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(54) **OPERATING MACHINE AND METHOD TO MAKE IT WORK SAFELY**

(57) Operating machine (10) and method to make it work safely, wherein the operating machine (10), which comprises an acquisition unit to acquire a maximum pressure value applicable on a ground (S) as a function of the characteristics of the latter, a detection unit to operationally detect the current dynamic work configuration of the operating machine (10) and to know the overall force effectively applied to the ground (S), and a processing unit to calculate the instantaneous ground pressure of the operating machine (10), corresponding to the overall force.

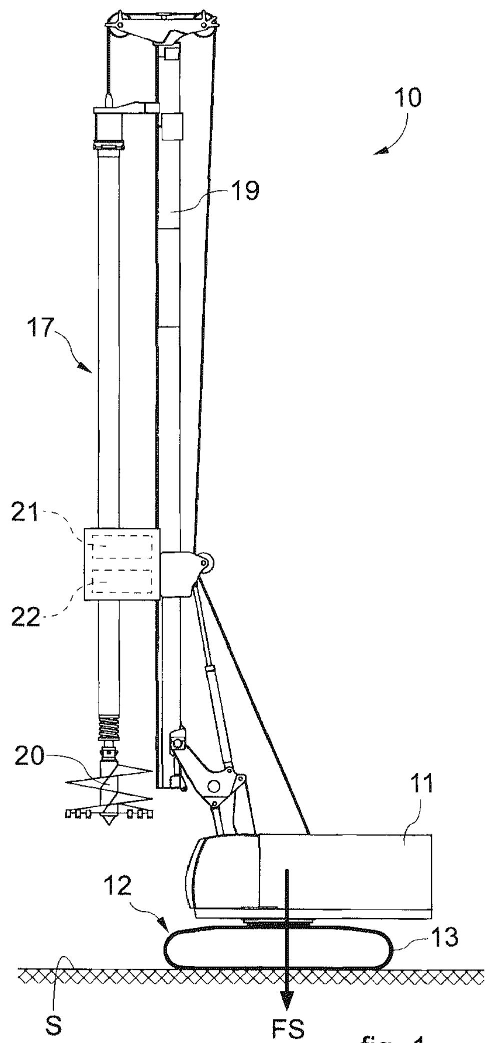

fig. 1

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## Description

FIELD OF THE INVENTION

**[0001]** The present invention concerns an operating machine, herein understood as, for example, a crane, a drilling rig, a drilling machine, an excavator, or the like, and a method to make it work safely, above all, but not only, to prevent the operating machine from overturning or sinking into the ground, understood as any surface on which it rests and which can be a ground, a platform, an asphalt surface or the like.

BACKGROUND OF THE INVENTION

**[0002]** Operating machines, as defined above, are known that can be used during the construction of civil works, for example for the excavation and/or the realization of foundations, in the construction of buildings, roads or other artefacts.

**[0003]** In use, due to the conformation and the consistency of the ground, due to the yield of the latter and/or an incorrect use of the operating machine, it may happen that it overturns, endangering the safety of the operator and any persons close to the operating machine and causing considerable material damage both to the latter, and to any surrounding infrastructures, as well as the temporary blocking of the work in progress.

**[0004]** For example, the ground may yield if the pressure exerted thereon, which hereafter and in the appended claims is defined as "ground pressure", by the operating machine exceeds the maximum allowed pressure value. In fact, before starting any work on a determinate ground, it is necessary to know well the characteristics of the latter.

**[0005]** The pressure on the ground varies during the different work steps both as a function of the movements of the operating machine and based on the forces applied by the latter to the ground.

**[0006]** An operating machine is known from document US 2018/245304 in which the ground pressure exerted by it is calculated on the basis of detection devices that detect the applied loads. The measured values are instantaneously compared with determinate threshold pressure values, obtained from the information related to the ground characteristics, beyond which the pressure can cause a yield of the ground and/or the overturning of the operating machine. The instantaneous comparison, variable over time, is shown to the operator of the operating machine with a dynamic graphic comparison, and, in the event that the pressure on the ground exceeds the threshold value, it can also be used to automatically stop the movements of the operating machine, blocking it.

**[0007]** For the operator of said operating machine it can be complex to manage additional information compared to those necessary due to the complex operation thereof, or to restart it in the event that it is automatically stopped.

