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(54) A CONVEYOR SYSTEM

(57) The invention relates to a conveyor system comprising a measurement system. The measurement system comprises a sensing head and a microwire sensing element. Sensing element is embedded into a conveyor component and disposed in a non-contact manner within an operational range of the sensing head. Measurement system determines an operating condition of the conveyor component by means of the sensing element and the sensing head.

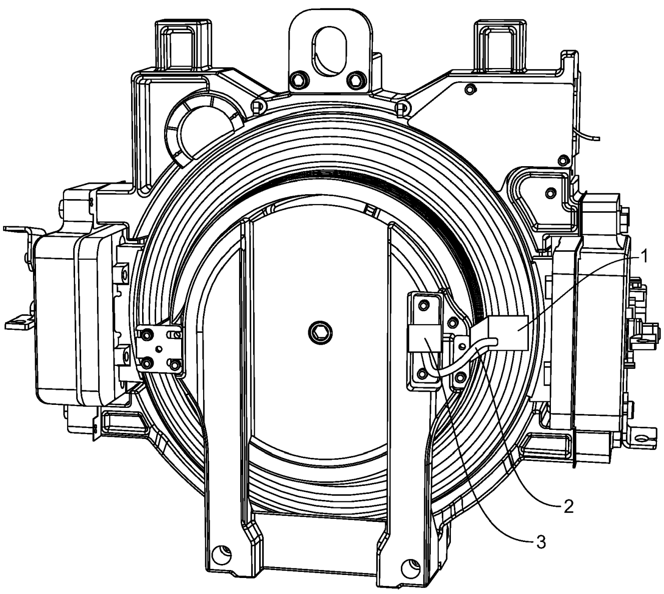

FIG. 1

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Description

FIELD OF THE INVENTION

[0001] This invention relates to conveyor systems utilizing non-contact measurement systems, and in particular to elevator systems, escalator systems or travelator systems.

BACKGROUND

[0002] Modern conveyor systems, in particular elevator systems have a rising amount of safety features, digitalization, diagnostics, and embedded functionality. Thus they may require an increasing number of control units, sensors and cabling. Therefore they may become complex, expensive and/or laborious to maintain and/or install.

SUMMARY

[0003] An object of the present invention is to solve the above-mentioned drawback and to provide a conveyor system with an improved measurement system, which is cost-efficient, simple and/or easy to install. This object is achieved with a conveyor system according to independent claim 1. Preferred embodiments are disclosed in the dependent claims.

[0004] According to an aspect, a conveyor system is provided. The conveyor system comprises a plurality of conveyor components and a measurement system. The measurement system comprises a processing unit, a wireless sensing head and a magnetic microwire sensing element, which is responsive to a physical phenomena when exposed to said physical phenomena.

[0005] The sensing element comprises a metal, preferably ferromagnetic core, and it is embedded into a conveyor component and located within an operational range of the sensing head to measure a physical quantity.

[0006] The sensing head comprises an excitation coil configured for generating a magnetic field as an excitation signal, to cause propagation of a magnetic domain wave, i.e. a magnetic wall, throughout the microwire sensing element. The sensing coil is configured for sensing a response caused by said magnetic domain wave.

[0007] Further, the measurement system is configured to determine the physical quantity based on said response, and to determine an operating condition of the conveyor component based on said physical quantity.

[0008] Said response may be a response signal induced in the sensing coil due to propagation of the magnetic domain wave.

[0009] According to an embodiment, the measurement system is configured to register an amplitude of the response signal, to determine the physical quantity based on said amplitude, and to determine an operating condition of the conveyor component based on said physical quantity.

[0010] According to an embodiment, additionally or alternatively, the measurement system is configured to register a pulse width of the response signal, to determine the physical quantity based on said pulse width, and to determine an operating condition of the conveyor component based on said physical quantity.

[0011] According to an embodiment, additionally or alternatively, the measurement system is configured to register a time difference between the excitation signal and the response signal, to determine the physical quantity based on said time difference, and to determine an operating condition of the conveyor component based on said physical quantity.

[0012] Preferably, the physical quantity is one of temperature, pressure and magnetic field.

[0013] Preferably, the sensing coil is located concentrically to the excitation coil, and the processing unit, or at least part of, it is located in the sensing head and connected to the excitation coil and the sensing coil. Preferably, the sensing coil is located inside of the excitation coil.

[0014] Preferably, the microwire sensing element has a very cost-efficient structure, comprising a metal wire, preferably made of ferromagnetic material and having a diameter of 1 to 100 microns, covered by a glass insulator.

[0015] According to an aspect, the conveyor system is an elevator system, and the conveyor component is an elevator component.

[0016] The elevator component may be e.g. a permanent magnet motor of an elevator hoisting machine, a machinery brake, an elevator safety gear, a hoisting rope, a sliding guide shoe of an elevator car or a counterweight and / or a position detection device of an elevator car.

