



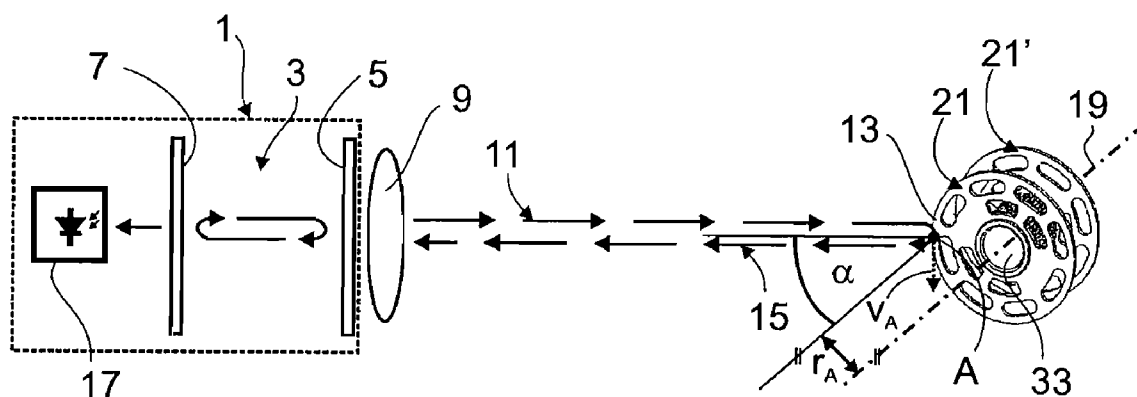
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(19) **United States**(12) **Patent Application Publication**
Wentkowski(10) **Pub. No.: US 2007/0163479 A1**(43) **Pub. Date: Jul. 19, 2007**(54) **SEWING MACHINE AND METHOD FOR
DETECTING MOVEMENTS IN SEWING
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D05B 1/00 (2006.01)(52) **U.S. Cl.** **112/475.01**(57) **ABSTRACT**

A sewing machine having a detection device for movements of objects (13) is provided. Here, a coherent light beam (11) is emitted, scattered on the object (13), and returns to form an interference with the emitted light. For movements of the object (13), a frequency shift of the scattered light is produced due to the Doppler effect, which can be detected and evaluated in the form of intensity fluctuations.



