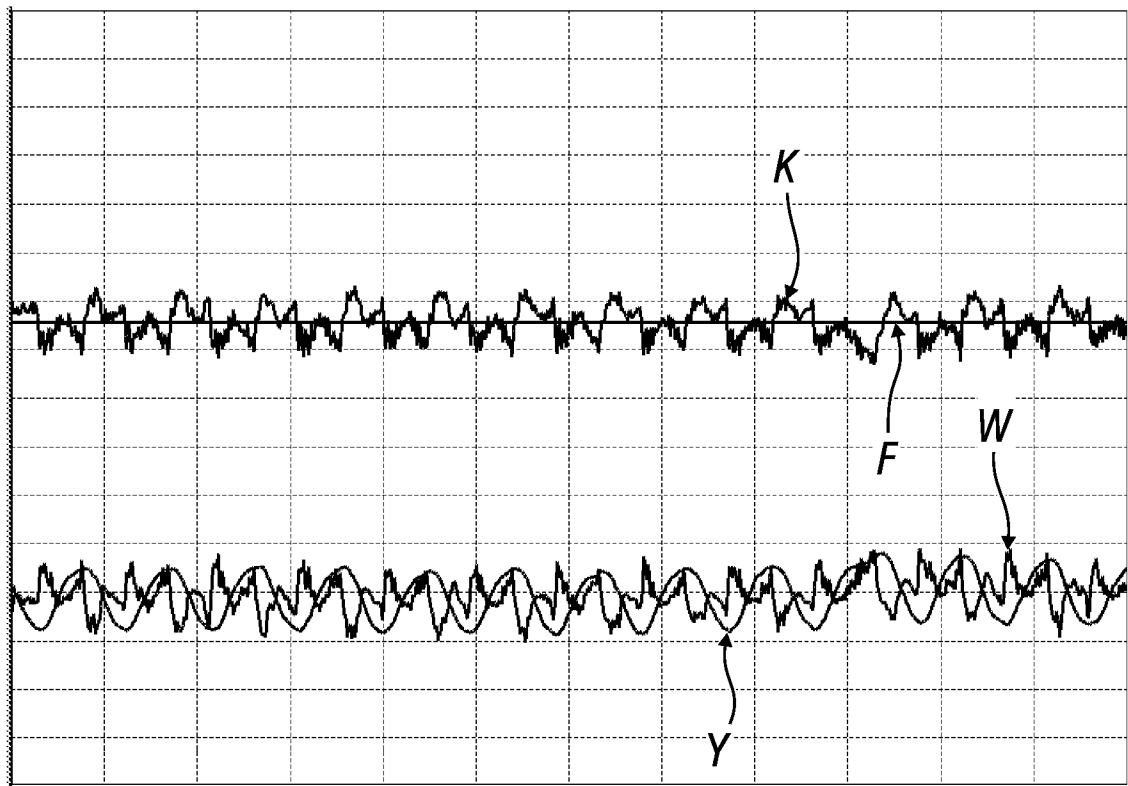


Fig. 11C

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2019/050874

A. CLASSIFICATION OF SUBJECT MATTER

INV. B65H51/20 B65H51/22 B65H59/36 B65H59/38 D04B15/48
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B65H D04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 752 044 A (MEMMINGER GUSTAV [DE] ET AL) 21 June 1988 (1988-06-21) cited in the application figures 3,4,15	15,16
A	----- WO 2013/064879 A1 (BTSR INT SPA [IT]) 10 May 2013 (2013-05-10) cited in the application pages 6,7,11; figures 1-4	1-14
A	----- EP 2 262 940 A1 (BTSR INT SPA [IT]) 22 December 2010 (2010-12-22) cited in the application claim 1; figure 1	1-14
A	----- WO 2014/199281 A1 (BTSR INT SPA [IT]) 18 December 2014 (2014-12-18) figures 1-5	1-14
	----- -/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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INTERNATIONAL SEARCH REPORT

International application No
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