[0017] According to another aspect, the conveyor system is an escalator system or a travelator system and the conveyor component is an escalator component or a travelator component.

[0018] The escalator component or the travelator component may be e.g. a handrail of the escalator system / travelator system, an step of an escalator system or a pallet of a travelator system and / or a comb plate of an escalator system or a travelator system.

[0019] The measurement system enables reading of more than one sensing elements with the same sensing head. Preferably, at least two sensing elements may be embedded into the same conveyor component and/or located within an operational range of the same sensing head to achieve a very cost-efficient measurement system.

BRIEF DESCRIPTION OF DRAWINGS

[0020] In the following the present invention will be described in closer detail by way of example and with reference to the attached drawings, in which

Figure 1 illustrates a hoisting machine, provided with a measurement system according to an exemplary embodiment.

Figures 2 illustrates wear depth monitoring in in connection with a bottom of semicircular groove undercut of a pulley or a traction sheave of an elevator hoisting machine.

Figure 3 illustrates a rope force and load weighing device according to an exemplary embodiment.

Figure 4 illustrates sliding guide shoe monitoring according to an exemplary embodiment.

Figure 5 illustrates car floor position detection according to an exemplary embodiment.

Figure 6 illustrates a response signal induced in the sensing coil due to propagation of the magnetic domain wave.

DESCRIPTION OF EMBODIMENTS

[0021] Base idea of the disclosure is conveyor system, in particular an elevator system, an escalator system or a travelator system, equipped with a new kind of advanced contactless measurement system for e.g. temperature, pressure and/or magnetic field sensing. The measurement system has a processing unit, a wireless sensing head and a magnetic sensing element referred to as "microwire sensing element" or "microwire". One or more microwires have been embedded into at least one conveyor component.

[0022] Microwire is a passive, extremely small (about 100 micrometers) sensor which consists of a magnetic metal wire inside an insulating glass sheath. It is read in a non-contact manner by means of the sensor head, which has an excitation coil and a sensing coil. Excitation coil generates magnetic waves, also referred to as magnetic walls, causing a voltage spike to the sensing coil when the wave propagates through the microwire. Timing, amplitude and/or width of the spike may be dependent on physical phenomena effecting on the microwire. Several microwires with dedicated time slots for the spike may be arranged to be read simultaneously with same sensing head. Basic structure of a microwire element has been disclosed in document EP 3150998 B1.

[0023] Different aspects of the disclosure are directed to providing integrated functions for operational monitoring, as well as state feedback, healthy, and components' condition-based maintenance to reduce need for human interventions and to communicate becoming replacements with the customer. This can mean integrated functions for operational monitoring, and state feedback, healthy, and components' condition-based maintenance to reduce need for human interventions and to communicate becoming replacements with the customer.

[0024] The microwire is enabling new range of contactless measurements in area of elevator in control and condition-based measurement domain. Microwire is μm scale metallic wire coated by class shielding with unique characteristics in magnetic excitation, which correlates physical quantities such as for temperature, pressure, and magnetic field. Indirectly by using these physical quantities we can measure items such as position, electrical current, force, and presence. This technology enables new range of applications within a conveyor system which have not been possible by using existing measurement methods. Base phenomena on the microwire measurement are magnetic domain wave propagation time measurement which is affected by previously mentioned physical quantities. Probation wave is only sensitive for specific magnetic field resonance frequency which also enables usage of these sensors under high magnetic field and even dynamic ones.

[0025] Microwire system consists of three main components. Microwire, sensing head and MCU for reading signals. Microwire part is the part, which is under effect of physical phenomena under interest, sensing head (could be called also as antenna) which consists excitation coil and sensing coil for propagation wave measurement and MCU unit which registers a time difference between the excitation and response from propagation wave, and/or an amplitude and/or pulse width of said response. Microwire element can be read contactless from distance up to 10cm from sensing head. Distance between sensing head and MCU can be longer than that. Microwire is not needing any additional power than what is provided by sensing head.

[0026] Figure 6 shows a response signal induced in the sensing coil due to propagation of the magnetic domain wave, as a function of time t. Response signal, as caused by the magnetic domain wave (i.e. propagation wave) propagating throughout a microwire is induced in the sensing coil together with the excitation voltage v, caused by the excitation coil. The measurement system is configured to register a time difference 10 between the excitation signal and the response signal (in Fig. 6 excitation signal is generated at t = 0) and/or an amplitude 8 of the response signal and/or a pulse width 9 of the response signal. Further, the measurement system is configured to determine a physical quantity, to which the microwire is exposed in the conveyor component, based on said amplitude, pulse width and/or time difference, and to determine an operating condition of the conveyor component based on said physical quantity.

