(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 474 553 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.12.2024 Bulletin 2024/50

(21) Application number: **23382562.9**

(22) Date of filing: **07.06.2023**

(51) International Patent Classification (IPC):
D04B 9/02 *(2006.01)* ***D04B 15/06*** *(2006.01)*
D04B 35/10 *(2006.01)* ***D04B 37/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
D04B 35/10; D04B 9/02; D04B 15/06; D04B 37/02

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(54) METHOD FOR DETECTING WEAR IN THE SINKERS OF AN AUTOMATIC KNITTING MACHINE, AND CORRESPONDING SYSTEM AND SINKER

(57) Method for detecting wear in the sinkers of an automatic knitting machine, and corresponding system and sinker. A conductive track (5) is applied on a friction area (6) of a testing sinker (4a) that replaces a normal sinker in an automatic knitting machine. By means of an electrical testing device (7) that is connected to the terminals (8) of the conductive track (5), at least one parameter related to an electrical resistance of the conductive track (5) is automatically measured, and in function of this parameter, a level of wear in the friction area (6) of the testing sinker (4a) is automatically deduced.

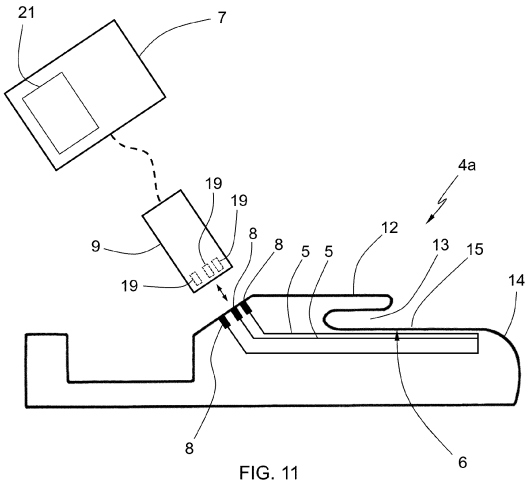

FIG. 11

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Description

Field of the invention

[0001] The invention is comprised in the field of automatic knitting machines.

[0002] The invention more specifically relates to a method for detecting wear in the sinkers of an automatic knitting machine of the type comprising a plurality of yarn feeders, a plurality of movable needles and a plurality of movable sinkers shaped as thin plates and arranged between said needles, each of said needles being adapted to subsequently catch and free a yarn provided by one of said yarn feeders when said needle is moved, and each of said sinkers being adapted to subsequently hold and free a loop of a stitch of yarn when said sinker is moved, said automatic knitting machine further comprising an actuating device for automatically moving said needles and said sinkers according to a preestablished pattern for manufacturing a knitted fabric from the yarns provided by said yarn feeders by a cooperation between said needles and said sinkers.

[0003] The invention also relates to a system for detecting wear in the sinkers of an automatic knitting machine of this type, and a corresponding sinker.

Prior art

[0004] Automatic knitting machines are commonly used for manufacturing knitted fabrics at industrial scale. These machines are designed to work intensively. They have a high number of components, including a high number of needles and sinkers as well as the mechanics to move them, which must work in a very precise manner to knit each stitch without defects. The machine is usually equipped with sensors and monitored by a human knitter who can stop the process if something goes wrong. Both the machine components and the produced knitted fabric can be monitored. When the machine is stopped because a defect has been detected in the knitted fabric, there is a high cost associated to the interruption because the human knitter must check the knitted fabric, discard the section with defects, fix the problem and restart the machine. Therefore, it is of great importance to early detect the signs of defects in machine components which can cause defects in the fabric.

[0005] Defects in the sinkers are one of the causes of defects in the fabric. The sinkers are continuously moved in reciprocating movement and, to form the stitch, they come into contact with the yarn that is under tension. This interaction of the sinkers with the yarn progressively causes wear of the sinkers that can cause defects in the fabric.

[0006] It is known and common to carry out an inspection of the sinkers with the knitting machine stopped. To do this, a few sinkers are disassembled and their thickness is measured in the areas in contact with the yarn, in order to determine if they have suffered excessive wear. When an excessive wear is observed, all sinkers of the knitting machine are replaced. This method is inaccurate, time-consuming, and requires the intervention of an experienced worker.

Description of the invention

[0007] The purpose of this invention is to provide a method for detecting wear in the sinkers of an automatic knitting machine of the type indicated above in the chapter "Field of the invention", which can be easily implemented at low cost without modifying the knitting machine and allowing a reliable detection of excessive wear in the sinkers without the intervention of an experienced worker being necessary.

[0008] This is achieved by means of a method for detecting wear in the sinkers of an automatic knitting machine of this type, characterized in that at least one of the sinkers of the automatic knitting machine, named testing sinker, comprises at least one conductive track applied on a friction area of said testing sinker, said friction area being an external surface of said testing sinker which comes into contact with a yarn when the actuating device automatically moves said plurality of sinkers, and said conductive track having terminals for connecting it to an electrical testing device;
and in that said method comprises the following steps:

[a] by means of an electrical testing device that is connected to said terminals of the conductive track, automatically measuring at least one parameter related to an electrical resistance of said conductive track;

[b] in function of said parameter, automatically deducing a level of wear in said friction area of the testing sinker.

[0009] Preferably, the shape of the testing sinker, at least in its functional parts of interaction with the yarns, is the same as the shape of the normal sinkers of the automatic knitting machine (the sinkers devoid of conductive track), so that a testing sinker replaces a normal sinker in said machine without altering its normal operation.

[0010] The conductive track applied on the friction area of the testing sinker suffers a wear caused by the friction of the yarns when the automatic knitting machine is working. This wear causes a progressive decrease in the thickness of the track which in turn causes an increase in the electrical resistance of the conductive track between the terminals. The wear can also cut the conductive track, and in this case the electrical resistance suddenly increases to a high value (infinite in practice). By directly or indirectly measuring this electrical resistance, a level of wear in the conductive track is automatically deduced, which is representative of the wear suffered by the testing sinker and also by normal sinkers (the sinkers that do not have the conductive track) in the automatic

knitting machine. Therefore, putting the method into practice simply requires replacing at least one on the normal sinkers of the automatic knitting machine by a testing sinker according to the invention, providing an electrical testing device suitable to be connected to the terminals of the conductive track of the testing sinker and to automatically measure a parameter related to an electrical resistance of the conductive track, and providing a system, normally a computer system which executed a computer program, configured to interpret this parameter, deduce a level wear from it and, preferably, issue a warning message if this level wear is considered excessive.

[0011] Preferably, in step [a] a voltage is applied by the electrical testing device between the terminals of the conductive track and the parameter is the intensity of a current through said conductive track driven by said voltage. This is a simple and reliable method for indirectly measuring the electrical resistance of the conductive track.

[0012] In some embodiments, in step [b] the level of wear is automatically deduced by the fact that the parameter indicates an open circuit between the terminals of the conductive track. When the wear has completely removed the material of the conductive track in a section thereof, an open circuit is created between the terminals. If, for instance, the parameter is the intensity of a current driven by a voltage applied between the terminals, the intensity suddenly drops to zero. This is automatically detected, and a level of wear is automatically deduced.

[0013] In other embodiments, in step [b] a level of wear is automatically deduced by comparing the parameter measured in step [a] with a predetermined reference value. This allows to progressively monitor a wear.

[0014] Preferably, only when the automatic knitting machine is stopped the electrical testing device is connected to the terminals of the conductive track and step [a] is carried out. This greatly simplifies the design of the electrical testing device, since with the machine stopped it is easier to connect said device to the terminals. The system is therefore simpler and less expensive. Checking the wear in the sinkers discontinuously over time, when the machine is stopped between two operating cycles, is sufficient in most cases since the wear on the sinkers is progressive over time. The electrical testing device can be in a fixed position with respect to the automatic knitting machine. The electrical testing device can also be a handheld unit, or have a handheld part, which a worker can manually connect to the conductive track of the testing sinker when the machine is stopped.

[0015] In more sophisticated embodiments, the wear in the sinkers can be continuously checked over time. In these cases, the electrical testing device is connected to the terminals of the conductive track, and step [a] is carried out, while the automatic knitting machine is working manufacturing the knitted fabric.

[0016] In some embodiments, the testing sinker comprises several of said conductive tracks. In step [a], the electrical testing device is connected to the terminals of each of said conductive tracks, and the at least one parameter related to an electrical resistance of the conductive track is automatically measured, simultaneously or at different times, for each of said conductive tracks. In step [b], a level of wear in the friction area of the testing sinker is automatically deduced in function of at least one of said parameters automatically measured for each of the conductive tracks. This allows to check the level of wear in different areas of the testing sinker. Optionally, to better check the progression of the wear, several conductive tracks are arranged side by side in the friction area of the testing sinker. For instance, as discussed above, in step [b] the level of wear can be automatically deduced by the fact that each parameter indicates an open circuit between the terminals of a conductive track. This makes it possible to deduce the level of wear by progressive steps: the conductive tracks are successively cut by friction with the yarns as the wear progresses, and this indicates successive levels of wear.

[0017] Preferably, only some of the sinkers of the automatic knitting machine are testing sinkers with a conductive track, the rest of the sinkers of the automatic knitting machine being devoid of said conductive track. For instance, the number of sinkers of the automatic knitting machine which are testing sinkers with a conductive track can be comprised between one and four. This is a simple but effective implementation of the method. In an automatic knitting machine, the sinkers, the needles and the yarn feeders are usually well adjusted, so that all the sinkers interact in the same manner with the yarns and suffer an equivalent wear. The wear of the sinkers is therefore quite uniform. It is enough to check the wear of a single or a few sinkers since this wear will be representative of the mostly uniform wear of all the sinkers.

