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(54) **DEVICE AND METHOD FOR SENSING A TENSION IN A THREAD, AND METHOD FOR MOUNTING A SENSOR UNIT**

(57) The invention relates to a sensor device and a method for sensing a tension in a weft thread (1) between a weft presenter (4) and a gripper (6) on a gripper weaving machine (100), the sensor device (10) comprising a sensor unit (20) with a contact area (21), which sensor unit (20) is adapted to generate a response signal in response to a force applied by the weft thread (1) at the contact area (21), and a mounting arrangement (22) adapted for mounting the sensor unit (20) to the weaving machine (100) in a region between the weft presenter (4) and a shed (5), wherein the mounting arrangement (22) comprises an elastic damping element (25) adapted for isolating the sensor unit (20) mounted to the weaving machine (100) from vibrations of the weaving machine (100). The invention further relates to a weaving machine with a sensor unit for sensing a tension in a weft thread, and to a method for mounting a sensor unit to a weaving machine.

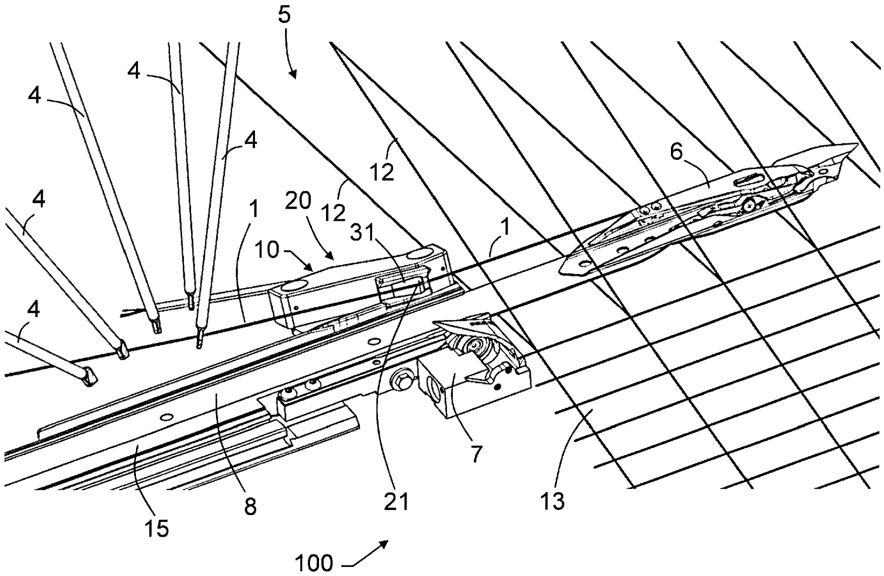

Fig. 1

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Description

TECHNICAL FIELD AND PRIOR ART

[0001] The invention relates to a sensor device and a method for sensing a tension in a weft thread on a weaving machine, to a weaving machine with a sensor unit for sensing a tension in a weft thread, and to a method for mounting a sensor unit to a weaving machine.

[0002] From US 5,050,648 a thread brake is known for braking an inserted weft thread between the weft thread feeding device and the shed. Further, US 5,050,648 shows a tension sensor for sensing the actual tension of the weft thread during a weaving cycle, which actual tension is variable during the weaving cycle. An actuator of the thread brake can be controlled by a control unit dependent on the measured actual tension in the weft thread, so that the tension in the weft thread can vary according to a reference course during a current weaving cycle or during a subsequent weaving cycle, which reference course can be preset in the control unit.

[0003] A sensor for sensing the tension of a weft thread near the shed is also known from US 5,725,029 and US 6,112,776. The weft thread tension can be sensed by the sensor during the entire weaving cycle or over a particular zone of the weaving cycle. A single thread sensor for all weft threads to be inserted can be arranged near the shed, so that the weft thread can be brought into contact with the sensor during the insertion of the weft thread. Further, it is known that the weft thread deflects at the sensor, so that the path of the weft thread forms a deflection angle about the sensor. The sensor is arranged such that the path of the weft thread has only a small deflection angle about the sensor, so that the sensor does not disturb the running of the weft thread during a weaving cycle. Because each different weft thread is presented by an associated weft presenter, this deflection angle will be different for each weft thread. For each weft thread this deflection angle can be stored in a control unit. The actual tension in the weft thread can be calculated by a control unit from the measured signal of the sensor, the deflection angle that the weft thread forms about the sensor and possibly the type of the inserted weft thread. The sensitivity of the sensor can also be set based on the inserted weft thread or in case two weft threads are inserted simultaneously based on the two inserted weft threads. An unexpected absence of a signal of the sensor can be evaluated as a weft thread break.

SUMMARY OF THE INVENTION

[0004] It is the object of the invention to provide a device and a method for sensing a tension in a thread on a weaving machine using a sensor unit. It is another object of the invention to provide a weaving machine with a sensor unit for sensing a tension in a thread. It is a further object of the invention to provide a method for mounting a sensor unit to a weaving machine.

[0005] These objects are solved by the device and the method with the features of claims 1, 11, 12 and 15. Preferred embodiments are defined in the dependent claims.

[0006] According to a first aspect, a sensor device for sensing a tension in a weft thread between a weft presenter and a gripper on a gripper weaving machine, is provided, wherein the sensor device comprises a sensor unit and a mounting arrangement, which sensor unit has a contact area and is adapted to generate a response signal in response to a force applied by the weft thread at the contact area, and which mounting arrangement is adapted for mounting the sensor unit to the weaving machine in a region between the weft presenter and a shed, wherein the mounting arrangement comprises an elastic damping element adapted for isolating the sensor unit mounted to the weaving machine from vibrations of the weaving machine.

[0007] Throughout this application and the claims the indefinite article "a" or "an" means "one or more". Reference to "a first element" does not mandate presence of "a second element". Further, the expressions "first" and "second" are only used to distinguish one element from another element and not to indicate any order of the elements.

[0008] A force applied at the contact area by the weft thread, depends on the tension in the weft thread. Hence, the response signal can be correlated to a tension in the weft thread. In one embodiment, the response signal provided by the sensor unit is used for controlling an additional device acting on said weft thread. In one embodiment, a tension in a weft thread is sensed, wherein the response signal is used for controlling a weft thread brake acting on the weft thread. In one embodiment, the response signal is evaluated in amount and a sensed tension of the weft thread is displayed at a monitor and/or is used in a control unit. In other embodiments, the response signal is not evaluated in amount, but is only compared to predefined threshold levels, wherein such derived information is used in a control unit and/or is displayed at a monitor.

[0009] Due to a vibration of the weaving machine, a noise level of prior art devices for sensing a tension in a weft thread, which are mounted to a weaving machine, is high. Depending on a type of sensor unit and a tension in the weft thread, a value of a signal in response to a force applied by the weft thread may be in the same order of magnitude as the noise on the signal due to vibrations of the weaving machine.

[0010] Providing a mounting arrangement that comprises one or more elastic damping elements allows isolating the sensor unit from vibrations of the weaving machine, thus reducing a noise on the signal due to vibrations of the weaving machine. This allows sensing even low tensions in a weft thread or low tension variations in a weft thread. In the context of the application, an elastic damping element is defined as a damping element having the ability to resume its normal shape after being stretched or compressed.

[0011] It will be understood, that the expression "vibration isolation" in the context of the application is used to describe a reduction of a transmissibility of a vibration from the weaving machine to the sensor unit at a selected excitation frequency, wherein in particular the selected excitation frequency or several selected excitation frequencies are frequencies generated by the movement of the weaving machine. Depending on a structural design of the elastic damping element, also referred to as simply damping element, the vibration transmissibility is only slightly attenuated or in other cases almost fully avoided. A type of damping element and its structural design can be suitably chosen in order to allow a sufficient attenuation of the transmissibility of the vibration, wherein in particular a damping element having a low stiffness and high damping coefficient is provided for reducing a natural or resonant frequency of the vibration system including the sensor unit and the damping element, and allowing a high attenuation of the transmissibility of high frequency vibrations, e.g. vibrations generated by the weft thread having a frequency that is substantially higher than frequencies generated by the movement of the weaving machine. Further, a weight of the sensor unit influences a natural frequency of the vibration system and, thus, a vibration isolation, wherein in one embodiment for reducing a transmissibility of vibration, an additional mass is added to the sensor unit.