[0027] First major problem which microwire sensing element solves is possibility to have contactless low-cost measurement for temperature, pressure, and/or magnetic field in a moving object. As described above, microwire sensing element provides an opportunity to measure without need of extra measurement electronics or wirings on moving part.

[0028] Second problem which microwires solve is cost of multiple measurement points in object. Since traditional sensing elements are more expensive than microwires and they always need own cabling, in case of multiple measurement points cost is increasing when we are having more measurement points. Since with microwires we don't need to have wires for measurement elements and multiple microwires can be read and identified by one sensing head, cost of multiple measurements points is relatively low.

[0029] Third problem, which microwire element solves is location of measurement. Today measurements with traditional measurement elements are restricted by need of wiring and space. This is restricting us to implement measurements to points which are most interested from application point of view, but where the point is physically in challenging location. Since microwire elements are small and they are not needing any wiring, we can implement measurements to locations which have been previously impossible.

[0030] Microwire elements open various possibilities and in this disclosure we will give several implementation examples. First new opportunity is possibility to directly monitor magnet temperatures on hoisting machine's rotor. This would enable us to extend machine's range of use heavily because currently machine temperatures are kept under safety marginals to avoid magnet's demagnetization on conditions where rotor temperature has elevated over demagnetization threshold limit.

[0031] Also machine related problem is cost effective brake temperature and force monitoring. With microwires we can implement force and temperature measurement with low-cost since we can measure all the quantities with one sensing units.

[0032] Microwires can be used for sensing of mechanical components wear, temperature, pressure, and distances between moving objects, like car and counterweight. These potential applications are listed and described later. In parallel with direct measurement of physical property, worn and disappeared microwires can be used as an indicator of wear dept of surrounding material.

[0033] In traditional systems amount of measurement points has been limited to avoid extra costs for wiring and measurement electronics and there for valuable information from application condition is missing.

[0034] Microwire sensing element is cost effective. Microwire element cost is fractions from the traditional measurement methods. Receiver side can be manufactured with low cost and cost can be reduced even more by reading multiple sensing element with one receiver. To combine multiple functions in elevator system, location of active readers could be preferably in car sill, machinery and above main floor at guide rails.

[0035] By design of the metallic wire of microwire sensing element we can affect in a way that different microwires are identifiable with one receiver unit.

[0036] Since measurement is contactless, sensing element can be embedded to moving parts without need of additional signal wiring or conversion. This opens new measurement opportunities where we have not had possibility to measure signals under interest with reasonable cost.

[0037] In the following, measurement system utilizing microwire sensing elements is disclosed in connection with embodiments related to elevator systems. It is to be understood, that the measurement system may be used in an analogous manner for measuring other conveyor systems, in particular escalator systems and travelator systems as well.

[0038] Figure 1 illustrates a hoisting machine, provided with a measurement system according to an exemplary embodiment.

1. Hoisting machine's rotor temperature measurement.

[0039] Microwires provide an economical method to measure rotor magnets. Microwires can be read through metallic objects. This enables us to measure rotor magnet temperature through cast iron rotor body. One possible utilization location could be as shown in Figure 1.

[0040] Sensing head 1 is mounted to a support structure 2, which enables us to go near to the rotor surface and to the position which enables usage of same sensing head in other embodiments 2, 3, 4, 5, and 6 described down below. MCU 3 translates microwire signal to digital value signal.

[0041] By using this measurement system, we can extend current machine utilization since greater output requirement from hoisting machine is raising temperatures also rotor side. Too hot temperature in the rotor can cause magnet demagnetization. This is severe malfunction for hoisting machine (machine need to be replaced). Due to accurate information of magnet temperature, we can remove safety margins which have implement to protect machine against demagnetization

2. Machinery brake temperature supervision

[0042] Microwire enables us cost effective wireless method to monitor machine brake temperature. Both in magnet coil, but also brake pad temperature measurement is possible and cost effective to be done. Brake pad temperature measurement indicates if brake has performed proper release of hoisting machine brake. If brake is not correctly releasing or it is doing it partially, it will directly rise temperature at brake pad due friction between brake wheel and brake pad

3. Machinery brake state (release and close)

[0043] Since with microwire we can also measure pressure with different wire structure, implementation of brake release and close state monitoring becomes cost effective. Extra cost for this application is sub euro level if we have already available sensing head on near proximity. There are multiple possibilities to implement brake state monitoring with pressure sensor, but one example could be direct implementation to brake pad.

4. Machinery brake normal force and brake operation

[0044] By using linearization and calibration of pressure measurement in brake pad we could measure brake force directly from machine brakes. This could omit LWD device. One possible implementation could be by adding pressure sensing microwires on each end of brake pad. On loading condition, we see difference between these sensors which is having information of car weight inside it.