**[0008]** An excavating machine is known from document US2018/230673 in which the inclination of the excavating member is envisaged to be controlled. This inclination is related to the load borne by the excavating member. As a function of the load, the eccentricity and the inclination of the machine, the control method described by US2018/230673 provides for limiting the torque when a limit pressure value is reached. To do this, the method described by this document resorts to several sets of equations, resulting in a complex control algorithm to be implemented from the computational point of view, which is not easily usable for the operator.

**[0009]** There is therefore the need to perfect an operating machine and to develop a method to make it work safely that can overcome at least one of the disadvantages of the state of the art.

**[0010]** To do this, it is necessary to solve the technical problem of always keeping the operating machine stable, in whatever configuration it is, of both static and dynamic work, intervening as little as possible on the mechanical members responsible for carrying out the different works.

**[0011]** In particular, one purpose of the present invention is to realize an operating machine and to develop a method to make it work safely, that avoids imbalances and relative overturnings of the operating machine itself, during its use, as a function of the type of ground on which it rests.

**[0012]** One purpose is also to realize an operating machine and to develop a method to make it work safely, that does not require the installation of particular devices, or detection and control members, which would be too cumbersome, expensive and complicated to manage.

**[0013]** Another purpose of the present invention is to realize an operating machine and to develop a method to make it work safely, that does not automatically stop the operating machine when the forces applied on the ground reach certain threshold levels.

**[0014]** The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

**[0015]** The present invention is set forth and characterized in the independent claims. The dependent claims describe other characteristics of the present invention or variants to the main inventive idea.

**[0016]** In accordance with the above purposes, and to resolve the technical problem disclosed above in a new and original way, also achieving considerable advantages compared to the state of the prior art, the Applicant has developed a method according to the present invention to make an operating machine work safely comprising a plurality of actuation members configured to determine the movement of one or more moving parts of said operating machine, wherein said operating machine is configured to assume a determinate static configuration, in which the operating machine applies, on the resting ground, a corresponding static force, and one or more dynamic work configurations, in each of which the operating machine applies a corresponding dynamic force on the resting ground, whereby an overall force is instantaneously applied on the latter, which is the sum of the static force and the dynamic force.

**[0017]** It is specified that herein, in the following and in the appended claims, the term "static force" means the weight force of the operating machine under static conditions, that is, when it is stationary, whereas the term "dynamic force" means both the pure force applied dynamically to the ground, instant by instant, and expressed in Newton, and the corresponding momentum that it determines, expressed in Nm (Newton per metre), with respect to the resting base of the operating machine.

**[0018]** In particular, the method according to the present invention comprises: an acquisition step, in which acquisition means acquire a maximum ground pressure value applicable on the ground which is a function of the characteristics of the ground; a detection step, in which detection means operationally detect the overall force effectively applied on the ground; and a first processing step, in which processing means calculate the instantaneous ground pressure of the operating machine, corresponding to the overall force, which is a function of the dynamic work configuration in which the machine is placed.

**[0019]** In accordance with one aspect of the present invention, the method also comprises a second processing step, in which the aforesaid processing means calculates, based on the static configuration and the current dynamic work configuration, the maximum overall force to which the aforesaid maximum ground pressure corresponds, and define at least one threshold value of the overall force equal to or lower than the maximum overall force, and a third processing step in which said processing means control said plurality of actuation members so that said dynamic force is such that the overall force is lower than or equal to the at least one threshold value so as to automatically cause the limitation of the value of said overall force.

**[0020]** By doing so, the advantage of being able to use the operating machine under conditions of maximum safety is obtained, in any configuration, both of static and dynamic work, as a function of the characteristics of the ground on which it rests instantaneously, without stopping them. This prevents the operating machine from accidentally overturning or sinking.

**[0021]** Thanks to the method according to the present invention, the operating machine always works safely and reliably since the processing means command the movements of the moving parts of the machine, which include for example a drilling tower and a drilling tool, so that, based on the current configuration and the ground characteristics, the overall force effectively applied to the ground is always within safety values.

**[0022]** Thanks to the present invention it is therefore possible both to avoid damage to the operating machine or to some of its parts, and to avoid sudden stops of the machine, which are unwanted since they slow down the operation thereof and can require long and laborious restoration operations.

**[0023]** It is specified that the second processing step may be performed indifferently before, during, or after the first processing step.

**[0024]** In accordance with another aspect of the present invention, the aforesaid detection means, in order to detect the overall force effectively applied on the ground, operationally detect, between the one or more dynamic work configurations, the current one.