[0012] In one embodiment, rubber elements such as rubber pads are used as elastic damping elements, in other embodiments synthetic pads having properties similar as rubber pads are used.

[0013] An elastic damping element having a low stiffness, thus allowing a large movement caused by vibration forces, allows isolating the sensor unit from vibrations of the weaving machine, thus reducing a noise on the signal of the sensing unit due to vibrations of the weaving machine, while the response signal, i.e. the signal generated by the sensor in response to a change in the force applied by the weft thread on the sensor, may be significant.

[0014] The response signal can be sent or otherwise communicated to a control unit. It will be further understood that the sensor unit in embodiments of the invention comprises an electric circuit, which may comprise amplifiers and/or filters for processing the response signal and improving the quality of the response signal before sending it to the control unit and/or for reducing the amount of data to be communicated.

[0015] The sensor device, or in short referred to as the device, according to the invention can be used in a gripper weaving machine and is adapted and/or configured to sense or measure a tension in a weft thread presented by a weft presenter and transported through a shed by a gripper. As generally known, gripper weaving machines typically comprise two grippers for a transport of weft threads through the shed, referred to for example as drawing gripper and taker gripper, wherein the drawing gripper is designed to transport a weft thread through the first half of a shed, and the taker gripper is designed to transport a weft thread through the second half of the shed after having picked up the weft thread from the drawing gripper. A weft thread is presented to the drawing gripper using a weft presenter. Typically, a weaving machine comprises eight weft presenters to which weft threads from different sources are threaded. However, weaving machines with more or less than eight weft presenters are conceivable.

[0016] For measuring a tension in a weft thread on a gripper weaving machine, the sensor device is arranged between the weft presenters and the shed in a weft insertion direction, also referred to as simply insertion direction. The sensor device is arranged next to the shed such that a weft thread presented by the weft presenter and gripped by the gripper, or more particular gripped by one of the grippers, contacts the contact area of the sensor unit in a section extending between the weft presenter and the gripper, wherein the contact area protrudes into an imaginary path between the weft presenter and the gripper, such that the weft thread is deflected at the contact area. In order to reduce a tension in the weft thread caused by the sensor device, the sensor device is in embodiments arranged such that an angle formed between a section of the weft thread upstream of the contact area and a section of the weft thread downstream of the contact area, referred to as deflection angle, is close to 180°, in particular between 160° and 178°. The sensor device according to the invention deflects the weft thread only over a small deflection angle so that almost no extra tension in the weft thread is caused by the sensor device. Further the sensor device also acts as last guiding point for the weft thread when the weft thread is transported through the shed by a gripper, so that no additional guide is necessary.

[0017] In embodiments, the sensor unit comprises a displaceable mounted sensing element having a contact area, wherein the contact area protrudes into an imaginary path between the weft presenter and the gripper, such that the sensing element will be displaced due to forces applied by the weft thread at the contact area. In other embodiments, the sensor unit comprises a bendable sensing blade extending in a blade direction, which sensing blade is clamped at a proximal end, wherein the contact area is provided at a distal end of the sensing blade. The sensing blade in one embodiment is supported between the distal end and the proximal end by a deflector element, for example a roll or a rib, and has strain gauges provided at the sensing blade near the deflector element, for example at a side surface of the sensing blade facing away from the deflector element. When applying a force at the distal end of the sensing blade, the sensing blade is bent about the deflector element, wherein at least for a bending angle of less than 5° the distal end is displaced approximately in a direction perpendicular to the blade direction. An axis of the damping element in embodiments of the invention is arranged in parallel to the bending axis of the sensing blade.

[0018] In embodiments of the sensor device, the bendable sensing blade is wear resistant at the contact area. In particular, in one embodiment a wear resistant ceramic sensing blade is provided. In another embodiment the sensing blade is provided with a wear resistant part at the contact area, more particular a ceramic part. In another embodiment of the device, a roller is provided at the contact area, in particular a roller having a high wear resistance, more particular a ceramic roller. By providing a roller, forces applied by the device on the weft threads can be kept low. By providing a contact area having a high wear resistance, wear and tear of the sensor unit is reduced.

[0019] For sensing a tension in a weft thread, the sensor device is adapted to be mounted to the weaving machine such that the sensing blade is arranged perpendicular to a weft insertion plane, i.e. an at least approximately horizontal plane in which the weft insertion direction lies, wherein the sensing blade direction forms an obtuse angle with a section of the weft thread downstream of the contact area, which extends in the weft insertion direction, and the blade direction forms an acute angle with a section of the weft thread upstream of the contact area coming from the weft presenter.

[0020] In an embodiment, the mounting arrangement comprises a support adapted for being mounted to the weaving machine, wherein the sensor unit is mounted to the support via the damping element. The support in one embodiment is mounted to the weaving machine, in particular to a frame of the weaving machine, using bolts or other fixation elements allowing for a rigid and precise mounting of the support.

[0021] In an embodiment, the support comprises an elongated main body extending in a first direction, wherein the sensor unit is mounted to the support such that the blade direction forms an acute angle with the first direction. In use, in particular for sensing a tension in a weft thread, the support can be mounted to the weaving machine, such that the first direction is parallel to the weft insertion direction. This allows for a precise and easy alignment of the sensor device and the weaving machine.

[0022] In an embodiment, the support comprises a first lug and/or a second lug protruding from the main body perpendicular to the first direction, wherein the sensor unit is mounted to the lug or to the lugs via an associated damping element. In one embodiment the first lug and the second lug differ in length. The length of the lugs is adapted to the basic form of the sensor unit such that the sensor unit can be mounted to the support with the blade direction forming a desired acute angle with the first direction. This design allows for an easy mounting of the sensor device to a weaving machine, wherein the sensing blade is arranged with a desired orientation.

[0023] In an embodiment, the mounting arrangement further comprises a guide plate, wherein the guide plate is attached to a rear end of the support and extends in the first direction. The guide plate is thus adapted for guiding a weft thread presented by a weft presenter and gripped by the gripper towards the contact area of the sensor unit.

[0024] In alternative or in addition, in an embodiment the mounting arrangement comprises a cover element having a window, wherein the cover element at least partly covers a first side of the sensor unit provided with the contact area and wherein the contact area protrudes through the window. The cover element shields the sensor unit against dust. The cover element in embodiments is formed as a housing covering two or more sides of the sensor unit. The cover element in one embodiment is rigidly connected to the support, wherein the cover element is moved with respect to the sensor unit for vibration isolation. In other embodiments, the cover element is connected to the sensor unit, wherein a mass of the cover element increases a total mass of the vibration system. In alternative or in addition to the cover element, in embodiments, an air pressure cleaning nozzle is provided to remove dust from the sensor unit, wherein in embodiments the cleaning nozzle is operated to blow only on the sensor unit when no weft thread is in contact with the contact area of the sensor unit in order to avoid any influence on the sensing.

[0025] The mounting arrangement in embodiments further comprises a window element surrounding the window of the cover element, wherein the window element is provided with two ridges extending at an upper side and a lower side of the contact area protruding through the window. In use, the ridges extend at least essentially in parallel to the weft insertion plane. The window element in one embodiment is formed integrally with the cover element. In other embodiments, the window element and the cover element are formed as separate elements. In use, the weft thread extends between the two ridges and contacts the contact area between the two ridges, wherein the ridges extend at least essentially parallel to an axial direction of the weft thread. The ridges limit a movement of a weft thread contacting the contact area transverse to a nominal movement direction. In use, the sensor device can be arranged such that in normal operation the weft thread will not contact the ridges, and only contacts the sensor device at the contact area.

[0026] In one embodiment, a control unit is provided, which control unit is adapted for evaluating the response signal in consideration of information about a position of a gripper transporting the weft thread through a shed and/or about a weft presenter used for presenting the weft thread. As described above, the device is adapted for sensing or measuring a tension in a weft thread presented by a weft presenter and transported through the shed by a gripper, more particular a pair of grippers, wherein said weft thread contacts the contact area of the sensor unit in a section extending between the weft presenter and the gripper. A weaving machine typically comprises several weft presenters, wherein a position at which a weft thread is presented and guided by the weft presenter differs for different weft presenters. A deflection angle of the weft thread depends inter alia on the weft presenter presenting the weft thread and the position of the gripper transporting said weft thread, wherein the deflection angle influences a tension in the weft thread. When considering information about the position of the gripper transporting the weft thread through the shed and/or the weft presenter used for presenting the weft thread, a response signal can be adapted to an expected deflection angle of the presented weft thread at the contact area.