5. Machinery brake pad wear depth

[0045] Brake pad wearing monitoring can be done by monitoring of and identifying different microwires implemented into the brake pad. Wires shall be cast to different depths. When it is identified, that wires in specific depths are missing, we know that wear must be greater than that. This enables us to proactively react pad wearing. This innovation can be also directly used to safety gear brake pads where proper wear detection is safety critical. This innovation is described more in detail in next chapter.

6. Safety gear braking pads wear dept and temperature supervision

[0046] In the similar manner as described above, microwires can be embedded into brake pad to 1-3 different depths. Wearing of brake pad can then be monitored when microwires wear out.

[0047] Also, by monitoring temperature during safety gear operation (if system is just powered) it can differentiate safety gear testing (required by elevator standards) from real harsh safety gear stop. With this way, real number of safety gear operations can be counted and differentiated from tests. Normally, tests are not causing significant wear of brake pads and currently number of harsh stops are limited by KONE internal instructions for safety gears.

[0048] Use of this option requires additional sensing heads or sensing coils close to safety gears.

7. Groove wear depth

[0049] Fig. 2 shows sensing elements with wearing microwires at the bottom of semicircular undercut groove (left) and V-groove of traction sheave or OSG pulley (right) The first alternative is to use microwire technology and active sensor, which enables wear depth monitoring when microwires are embedded to wear element which is glued to the bottom of semicircular groove undercut. For V-grooves, it can similarly set to the bottom V or undercut V groove. Same can be done also for OSG V-grooves. Object which is glued or laminated can have multiple microwires with specific depth. It allows monitoring which interpolate wear speed when microwires wear out one per one.

[0050] The second alternative is to mill perpendicular slot to semicircular groove, where 1 to several microwires are fixed (glued, laminated, etc.) to specific depth. When groove wears slowly, then microwires wear out one per one.

8. Rope force and load weighing device (with compression pressure)

[0051] Figure 3 shows a compression element 4 in a rope terminal, where microwire is embedded and sense compression force of each rope. Microwire primary physical function offers sensing of pressure. This feature can be used for monitoring of rope or/and car load, if microwire is set between compressive surfaces of embedded into elastic material which behaves about linearly by transmitting compression force to the compression of microwire(s). One active reading sensor can read simultaneously many ropes equipped with pressure elements made with microwires.

9. Sliding guide shoe wear depth, shoe force with pressure, and shoe temperature

[0052] Figure 4 depicts a sliding insert 5 with embedded microwires for pressure sensing and wearing off. Microwires embedded into sliding guide shoe slider material offer possibility to sense wear of the sliding insert and its contact pressure. Microwires can be set inside of sliding insert mold and positioned close to all three wear surfaces, or thin machined slots can be milled to the molded sliding insert. Active reading sensor can detect all of them if they are still existing there, and what is the pressure of each microwire. Differentiation of each microwires can be done through their distance from the reading element as well as per their length.

[0053] Additional information for expected shoe lifetime reduction is temperature measurement. Sliding temperature generates more energy to be absorbed by shoe material. It is result of elevated friction or higher normal force. When pressure sensing shows level of normal force, then higher friction can be concluded as a root cause alone, and service need for shoes/guide rails lubrication can be initiated.

10. Car floor position detection and generic limit switch / distance to pit and overhead

[0054] Figure 5 shows microwire elements on each landing level for accurate positioning of an elevator car. Car position can be detected when car is either by-passing the floor, or decelerations and stopping on the floor level. There, also car sag of load change can be detected and changed car position for re-levelling initiation can be provided to elevator controller.

[0055] When car is stopped on landing level, distance changes to sill can be observed too. This could sometimes be important, e.g. when loading/unloading car to avoid too large deflections of sling - guide shoes - guide rail which are result of tilt forces and may cause too short sill-to-sill gap. At both ends of shaft, microwires can be positioned such ways where active reading sensor can detect the position in overhear or in the pit. Max. reading distance can be compensated with multiple microwires placed in the shaft.

[0056] It is to be understood that the above description and the accompanying figures are only intended to illustrate the present invention. It will be obvious to a person skilled in the art that the invention can be varied and modified without departing from the scope of the invention.

Claims

1. A conveyor system, comprising:

   a plurality of conveyor components; and
   a measurement system, comprising:

      a processing unit;
      a wireless sensing head;
      a magnetic sensing element having a metal core, which sensing element is embedded into a conveyor component and located within an operational range of the sensing head to measure a physical quantity;
      wherein the wireless sensing head comprises
      an excitation coil configured for generating a magnetic field as an excitation signal, to cause propagation of a magnetic domain wave throughout the sensing element; and
      a sensing coil configured for sensing a response caused by said magnetic domain wave;
      wherein the measurement system is configured
      to determine the physical quantity based on said response, and
      to determine an operating condition of the conveyor component based on said physical quantity.