[0018] Preferably, the electrical testing device comprises a connector with contact terminals configured to be connected and disconnected to said terminals of the conductive track. In some embodiments, the electrical testing device is arranged in a fixed position and has a movable part with the connector that is automatically moved to automatically connect and disconnect said contact terminals to the terminals of the conductive track when the testing sinker is in front of the connector. In this way, it is possible to use a single electrical testing device and one or more testing sinkers distributed in the automatic knitting machine. In preferred embodiments, at least a part of the electrical testing device comprising the connector is a handle unit, which a worker manually connects to the conductive track of the testing sinker when the machine is stopped. The electrical testing device can be a portable device. For instance, the electrical testing device can be a portable unit including a processor and a screen so that, when the worker manually connects the connector to the conductive track of the testing sinker, information of the level of wear in the testing sinker is automatically displayed on the screen.

[0019] Although the method according to the invention can be applied to a variety of automatic knitting machines,

in preferred embodiments the automatic knitting machine is a circular knitting machine in which the needles and the sinkers are arranged in a rotating cylinder which make said needles and said sinkers to travel along a circumference which is coaxial with said rotating cylinder.

[0020] The invention also comprises a corresponding system for detecting wear in the sinkers of an automatic knitting machine, comprising an automatic knitting machine with a plurality of yarn feeders, a plurality of movable needles and a plurality of movable sinkers shaped as thin plates and arranged between said needles, each of said needles being adapted to subsequently catch and free a yarn provided by one of said yarn feeders when said needle is moved, and each of said sinkers being adapted to subsequently hold and free a loop of a stitch of yarn when said sinker is moved, said knitting machine further comprising an actuating device for automatically moving said needles and said sinkers according to a pre-established pattern for manufacturing a knitted fabric from the yarns provided by said yarn feeders by a cooperation between said needles and said sinkers;

characterized in that at least one of said sinkers, named testing sinker comprises at least one conductive track applied on a friction area of said testing sinker, said friction area being an external surface of said testing sinker which comes into contact with a yarn when said actuating device automatically moves said plurality of sinkers, and said conductive track having terminals for connecting it to an electrical testing device;
and in that it further comprises:

- an electrical testing device configured to be connected to said terminals of the conductive track;
- a processor connected to said electrical testing device;
- a computer program comprising instructions which, when executed by said processor, cause said processor to carry out the following steps:

  [a] by means of said electrical testing device connected to said terminals of the conductive track, automatically measuring at least one parameter related to an electrical resistance of said conductive track;
  [b] in function of said parameter, automatically deducing a level of wear in said friction area of said testing sinker.

[0021] The invention also comprises a testing sinker suitable for replacing a sinker of an automatic knitting machine, said automatic knitting machine comprising a plurality of yarn feeders, a plurality of movable needles and a plurality of movable sinkers shaped as thin plates and arranged between said needles, each of said needles being adapted to subsequently catch and free a yarn provided by one of said yarn feeders when said needle is moved, and each of said sinkers being adapted to subsequently hold and free a loop of a stitch of yarn when said sinker is moved, said automatic knitting machine further comprising an actuating device for automatically moving said needles and said sinkers according to a pre-established pattern for manufacturing a knitted fabric from the yarns provided by said yarn feeders by a cooperation between said needles and said sinkers;
characterized in that said testing sinker comprises at least one conductive track, with terminals for connecting it to an electrical testing device, applied on a friction area of said testing sinker, said friction area being an external surface of said testing sinker intended to come into contact with a yarn when said testing sinker is replacing a sinker in said automatic knitting machine and said actuating device automatically moves said plurality of sinkers.

[0022] Preferably, the conductive track is a coating of conductive ink. This allows a more precise control of the initial thickness of the conductive track, and therefore a more reliable deduction of a level of wear.

[0023] In preferred embodiments, the testing sinker is made of a metallic material, as it is common in automatic knitting machines. The testing sinker preferably comprises a coating of electrical insulating material between the surface of said testing sinker and the conductive track. This allows a more accurate measure of the parameter related to the electrical resistance of the conductive track.

[0024] Preferably, the terminals of the conductive track are made of a conductive material having a greater hardness than the conductive material from which the conductive track is made. This solution avoids the conductive track to be damaged by the contact with the electrical testing device.

[0025] In some embodiments, several conductive tracks are arranged in said friction area of the testing sinker. The advantages of this arrangement have been discussed above in the description of the method.

[0026] In preferred embodiments, the testing sinker is suitable for replacing a sinker in a circular knitting machine in which the needles and the sinkers are arranged in a rotating cylinder which make said needles and said sinkers to travel along a circumference which is coaxial with said rotating cylinder. Preferably, the conductive track is applied to only one face of the testing sinker, which is the face that looks in the direction of advance of said testing sinker when the sinkers travel along said circumference in the automatic knitting machine. This is because the friction with the yarns mainly takes place on said face, which comes into contact with the yarns as the sinker travels along the circumference.

[0027] In preferred embodiments, the sinkers of the automatic knitting machine and the testing sinker comprise a nib, a throat under said nib, a curved end portion and an intermediate portion between said nib and said end portion. This is a common shape of sinkers in automatic knitting machines. The nib and the throat hold and free an old loop of a stitch of yarn when the sinker is moved, and the curved end portion supports the knitted

fabric that slides down over said curved end portion. The nib and the intermediate portion are portions of the sinker that wear out particularly due to friction with yarns. Preferably, the conductive track is applied adjacent to an edge of at least one between the nib and the intermediate portion.

[0028] The system optionally has the structural features according to the preferred embodiments discussed above for the method, and the computer program optionally comprises instructions to carry out the steps of the method according to said preferred embodiments.

[0029] The invention also comprises the computer program defined above in the description of the system.

[0030] The invention also comprises other features concerning details illustrated in the detailed description of embodiments of the invention and in the attached drawings.

Brief description of the drawings

[0031] The advantages and features of the invention can be seen from the following description in which, with a non-limiting character with respect to the scope of the main claim, preferred embodiments are described in reference to the drawings.

Fig. 1 is a schematic view of a system according to the invention. The automatic knitting machine is circular, of the kind with one set of vertical needles and one set of sinkers.

Fig. 2 is a photographic image showing a group of working needles and sinkers at work in the automatic knitting machine.

Fig. 3 is a schematic upper view showing the electrical testing device and the sinkers travelling along the circumference. Only four sinkers are showed for the sake of clarity. One of the sinkers in a testing sinker.

Fig. 4 is as Fig. 3, with the testing sinker in front of the connector of the electrical testing device.

Fig. 5 is a lateral view of a first kind of sinker.

Fig. 6 is a lateral view of a first embodiment of testing sinker corresponding to said first kind of sinker.

Fig. 7 is a lateral view of the testing sinker and the electrical testing device, with the movable part in a withdrawn position.

Fig. 8 is as Fig. 7, with the movable part in an advanced position so that it is connected to the terminals of the conductive track of the testing sinker.

Fig. 9 is a perspective view of the movable part of the electrical testing device.

Fig. 10 is a lateral view of a second kind of sinker.

Fig. 11 is a lateral view of a second embodiment of testing sinker corresponding to said second kind of sinker. The figure also shows a second embodiment of the electrical testing device.

Fig. 12 is a block diagram of the main steps of the method according to the invention.

Detailed description of embodiments of the invention

[0032] Figs. 1-12 refer to embodiments of a system and a method according to the invention. In these embodiments, the automatic knitting machine 1 is a circular knitting machine of the type having a set of vertical needles 3 and a set of sinkers 4 for manufacturing a knitted tubular fabric 16.

[0033] Fig. 1 is a schematic view of one embodiment of the system, in which the knitting machine 1 is represented in a schematic sectional view. The system comprises the automatic knitting machine 1, an electric testing device 7 and a computer system including a processor 11 which is connected to the electric testing device 7. A software, including instructions for carrying out the method as described below, is executed by the processor 11.

[0034] The automatic knitting machine 1 comprises a plurality of yarn feeders 2, a plurality of movable needles 3 and a plurality of movable sinkers 4 shaped as thin plates and arranged between the needles 3. Each of the needles is adapted to subsequently catch and free a yarn 17 provided by one of the yarn feeders 2 when said needle 3 is subsequently moved in vertical direction. Each of the sinkers 4 is adapted to subsequently hold and free a loop of a stitch of yarn 17 when said sinker 4 is subsequently moved in horizontal direction. The knitting machine 1 further comprises an actuating device for automatically moving the needles 3 and the sinkers 4 according to a preestablished pattern for manufacturing a knitted tubular fabric 16 from the yarns 17 provided by the yarn feeders 2 by a cooperation between said needles 3 and said sinkers 4. The needles 3 and the sinkers 4 are arranged in a rotating cylinder 10, so that they travel along a circumference which is coaxial with the rotating cylinder 10. The needles 3 and the sinkers 4 interact with cams which are statically arranged in a dial around the rotating cylinder 10, and which make each needle 3 to move vertically up and down, and each sinker 4 to move horizontally forward and backward, forming stitches while the cylinder 10 rotates continuously. The rotating cylinder 10, actuated by a motor, and the static cams are the actuating device referred to above for automatically moving the needles 3 and the sinkers 4.