**[0025]** In accordance with another aspect of the present invention, during the second processing step only one threshold value is defined at a determinate percentage, comprised between 85% and 95% of the maximum overall force.

**[0026]** In accordance with another aspect of the present invention, during the second processing step there are defined both a first threshold value at a determinate first percentage, comprised between 85% and 95% of the maximum overall force, and a second threshold value lower than the first threshold value.

**[0027]** By way of example, up to the second threshold value the dynamic force is substantially increased linearly with a first rate of increase, while between the second threshold value and the first threshold value the dynamic force is increased with a second rate of increase lower than the first rate of increase.

**[0028]** In accordance with another aspect of the present invention, between the second threshold value and the first threshold value the dynamic force is increased non-linearly, but with a rate of increase gradually degrading until it reaches zero in correspondence with said first threshold value.

**[0029]** In accordance with another aspect of the present invention, during the first processing step, the instantaneous ground pressure is calculated, for example, by means of rigid body dynamics processing methods.

**[0030]** In accordance with another aspect of the present invention, the method further comprises a communication step, in which one or more of the following values: static force; dynamic force; overall force; maximum overall force; one or more threshold values; instantaneous ground pressure; are communicated, in any known manner, to at least one operator of the operating machine, who may be either onsite or distant therefrom.

**[0031]** In accordance with another aspect of the present invention, said processing means control said plurality of actuation members in a coordinated manner so as to avoid the stop of said moving parts of said operating machine during its operation.

**[0032]** In accordance with another aspect of the present invention, an operating machine, comprising a plurality of actuation members configured to determine the movement of one or more moving parts comprised in said operating machine, is configured to assume a determinate static configuration, in which it applies, on the ground on which it rests, a corresponding static force, and one or more dynamic work configurations, in each of which it applies a corresponding dynamic force on the ground, whereby an overall force is instantaneously applied on the ground, which is the sum of the static force and the dynamic force, and comprises acquisition means, detection means and processing means. Said acquisition means are configured to acquire a maximum ground pressure value applicable on the ground as a function of the characteristics of the ground.

**[0033]** The aforesaid detection means are configured to operationally detect, amongst the one or more dynamic work configurations, the current dynamic work configuration of the operating machine in order to know the overall force effectively applied on the ground.

**[0034]** The aforesaid processing means are configured both to calculate the instantaneous ground pressure of the operating machine corresponding to the overall force, as a function of the current dynamic work configuration in which the operating machine is arranged and - based on the static configuration and the current dynamic work configuration - a maximum overall force to which the maximum ground pressure corresponds, and to define at least one threshold value of the overall force equal to, or lower than, the maximum overall force. Said processing means are further configured to control said plurality of actuation members so that said dynamic force is such that said overall force is lower than or equal to said at least one threshold value so as to automatically cause the limitation of the value of said overall force.

**[0035]** In accordance with another aspect of the present invention, the aforesaid detection means comprise one or more sensors each associated with one of the actuation members in order to generate corresponding feedback signals indicative of the movements performed thereby.

**[0036]** In accordance with another aspect of the present invention, the aforesaid acquisition means comprises a data entry interface.

**[0037]** In accordance with another aspect of the present invention, the operating machine further comprises communication means configured to communicate the results of the aforesaid processing means to at least one operator of the operating machine.

**[0038]** In accordance with another aspect of the present invention, the operating machine further comprises both a drilling tool configured to apply said dynamic force to the ground, and respective actuation members comprised in said plurality of actuation members for rotating, lifting and lowering said drilling tool.

DESCRIPTION OF THE DRAWINGS

**[0039]** These and other aspects, characteristics and advantages of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a schematized side view of an operating machine according to the present invention, in accordance with a first embodiment and represented in a static configuration;
- fig. 2 is a schematized side view of the operating machine of fig. 1, represented in a dynamic work configuration;
- fig. 3 is a block diagram of the operating machine of fig. 1;
- figures 4 and 5 are two schematic diagrams in which two examples are represented of how the overall forces applied to the ground by the operating machine of fig. 1 vary in a dynamic work configuration thereof;
- fig. 6 is a schematized side view of an operating machine according to the present invention, in accordance with a second embodiment and represented in a dynamic work configuration;
- fig. 7 is a block diagram of the operating machine of fig. 6;
- fig. 8 is a flowchart of a method to make an operating machine work safely, according to the present invention.