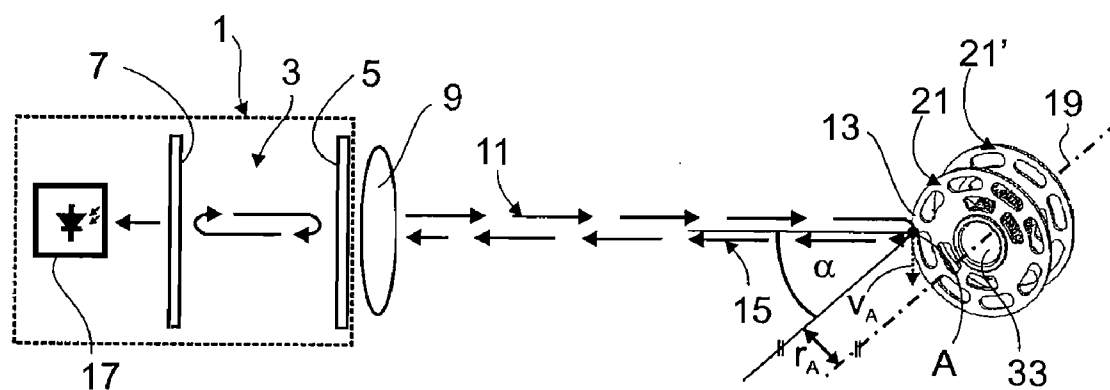


FIG. 1

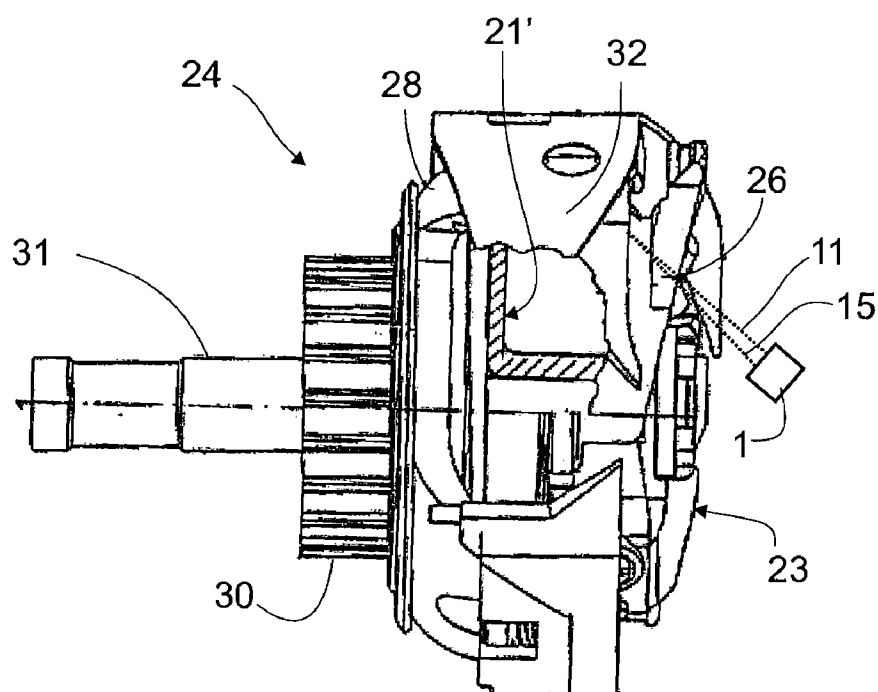


FIG. 2

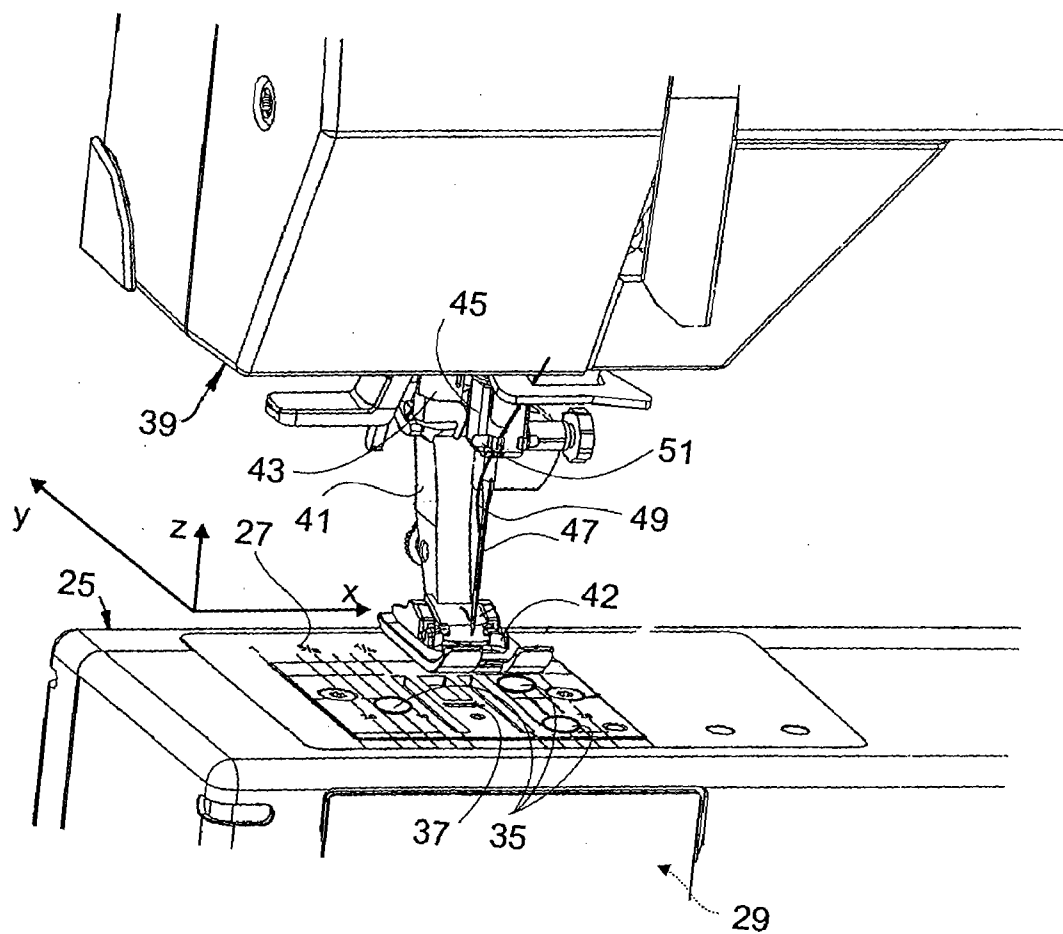


FIG. 3

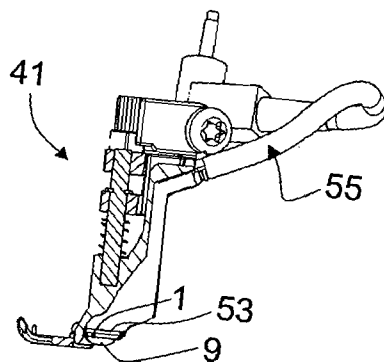


FIG. 4

SEWING MACHINE AND METHOD FOR DETECTING MOVEMENTS IN SEWING MACHINES

BACKGROUND

[0001] The subject matter of the invention is a sewing machine and a method for detecting movements in a sewing machine.

[0002] Sewing machines, embroidery machines, quilting devices, and the like often include sensors, with which, e.g., movements of the sewing material or the embroidery hoop can be detected. Through further processing of the signals of such sensors, e.g., control signals can be generated or displays can be driven.