2. The conveyor system according to claim 1, wherein said response is a response signal induced in the sensing coil due to propagation of the magnetic domain wave,

   and wherein the measurement system is configured to register

      - an amplitude of the response signal,
      - a pulse width of the response signal, and/or
      - a time difference between the excitation signal and the response signal,

   to determine the physical quantity based on said amplitude, pulse width and/or time difference, and
   to determine an operating condition of the conveyor component based on said physical quantity.

3. The conveyor system according to any of the preceding claims, wherein the conveyor system is an elevator system, and the conveyor component is an elevator component.

4. The conveyor system according to claim 3, wherein the elevator component is an permanent magnet motor of an elevator hoisting machine.

5. The conveyor system according to claim 3, wherein the elevator component is a machinery brake.

6. The conveyor system according to claim 3, wherein the elevator component is an elevator safety gear.

7. The conveyor system according to claim 3, wherein the elevator component is a hoisting rope of an elevator.

8. The conveyor system according to claim 3, wherein the elevator component is a sliding guide shoe of an elevator.

9. The conveyor system according to claim 3, wherein the elevator component is a car position detection device.

10. The conveyor system according to claim 1 or 2, wherein the conveyor system is an escalator system or a travelator system and the conveyor component is an escalator component or a travelator component.

11. The conveyor system according to claim 10, wherein the component is a handrail of the escalator system / travelator system.

12. The conveyor system according to claim 10 or 11, wherein the component is a step or a pallet of the escalator system / travelator system.

13. The conveyor system according to any of claims 10 - 12, wherein the component is a comb plate.

14. The conveyor system according to any of the precedent claims, wherein the physical quantity is one of temperature, pressure and magnetic field.

15. The conveyor system according to any of the precedent claims, wherein at least two sensing elements are embedded into the same conveyor component and/or located within an operational range of the sensing head.