**[0040]** We must clarify that in the present description the phraseology and terminology used, as well as the figures in the attached drawings also as described, have the sole function of better illustrating and explaining the present invention, their function being to provide a non-limiting example of the invention itself, since the scope of protection is defined by the claims.

**[0041]** To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can be conveniently combined or incorporated into other embodiments without further clarifications.

DESCRIPTION OF SOME EMBODIMENTS OF THE PRESENT INVENTION

**[0042]** With reference to fig. 1, an operating machine 10 according to the present invention, in accordance with a first embodiment, comprises a main body 11 mounted on an advancement assembly 12, which in the specific case comprises tracks 13 that rest on a ground S. The tracks 13 are driven by a first actuation member 15 (fig. 3). A second actuation member 16 (fig. 3) is present, for example, in the main body 11 in order to selectively rotate the latter with respect to the advancement assembly 12.

**[0043]** In the main body 11 (fig. 1) there is mounted a work assembly 17, substantially of a per se known type, which in the example provided herein comprises a drilling tower 19 and a drilling tool 20 selectively brought into rotation by a third actuation member 21 (figures 1, 2 and 3). A fourth actuation member 22 (figures 1, 2 and 3) is present in the main body 11 in order to selectively lift and lower the drilling tool 20.

**[0044]** Each of the actuation members 15, 16, 21 and 22 may be of any known type and may comprise, for example, an electric motor.

**[0045]** A fifth actuation member 23 and a sixth actuation member 25 (fig. 3), for example of fluid-dynamic type, are mounted in the main body 11 and are configured to selectively move the drilling tower 19 with respect to the latter and, respectively, tilt it with respect to a vertical axis.

**[0046]** When the operating machine 10 is stationary, it assumes a determinate static configuration, in which it applies a corresponding static force FS on the ground S, while when it is operating it can assume one or more dynamic work configurations, in each of which it applies on the ground S a corresponding dynamic force FD (fig. 2), whereby an overall force F is instantaneously applied on the latter, which is the sum of the static force FS and the dynamic force FD and is considered applied in the centre of gravity of the operating machine 10. The dynamic force FD corresponds to a dynamic momentum equal to the value of the latter, expressed in Newton, for its arm b measured in metres from the point of application of the same dynamic force FD to the nearest point of the resting base of the machine 10, which in this embodiment corresponds to the resting surface of the tracks 13 on the ground S.

**[0047]** The operating machine 10 further comprises a detection unit, or means, 26 configured to operationally detect the overall force F effectively applied on the ground S.

**[0048]** Specifically, the detection means 26 operationally detect, amongst the different dynamic work configurations that the operating machine 10 can assume, the current one, in order to know the aforesaid overall force F.

**[0049]** In the example provided herein the detection means 26 comprise a plurality of sensors 27 (fig. 3) which are each associated with one of the actuation members 15, 16, 21, 22, 23 and 25 in order to generate corresponding feedback signals indicative of the movements performed thereby.

**[0050]** The sensors 27 are chosen from a group comprising at least rotation sensors, inclinometers, accelerometers, load cells for force monitoring and similar or the like.

**[0051]** The operating machine 10 further comprises an acquisition unit, or means, 30, configured to acquire a maximum ground pressure value PSmax applicable on the ground S, as a function of the characteristics of the latter, including geophysical ones.

**[0052]** In the example provided herein the acquisition means 30 comprise a data entry interface, such as for example a keyboard or any other data entry device of known type.

**[0053]** The operating machine 10 further comprises a processing unit, or means, 31 configured at least to calculate the instantaneous ground pressure PSi, corresponding to the overall force F.

**[0054]** In the example provided herein the processing means 31 comprise a central control unit, or CPU, 32, and one or more memory devices 33 of known type, comprising at least one random access memory (RAM) and one read-only memory (ROM).

**[0055]** In particular, in accordance with an aspect of the present invention, in the memory devices 33 there is stored at least one algorithm configured both to calculate, based on the static configuration and the current dynamic work configuration of the operating machine 10, the maximum overall force Fmax to which the maximum ground pressure PSmax corresponds, and to define at least one threshold value FG, for example two (FG1 and FG2 in fig. 5), of the overall force F equal to or lower than the maximum overall force Fmax applicable on the ground S, and to automatically cause the limitation of the overall force F to a value lower than or equal to the threshold value FG.