[0035] Since the cams are static, each needle 3 and each sinker 4 travelling along the circumference has a

unique position at each point of said circumference. The sinkers 4 are arranged between the needles 3 and move horizontally to control the movement of the fabric as the machine knits. More concretely, the function of the sinkers 4 is to hold the old loop of stitch at a lower level on the needle 3 stem than the new loop of the stitch being formed, and to prevent the old loop from being lifted by the needle 3 as it rises to clear the loop from its hook. In addition, the sinkers 4 support the fabric 17 as it is produced and slides down over a curved end portion of said sinkers 4.

[0036] In this system, at least one of the sinkers 4 of the automatic knitting machine 1 has been replaced by a testing sinker 4a with a conductive track 5, as described below. Preferably, the number of testing sinkers 4a in the automatic knitting machine 1 is between 1 and 4. In the exemplary embodiments described here, the automatic knitting machine 1 has a single testing sinker 4a. The rest of the sinkers 4 of the automatic knitting machine 1 are devoid of conductive track 5.

[0037] The shape of the testing sinker 4a, at least in its functional parts to interact with the yarns 17, is the same as the shape of the normal sinkers 14 of the automatic knitting machine 1, so that a testing sinker 4a replaces a normal sinker 4 without altering the normal operation of the automatic knitting machine 1. In the exemplary embodiments, the testing sinker 4a has the same shape as a normal sinker 4.

[0038] Fig. 2 is a is a photographic image of a group of working needles 3 and sinkers 4 in the automatic knitting machine 1. In this image, the sinkers 4 are the parallel thin plates, the top of the needles 3 are visible at half height in the image, and the knitted fabric 16 as it is being produced is seen in the upper part of the image. The needles 3 are all identical. The sinkers 4 are also all identical, except at least one of them (not visible in this figure) which has been replaced by a testing sinker 4a.

[0039] Figs. 5 and 6 respectively show a first kind of sinker 4 and the corresponding testing sinker 4a. Another kind of sinker 4 and the corresponding testing sinker 4a are shown in Figs. 10 and 11. These are exemplary embodiments. There are many sinkers on the market with different shapes, depending on the knitting machine model and the fabric to be manufactured. The invention is applicable to any of these sinkers by applying a conductive track 5 on a friction area 6 of the sinker 4.

[0040] The sinkers 4 and the corresponding testing sinkers 4a are thin plates made of steel. As can be seen in the lateral views of Figs 5-6 and 10-11, the upper edge of the sinkers 4 and 4a has different functional portions. From left to right in these figures, the upper edge of the sinker defines a nib 12 and a throat 13 under said nib 12, which holds and frees an old loop of a stitch of yarn when the sinker 4, 4a is horizontally moved, and a curved end portion 14 of the sinker 4, 4a, currently known as "knock-over edge", which supports the knitted fabric 16 that slides down over said curved end portion 14. Between the nib 12 and the curved end portion 14 there is an intermediate portion 15, currently known as "knock-over platform". The nib 12 and the intermediate portion 15 are portions of the sinker 4, 4a that wear out particularly due to friction with yarns 17. The yarns 17 laterally rest on these portions as the sinkers 4, 4a move along the circumferential path, and at the same time the yarns 17 run and rub over the surface of the sinkers 4, 4a. As previously said, the invention is not limited to sinkers 4, 4a shaped as shown in the figures. The invention can also be applied to other sinkers with a great variety of shapes.

[0041] The operation of this type of circular automatic knitting machine with needles and sinkers, as well as the movements of the needles and the sinkers to form the knit loops, are not described in greater detail here since they are well known to those skilled in the art.

[0042] In the embodiment shown in Figs. 6-8, the testing sinker 4a comprises one conductive track 5 applied on a friction area 6 of said testing sinker 4a. The friction area 6 is an external surface of the testing sinker 4a which comes into contact with a yarn 17 when the actuating device of the automatic knitting machine 1 automatically moves the plurality of sinkers 4, 4a. In the example shown of Figs. 6-8, the friction area 6 on which the conductive track 5 is applied is an area adjacent to the edge of the nib 12 along its perimeter. In some variants (not shown in the figure), the same conductive track 5, or a second conductive track 5, can also be applied in an area adjacent to the upper edge of the intermediate portion 15, preferably near the nib 12, which is also an area of friction 6. The conductive track 5 is a coating of conducting ink. For instance, the conductive ink is a silver ink reference Dupont® 5000 Silver Conductor. The thickness of the coating of conductive ink is between 7 and 15 micrometers. At the two ends of the conductive track 5 there are terminals 8 for connecting it to an electrical testing device 7. Preferably, the terminals 8 are made of a conductive material having a greater hardness than the conductive material from which the conductive track 5 is made. For instance, the terminals 8 are made of a coating of conductive carbon ink, reference Sun Chemical® Graphene Carbon BG04, with a thickness between 5 and 10 micrometers. A coating of electrical insulating material 18 is applied between the steel surface of the testing sinker 4a and the conductive track 5. For instance, the coating of electrical insulating material 18 is made of an insulating ink, reference Dupont® Dielectric Ink 8153, with a thickness between 5 and 7 micrometers. As can be seen in Fig. 6, the two terminals 8 are located near the edge of the rear part of the nib 12 (the left side in Fig. 6). In this position, the terminals 8 are more easily accessible to connect the electrical testing device 7 when the testing sinker 4a is mounted on the automatic knitting machine 1 replacing a normal sinker 4. The conductive track 5 is applied to only one face of the testing sinker 5, which is the face that looks in the direction of advance of said testing sinker 5 when the sinkers 4, 4a travel along the circumference in the automatic knitting machine 1.

[0043] The electrical testing device 7 can be in a fixed

position with respect to the automatic knitting machine 1. This is the case shown in Figs. 1, 3 and 4. In this case, the electric testing device 7 is positioned outside the circumference, facing the rear part of the sinkers 4, 4a (the left side in Fig. 6). The sinkers 4, 4a successively pass in front of the electrical testing device 7 es they travel along the circumference. The electrical testing device 7 has a fixed part and a movable part comprising a connector 9 with contact terminals 19 configured to be connected and disconnected to the terminals 8 of the conductive track 5. As shown in Fig. 9, the movable part is an arm 20 which is automatically moved forward and backward by means of a controlled motor (not shown in the figures). The connector 9 has the shape of a fork. The contact terminals 19 are two elastically retractable protuberances inside the fork. The fork and the contact terminals 19 are dimensioned so that the edge of the rear part of the nib 12 fits inside the fork, and the two contact terminals 19 are in pressure contact with the two terminals 8. Figs. 3 and 4 are a schematic top view of the automatic knitting machine 1. Only the testing sinker 4a and three normal sinkers 4 are shown for the sake of simplicity. In fact, the ring shown with dashed lines in the figure is filled with sinkers 4 arranged side by side. In Fig. 3 the testing sinker 4a is not facing the connector 9 of the electrical testing device 7. In Fig. 4 the actuating rotating cylinder 10 has rotated and the testing sinker 4a is facing said connector 9. The movable part comprising the connector 9 can be automatically moved forward and backward when the testing sinker 4a is in this position. In the backward position of Fig. 7 the rear part of the nib 12 is outside the fork, the testing sinker 4a is free (it is not linked to the connector 9) and the contact terminals 19 are not connected to the terminals 8 of the conductive track 5. In the forward position of Fig. 8 the rear part of the nib 12 has entered the fork and the contact terminals 19 are connected to the terminals 8 of the conductive track 5.

[0044] According to a non-limiting example, the method is carried out when the automatic knitting machine 1 is stopped. The movable part comprising the connector 9 is always in the backward position of Fig. 7 while the automatic knitting machine 1 is working producing the knitted fabric 16. It is moved to the forward position of Fig. 8, to connect the contact terminals 19 to the terminals 8, only when the machine 1 is stopped. The system automatically recognises the position of the testing sinker 4a and makes the rotating cylinder 10 to rotate until said testing sinker 4a is facing the connector 9 of the electrical testing device 7, as schematically shown in Fig. 4. The movable part comprising the connector 9 is then moved forward to the position shown in Fig. 8, so that the contact terminals 19 are in contact with the terminals 8. In this position, the electrical testing device 7 is connected to the terminals 8 of the conductive track 5. The following steps are automatically carried out by a software executed by a processor 11 which is connected to the electrical testing device 7:

[a] The electrical testing device 7 automatically applies a predefined voltage between the terminals 8 and measures the intensity of the current through said conductive track 5 driven by said voltage. This intensity is directly related to the electrical resistance of the conductive track 5.

[b] The intensity measured in step [a] is compared to a reference value. For instance, the reference value is an intensity of current initially measured when the testing sinker 4a is new, without any wear, by applying the same procedure as in step [a]. A level of wear in the friction area 6 is deduced from the difference between the intensity measured in step [a] and the reference value. The electrical resistance of the conductive track 5, and therefore also the intensity of the current at constant voltage, is directly related to the sectional area of the conductive track 5 in the friction area 6, which is progressively reduced by a loss of conductive ink due to friction with the yarn 17. The level of wear thus deduced can be automatically displayed on a screen. A warning message can also be displayed when the level of wear has exceeded a predefined threshold.

[0045] It is also possible to carry out the same method while the automatic knitting machine 1 is working producing the knitted fabric 16. However, this requires a more sophisticated control for quickly moving forward and backward the movable part comprising the connector 9 so that its contact with the testing sinker 4a does not disturb the normal operation of the automatic knitting machine 1. In general, it is enough to monitor the wear of the testing sinker 4a only when the automatic knitting machine 1 is stopped, between two work cycles.