[0027] In one embodiment, the control unit is adapted for comparing the response signal with a desired tension, wherein the desired tension varies with the angular position of the weaving machine in the weaving cycle. Data representing the desired tension can be stored in a memory of the control unit.

[0028] In one embodiment, for a calibration of the sensor device, an additional tension sensor is added to the weaving machine, for example a tension sensor as described in US 5,050,648, wherein a response signal of the sensor device according to the invention is compared to a measurement signal of the additional tension sensor for calibrating the response signal. In use, a weft thread, may not permanently contact the sensor device, hence, using said sensor device it is not possible to determine a tension in the weft thread for each angular position. In one embodiment, in case the weft thread does not contact the sensor device, the tension in said weft thread is estimated based on the response signal previously generated and a tension measured by the additional tension sensor during calibration.

[0029] Based on stored information that was obtained through measurements with a sensor device not according to the invention that continuously measures the tension, such as a tension sensor as described in US 5,050,648, it is possible to determine a value of the weft tension in a zone where the sensor device according to the invention does not come into contact with the weft thread. In one embodiment first values at an angular position within the weaving cycle in which the weft thread contacts the sensor device according to the invention are determined based on the signal of the sensor device according to the invention, and second values at an angular position within the weaving cycle before the weft thread contacts the sensor device according to the invention are estimated based on these first values and an associated course of the weft thread tension measured in test facilities, using for example a tension sensor as described in US 5,050,648, wherein the course of the weft thread tension or selected values thereof is/are stored in the memory of the control device of the sensor device according to the invention. For example if at 60° the measured value of the tension is X1, then it is possible to estimate that at 30° the value of the tension will be Y1, whereas if at 60° the measured value of the tension is X2, then it is possible to estimate that at 30° the value of the tension will be Y2.

[0030] According to a second aspect, a method for sensing a tension in a weft thread between a weft presenter and a gripper on a gripper weaving machine is provided, wherein a sensor unit with a contact area generates a response signal in response to a force applied by the weft thread at the contact area, and wherein the response signal is evaluated in consideration of information about a position of a gripper transporting the weft thread through a shed and/or a position of a weft presenter used for presenting the weft thread.

[0031] According to a third aspect, a weaving machine comprising the sensor device for sensing a tension in a weft thread is provided. The sensor device in one embodiment is mounted to a frame of the weaving machine in a region between a weft presenter and a shed for sensing a tension in the weft thread between the weft presenter and a gripper of the gripper weaving machine.

[0032] The sensor device in embodiments is mounted to the weaving machine such that the contact area is arranged in a weft insertion direction between a weft presenter closest to the shed and a shed. In case the weaving machine comprises only one weft presenter, said one weft presenter is also the weft presenter closest to the shed. Typically, more than one weft presenter is provided.

[0033] In embodiments, the sensor unit comprises a bendable sensing blade extending in a blade direction, which sensing blade is clamped at a proximal end, wherein the contact area is provided at a distal end of the sensing blade, wherein for sensing a tension in a weft thread the device is mounted to the weaving machine such that the sensing blade is arranged perpendicular to a weft insertion plane, and the blade direction forms an obtuse angle with a section of the weft thread downstream of the contact area, which extends in the weft insertion direction, and the blade direction forms an acute angle with a section of the weft thread upstream of the contact area. Due to the different positions of the guide means such as eyes of different weft presenters, the acute angle formed with the blade direction differs for different weft threads presented by different weft presenters. The blade direction is chosen such that the weft thread coming from any weft presenter contacts the device only at the contact area and that the acute angle is minimized such that the force applied by the weft thread at the contact area is applied approximately perpendicular to the blade direction. The device in embodiments of the invention is mounted, such that for each weft presenter and every gripper position, the contact area only marginally protrudes into imaginary paths of the weft threads between the weft presenters and the gripper.

[0034] According to a fourth aspect, a method for mounting a sensor unit for sensing a tension in a weft thread to a gripper weaving machine in a region between a weft presenter and a shed is provided, wherein the sensor unit is mounted to the weaving machine via an elastic damping element adapted for isolating the sensor unit mounted to the gripper weaving machine from a vibration of the weaving machine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] In the following, embodiments of the invention will be described in detail with reference to the drawings. Throughout the drawings, the same elements will be denoted by the same reference numerals.

Fig. 1 shows an insertion side of a weaving machine with a sensor device for sensing a tension in a weft thread in a perspective view.

Fig. 2 shows the insertion side of the weaving machine of Fig. 1 in a perspective view from above.

Fig. 3 shows the device for sensing a tension in a weft thread of Fig. 1 in a perspective view.

Fig. 4 shows the device for sensing a tension in a weft thread of Fig. 3 in an explosive view.

Fig. 5 shows a cross section along line V-V of the sensor unit of the device for sensing a tension in a weft thread of Fig. 3.

Fig. 6 shows a cross section along line VI-VI of the sensor unit of the device for sensing a tension in a weft thread of Fig. 3.

Fig. 7 shows a sensor unit of the device for sensing a tension in a weft thread of Fig. 3 in a perspective view from above.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0036] Figs. 1 and 2 are schematic illustrations of an insertion side of a gripper weaving machine 100, wherein weft threads (of which only one weft thread 1 is shown) coming from a plurality of weft feeding devices (not shown) are woven in with the weaving machine 100.

[0037] Each weft thread 1 coming from an associated weft feeding device is guided along a thread brake (not shown) and a weft presenter 4. For an insertion of a weft thread 1 into a shed 5 formed by warp threads 12, the weft thread 1 is presented by the weft presenter 4 to a gripper 6. The gripper 6 is attached to a rapier 8 in order to move the presented weft thread 1 into the shed 5. In the context of the application, a direction along which the weft thread 1 extends in a woven fabric 13 is referred to as weft direction. A direction perpendicular to the weft direction along which the warp threads 12 extend in a woven fabric 13 is referred to as warp direction.

[0038] As generally known, the weaving machine 100 comprises two grippers for a transport of weft threads 1 through the shed 5, referred to as drawing gripper and taker gripper, wherein gripper 6 shown in the figures is the drawing gripper, which is designed to transport the weft thread 1 through the first half of the shed 5, and the taker gripper (not shown) is designed to transport the weft thread 1 through the second half of the shed 5 after having picked up the weft thread 1 from the drawing gripper.

[0039] Typically, a weaving machine comprises eight weft presenters 4, wherein each weft presenter 4 is configured for presenting a weft thread 1 coming from an associated weft feeding device, however, weaving machines with more or less weft presenters are conceivable. For multi-thread weaving, two or more weft threads 1 can be presented simultaneously.

[0040] Further, a reed 9 for beating up an inserted weft thread 1 against the fabric 13, and a weft cutter 7 for cutting an inserted weft thread 1 near the fabric 13 are provided.

[0041] The weft feeding device (not shown), the thread brake (not shown), the weft presenter 4, and the weft cutter 7 are controlled by a control unit 14 (shown schematically in Fig. 2).

[0042] A sensor device for sensing the tension of an inserted weft thread 1 is arranged near the shed 5, which device in the following is further referred to as device or sensor device 10. In the embodiment shown, the sensor device 10 is attached to a rapier guide 15, which rapier guide 15 is mounted stationary on the frame of the weaving machine 100 and acts as a holder for the sensor device 10. The sensor device 10 is mounted in the warp direction between the fabric 13 and the reed 9, when the reed 9 is moved into its rearward position as shown in Fig. 2. In the weft direction the sensor device 10 is mounted near the shed 5 in a region between the weft presenter 4 and the shed 5.