**[0056]** By way of example, the aforesaid limitation of the overall force F is obtained by the processing means 31 which selectively and suitably control, in particular through a communication BUS 34, the actuation members 15, 16, 21, 22, 23 and 25, so that the dynamic force FD applied to the ground S, specifically by the drilling tool 20, is such that the overall force F is always equal to or lower than the threshold value FG.

**[0057]** The operating machine 10 further comprises communication means 35 configured to communicate the results of the processing means 31 to an operator of the operating machine 10, for example by displaying them on a display and/or by pronouncing them with a loudspeaker of known type and not represented in the drawings.

**[0058]** With reference to fig. 6, an operating machine 110 according to the present invention, in accordance with a second embodiment, has the form of a tower construction crane, substantially of known type.

**[0059]** The operating machine 110, unlike the operating machine 10 described above, comprises a lattice tower 41, installed on the ground S by means of resting feet 42, at the base of which there are optionally corresponding load cells 43. On the upper part of the tower 41 there is rotatably mounted a horizontal lattice beam 45, having an operating arm 46 along which a carriage 47 is slidable which, by means of ropes 49, supports a hook 50.

**[0060]** The aforesaid load cells 43 are configured to detect the ground pressure in correspondence with the resting feet 42.

**[0061]** In the operating machine 110 there are a corresponding first actuation member 115 (fig. 7), configured to selectively rotate the horizontal beam 45, a corresponding second actuation member 116, configured to move the carriage 47 along the operating arm 46 and a corresponding third actuation member 121 to lift and lower the hook 50 with the relative load C, which represents the dynamic force FD. Also in this case, the dynamic force FD corresponds to a dynamic momentum equal to the value of the latter, expressed in Newton, multiplied by its arm b (fig. 6) measured in metres from the point of application of the same dynamic force FD to the nearest point of the resting base of the machine 10, which in this embodiment corresponds to the resting surface of the resting feet 42 on the ground S.

**[0062]** The detection means 26, the acquisition means 30 and the processing means 31 are also present in the operating machine 110. In this case the detection means 26 also comprise the load cells 43.

**[0063]** The operation of the operating machine 10, 110 described so far, which corresponds to the method according to the present invention, comprises an initial step of entering input data, such as for example the characteristics of the operating machine 10, 110, such as masses, centres of gravity, geometries (for example, the extension of the resting surface of the tracks 13) and others known to those skilled in the art.

**[0064]** It is then followed by an acquisition step 201 (fig. 8), in which by means of the acquisition means 30 the maximum ground pressure value PSmax applicable on the latter is acquired. This value is transferred to the processing means 31.

**[0065]** The method further comprises both a detection step 202, in which the detection means 26 operationally detect, amongst the different dynamic work configurations, the current one in order to know the overall force F effectively applied on the ground S, and a first processing step 203, in which the processing means 31 calculate the instantaneous ground pressure PSi of the operating machine 10, 110, corresponding to the overall force F.

**[0066]** In the detection step 202, the detection of the instantaneous dynamic work configuration of the operating machine 10, 110 comprises detecting at least the feedback signals provided by the plurality of sensors 27, each associated with one of the actuation members 15, 115; 16, 116; 21, 121; 22, 23 and 25, in order to generate corresponding indicative of the movements performed thereby.

**[0067]** Detecting the instantaneous dynamic work configuration of the operating machine 10, 110 further comprises detecting the signals provided by the load cells 43.

**[0068]** The first processing step 203 provides that the instantaneous ground pressure PSi of the operating machine 10, 110 is calculated by means of rigid body dynamics processing methods.

**[0069]** In accordance with the above second embodiment, the first processing step 203 provides that the instantaneous ground pressure PSi of the operating machine 10, 110 is calculated starting from the signals provided by the load cells 43.

**[0070]** In accordance with one aspect of the present invention, the method further comprises a second processing step 204, which may be performed indifferently before, during, or after the first processing step 203, in which the processing means 31 calculates 205, based on the static configuration and the current dynamic work configuration, the maximum overall force Fmax to which the maximum ground pressure PSmax corresponds and defines 206 the threshold value FG, or the threshold values FG1 and FG2, of the overall force F which must be equal to, or lower than, the maximum overall force Fmax.

**[0071]** Subsequently, a third processing step 207 is performed in which processing means 31, by suitably driving the different actuation members 15, 115; 16, 116; 21, 121; 22, 23 and 25, cause a limitation of the overall force F to a value lower than or equal to the threshold value FG or FG1.