[0003] From EP1321556, a method for regulating the material transport in a sewing or embroidery machine is known, in which a sensor is arranged for detecting advancing widths of the sewing material in the area of the needle plate. The sensor is constructed as a CCD camera and records images of the surface of the sewing material in rapid succession. With reference to the change in position and orientation of structural features of the sewing material surface in successive images, a controller calculates the position and orientation of the sewing material or information on its movement. If deviations in the detected measurement parameters from given desired parameters are determined, the transport device for the sewing material is controlled so that such deviations are minimal.

[0004] From WO2005056903, a device for controlling or regulating the needle motion in a sewing machine is known. It comprises a detection device with an image sensor, which records a section of the sewing material surface from above at a high scanning rate. For quilting, the sewing material is shifted manually. The detection device records a section of the sewing material surface in the area of the sensor and the sewing needle in rapid succession of approximately 1500 images per second. The movements of the sewing material are determined with reference to this information and the needle drive is controlled such that successive stitches are formed at uniform intervals.

[0005] Despite high scanning rates, such systems can generate errors, e.g., for high acceleration values. This is especially disruptive when a cyclical sewing pattern is to be formed, which begins and ends at one and the same position. In addition, such systems have the peculiarity that a two-dimensional surface section with usually low sharpness is imaged onto an image sensor. Thus, objects can be recorded reliably only when they are sufficiently large and lie within the respective depth of focus. Object movements can be detected only in a detection plane, but not vertical to this plane.

SUMMARY

[0006] Therefore, one objective of the present invention is to provide an improved detection device and a method for detecting movements in sewing machines, which allows reliable and quick detection of movements of small parts. Another objective of the invention is to construct the detection device and the method so that object movements can be detected in a plane and/or vertical to this plane.

[0007] These objectives are met by a sewing machine and by a method according to the invention. Advantageous constructions of the sewing machine and the method are further provided.

[0008] The method according to the invention and the sewing machine, embroidery machine, or quilting machine with the detection device according to the invention are based on the consideration that the calculation of object velocities or changes in position or orientation of objects by evaluating individual images in time succession push up against the limits of technical feasibility when the objects are small and/or the velocity or acceleration values are large or when the object movements do not take place within a given detection plane.

[0009] For the method according to the invention and for the sewing machine according to the invention, movements are detected directly, i.e., without the conversion of images of the object surface recorded successively in time. Here, a laser generates a coherent light beam, which is deflected by a lens or by optical elements in the direction of the object surface to be detected. A portion of the light scattered at the object surface is reflected back in the direction of the laser. Preferably, the lens is constructed so that light scattered at the object is collected and reflected back to the laser. There, at least a portion of the scattered light enters through the semi-transparent mirror back into the resonator, where it interferes with the light generated in the resonator. In this way, fundamental properties of the laser and the light emitted by the laser are changed. This phenomenon is also designated as the "self-mixing effect." Alternatively, another interference detector independent of the laser resonator can also be used, wherein light generated, for example, by the laser is decoupled by semi-transparent mirrors and forms interference with light scattered at the object outside of the resonator.

[0010] If the object surface moves relative to the laser, due to the Doppler effect the frequency of the light scattered and reflected in the direction of the laser changes as a function of the velocity component in the direction of the laser beam. This change in frequency is realistic for object movements to be recorded on the order of magnitude of approximately one kilohertz up to a few megahertz and thus can be easily evaluated without delay with conventional electronic means. A frequency shift can still be measured even for objects with nearly unstructured, smooth, or reflective surfaces. Thus, very small inhomogeneities and scattered light portions are sufficient for creating a measurable change in frequency.

[0011] Parameters, which can change based on the self-coupling effect of the laser, are, e.g., the power consumption or junction resistance, the intensity of the scattered laser light, the frequency and the diameter of the laser beam, or the threshold amplification of the laser. These parameter values change with a frequency corresponding to the frequency difference between the laser light generated by the laser and scattered back into the laser. This frequency difference is, in turn, proportional to the velocity component of the object surface in the direction of the laser light beam. It is also possible to determine the velocity component of the object surface in the respective direction by detecting and evaluating the fluctuations or one or more of these parameter values.

[0012] If the relationship between the widening direction of the laser beam and the movement direction of the object surface is unambiguous and known a priori (for movements

of the object surface along a given path or for one-dimensional object movements), the velocity of the object surface in the respective direction can be calculated from the frequency difference detected directly or indirectly according to the measurement technique between the light beam emitted by the laser and the light beam scattered by the object and coupled back into the laser. By integrating the velocity values, the respective positions or changes in position of the object or the object surface can be calculated practically without delay. For detecting movements of the object surface with two or more degrees of freedom, in an analogous way two or more sensors can be provided with lasers as light sources and with detectors for detecting the respective parameter fluctuations, wherein the directions of radiation and/or the positions of these laser-light sources are different.