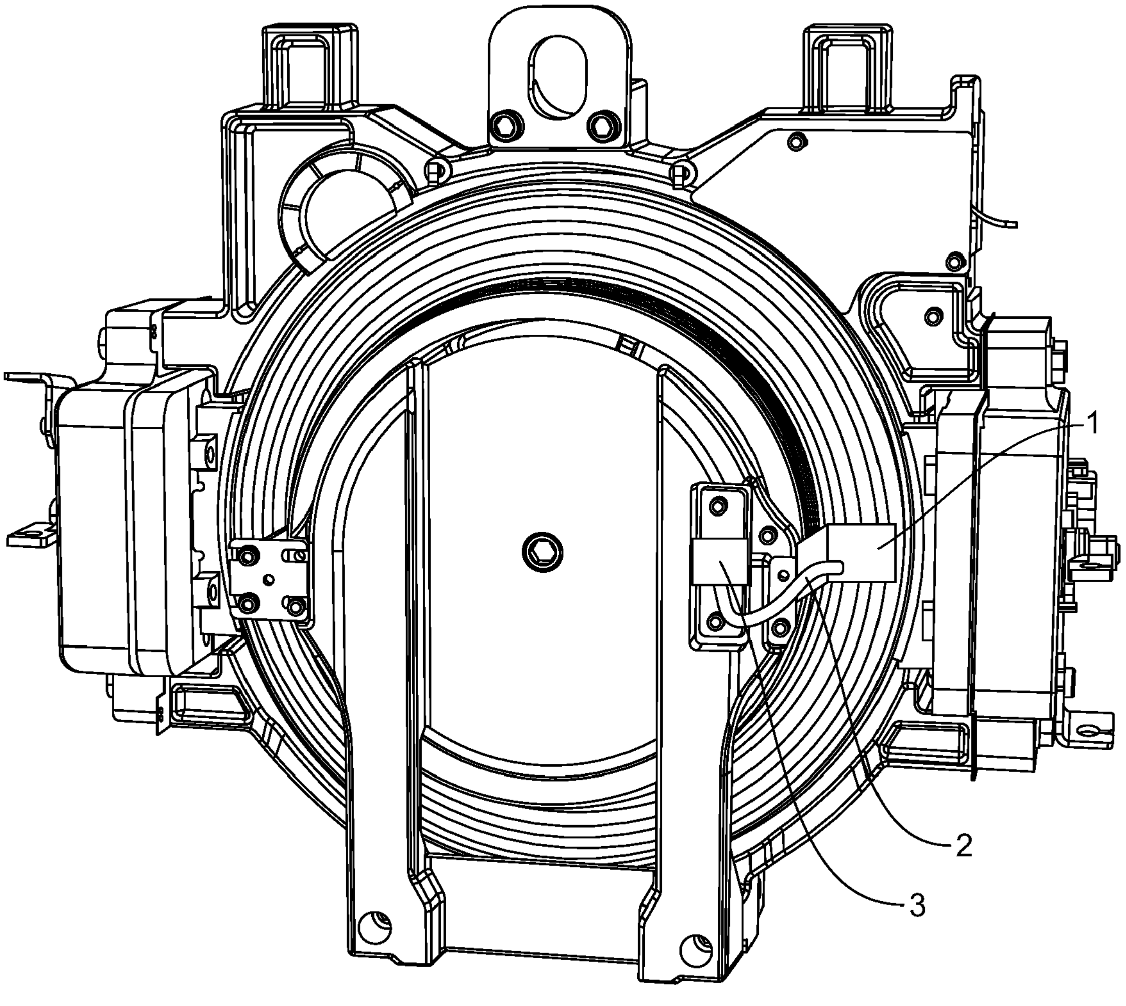


FIG. 1

FIG. 2

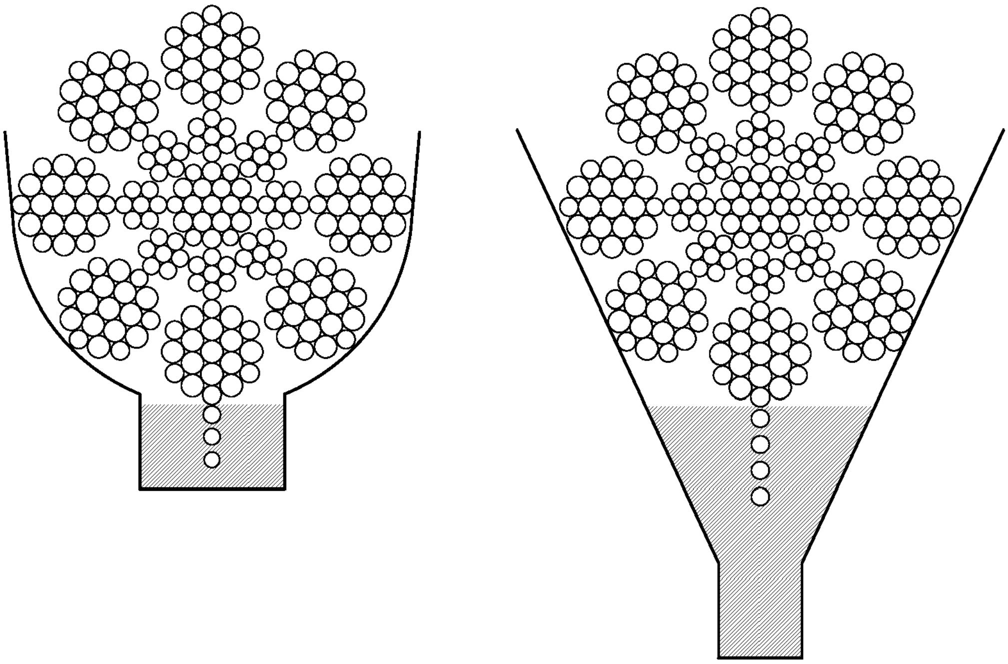
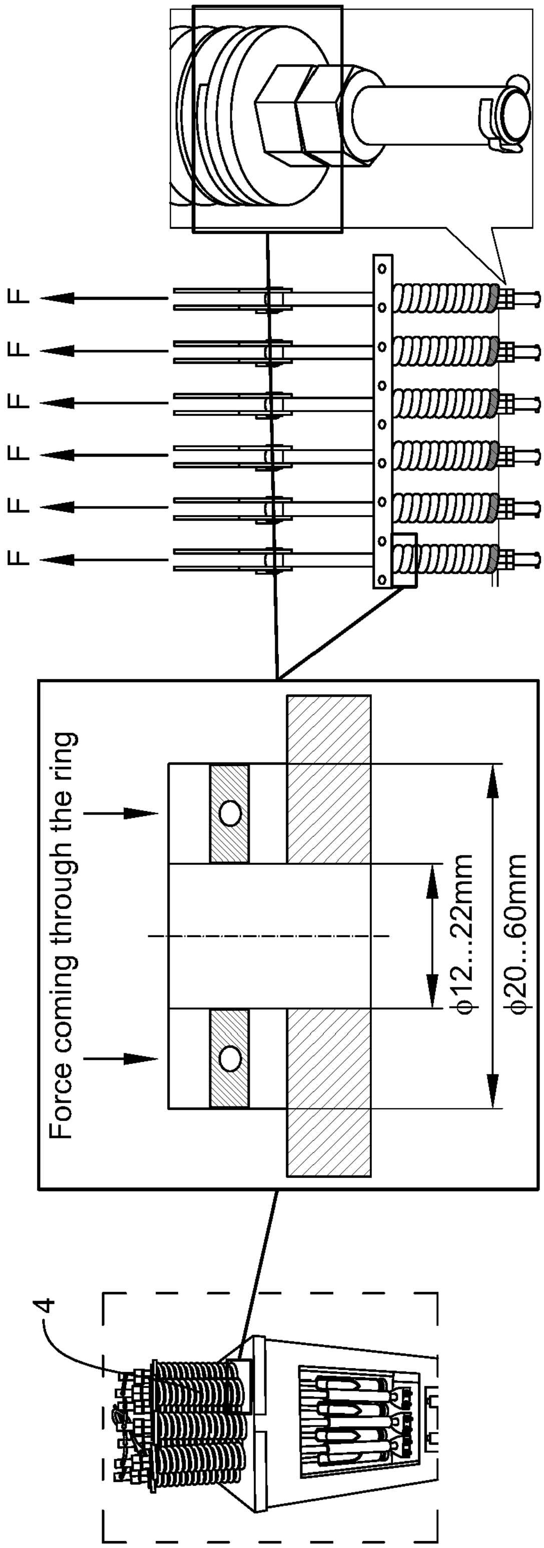