[0046] In other possible embodiments, the electrical testing device 7 can be a handheld unit, or can have a handheld part, which a worker can manually connect to the terminals 8 of the conductive track 8 of the testing sinker 5 when the machine is stopped. The embodiment shown in Figs. 9-10 is an example of such solution. It also differs from the previously described embodiment in the shape of the sinker 4 and the corresponding testing sinker 4a, in that the testing sinker 4a has several conductive tracks 5 arranged side by side, and in that the level of wear is deduced by detecting an open circuit in each of said conductive tracks 5 when they are successively cut but the wear.

[0047] More concretely, in the embodiment of Figs. 9-10 the shape of the sinker 4 is as shown in Fig. 9. The testing sinker 4a has the same shape as the sinker 4, as shown in Fig. 10. In this case, the friction area 6 is mainly an area adjacent to the upper edge of the intermediate portion 15 near the nib 12. The testing sinker 4a has two conductive tracks 5 formed by two thin lines extending side by side and parallel to the upper end of the intermediate portion 15, very close to said upper end. These two lines are separated by a very low distance, and they are connected on an end (the end on the right in Fig. 10) by

a third line. Each of these three lines has on the opposite end (the end on the left in Fig. 10) a terminal 8 located near the edge of the rear part of the nib 12 (the left side in Fig. 10). The three lines are made by a coating of conductive sink. They are separated from the steel surface of the testing sinker 4a by a coating of electrical insulating ink. The terminals 8 are made by a coating of ink having a higher hardness than the conductive ink. The inks can be the same as those described above for the previous embodiments.

[0048] The electrical testing device 7 is a portable device comprising a main body with a processor and a screen 21, and a connector 9 connected to the main body. The connector 9 is a handle unit which is connected by cable or wirelessly (for instance, by Bluetooth) to the main body, and which a worker manually connects to the terminals 8 of the conductive tracks 5. The connector 9 has three contact terminals 19 arranged to be connected to the three terminals 8. The connector 9 and the terminals 8 can be designed as a bus connection, similar to those commonly used in computer equipment.

[0049] According to a non-limiting example, the method is as follows. When the automatic knitting machine 1 is stopped, the worker manually connects the connector 9 to the terminals 8 of the testing sinker 4a. The following steps are automatically carried out by a software executed by a processor which is comprised in the electrical testing device 7:

[a] The electrical testing device 7 automatically applies a pulse of voltage between the terminal 8 at the lower position in Fig. 10, which has the function of a ground terminal, and each of the two upper terminals 8 (in Fig. 10) and measures a corresponding pulse of intensity of current at each of said two upper terminals 8. If one of the conductive tracks 5 has been cut by wear, there is an open circuit between the terminal 8 of said conductive track 5 and the ground terminal 8, and the electrical resistance is very high (infinite in practice). The open circuit is detected because there is no pulse of intensity at said terminal 8 of said conductive track 5.

[b] If no pulse of intensity of current is detected at the terminal 8 of one of the conductive tracks 5, it is automatically deduced that the level of wear in the friction area 6 is such that said conductive track 5 has been cut by wear. In practice, the wear in the friction area 6 at the intermediate portion 15 proceeds in the direction from top to bottom in Fig. 10, so that the wear first cuts the upper conductive track 5, and later cuts the lower conductive track 5 if the testing sinker 4a continues to be used on the automatic knitting machine 1. When the method automatically deduces a first level of wear that has caused the cutting of the first conductive track 5 from the top, a warning message can be displayed at the screen 21 indicating that a certain percentage of an inadmissible level of wear has been reached. When the method automatically deduces a second level of wear that has caused the cutting of the second conductive track 5 from the top, a warning message can be displayed at the screen 21 indicating that an inadmissible level of wear has been reached and, therefore, the sinkers 4 of the automatic knitting machine should be replaced.

[0050] The same method can be applied in the same manner with a different number of conductive tracks 5. For instance, the number of conductive tracks 5 can be between one and five, so that between one and five increasing levels of wear can be deduced.

Claims

1. - Method for detecting wear in the sinkers of an automatic knitting machine (1), said automatic knitting machine (1) comprising a plurality of yarn feeders (2), a plurality of movable needles (3) and a plurality of movable sinkers (4) shaped as thin plates and arranged between said needles (3), each of said needles (3) being adapted to subsequently catch and free a yarn provided by one of said yarn feeders (2) when said needle (3) is moved, and each of said sinkers (4) being adapted to subsequently hold and free a loop of a stitch of yarn when said sinker (4) is moved, said automatic knitting machine (1) further comprising an actuating device for automatically moving said needles (3) and said sinkers (4) according to a preestablished pattern for manufacturing a knitted fabric (16) from the yarns provided by said yarn feeders (2) by a cooperation between said needles (3) and said sinkers (4);

characterized in that at least one of said sinkers (4), named testing sinker (4a), comprises at least one conductive track (5) applied on a friction area (6) of said testing sinker (4a), said friction area (6) being an external surface of said testing sinker (4a) which comes into contact with a yarn when said actuating device automatically moves said plurality of sinkers (4, 4a), and said conductive track (5) having terminals (8) for connecting it to an electrical testing device (7) ;
and **in that** said method comprises the following steps:

[a] by means of an electrical testing device (7) that is connected to said terminals (8) of the conductive track (5), automatically measuring at least one parameter related to an electrical resistance of said conductive track (5);

[b] in function of said parameter, automatically deducing a level of wear in said friction area (6) of the testing sinker (4a).

2. - Method according to claim 1, wherein in step [a] a voltage is applied by said electrical testing device (7) between said terminals (8) of the conductive track (5) and said parameter is the intensity of a current through said conductive track (5) driven by said voltage.

3. - Method according to any one of claims 1 or 2, wherein in step [b] a level of wear is automatically deduced by the fact that said parameter indicates an open circuit between said terminals (8) of the conductive track (5).

4. - Method according to any one of claims 1 or 2, wherein in step [b] a level of wear is automatically deduced by comparing said parameter measured in step [a] with a predetermined reference value.

5. - Method according to any one of claims 1 to 4, wherein only when said automatic knitting machine (1) is stopped said electrical testing device (7) is connected to said terminals (8) of the conductive track (5) and said step [a] is carried out.

6. - Method according to any one of claims 1 to 4, wherein said electrical testing device (7) is connected to said terminals (8) of the conductive track (5), and said step [a] is carried out, while said automatic knitting machine (1) is working manufacturing said knitted fabric (16).

7. - Method according to any one of claims 1 to 6, wherein said testing sinker (4a) comprises several of said conductive tracks (5); in step [a], the electrical testing device (7) is connected to the terminals (8) of each of said conductive tracks (5), and the at least one parameter related to an electrical resistance of the conductive track (5) is automatically measured, simultaneously or at different times, for each of said conductive tracks (5); and in step [b], a level of wear in said friction area (6) of the testing sinker (4a) is automatically deduced in function of at least one of said parameters automatically measured for each of the conductive tracks (5).

8. - Method according to any one of claims 1 to 7, wherein only some of the sinkers (4) of said automatic knitting machine (1) are testing sinkers (4a) with a conductive track (5), the rest of the sinkers (4) of the automatic knitting machine (1) being devoid of said conductive track (5).

9. - Method according to any of claims 1 to 10, wherein said electrical testing device (7) comprises a connector (9) with contact terminals (19) configured to be connected and disconnected to said terminals (8) of the conductive track (5).

10. - System for detecting wear in the sinkers (4) of an automatic knitting machine (1), comprising an automatic knitting machine (1) with a plurality of yarn feeders (2), a plurality of movable needles (3) and a plurality of movable sinkers (4) shaped as thin plates and arranged between said needles (3), each of said needles (3) being adapted to subsequently catch and free a yarn provided by one of said yarn feeders (2) when said needle (3) is moved, and each of said sinkers (4) being adapted to subsequently hold and free a loop of a stitch of yarn when said sinker (4) is moved, said knitting machine (1) further comprising an actuating device for automatically moving said needles (3) and said sinkers (4) according to a pre-established pattern for manufacturing a knitted fabric (16) from the yarns provided by said yarn feeders (2) by a cooperation between said needles (3) and said sinkers (4);
characterized in that at least one of said sinkers (4), named testing sinker (4a) comprises at least one conductive track (5) applied on a friction area (6) of said testing sinker (4), said friction area (6) being an external surface of said testing sinker (4a) which comes into contact with a yarn when said actuating device automatically moves said plurality of sinkers (4, 4a), and said conductive track (5) having terminals (8) for connecting it to an electrical testing device (7); and **in that** it further comprises:

- an electrical testing device (7) configured to be connected to said terminals (8) of the conductive track (5);
- a processor (11) connected to said electrical testing device (7);
- a computer program comprising instructions which, when executed by said processor (11), cause said processor (11) to carry out the following steps:

  [a] by means of said electrical testing device (7) connected to said terminals (8) of the conductive track (5), automatically measuring at least one parameter related to an electrical resistance of said conductive track (5);
  [b] in function of said parameter, automatically deducing a level of wear in said friction area (6) of said testing sinker (4a).