[0013] WO2005/076116 discloses an arrangement with two laser diodes, which are arranged preferably orthogonal to each other on a common flat substrate. The two laser beams are bundled diagonally upwards according to the alignment of the respective laser diodes by a common collecting lens, such that they are focused on the top side or just above a detection window close to each other. Such an arrangement can be used in input devices—for example, in computer mice or in input devices for computers, mobile telephones, and the like—for detecting movements in a plane. The lens or a different optical collecting means is constructed so that the laser beam has a focal area expanded in the direction of radiation, wherein the radiation is not focused there on the smallest possible diameter, but instead has an approximately constant beam diameter over a longer area.

[0014] In the present invention, the principle of detecting movements by means of self-coupling of laser beams in connection with the Doppler effect is used for detecting movements and changes in position or orientation in sewing machines, embroidery machines, quilting devices, and the like. Here, moving objects can be both machine components or accessories, such as sewing needle, needle holder, pressure foot, feed dog, hook, bobbin, embroidery hoop, etc., or else objects or components to be processed, such as, the sewing material—or for several sewing layers, one sewing layer—the top thread, or the bottom thread.

[0015] According to the type, size, shape, location, and movement of the object to be detected, the construction and arrangement of the detection device can vary. Possible applications are:

[0016] Detection of the sewing material movement, especially the detection of the velocity vector or the sewing direction and the sewing material velocity, the determination of the acceleration vector or the calculation of the respective orientation and/or position of the sewing material by integrating the velocity or the velocities detected by one or more sensors. The obtained data can be used, e.g., for controlling or regulating a transport device for the sewing material or for quality assurance in sewing or embroidery (detection of actual-value deviations in one or two dimensions of the sewing plane, slippage minimization) or for controlling or regulating the needle movement (freehand sewing or quilting). Based on the sensor information, a transport device can be regulated so that the deviations of the effective material movement from the given material movement are minimal. The transport device can comprise, for example, transport rollers or a feed dog acting on the sewing material from below and/or from above for the material advance in the

sewing direction and, if necessary, also for the transverse transport of the sewing material. In the arrangement of a sensor above the sewing material—for example, in the sewing foot or sewing foot shaft—and below the sewing material—for example, in the needle plate—the difference between the movement signals of the two sensors can be used for determining material layer displacement. Thus, in connection with a device for transporting the bottom and the top sewing material layer, regulation can be created, which keeps the displacement between the two material layers to a minimum.

[0017] For embroidery, relative movements of parts of the embroidery hoop and preferably the sewing material clamped therein can be detected. These can be used, e.g., for calibrating the embroidery hoop. In particular, it is possible to detect quick accelerations and vibrations of an embroidery frame and to optimize its movements so that vibrations are minimal even for large acceleration values. Therefore, the precision of the stitching positions of the sewing needle into the sewing material can be improved.

[0018] A type of barcode, e.g., can be attached to the embroidery hoop or to a different machine or accessory part. When this code moves relative to the light beam of the sensor, the code can be read based on the resulting intensity fluctuations of the scattered light.

[0019] Because relative movements of the sewing material vertical to the sewing plane can also be detected for a corresponding construction and orientation of the sensor, it is also possible, e.g., with a sensor directed from above onto the sewing material or onto the sewing foot, to monitor skipping movements of the sewing foot or to monitor hems or material edges before reaching or leaving the piercing area of the sewing needle.

[0020] Detecting and/or monitoring a thread length or thread motion, e.g., the velocity of the bottom or top thread during take-up during the sewing, quilting, or embroidering, or during a spool loading, changing, or unloading process.

[0021] Detecting the rotational speed of the bottom thread bobbin or—with a corresponding arrangement of the sensor—the top thread spool.

[0022] The fill level of the bobbin, e.g., can be determined through common processing of the rotational speed of the bottom thread bobbin and the take-up velocity of the bottom thread.

[0023] Detecting movements and/or positions or orientations of any movable machine or accessory parts, such as transfer belts, main shaft, sewing foot rod, sewing foot height, transfer or deflection gears, levers, etc., especially when these are not defined or definable unambiguously through other parameters. According to the construction of the sensor device, translation movements and/or rotational movements can be detected and processed in one, two, or three dimensions. The measurement parameters detected by the sensor or sensors can be used for controlling or regulating these parts.

[0024] A sensor arranged suitably on the sewing machine (e.g., in the needle plate 27) can be used for measuring material lengths, e.g., instead of a ruler, wherein preferably switch-over means are provided, with which the desired application purpose of the sensor can be selected. Here, the sensor can be fixed to the machine or freely movable and connected to the machine controller via a wired or alternatively a wireless communications connection, in order to

detect the relative movement between sensor and sewing material (or a different pattern).

[0025] For detecting and storing movements of the sewing material or, in general, a pattern, the sensor can be integrated, e.g., in a sewing foot and connected to storage means. Then a learning mode can be activated and a pattern can be scanned by detecting means on the sewing machine. The detected movements can be stored in the memory, which is integrated, e.g., in the sewing foot or which is provided in the machine controller, or which is arranged outside of the sewing machine, and recalled later, e.g., in connection with an embroidery module.