FIG. 3



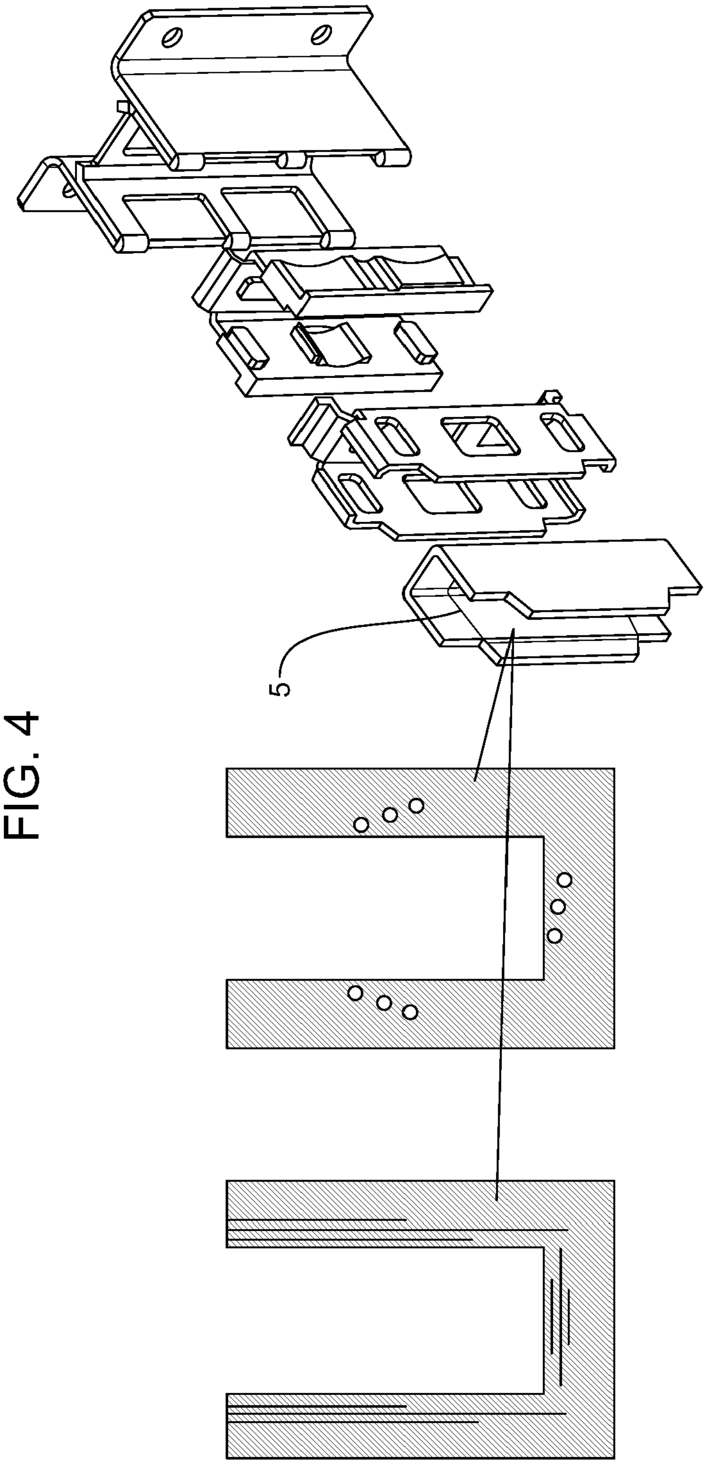
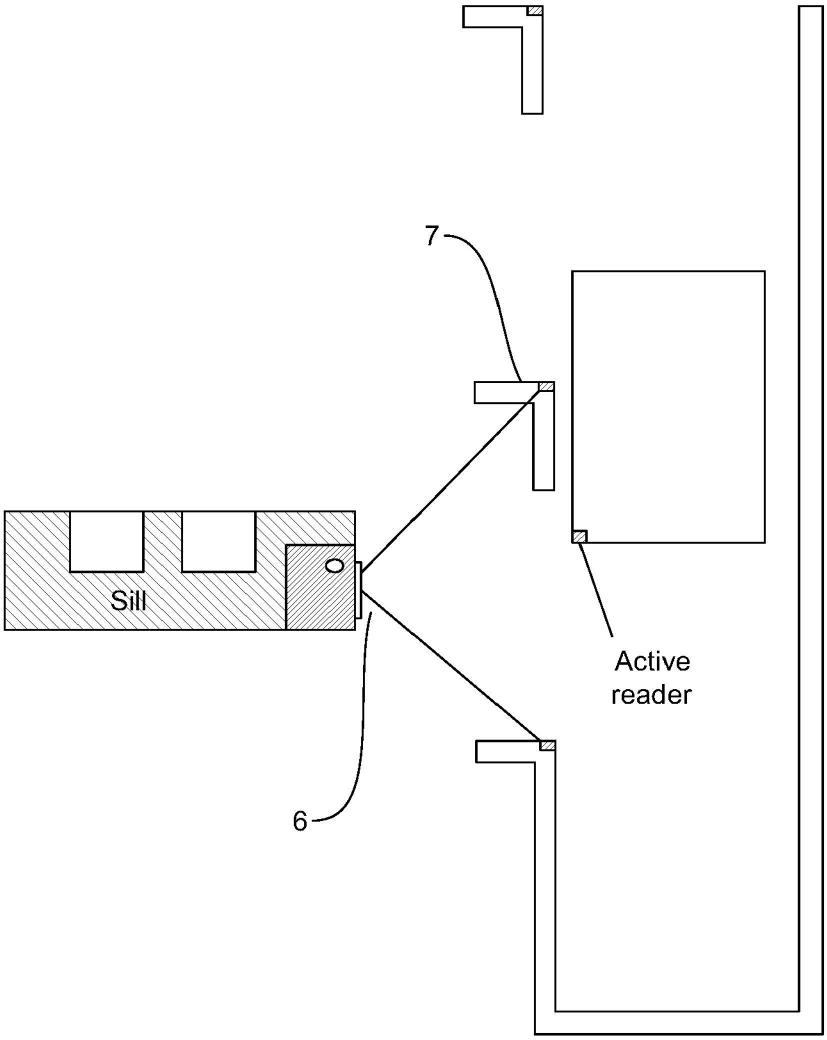