[0043] The sensor device 10 is shown in more detail in Figs. 3 and 4. The sensor device 10 comprises a sensor unit 20 with a sensing blade 31 having a contact area 21 for a weft thread at its distal end, and a mounting arrangement 22. The mounting arrangement 22 comprises a support 24, two elastic damping elements 25 (in short referred to as damping elements 25), a cover element 26 with a window 27, a window element 28 mounted on the cover element 26 in the periphery of the window 27, and a guide plate 29 arranged at a rear end of the support 24.

[0044] The sensor unit 20 is shown in more detail in Fig. 7. The sensor unit 20 comprises a base frame 30 and the bendable sensing blade 31, also referred to as blade spring. The contact area 21 is provided at the distal end 54 of the sensing blade 31. The sensing blade 31 is clamped at a proximal end 55 in the base frame 30 via a clamping unit 23. The sensing blade 31 is supported between the distal end 54 and the proximal end 55 by a deflector element 32, for example a roll. Strain gauges 33 are provided at a side surface of the sensing blade 31 opposite the deflector element 32 and facing away from the deflector element 32.

[0045] At the distal end 54 a stop limit 34 is provided, limiting a bending of the sensing blade 31. Further, an elastic block 35 for damping a movement of the sensing blade 31 towards the stop limit 34 is provided. This stop limit 34 allows that the movement of the distal end 54 of the sensing blade 31 is limited so that the weft thread 1 can always be in contact with the distal end 54 of the sensing blade 31 of the sensor unit 20, thus the contact area 21 at the distal end 54 of the spring shaped sensing blade 31 will always protrude out of the window 27 (see Figs. 3 and 4).

[0046] As shown in Figs. 1 and 2, the sensor device 10 is arranged such that in normal use a section of the inserted weft thread 1 extending between the associated weft presenter 4 and the gripper 6 contacts the contact area 21 of the sensing blade 31 of the sensor device 10, but does not contact other parts of the sensor device 10. Hence, the sensor unit 20 of the sensor device 10 comes only with one side of the sensor unit 20 into contact with the weft thread 1, which side is covered by the cover element 26 so that a risk that dust will accumulate on the sensor unit 20 is kept small.

[0047] The support 24 and the guide plate 29 are attached to a frame of the weaving machine 100, for example to the gripper guide 15 (see Figs. 1 and 2) using screws 40. As best seen in Fig. 4, the sensor unit 20 is received within the cover element 26, wherein the contact area 21 protrudes through the window 27. The sensor unit 20 is fixed to the cover element 26 using two screws 41 passing along through holes 51 in the sensor unit 20 and cooperating with threaded holes 52 in the cover element 26. The sensor unit 20 and the cover element 26 together are mounted to the support 24 via the damping elements 25. In the embodiment shown, the support 24 is provided with a first lug 42 and a second lug 43 protruding from a main body 44, wherein the main body 44 extends in a first direction I and the lugs 42, 43 protrude from the main body 44 in a direction perpendicular to the first direction I. The first lug 42 is longer than the second lug 43. The damping elements 25 are arranged at the distal end of the first lug 42 and the second lug 43.

[0048] The window element 28 has two parallel ridges 36 provided at an upper edge and a lower edge of the window 27 which restrict a position of the weft thread 1 (see Figs. 1 and 2) in a direction perpendicular to the axial direction of the weft thread 1. The window element 28 further has side ridges that are connecting the parallel ridges 36.

[0049] As best seen in Fig. 3, the support 24 is provided with a wedge-shaped protrusion 37 functioning as a thread guide for guiding a weft thread towards a position between the two parallel ridges 36 and into contact with the contact area 21 of the sensing blade 31. The wedge-shaped protrusion 37 may also be used to position the cover element 26 with respect to the support 24. Further, a wire 38 and connector 39 are provided for allowing a communication between the sensor unit 20 and the control unit 14 (see Fig. 2), for example a bi-directional communication. In an alternative, a wireless communication may be provided between the sensor unit 20 and the control unit 14.

[0050] The mounting arrangement 22 that comprises one or more damping elements 25, in the embodiment shown two damping elements 25, allows isolating the sensor unit 20 from vibration of the weaving machine 100 (see Fig. 1), to which the sensor device 10 is mounted. By isolating the sensor unit 20 from a vibration of the weaving machine, a noise on the response signal due to vibrations of the weaving machine 100 is reduced.

[0051] A vibration isolation or reduction of a transmissibility of a vibration from the weaving machine 100 to the sensor unit 20 depends inter alia on a structural design of the damping elements 25 and a mass of the sensor unit 20 together with the cover element 26. In the embodiment shown, viscoelastic vibration dampers made of rubber are used. However, the invention is not limited to this type of damping elements 25, in particular other damping materials having a low stiffness and damping properties can be used for the damping elements 25.

[0052] Figs. 5 and 6 show a cross section of the sensor unit 10 along line V-V and along line VI-VI of Fig. 3, respectively. As shown in Figs. 5 and 6, the damping elements 25 are fixed to a respective lug 42, 43 using fixing elements, such as a bolt 46 and a nut 47. In the embodiment shown, the nut 47 is fixed to the damping element 25, for example is glued to the damping element 25. Further, to each damping element 25 a pin 45 is fixed, for example glued, which pin 45 has a threaded end that can cooperate with a nut 49. The sensor element 20, more particular its base frame 30, is provided with through holes 48 for receiving the pins 45, so that the base frame 30 of the sensor element 20 can be fixed via the pins 45 and the nut 49 to the damping element 25. The damping elements 25 are arranged within a bore cavity 55 provided in the base frame 30 and extending in the prolongation of the through hole 48. The cover element 26 is provided with two through holes 50 to allow access to the nuts 49, which through holes 50 can be covered by the plugs 53.

[0053] As shown in Figs. 1 and 2, the sensor device 10 is arranged such that during the insertion of a weft thread 1, said weft thread 1 comes into contact with the contact area 21 of the sensing blade 31 protruding via the window 27, and applies a force to the contact area 21. The force applied to the contact area 21 causes bending of the sensing blade 31, wherein the sensor unit 20 is adapted to generate a response signal in response to the force applied by the weft thread 1. The force applied by the weft thread 1 is dependent on the tension in the weft thread 1, so that the tension in the weft thread 1 can be monitored or sensed during the insertion of each weft thread 1, using the sensor device 10.

[0054] In one embodiment, the sensed tension is compared by the control unit 14 with data about a "desired" tension, which data is stored in a memory of the control unit 14. Typically, a desired tension varies over the weaving cycle, wherein the response signal is evaluated based on an angular position of the weaving machine in the weaving cycle.

[0055] As shown in Fig. 2, an angle formed between a section of the weft thread 1 upstream of the contact area

21 and section of the weft thread downstream of the contact area 21, also referred to as deflection angle of the weft thread 1, differs for weft threads 1 inserted from different weft feeding devices. Therefore, in one embodiment the control unit 14 is adapted for evaluating the response signal from the sensor device 10 in consideration of information about which weft thread 1 of the plurality of weft threads 1 contacts the contact area 21 of the sensor device 10. Information of the active weft presenter 4 and a position of the weft presenter 4, more particular the position of an eye of the needle of the weft presenter 4 guiding the weft thread 1, is known for each angular position of the weaving machine during the weaving cycle, and can be used by the control unit 14 for evaluating the response signal from the sensor device 10.

[0056] The deflection angle of the weft thread 1 further depends on a position of the gripper 6 in the shed 5. The position of the gripper 6 is also known for each angular position of the weaving machine during the weaving cycle. Hence, in alternative or in addition to information about the weft presenter 4, the control unit 14 evaluates the response signal based on information about a position of the gripper 6.

[0057] Depending on the response signal and the deflection angle of the inserted weft thread, it is possible to calculate for each angular position of the weaving machine the tension in the weft thread and to compare this calculated tension with the "desired" tension for the angular position of the weaving machine. The weft thread 1 is deflected at the weft presenter 4, the sensor device 10, and the gripper 6, wherein using the sensor device 10, the weft thread 1 deflection at the sensor device 10 is small, so that the tension in the thread is almost not influenced by the sensor device 10.

[0058] During weaving, the weft threads do not make permanent contact with the sensor device 10. Therefore, a zero value of the sensor device 10 can be set, when the sensor device 10 is not in contact with any of the weft threads, so that during each weaving cycle it is possible to reset the sensor device 10 to the zero value. In case it is observed that the zero value needs to be adjusted after each weaving cycle, this may indicate that the sensor device 10 is "dirty", for example due to dust, and should be cleaned.