[0026] The light sources of the sensors emit at least approximately monochromatic light. According to the object to be detected, they can be arranged spatially close to each other, preferably on a common chip, or at a greater spacing relative to each other. They can be directed onto the object to be detected such that the intersection points or areas on the object surface lie close to each other (e.g., within a few millimeters) or are spaced apart from each other. To prevent mutual interference between several sensors, they can be driven using a clocked method, e.g., in a given sequence, or several light sources with different frequencies can be used. For bundling or collimating the light beams, optical elements, such as lenses, mirrors, or grating structures can be used, wherein these elements can be used separated for each of the light sources or in common for two or more of the light sources—according to the position of the individual light sources. For detecting and evaluating the parameter fluctuations, a detection device is allocated to each of the light sources. For several detection devices, these also can include common parts, e.g., one evaluation unit for alternating or parallel processing of the individual measurement parameters. The “self-mixing” effect allows a very compact and space-saving construction of the sensors, because the detection device is coupled directly with the light source and can be integrated together with the light source on a common chip, and because the transmission beam and the detection beam are influenced by a common optical system. The evaluation unit for processing the detected signals is preferably also integrated on the chip and freely configurable or programmable. An external controller is not absolutely necessary and the sensors can be easily adapted to different tasks. It is also possible to arrange the optical system directly on the chip and to connect it rigidly to this chip directly or indirectly. In this way, additional optical elements and associated calibration work can be eliminated. The spatial requirements are thus extremely small.

[0027] The detectors, which detect the intensity fluctuations in the laser resonator, can be constructed as photoelectric detectors, wherein preferably photodiodes are used, which are already placed on a rear resonator mirror for a laser diode and are used conventionally for maintaining the laser output.

[0028] The device according to the invention and the method according to the invention can be used for sewing machines, embroidery machines, quilting devices, and the like for detecting and controlling or regulating different movements. Alternatively or additionally, such detected movement information can also be stored and recalled at a later time. This is especially advantageous for the detection of sewing and embroidery patterns. Usually, the detection device is arranged, at least in part, stationary in the vicinity of a movable machine part or sewing object to be detected.

Alternatively or additionally, the detection device or the detection optics can also be moved relative to an object to be detected, for example, when they are integrated into a stylus or other corresponding input means for detecting patterns or sewing processes. In this case, the detection device can be connected to a sewing machine controller or a data recording device, e.g., via radio or a communications line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The invention is described in more detail below with reference to a few figures. Shown are:

[0030] FIG. 1 is a block diagram for illustrating the movement recording in a sewing machine using a self-coupling laser Doppler interferometer,

[0031] FIG. 2 is a side view of a partially cut-away hook with bottom thread bobbin set therein,

[0032] FIG. 3 is a detail view of a sewing machine in the area of the stitch forming device with sensors integrated into the needle plate,

[0033] FIG. 4 is a view of a sewing foot with integrated detection device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] In FIG. 1, the principle function of detecting movement using a self-coupling laser Doppler interferometer is shown. As the light source 1, a laser—preferably a semiconductor laser—generates coherent light, which is amplified in a cavity or a resonator 3 with a front, semi-transparent mirror 5 and a rear mirror 7. At the front mirror 5, the decoupled coherent light is bundled by one or more optical elements, for example, by a collection lens 9, into a light beam or a transmission beam 11. This beam intersects an object 13 to be detected and is scattered there at least partially. A portion of the scattered light is reflected back in the direction of the laser as reception beam 15. There it passes through the optical elements and then enters into the resonator 3 again through the mirror 5. The light coupled in this way back into the resonator 3 interferes with the light amplified in the resonator 3, as is known, e.g., from WO-A1-02/37410. This interference phenomenon affects the amplification of the laser and the intensity of the light or transmission beam 11 generated by the laser. The intensity of the transmission beam 11 has minimum and maximum values as a function of the range. If the object 13 (or the area of the object surface, where the transmission beam 11 intersects the object 13) moves with a velocity featuring at least one positive or negative component in the propagation direction of the transmission beam 11 (in other words, comprises a component in the same or opposite direction of propagation), then the frequency of the reception beam 15 changes a little due to the Doppler effect. By evaluating the intensity fluctuations, for example, by means of a photodiode 17 arranged behind the rear, only slightly semi-transparent laser mirror 7, the component of the object velocity in the direction of the transmission beam 11 can be determined. Such photodiodes 17 are used conventionally for maintaining the intensity of the laser light. Through time integration of the velocity components detected in one or more directions, ranges or changes in position or orientation can be determined. In WO-A1-02/37410, on pg. 11, line 8 to pg. 15,

line 22, several methods are explained, how the magnitude of a velocity component and its sign or direction could be determined.

[0035] In particular, it is noted that the direction of movement can be determined based on the asymmetry of the functions $f(L)$ or $g(L)$, where f is the frequency of the laser, g is the amplification in the laser resonator 3, and L is the object range from the front resonator mirror 5.