11. Testing sinker (4a) suitable for replacing a sinker (4) of an automatic knitting machine (1), said automatic knitting machine (1) comprising a plurality of yarn feeders (2), a plurality of movable needles (3) and a plurality of movable sinkers (4) shaped as thin plates and arranged between said needles (3), each of said needles (3) being adapted to subsequently catch and free a yarn provided by one of said yarn feeders (2) when said needle (3) is moved, and each of said

sinkers (4) being adapted to subsequently hold and free a loop of a stitch of yarn when said sinker (4) is moved, said automatic knitting machine (1) further comprising an actuating device for automatically moving said needles (3) and said sinkers (4) according to a preestablished pattern for manufacturing a knitted fabric (16) from the yarns provided by said yarn feeders (2) by a cooperation between said needles (3) and said sinkers (4); **characterized in that** said testing sinker (4a) comprises at least one conductive track (5), with terminals (8) for connecting it to an electrical testing device (7), applied on a friction area (6) of said testing sinker (4a), said friction area (6) being an external surface of said testing sinker (4) intended to come into contact with a yarn when said testing sinker (4a) is replacing a sinker (4) in said automatic knitting machine (1) and said actuating device automatically moves said plurality of sinkers (4, 4a).

12. Testing sinker (4a) according to claim 11, wherein said conductive track (5) is a coating of conductive ink.

13. Testing sinker (4a) according to any one of claims 11 and 12, wherein said testing sinker (4a) is made of a metallic material and comprises a coating of electrical insulating material (12) between the surface of said testing sinker (4a) and said conductive track (5).

14. - Testing sinker (4a) according to any one of claims 11 to 13, wherein several conductive tracks (5) are arranged side by side in said friction area (6) of the testing sinker (4a).

15. - Testing sinker (4a) according to any one of claims 11 to 14, comprising a nib (12), a throat (13) under said nib (12), a curved end portion (14) and an intermediate portion (15) between said nib (12) and said end portion (14), wherein said conductive track (5) is applied adjacent to an edge of at least one between said nib (12) and said intermediate portion (15).