**[0072]** According to one embodiment, during the second processing step 204 and as represented in fig. 4, only a threshold value FG is defined at a determinate percentage, comprised between 85% and 95% of the maximum overall force Fmax.

**[0073]** According to an embodiment variant, during the second processing step 204 and as represented in fig. 5, it can be defined both a first threshold value FG1 at a determinate first percentage, comprised between 85% and 95% of the maximum overall force Fmax, and a second threshold value FG2 lower than the aforesaid first threshold value FG1.

**[0074]** In the aforesaid embodiment variant, the dynamic force FD is substantially increased linearly with a first rate of increase up to the aforesaid second threshold value FG2. The dynamic force FD is then increased with a second rate of increase, lower than said first rate of increase, between the second threshold value FG2 and the first threshold value FG1.

**[0075]** Between the second threshold value FG2 and the first threshold value FG1 the dynamic force FD is increased non-linearly, but with a rate of increase gradually degrading until it reaches zero in correspondence with the first threshold value FG1.

**[0076]** In figures 4 and 5, there are exemplarily reported the trend F' of the dynamic force FD in the case, not envisaged by the present invention, that the dynamic force FD can increase without limitation and the trend F" of the dynamic force FD in the case, described in the present invention, that the dynamic force FD is limited.

**[0077]** The method further comprises a communication step 208, in which one or more values are communicated to at least one operator of the operating machine 10, 110 selected from: static force FS; dynamic force FD; overall force F; maximum overall force Fmax; one or more threshold values FG, FG1, FG2; instantaneous ground pressure PSi, position of the centre of gravity of the operating machine 10 or similar and the like.

**[0078]** The communication step 208 also comprises communicating a trend or an absolute value of the one or more of the aforesaid values.

**[0079]** Advantageously, knowing one or more of the aforesaid values allows the operator to understand whether the work, in the current dynamic work configuration, is possible; for example, knowing that the operating machine 10, 110 has 500 kN of extraction force makes it possible for the operator to determine the weight that the extracted load and the work assembly 17 can reach.

**[0080]** It is clear that modifications and/or additions of parts can be made to the operating machine 10, 110 and to the method to make it work safely as described heretofore, without departing from the field and scope of the present invention, as defined by the claims.

**[0081]** It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve other equivalent forms of operating machines and methods to make them work safely, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

**[0082]** In the following claims, the sole purpose of the references in brackets is to facilitate their reading and they must not be considered as restrictive factors with regard to the field of protection defined by the claims.

## Claims

1. Method to make an operating machine (10; 110) work safely comprising a plurality of actuation members (15, 16, 21, 22, 23, 25; 115, 116, 121) configured to determine the movement of one or more moving parts of said operating machine (10; 110), wherein said operating machine (10; 110) is configured to assume a determinate static configuration, in which it applies, on the resting ground (S), a corresponding static force (FS), and one or more dynamic work configurations, in each of which it applies a corresponding dynamic force (FD) on said ground (S), whereby an overall force (F) is instantaneously applied on said ground (S) which is the sum of said static and dynamic forces (FS, FD), wherein said method comprises:

    - an acquisition step in which acquisition means (30) acquire a maximum ground pressure (PSmax) value applicable on said ground (S), which is a function of the characteristics of the ground (S);
    - a detection step in which detection means (26) operationally detect the overall force (F) effectively applied on said ground (S); and
    - a first processing step in which processing means (31) calculate the instantaneous ground pressure (PSi) of said operating machine (10; 110), corresponding to said overall force (F), which is a function of the dynamic work configuration in which the machine is placed; and said method is

    **characterized in that** it comprises both a second processing step, in which said processing means (31) calculate the maximum overall force (Fmax) to which said maximum ground pressure (PSmax) corresponds, and define at least one threshold value (FG) of said overall force (F) equal to or lower than said maximum overall force (Fmax), and a third processing step in which said processing means (31) control said plurality of actuation members (15, 16, 21, 22, 23, 25; 115, 116, 121) so that said dynamic force (FD) is such that said overall force (F) is lower than or equal to said at least one threshold value (FG) so as to automatically cause the limitation of the value of said overall force (F).

2. Method as in claim 1, **characterized in that** in order to detect said overall force (F) effectively applied on said ground (S), said detection means (26) operationally detect, amongst said one or more dynamic work configurations, a current dynamic work configuration.