[0059] A bending movement of the sensing blade 31 caused by the force acting thereon depends on the stiffness of the sensing blade 31 and its length between the distal end 54 at which the weft thread 1 contacts the sensing blade 31 and the deflecting element 32. In embodiments, a light and stiff sensing blade 31 is used, which has a natural frequency, so that vibrations due to resonance of the sensing blade 31 are minimized.

[0060] As shown in Figs. 1 and 2, the sensor device 10 in the embodiment shown is mounted to the weaving machine 100 such that the sensing blade 31 is arranged perpendicular to the weft insertion plane and a direction, in which the sensing blade 31 extends, referred to as blade direction II, forms an obtuse angle with a section of the weft thread 1 downstream of the contact area 21, which extends in the weft insertion direction I, in particular an obtuse angle between 150° and 170°, and the blade direction II forms an acute angle with a section of the weft thread 1 upstream of the contact area 21, for example an acute angle of about 32°. In other words, the blade direction II is almost parallel to the section of the weft thread 1 upstream of the contact area 21 and allows that the weft thread 1 only contacts the contact area 21 of the sensing blade 31.

[0061] Hence, the force applied by the weft thread 1 at the contact area 21 has a force direction, which is almost perpendicular to the blade direction II. This allows a good responsiveness of the sensor device 10. Therefore, the sensor device 10 in embodiments of the invention can be mounted, such that for each weft presenter 4 and for every gripper position, the contact area 21 only marginally protrudes into imaginary paths of the weft threads 1 between the weft presenters 4 and the gripper 6. Due to this arrangement, the sensor device 10 only marginally influences a tension in the weft thread 1 contacting the contact area 21.

[0062] The sensor unit 20 is mounted to the weaving machine 100 via a damping element 25 adapted for isolating a vibration of the weaving machine 100 from the sensor unit 20 mounted to the weaving machine 100, in particular via a damping element 25 having a low stiffness and high damping coefficient. In case a weft thread 1 contacts the sensor unit 20 at the contact area 21, the sensor unit 20 is able to generate a response signal in response to a force applied by the weft thread 1 at the contact area 21. For sensing a tension in a weft thread 1, the response signal can be determined and evaluated in consideration of information about a position of a gripper 6 transporting the weft thread 1 through a shed 5 and/or a position of a weft presenter 4 used for presenting the weft thread 1.

Claims

1. A sensor device for sensing a tension in a weft thread (1) between a weft presenter (4) and a gripper (6) on a gripper weaving machine (100), the sensor device (10) comprising a sensor unit (20) with a contact area (21), which sensor unit (20) is adapted to generate a response signal in response to a force applied by the weft thread (1) at the contact area (21), and a mounting arrangement (22) adapted for mounting the sensor unit (20) to the weaving machine (100) in a region between the weft presenter (4) and a shed (5), **characterized in that** the mounting arrangement (22) comprises an elastic damping element (25) adapted for isolating the sensor unit (20) mounted to the weaving machine (100) from vibrations of the weaving machine (100).

2. The sensor device according to claim 1, **character-**

ized in that the sensor unit (20) comprises a bendable sensing blade (31) extending in a blade direction (II), which sensing blade (31) is clamped at a proximal end (55), wherein the contact area (21) is provided at a distal end (54) of the sensing blade (31), wherein in particular the sensing blade (31) is supported between the distal end (54) and the proximal end (55) by a deflector element (32), and wherein strain gauges (33) are provided at the sensing blade (31) near the deflector element (32).

3. The sensor device according to claim 2, **characterized in that** the bendable sensing blade (31) is wear resistant at the contact area (21).

4. The sensor device according to claim 2 or 3, **characterized in that** the mounting arrangement (22) comprises a support (24) adapted for being mounted to the weaving machine (100), wherein the sensor unit (20) is mounted to the support (24) via the damping element (25), wherein the support (24) comprises an elongated main body (44) extending in a first direction (I), wherein the sensor unit (20) is mounted to the support (24) such that the blade direction (II) forms an acute angle with the first direction (I).

5. The sensor device according to claim 4, **characterized in that** the support (24) comprises a lug (42, 43) protruding from the main body (44) perpendicular to the first direction (I) and wherein the sensor unit (20) is mounted to the lug (42, 43) via an associated damping element (25), in particular the support comprises a first lug (42) and a second lug (43) protruding from the main body (44) perpendicular to the first direction (I), wherein the sensor unit (20) is mounted to the first lug (42) and the second lug (43) via associated damping elements (25), wherein further in particular the first lug (42) and the second lug (43) differ in length.

6. The sensor device according to claim 4 or 5, **characterized in that** the mounting arrangement (22) comprises a guide plate (29), wherein the guide plate (29) is attached to a rear end of the support (24) and extends in the first direction (I).

7. The sensor device according to any one of claims 1 to 6, **characterized in that** the mounting arrangement (22) comprises a cover element (26) having a window (27), wherein the cover element (26) at least partly covers a first side of the sensor unit (20) provided with the contact area (21) and wherein the contact area (21) protrudes through the window (27).

8. The sensor device according to claim 7, **characterized in that** the mounting arrangement (22) comprises a window element (28) surrounding the window (27) of the cover element (26), wherein the window element (28) is provided with two ridges (36) extending at an upper side and a lower side of the contact area (21) protruding through the window (27).

9. The sensor device according to any one of claims 1 to 8, **characterized in that** a control unit (14) is provided, which control unit (14) is adapted for evaluating the response signal in consideration of information about a position of a gripper (6) transporting the weft thread (1) through a shed (5) and/or a weft presenter (4) used for presenting the weft thread (1).

10. The sensor device according to claim 9, **characterized in that** the control unit (14) is adapted for comparing the response signal with a desired tension, wherein the desired tension varies with the angular position of the weaving machine (100) in the weaving cycle.

11. A method for sensing a tension in a weft thread (1) between a weft presenter (4) and a gripper (6) on a gripper weaving machine (100), **characterized in that** a sensor unit (20) with a contact area (21) generates a response signal in response to a force applied by the weft thread (1) at the contact area (21), and wherein the response signal is evaluated in consideration of information about a position of a gripper (6) transporting the weft thread (1) through a shed (5) and/or a position of a weft presenter (4) used for presenting the weft thread (1).

12. A weaving machine comprising a sensor device (10) according to any one of claims 1 to 10, wherein the sensor device (10) is mounted to a frame of the gripper weaving machine (100) in a region between a weft presenter (4) and a shed (5) for sensing a tension in the weft thread (1) between the weft presenter (4) and the gripper (6) of the gripper weaving machine (100).

13. The weaving machine according to claim 12, **characterized in that** the device (10) is mounted to the weaving machine (100) such that the contact area (21) is arranged in a weft insertion direction between the shed (5) and a weft presenter (4) closest to the shed (5).

14. The weaving machine according to claim 12 or 13, **characterized in that** the sensor unit (20) of the device (10) comprises a bendable sensing blade (31) extending in a blade direction (II), which sensing blade (31) is clamped at a proximal end (55), wherein the contact area (21) is provided at a distal end (54) of the sensing blade (31), wherein for sensing a tension in a weft thread (1) the device (10) is mounted to the weaving machine (100) such that the sensing blade (31) is arranged perpendicular to a weft inser-

tion plane, and the blade direction (II) forms an obtuse angle with a section of the weft thread (1) downstream of the contact area (21), which extends in the weft insertion direction, and the blade direction (II) forms an acute angle with a section of the weft thread (1) upstream of the contact area (21).

15. A method for mounting a sensor unit (20) for sensing a tension in a weft thread (1) to a gripper weaving machine (100) in a region between a weft presenter (4) and a shed (5), **characterized in that** the sensor unit (20) is mounted to the weaving machine (100) via an elastic damping element (25) adapted for isolating the sensor unit (20) mounted to the gripper weaving machine (100) from a vibration of the gripper weaving machine (100).