[0036] Even with real, transparent and reflective objects 13, as a rule a small portion of the incident light is scattered diffusely. So that this portion is sufficiently large for an evaluation of the fluctuations based on the self-coupling effect, the surface of the machine or accessory parts to be detected can be roughened or coated, e.g., whereby the diffusely scattered portion of the laser light is increased.

[0037] In the example of FIG. 1, the object 13 to be detected is a bottom thread bobbin that can rotate about a bobbin axis 19. The transmission beam 11 intersects the flange surface at the edge area of the front bobbin flange 21 at an angle of incidence α . Here, the transmission beam 11 has at least one directional component corresponding to the surface velocity v_A of the flange surface at the intersection position A. The transmission beam 11 is preferably oriented so that its directional component is relatively large in the direction of the surface velocity v_A at the intersection position A. During the operation of the sewing machine, the bottom thread bobbin, as shown in FIG. 2, is set in a bobbin cartridge 23 and together with this cartridge into the hook 24, which is arranged in the bottom arm 25 of the sewing machine underneath the needle plate 27 in a hook housing 29 (FIG. 3).

[0038] The remaining parts of a commercially available hook 24, like the hook body 28, the pinion 30 sitting on the drive shaft 31, as well as the thread catch plate 32, are not described in more detail.

[0039] The bottom thread bobbin can be detected from different directions according to the visibility of the respective hook arrangement. In particular, the front flange 21 or the rear flange 21' of the bobbin can be detected from the front or from the back or radially from the outside. Alternatively, the sensor or sensors can be integrated into the drive shaft 31 of the hook 24 (not shown) and the rotational movement of the bobbin relative to this shaft can be detected, in that the sleeve-like bobbin spindle or core 33 (FIG. 1) is scanned from the inside out. The sensor or sensors can be arranged, e.g., on the bobbin cartridge 23 or within the hook housing 29. For the arrangement of a sensor on the bobbin cartridge 23 or on the hook 24, the power supply and communication to the sensor can be guaranteed, e.g., via sliding contacts (not shown) on the drive shaft 31. For detecting the rotational movement of the bobbin from the hook housing 29, in the bobbin cartridge 23 there can be openings 26, through which the bobbin can be scanned. It is also possible to arrange several sensors distributed in a ring shape around the bobbin shaft 19 of the inserted bobbin in the hook housing 29 (not shown), so that at least one of these sensors can always detect the bobbin through the opening 26 in the bobbin cartridge 23, even when the bobbin cartridge 23 is also turning. In this case, the sensor electronics or the controller evaluates the different sensor signals and takes into account only those signals detecting the bobbin movement at the respective time.

[0040] During operation, the bottom thread bobbin has only a single degree of freedom, namely the rotational

movement about the bobbin shaft 19. Therefore, in a suitable arrangement, a single sensor is sufficient with only one transmission beam 11, in order to detect this movement unambiguously. The electronics or controller necessary for evaluating the sensor signals can be integrated partially or completely in the sensor or can be included partially or completely in the machine controller. Here, preferably a non-volatile storage medium is provided (not shown), in which, if necessary, information on the object 13 to be detected, its position, orientation in space, and its possible movements, as well as the arrangement of the sensor or sensors, can be stored. In connection with such stored information, the controller can determine the associated movements, positions, etc., of the detected object 13 from the sensor signals. In an arrangement according to FIG. 1, the direction of the object movement at the intersection position A can be broken down into several components, of which one has the direction of the transmission beam 11. Then, e.g., the ratio of these movement components to the total object movement, as well as the distance r_A of the intersection position A from the bobbin shaft 19 can be stored in the memory (FIG. 1). Thus, the controller can calculate the rotational velocity $\omega = 2\pi/T = v_A/r_A$ of the bottom thread bobbin unambiguously from the detected sensor signals while incorporating the stored data.

[0041] Analogously, any movements in objects 13 with several degrees of freedom can also be detected by several sensors or by sensors with several transmission beams 11, wherein the transmission beams 11 intersect the object 13 in various directions. The number of degrees of freedom of movement determines the number of transmission beams 11 necessary for an unambiguous detection of the object motion.

[0042] For detecting small objects 13, two or more light sources 1 can be arranged close to each other on a common chip or substrate, wherein the respective transmission beams 11 are preferably emitted from different sides through a common optical system 9 in the direction of the respective object 13 to be detected. Alternatively, several transmission beams 11 can also be emitted independent from each other from different directions onto the object 13. If the individual light sources 1 are separated from each other spatially, object movements can also be detected from a greater range (e.g., 10 cm to 15 cm). The optical elements 9 can be constructed, so that the transmission beams 11 are not sharply focused onto a point, but instead have a slight lack of focus over a greater area. In the propagation direction, such transmission beams 11 have a uniform or only slightly varying beam diameter within the usable measurement area. In this way, object movements in the direction of the transmission beam 11 can also be detected reliably, because the intensity of the scattered light component, which is coupled back into the resonator 3, varies only slightly for such movements.