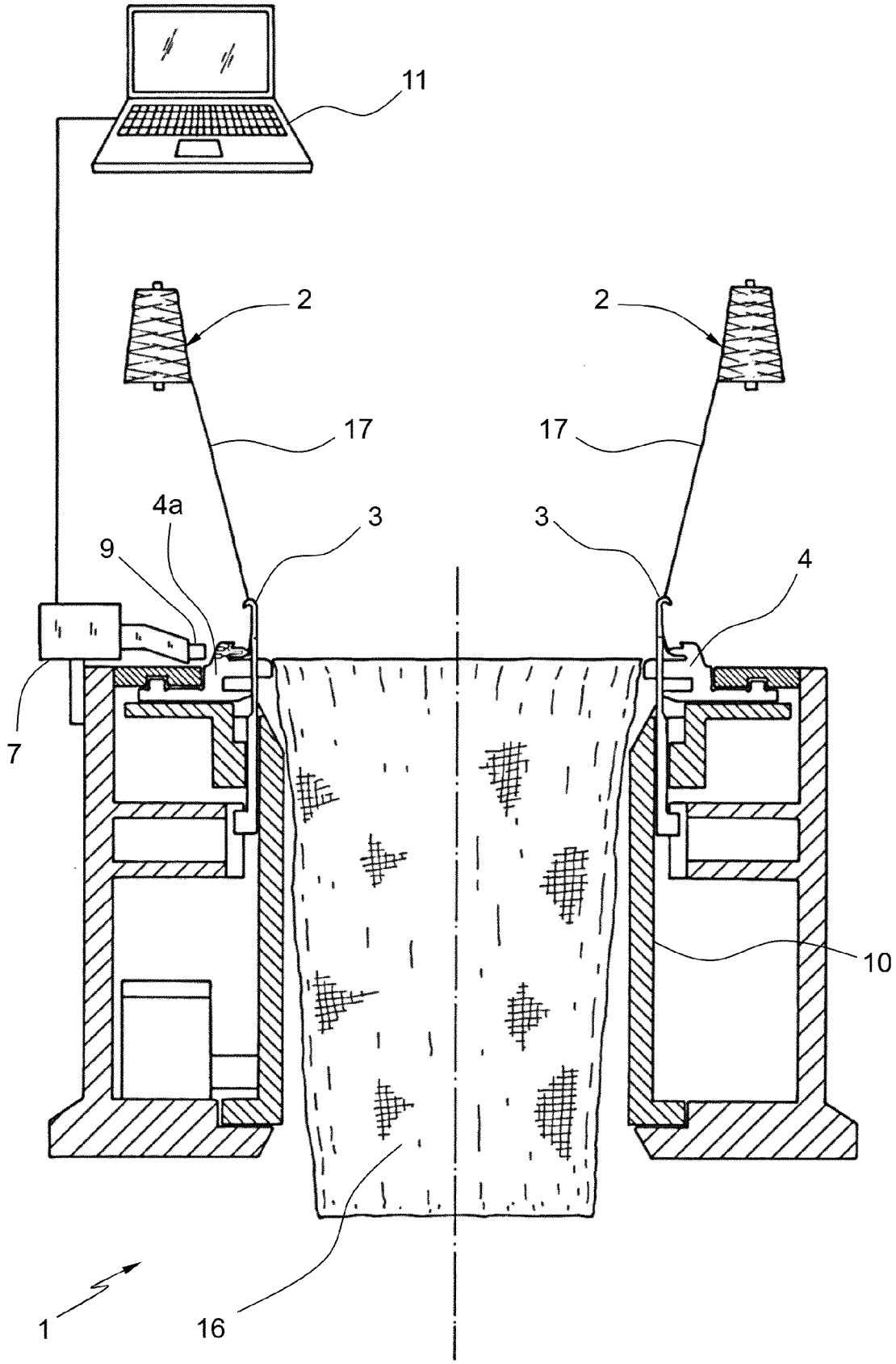

FIG. 1

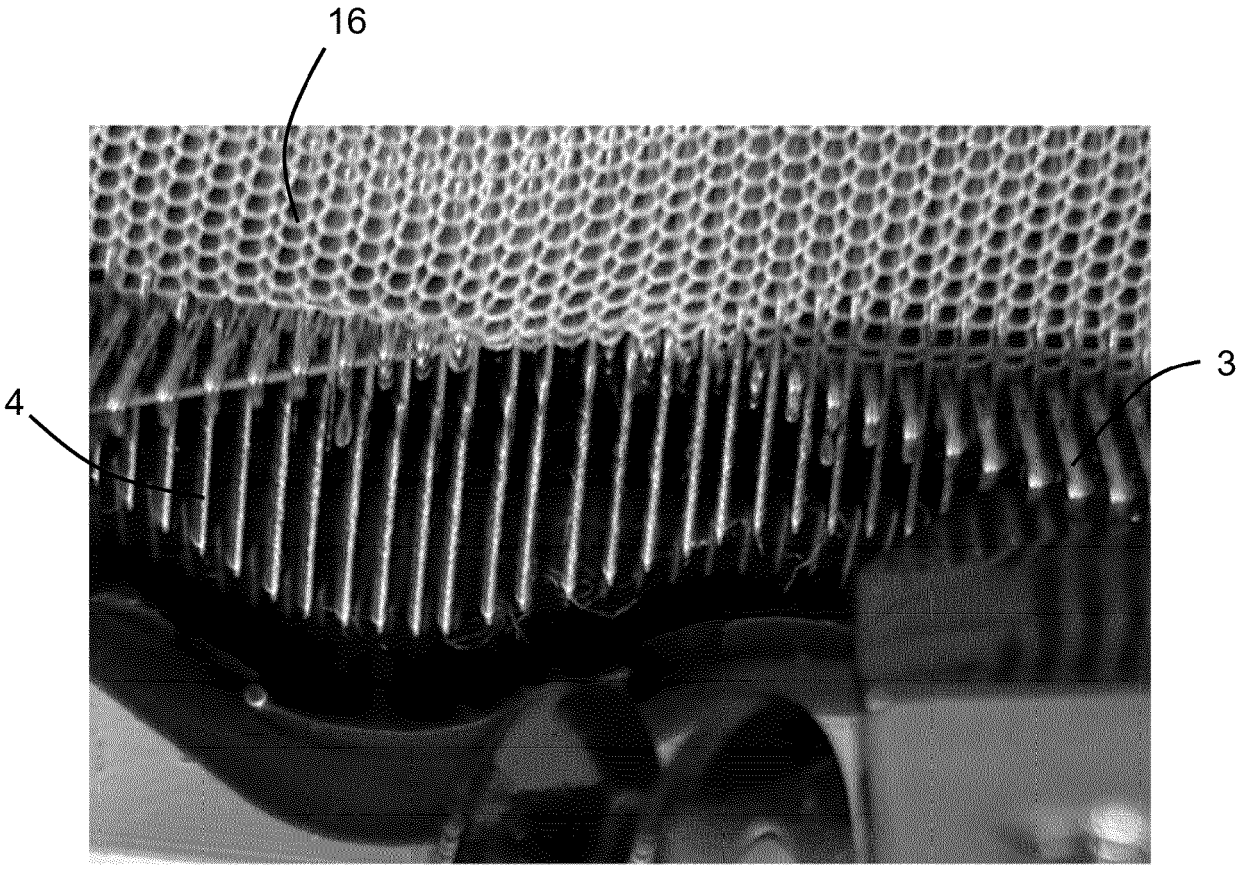

FIG. 2

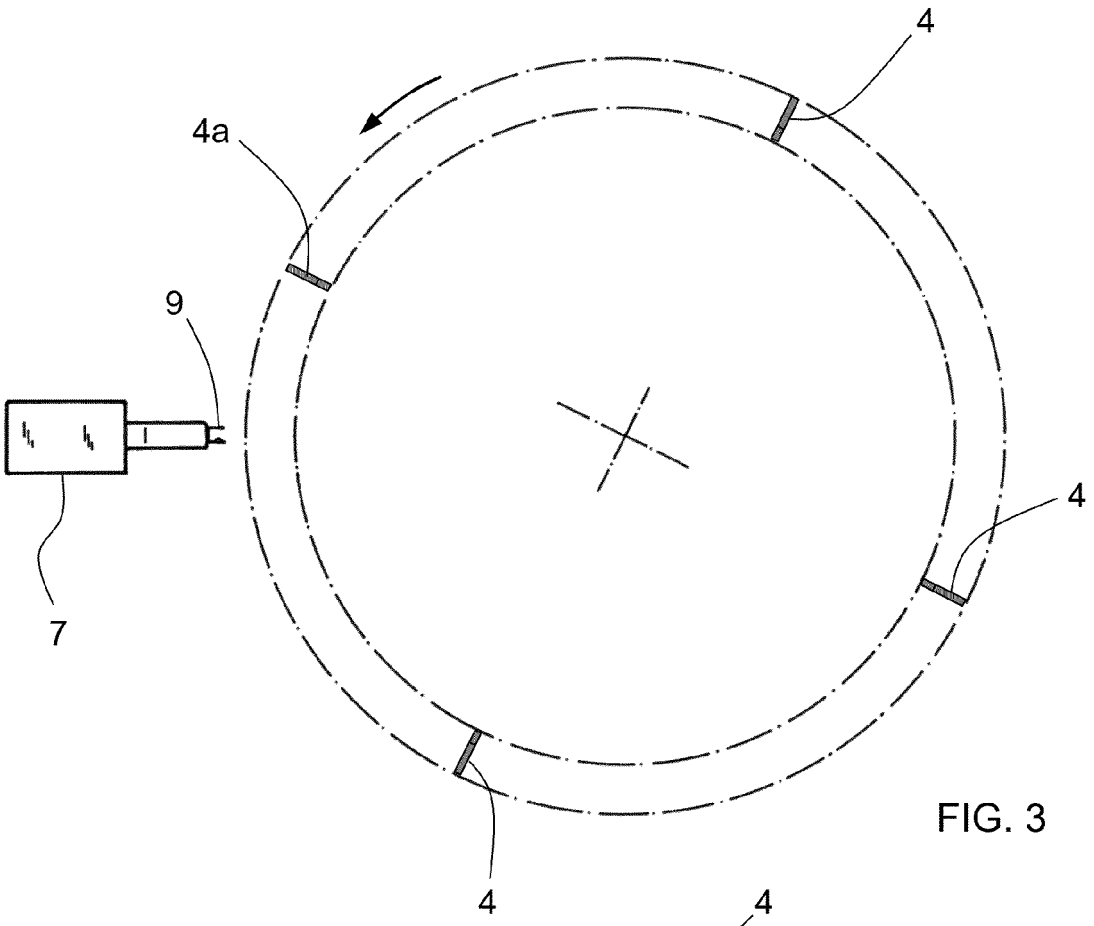

FIG. 3

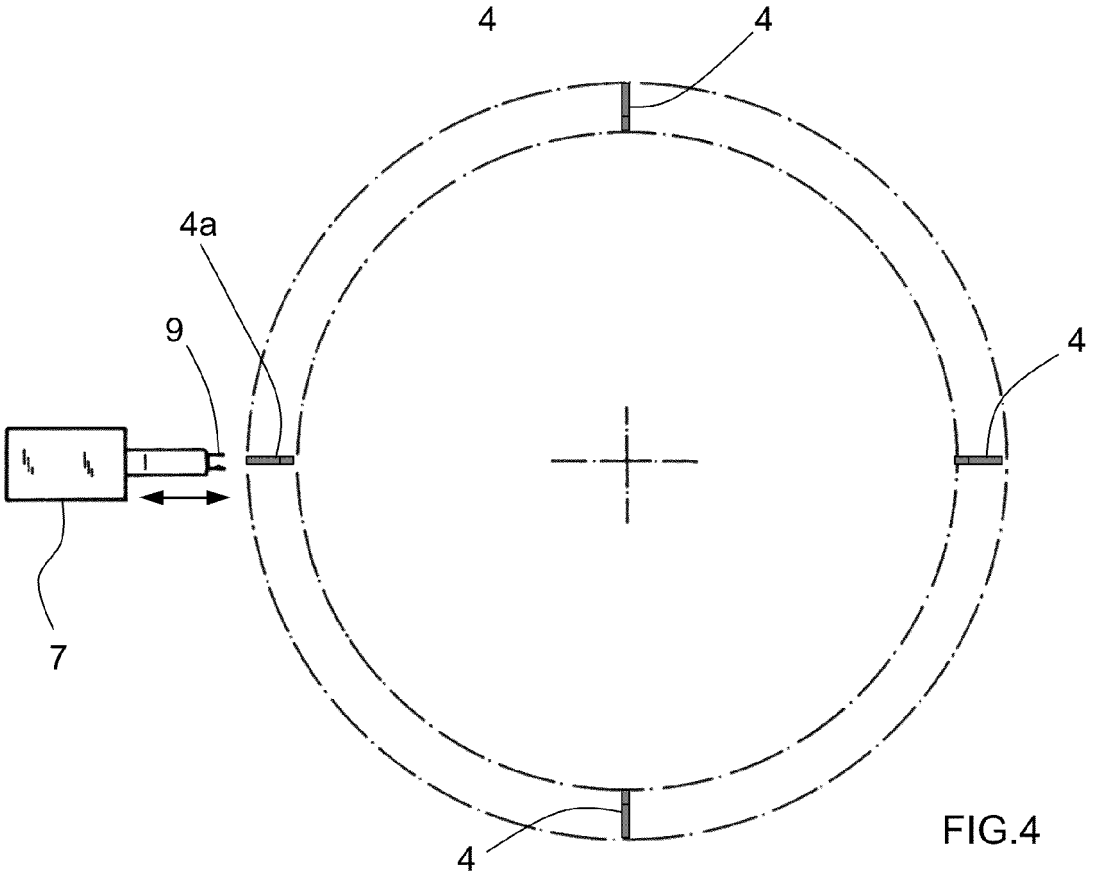

FIG.4

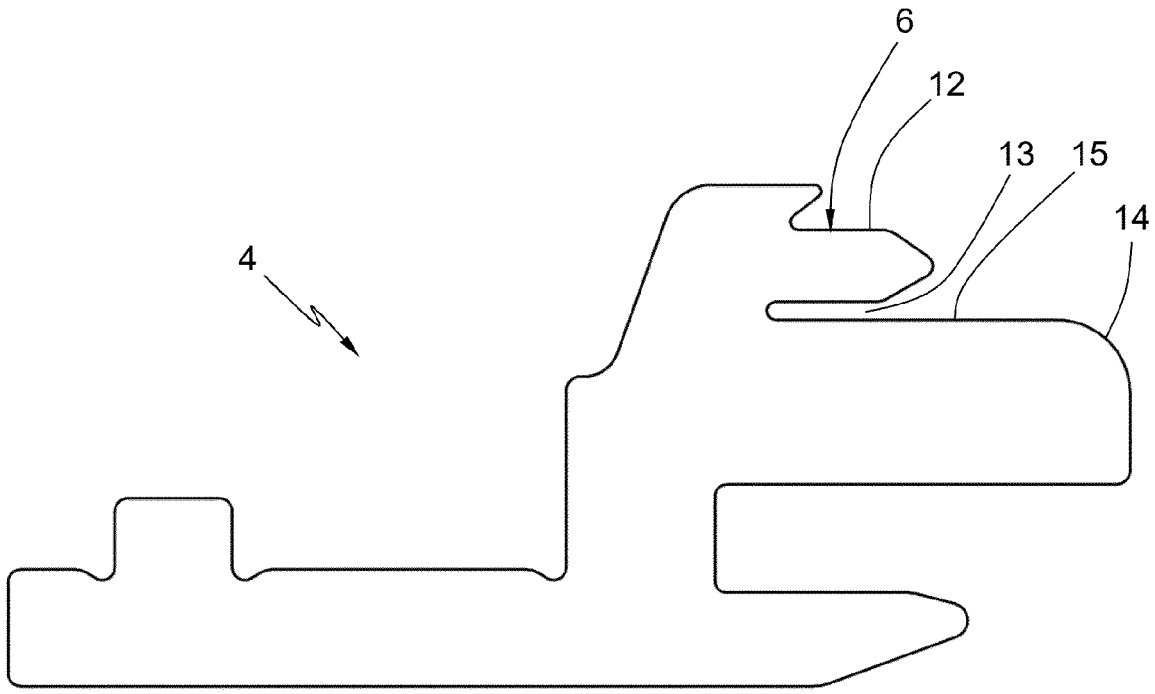

FIG. 5

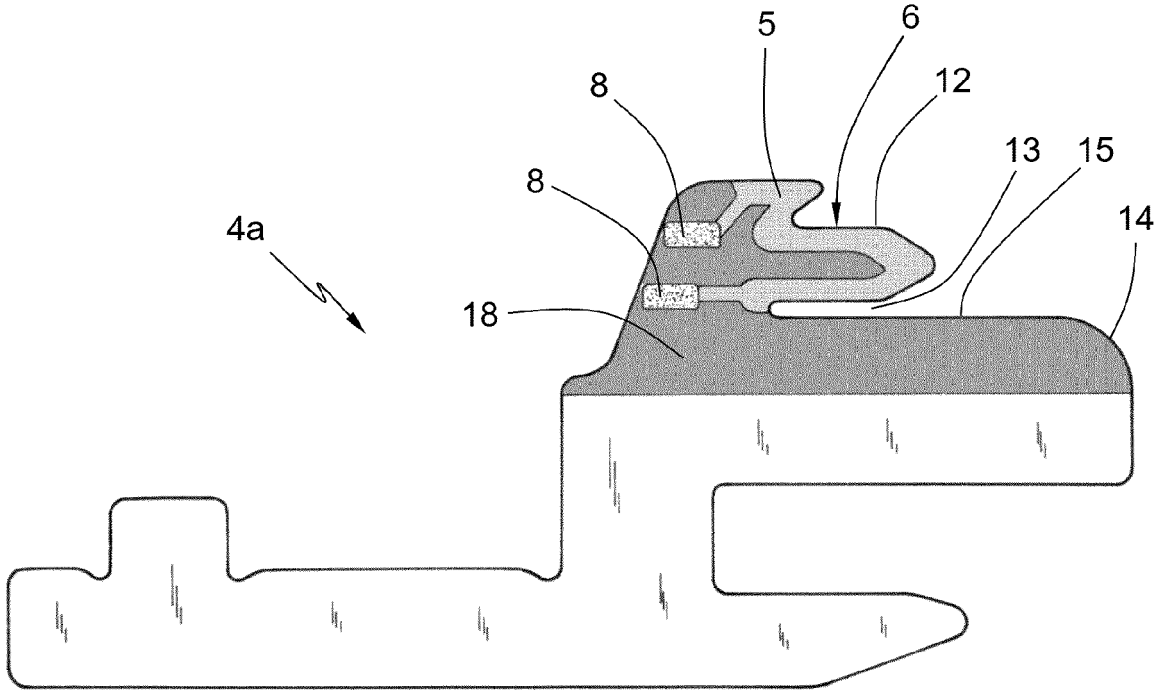

FIG. 6

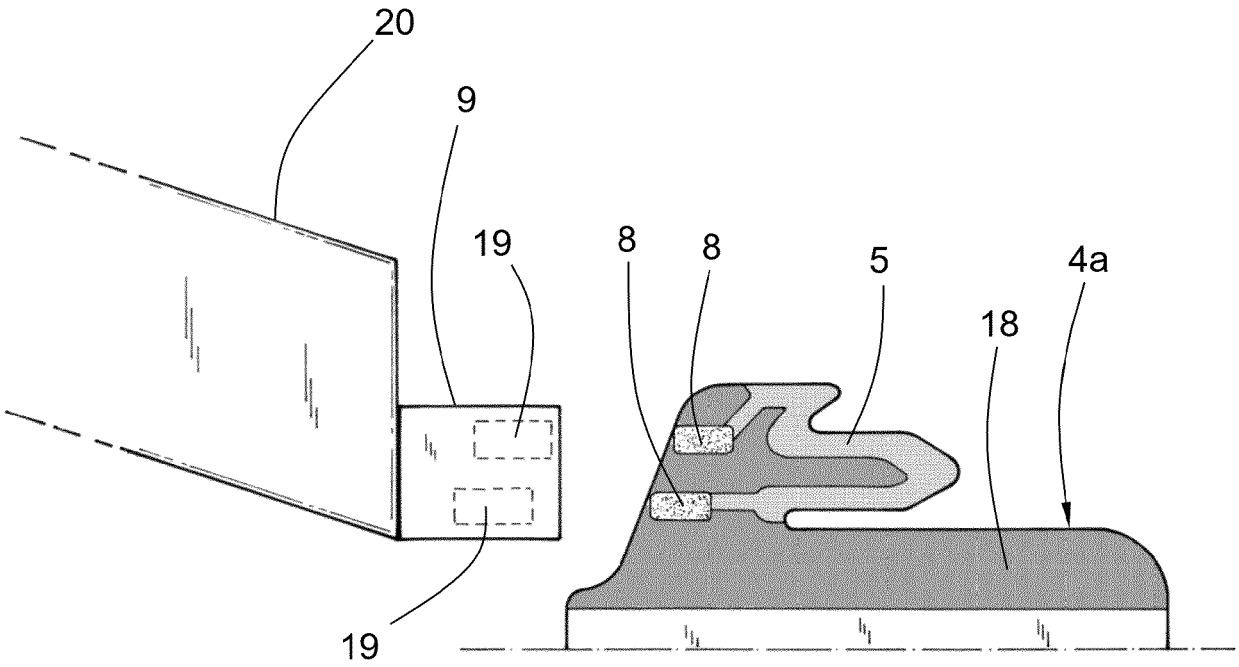

FIG. 7

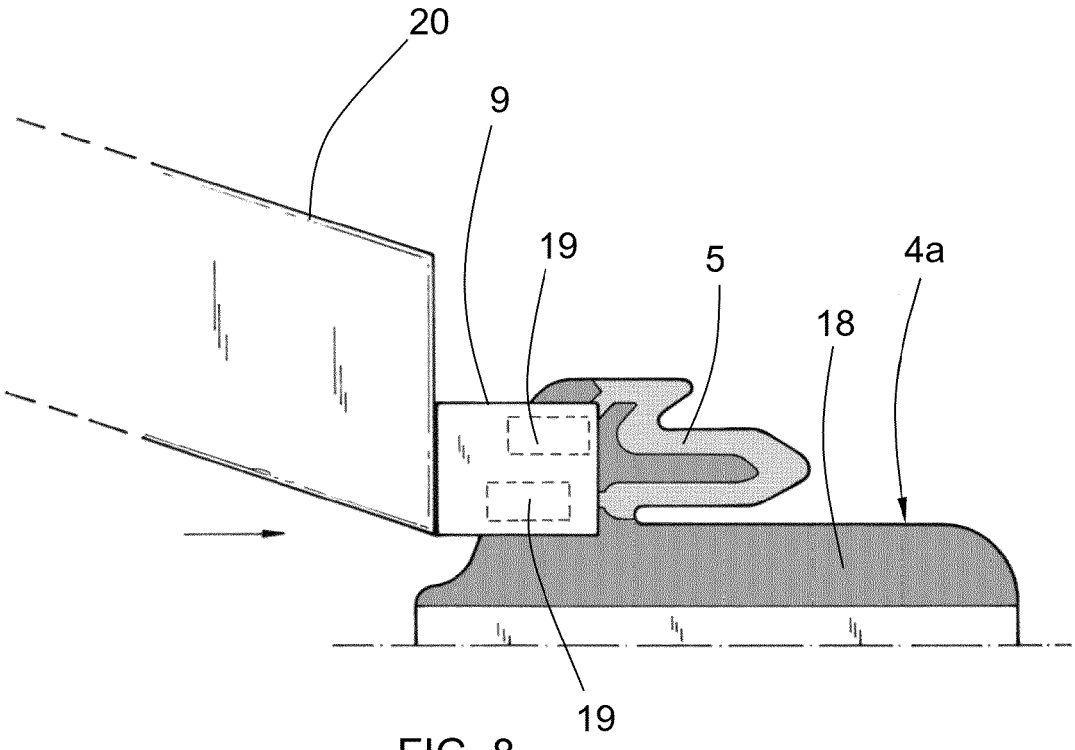

FIG. 8

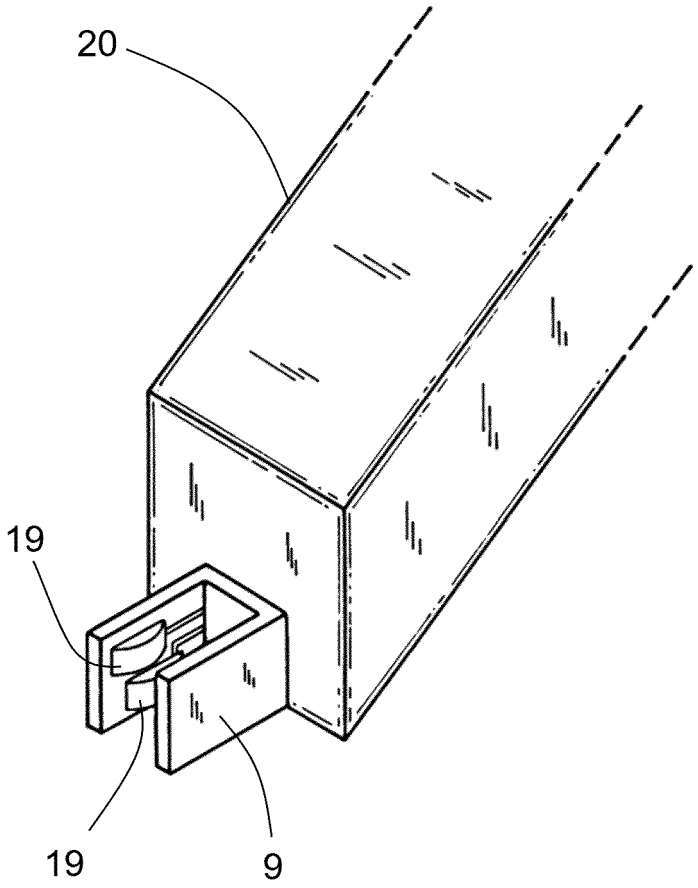

FIG. 9

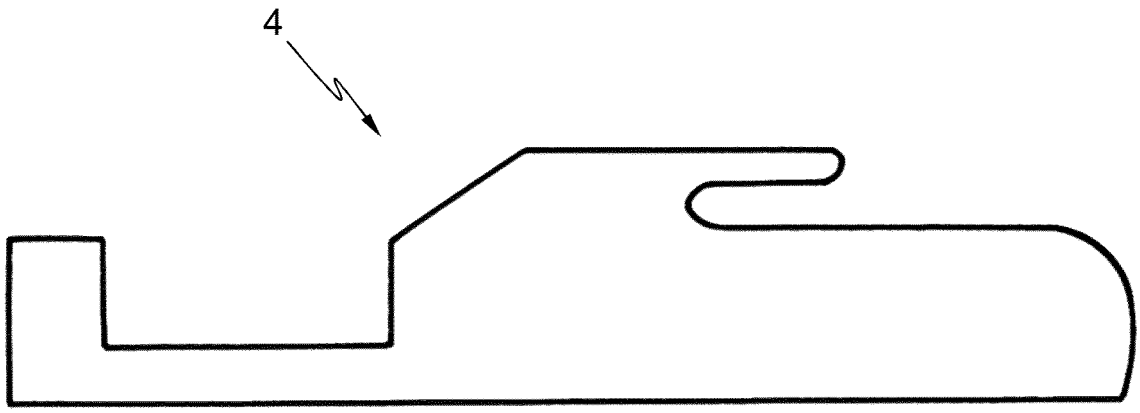

FIG. 10

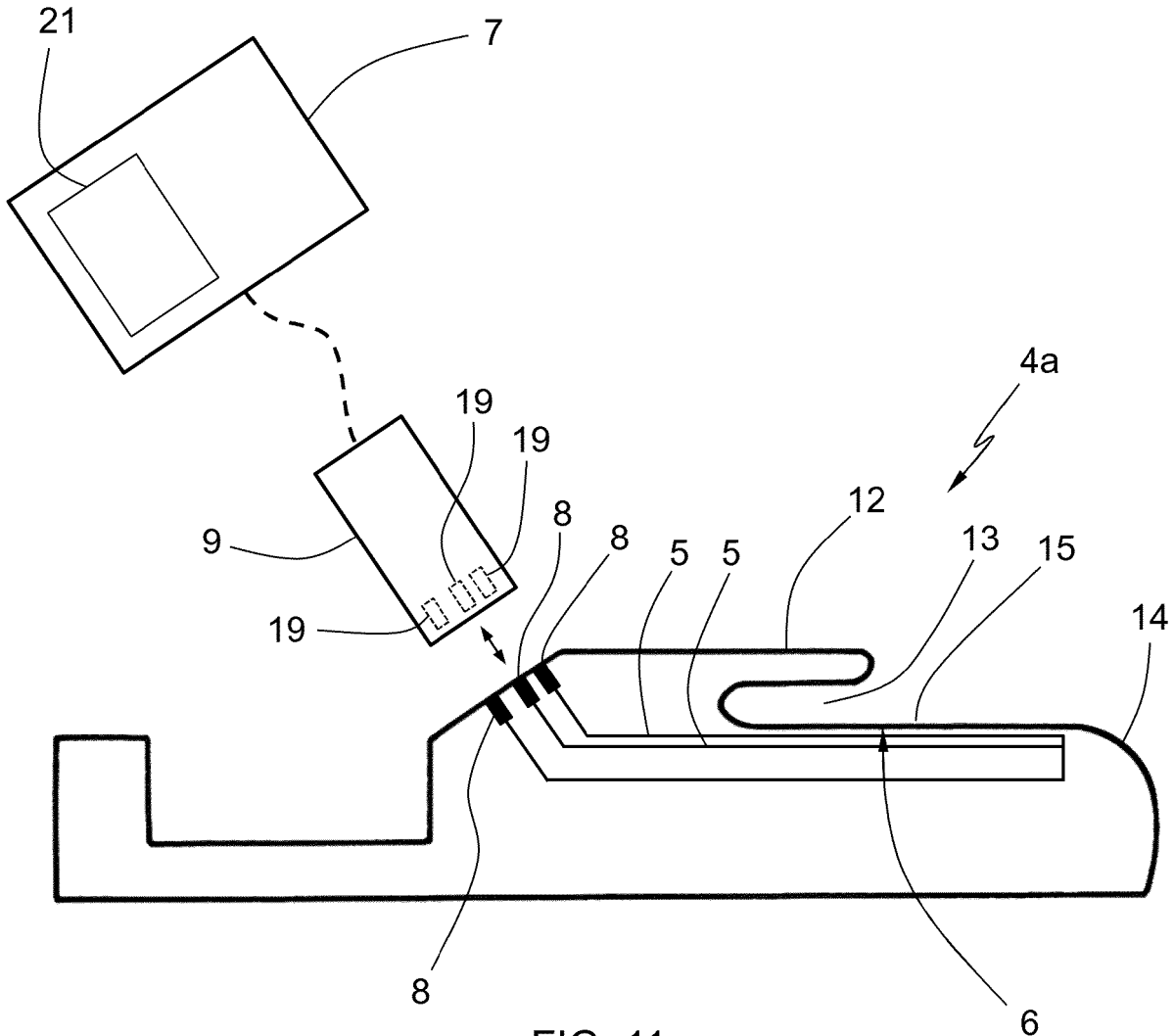

FIG. 11

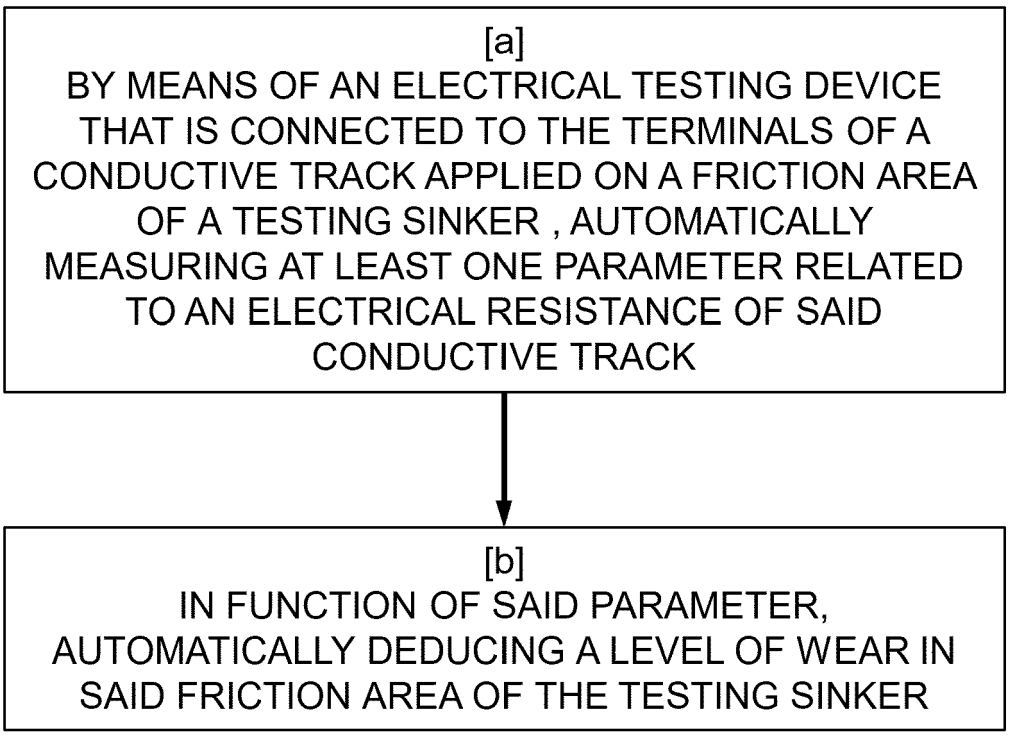
[a]