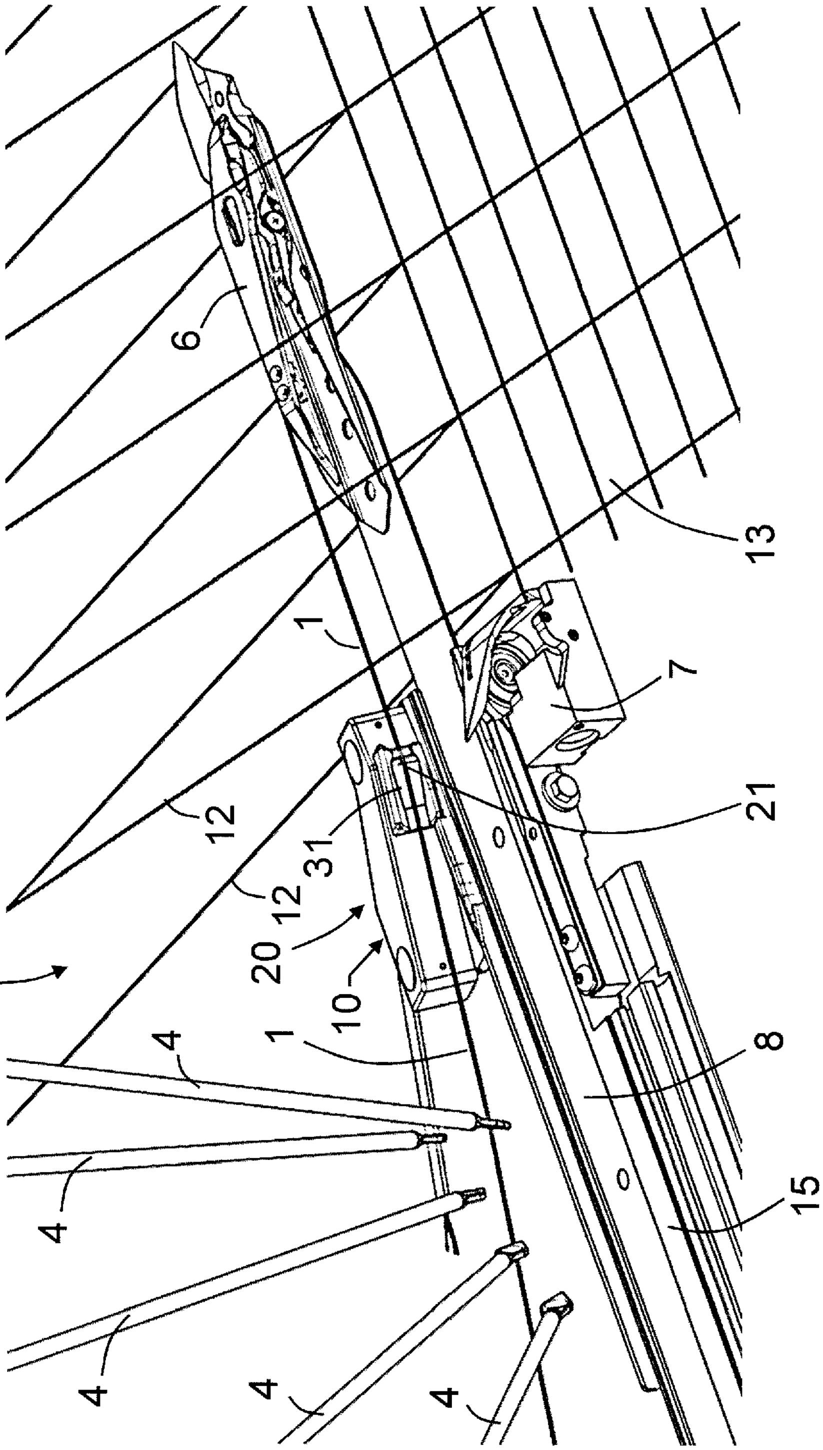

Fig. 1

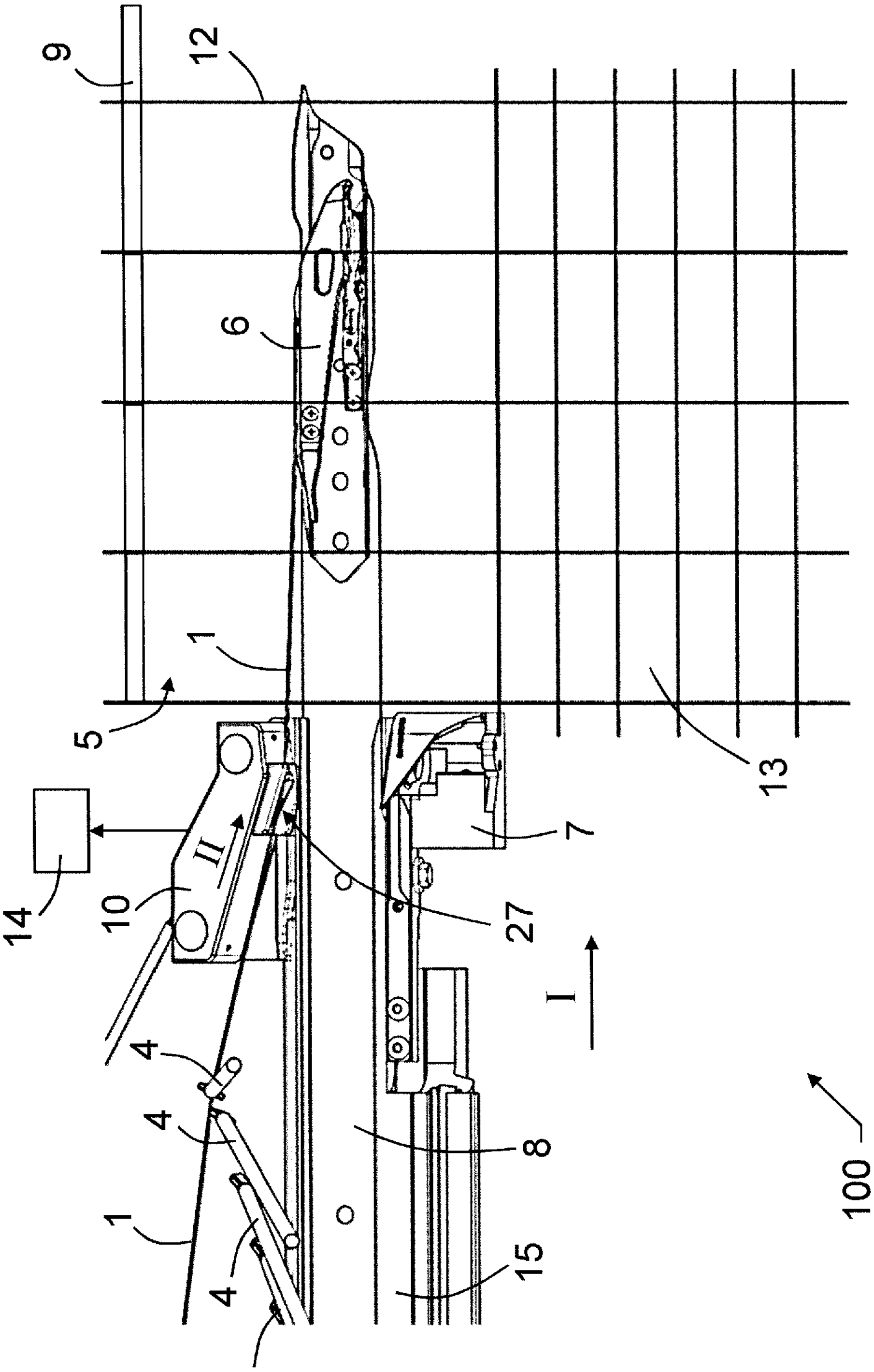

Fig. 2

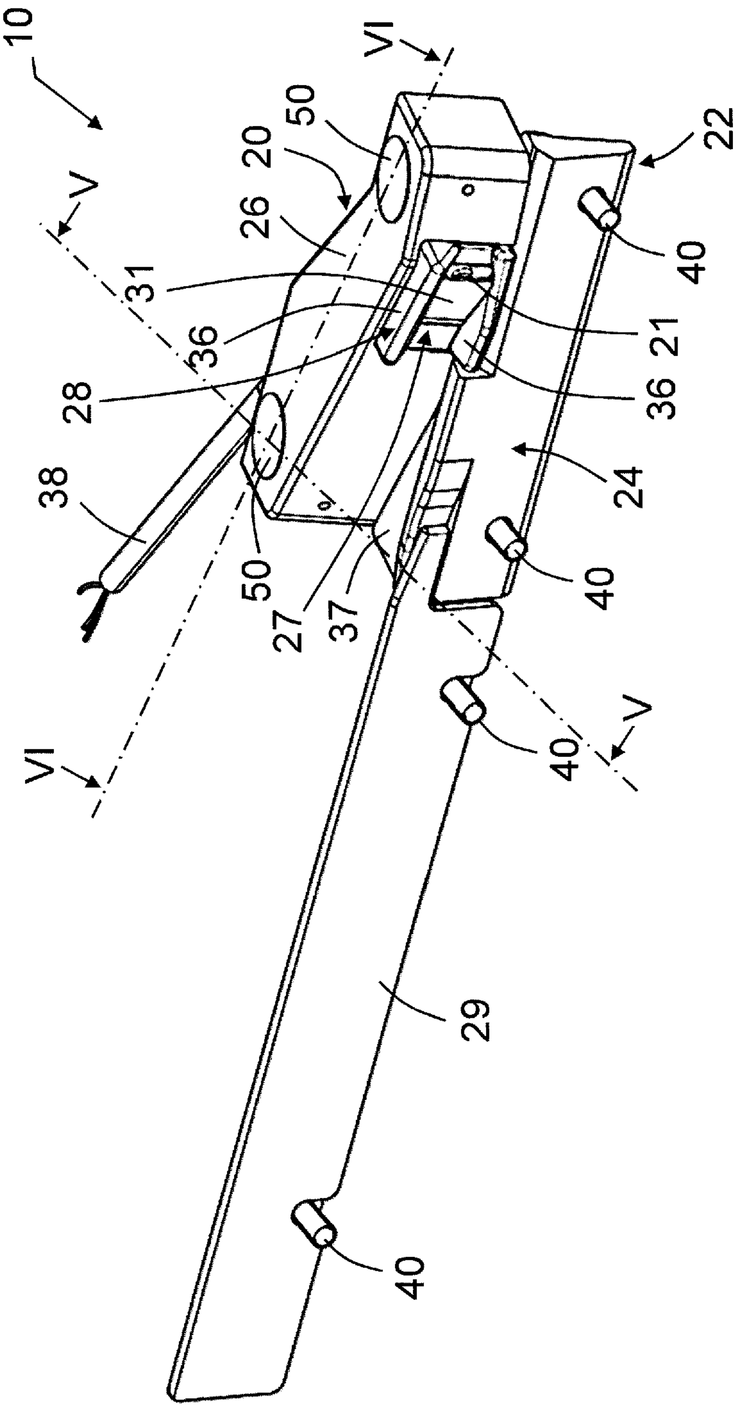