[0043] For further constructions of the invention, other objects 13 are detected by one or more sensors, e.g., sewing machine parts, such as sewing needles, needle holders, material presser foot, feed dog, hook, bottom thread bobbin, embroidery hoop, etc., or objects 13 or components to be processed, e.g., the sewing material or—for several sewing material layers—the top-most and/or the bottom-most sewing material layer, the top thread or the bottom thread. The sensors are arranged at suitable positions of the sewing or embroidery machine accordingly.

[0044] FIG. 3 shows a section of a sewing machine in the region of the stitch-forming unit. Here, three openings 35 (alternatively also only one or two openings could be provided) are formed in the needle plate 27 with optical elements arranged in these openings. These optical elements can include, e.g., windows that are transparent for the light of the light sources 1 and that are set flush with the top side of the needle plate 27 in the openings 35. Alternatively or additionally, the optical elements could also include collection lenses 9 (FIG. 1). For convex lenses 9, the curvature can project slightly past the plane of the needle plate 27. Underneath the lenses 9, the sensors are arranged with the light sources 1. Under each of the lenses 9, one or more sensors can be arranged. Preferably, in the region of each of the openings 35 there are two sensors each with a light source 1 (FIG. 1), so that the transmission beams 11 generated by the light sources 1 intersect the sewing plane in different directions, preferably in the sewing direction y and in the transverse direction x, from below at an angle of incidence α (FIG. 1) on the order of magnitude from approximately 15° to approximately 75° to the sewing material. Obviously, the two transmission beams 11 can also intersect the sewing material at different angles of incidence α . By evaluating the signals of two such sensors, movements within the sewing plane can be detected. For a refinement of the invention, a third sensor can be provided, wherein its transmission beam 11 preferably intersects the sewing material at an angle of incidence α of 0°—that is, vertical. Alternatively, the transmission beam 11 of the third light source 1 can also intersect the sewing material at a different angle of incidence α . This should differ as much as possible, however, from the angles of incidence α of the other transmission beams 11. By evaluating the signals of the third sensor—if necessary, under consideration of the signals of one or more other sensors—relative movements of the sewing material surface vertical to the sewing plane can be detected, as can occur, for example, in the area of seams or edges of the sewing material or due to the lifting movements of the feed dog.

[0045] So that rotational movements of the sewing material can be detected and distinguished from displacements in the sewing plane, the sewing material surface can be detected by several sensors at different positions, e.g., in the region of two openings 35. The openings 25 with the sensors can be arranged, for example, on one side or on two sides of the needle piercing opening 37 in the needle plate 27 and/or in front of or behind the needle piercing opening 37 viewed in the sewing direction y. Its mutual distance is large enough with a few centimeters that rotational movements can be distinguished from linear displacements and small enough that errors due to possible draping of the sewing material are minimal.

[0046] In FIG. 3, additional elements are visible at the bottom on the sewing machine head 39, especially a sewing foot 41 held on a material presser rod 43 with articulated sewing foot sole 42 and a needle bar 45 with sewing needle 47 set therein, and also a section of the top thread 49, which is suspended in a thread guide 51 on the needle bar 45.

[0047] The detection of movements or changes in position of the sewing material in the region of the needle piercing position can be used, e.g., for recognizing deviations in the actual sewing material movement from a given sewing material movement and for regulating the transport device (e.g., feed dog or embroidery hoop). In a different applica-

tion, namely freehand quilting, the transport device is not active. The sewing material is guided by hand. With the help of the material movement detected by the sensors, the stitch-forming unit can be driven, so that needle stitches are set in the sewing material at uniform intervals of the piercing positions—independent of the sewing material velocity. In another application, the detection device can be used to detect and to store a sewing pattern. With reference to the stored data, this sewing pattern can be reconstructed at a later time (for example, under the use of an embroidery hoop) as many times as needed. For detecting patterns for sewing and embroidery machines, the sensor device can also be integrated alternatively in a stylus or an equivalent scanning device. For scanning the pattern, the pattern remains at rest and the stylus is moved relative to the pattern.

[0048] In another construction of the invention, sensors are installed in the sewing foot 41 or in a sewing foot sole 42, as shown schematically in FIG. 4. There, for the sake of better clarity, only one laser light source 1 and one collection lens 9 are shown. The electronics for detecting and evaluating the sensor signals are integrated in common with the light source 1 on a chip 53. The electronics of the sewing foot 41 can be connected, e.g., by a cable plug 55 to the controller of the sewing machine (not shown). Alternatively, the connection between the sewing foot and machine controller can also be realized in other ways, for example, by spring contacts between the sewing foot 41 and material presser bar 43 or by a wireless communications connection.

[0049] For detecting the sewing material movement from above or for detecting movements of sewing machine parts in the region of the machine head 39, sensors—with correspondingly adapted optics—can also be arranged directly next to or underneath the machine head 39.