FIG. 4

FIG. 5



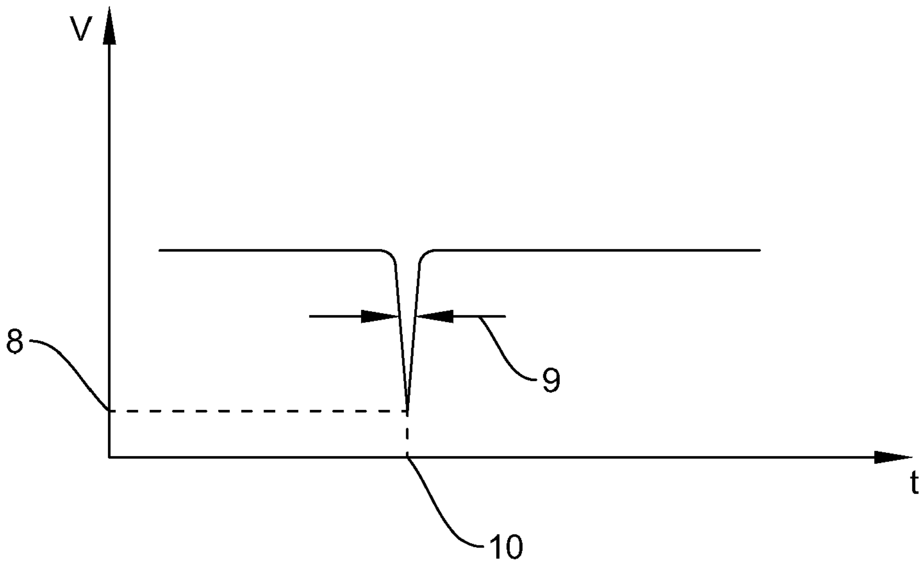


FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 5371

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2014/202236 A1 (INVENTIO AG [CH]) 24 December 2014 (2014-12-24) * page 22 - page 23 * -----	1-15	INV. B66B5/00 B66B7/12
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TECHNICAL FIELDS SEARCHED (IPC)

B66B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	25 September 2023	Szován, Levente

CATEGORY OF CITED DOCUMENTS

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