Fig. 3

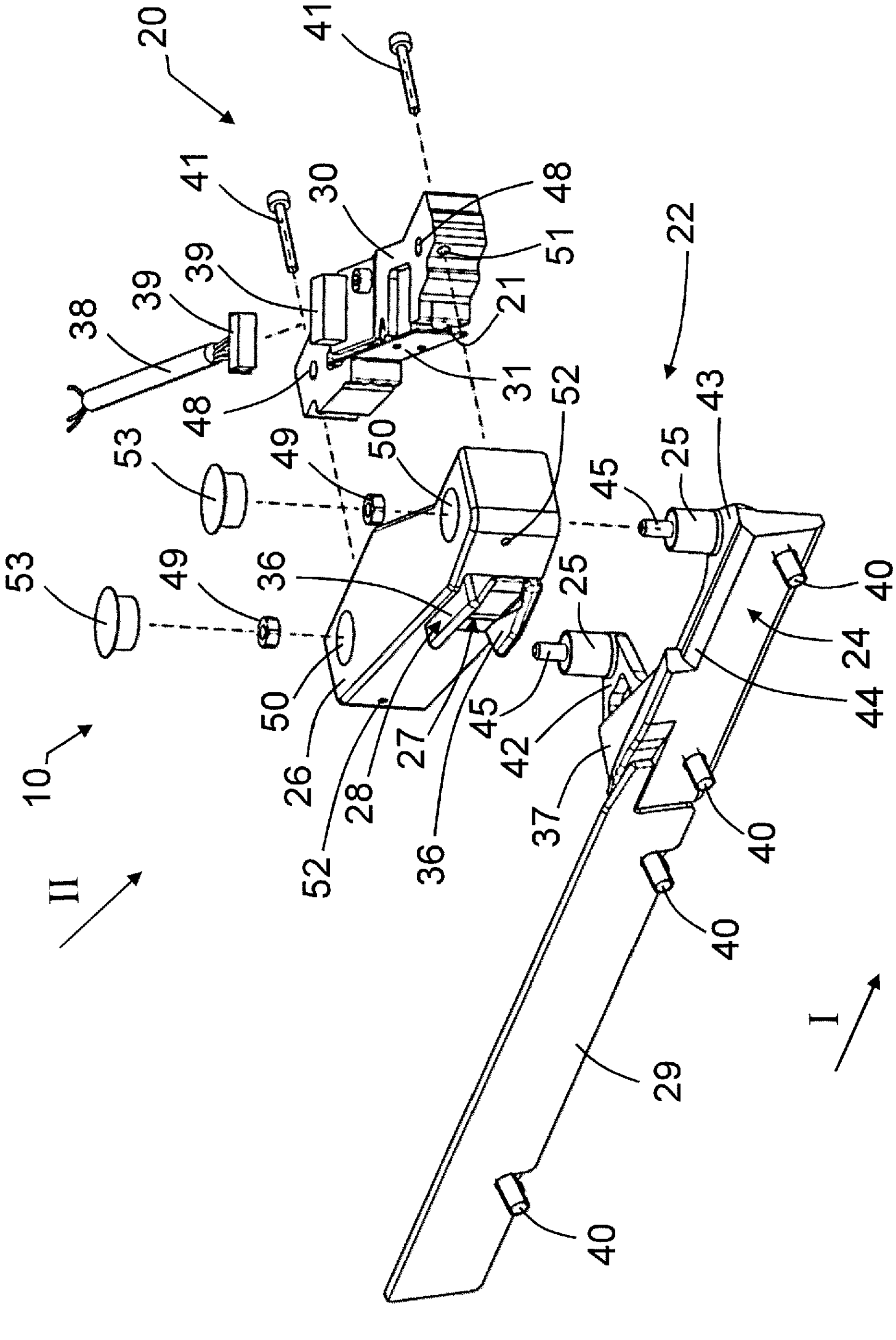
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Fig. 4