[0050] In another construction of the invention, at least one sensor is arranged on the sewing machine so that it can detect the take-off velocity of the bottom thread or the top thread, that is, in the region of the thread guide 51, it is connected rigidly, for example, to the moving needle bar 45 or at the upper arm of the sewing machine in the region of a spring-like or elastic thread tensioning device (not shown) or in the region of the bobbin carrier for the top thread bobbin (not shown). Because both the top thread and also the bottom thread are taken off in jerk-like motions during the sewing, in the respective evaluation electronics, there can be a processing step for smoothing these signals or for continuous average value calculation. Integrating the detected velocity measurement parameters gives the amount of thread. If the amount of thread located on the thread bobbin is stored, then this value can be updated continuously. In particular, the sewing process can be stopped before reaching the end of the thread.

[0051] In embroidery hoops, large acceleration values can occur, which lead to vibrations in the moving masses. Consequently, the piercing positions of the sewing needle into the sewing material can be incorrect. Because high velocities and accelerations can be detected with the movement detection device according to the invention without significant delay, this is excellently suited to detecting movements of the embroidery hoop and for regulating the embroidery hoop drives. The control algorithm can be realized so that disruptive vibrations of the hoop are prevented or minimized. Instead of the frame, the sewing material in the embroidery hoop can also be detected. Here, it must be taken into account that the sewing material

clamped in the embroidery hoop is also elastic and passive and thus can be excited into vibrations within the embroidery hoop.

[0052] In the proposed method for movement detection, a minimum relative velocity between the sensor and the object 13 to be detected is necessary. For reliable detection of very slow movements, a conventional device for detecting changes in position can optionally be provided, which evaluates, for example, changes in orientation of features of the object surface by means of image processing.

[0053] The term “sewing machine” is to be interpreted broadly and also includes quilting devices, embroidery machines, or other stitch-forming devices or devices suitable for joining flat textiles.

LEGEND OF REFERENCE SYMBOLS

[0054]

1	Light source
3	Resonator
5	Front mirror (semi-transparent)
7	Rear mirror
9	Collection lens (in general, optical elements)
11	Transmission beam
13	Object to be detected
15	Reception beam
17	Photodiode
19	Bobbin shaft
21	Front bobbin flange
21'	Rear bobbin flange
23	Bobbin cartridge
24	Hook
25	Lower arm
26	Openings in bobbin cartridge
27	Needle plate
28	Hook body
29	Hook housing
30	Pinion
31	Drive shaft
32	Thread catch plate
33	Bobbin spindle or core
35	Openings
37	Needle piercing opening
39	Sewing machine head
41	Sewing foot
42	Sewing foot sole
43	Material presser bar
45	Needle bar
47	Sewing needle
49	Top thread
51	Thread guide
53	Chip
55	Cable plug
α	Angle of incidence
A	Intersection position
v_A	Surface velocity at intersection position
r_A	Distance of intersection position from bobbin shaft

1. Sewing machine with a device for detecting movements, comprising at least one light source (1) that emits coherent light, an interference detector allocated to the light source (1), the interference detector is constructed for detect-

ing a measurement parameter that characterizes an interference between reflected light from the light source (1) that is scattered by an object (13) to be detected and the light emitted from the light source (1).

2. Sewing machine according to claim 1, wherein the light source (1) comprises a laser with a resonator (3), an optical system (9) is provided for influencing a transmission beam (11) and the optical system (9) is simultaneously constructed for collecting and re-coupling the reflected light of the light source (1) that is scattered by the object (13) into the resonator (3), and the interference is created in the resonator (3).

3. Sewing machine according to claim 2, wherein the device comprises several light sources (1), the arrangement of the light sources (1) and a construction of the optical system (9) are such that transmission beams (11) of the light sources (1) intersect a surface of the object at different angles of incidence (α).

4. Sewing machine according to claim 1, wherein the device for detecting movements is integrated at least partially into a sewing foot (41) or a sewing foot sole (42).

5. Sewing machine according to claim 1, wherein the device for detecting movements is arranged at least partially in a hook housing (29) inside or underneath a needle plate (27) or on or underneath a sewing machine head (39).

6. Sewing machine according to claim 1, wherein the device for detecting movements comprises a programmable or configurable evaluation unit.

7. Sewing machine according to claim 1, wherein the device comprises a memory for storing information about the objects (13) to be detected and/or movements of the objects (13) and/or an arrangement of sensors.

8. Method for detecting movements in a sewing machine, comprising:

using one or more light sources (1) to emit coherent light in a direction of an object (13) to be detected,

detecting scattered light of these light sources (1) that is scattered by the object which then forms an interference with the light of the respective light source (1), wherein, when the object (13) moves, the scattered light undergoes a frequency shift that is dependent on the object movement due to the Doppler effect, and for each of the light sources (1), and

determining and evaluating a measurement parameter, which changes as a function of the interfering light.

9. Method according to claim 8, wherein processing of the detected measurement parameter or the detected measurement parameters is performed using stored information on the object (13) to be detected and/or its degrees of freedom in terms of movement and/or using information obtained from other known measurement parameters.

10. Method according to claim 8, further comprising the determining and evaluating step including determining velocities and/or movement directions and/or absolute or relative orientation or position vectors from the measurement parameter or parameters.

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