BY MEANS OF AN ELECTRICAL TESTING DEVICE THAT IS CONNECTED TO THE TERMINALS OF A CONDUCTIVE TRACK APPLIED ON A FRICTION AREA OF A TESTING SINKER , AUTOMATICALLY MEASURING AT LEAST ONE PARAMETER RELATED TO AN ELECTRICAL RESISTANCE OF SAID CONDUCTIVE TRACK
[b]
IN FUNCTION OF SAID PARAMETER, AUTOMATICALLY DEDUCING A LEVEL OF WEAR IN SAID FRICTION AREA OF THE TESTING SINKER

FIG. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 23 38 2562

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	EP 3 483 319 B1 (GROZ BECKERT KG [DE]) 22 December 2021 (2021-12-22) * paragraph [0001]; figure 3 * * paragraph [0008] * * paragraph [0010] - paragraph [0015] * * paragraph [0020] * * paragraph [0034] * * paragraph [0039] - paragraph [0040] *	1-15	INV. D04B9/02 D04B15/06 D04B35/10 D04B37/02
A	EP 3 594 613 A1 (KARL MAYER R&D GMBH [DE]) 15 January 2020 (2020-01-15) * paragraph [0004] - paragraph [0007]; figures 1-4 * * paragraph [0011] - paragraph [0016] * * paragraph [0019] - paragraph [0024] *	1-15	
A	US 4 035 696 A (KESSLER GERHARD ET AL) 12 July 1977 (1977-07-12) * column 2, lines 8-20, 48-53; figures 3, 3a * * column 5, lines 44-49 *	1-15	TECHNICAL FIELDS SEARCHED (IPC) D04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 November 2023	Wendl, Helen

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

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22-11-2023

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