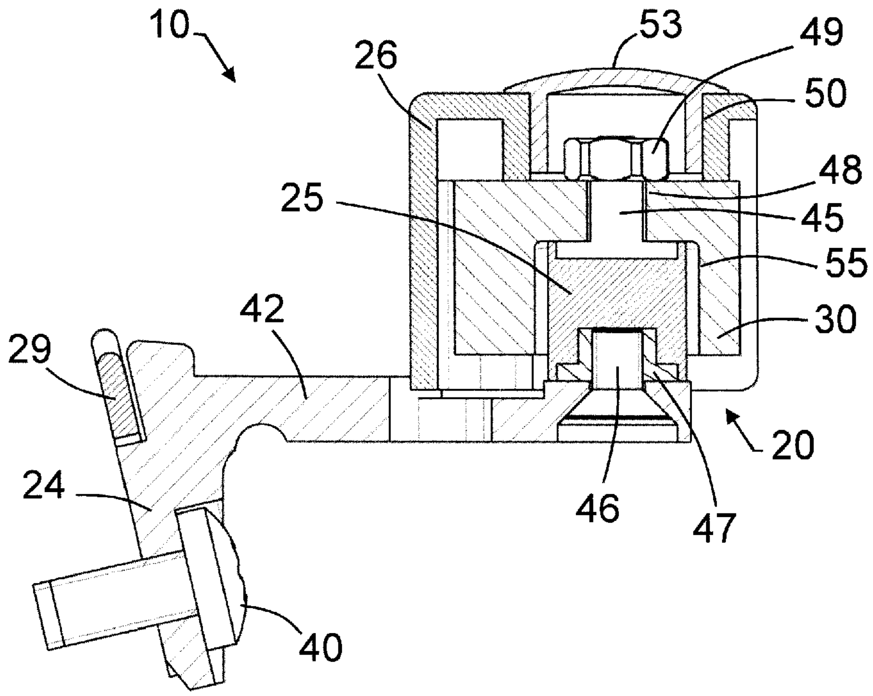

Fig. 5

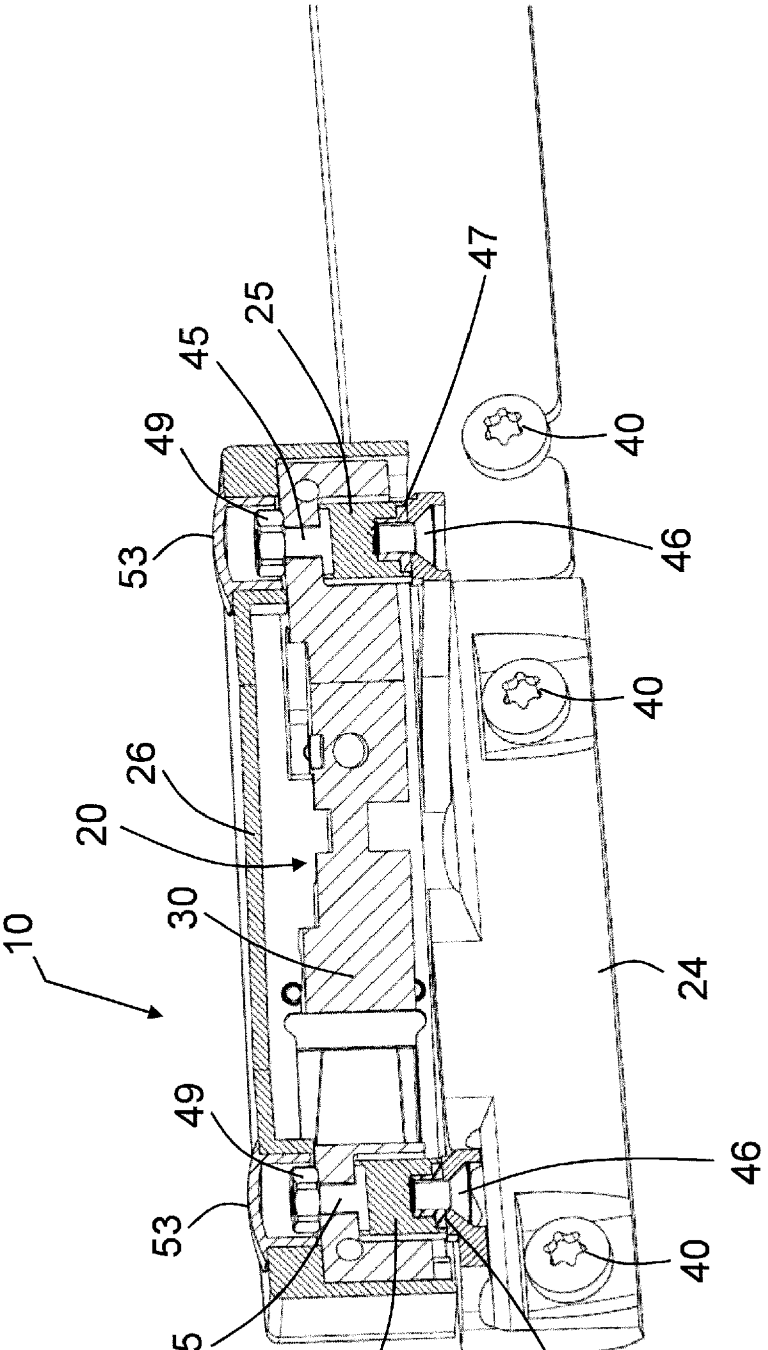

Fig. 6

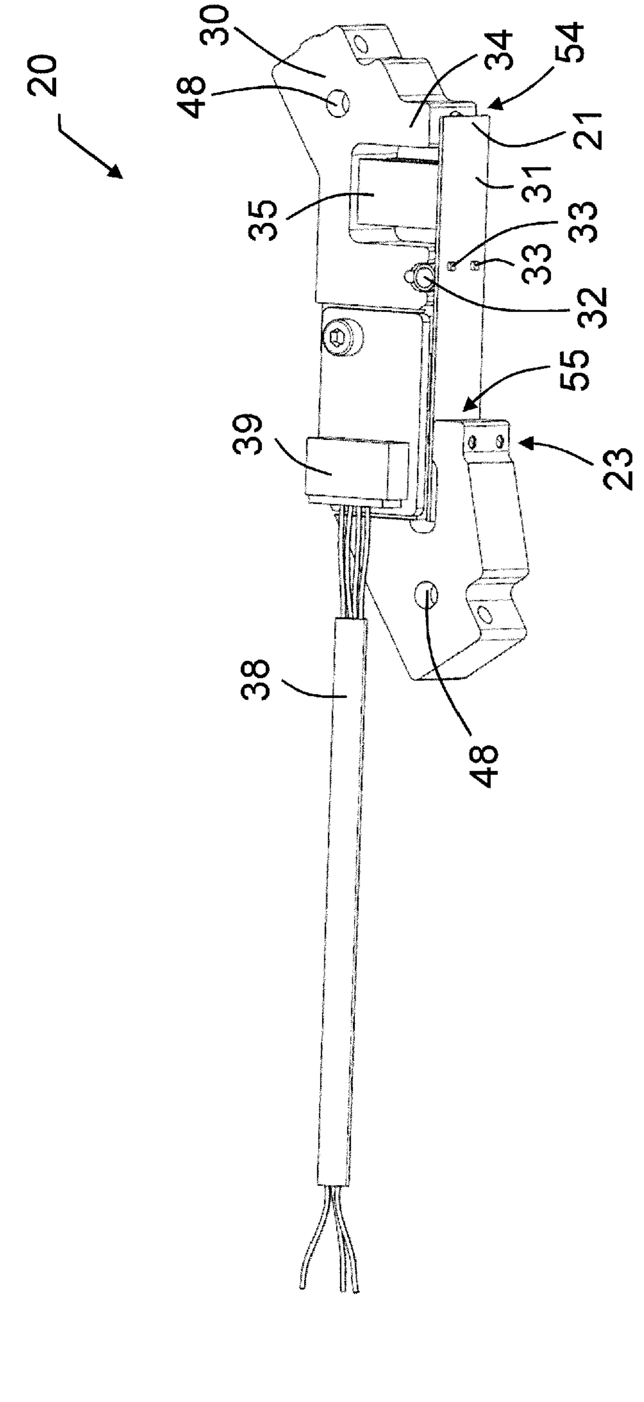

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 20 19 5781

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 1 005 435 B1 (ELTEX SWEDEN AB [SE]) 9 April 2003 (2003-04-09) * paragraphs [0011], [0012]; figures 1-6,12 * -----	1-5,7,8 6,9,10, 12-15	INV. D03D47/34 B65H59/00 D03D47/38
X Y	EP 0 943 713 A2 (MEMMINGER IRO GMBH [DE]) 22 September 1999 (1999-09-22) * abstract; figures 1-8 * * paragraphs [0025] - [0033] * -----	1,7 6,9,10, 12,13,15	
Y,D	DE 195 35 895 C1 (DORNIER GMBH LINDAUER [DE]) 13 June 1996 (1996-06-13) * abstract; figures 1,2 * * column 2, line 43 - column 4, line 16 * -----	6,9,10, 12-15	

TECHNICAL FIELDS SEARCHED (IPC)

D03D
B65H

~~The present search report has been drawn up for all claims~~

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Place of search	Date of completion of the search	Examiner
Munich	27 January 2021	Louter, Petrus

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 20 19 5781

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-10, 12-15

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 20 19 5781

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-10, 12-15

   Sensor element with a damping device

   ---

2. claim: 11

   Method for sensing a tension

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 19 5781

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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27-01-2021

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

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- US 6112776 A **[0003]**