3. Method as in claim 1 or 2, **characterized in that** during said second processing step only one threshold value (FG) is defined at a determinate percentage, comprised between 85% and 95% of said maximum overall force (Fmax).

4. Method as in claim 1 or 2, **characterized in that** during said second processing step there are defined both a first threshold value (FG1) at a determinate first percentage, comprised between 85% and 95% of said maximum overall force (Fmax), and a second threshold value (FG2) lower than said first threshold value (FG1).

5. Method as in claim 4, **characterized in that** up to said second threshold value (FG2) said dynamic force (FD) is substantially increased linearly with a first rate of increase, while between said second threshold value (FG2) and said first threshold value (FG1) said dynamic force (FD) is increased with a second rate of increase lower than said first rate of increase.

6. Method as in claim 5, **characterized in that** between said second threshold value (FG2) and said first threshold value (FG1) said dynamic force (FD) is increased non-linearly, but with a rate of increase gradually degrading until it reaches zero in correspondence with said first threshold value (FG1).

7. Method as in any claim hereinbefore, **characterized in that** during said first processing step, said instantaneous ground pressure (PSi) is calculated by means of rigid body dynamics processing methods.

8. Method as in any claim hereinbefore, **characterized in that** it comprises a communication step, in which one or more of the following values are communicated to at least one operator of said operating machine (10, 110): static force (FS); dynamic force (FD); overall force (F); maximum overall force (Fmax); one

or more threshold values (FG, FG1, FG2); instantaneous ground pressure (PSi).

**9.** Method as in any claim hereinbefore, **characterized in that** said processing means (31) control said plurality of actuation members (15, 16, 21, 22, 23, 25; 115, 116, 121) in a coordinated manner so as to avoid the stop of said moving parts of said operating machine (10; 110) during its operation.

**10.** Operating machine (10; 110) comprising a plurality of actuation members (15, 16, 21, 22, 23, 25; 115, 116, 121) configured to determine the movement of one or more moving parts of said operating machine (10; 110), wherein said operating machine (10; 110) is configured to assume a determinate static configuration, in which it applies on the resting ground (S) a corresponding static force (FS), and one or more dynamic work configurations, in each of which it applies on said ground (S) a corresponding dynamic force (FD), whereby an overall force (F) is instantaneously applied on said ground (S), which is the sum of said static force (FS) and dynamic force (FD), wherein the operating machine (10; 110) comprises:

- acquisition means (30) configured to acquire a maximum ground pressure (PSmax) value applicable on said ground (S) as a function of the characteristics of the latter;
- detection means (26) configured to operationally detect, amongst said one or more dynamic work configurations, the current dynamic work configuration of said operating machine (10; 110) in order to know the overall force (F) effectively applied on said ground (S); and
- processing means (31) configured to calculate at least the instantaneous ground pressure (PSi) of said operating machine (10; 110), corresponding to said overall force (F) as a function of the dynamic work configuration in which the operating machine is arranged;

**characterized in that** said processing means (31) are also configured both to calculate, based on said static configuration and said current dynamic work configuration, a maximum overall force (Fmax) to which said maximum ground pressure (PSmax) corresponds, and to define at least one threshold value (FG) of said overall force (F) equal to or lower than said maximum overall force (Fmax), and to control said plurality of actuation members (15, 16, 21, 22, 23, 25; 115, 116, 121) so that said dynamic force (FD) is such that said overall force (F) is lower than or equal to said at least one threshold value (FG) so as to automatically cause the limitation of the value of said overall force (F).

**11.** Operating machine (10; 110) as in claim 10, **characterized in that** said detection means (26) comprise one or more sensors (27) each associated with one of said actuation members (15, 16, 21, 22, 23, 25; 115, 116, 121) in order to generate corresponding feedback signals indicative of the movements performed thereby.

**12.** Operating machine (10; 110) as in claim 10 or 11, **characterized in that** said acquisition means (30) comprise a data entry interface.

**13.** Operating machine (10; 110) as in claim 10, 11 or 12, **characterized in that** it further comprises communication means (35) configured to communicate the results of said processing means (31) to the operator of said operating machine (10; 110).

**14.** Operating machine (10) as in any claim 10-13, **characterized in that** it further comprises both a drilling tool (20) configured to apply said dynamic force (FD) to the ground (S), and respective actuation members (21, 22) comprised in said plurality of actuation members (15, 16, 21, 22, 23, 25) for rotating, lifting and lowering said drilling tool (20).

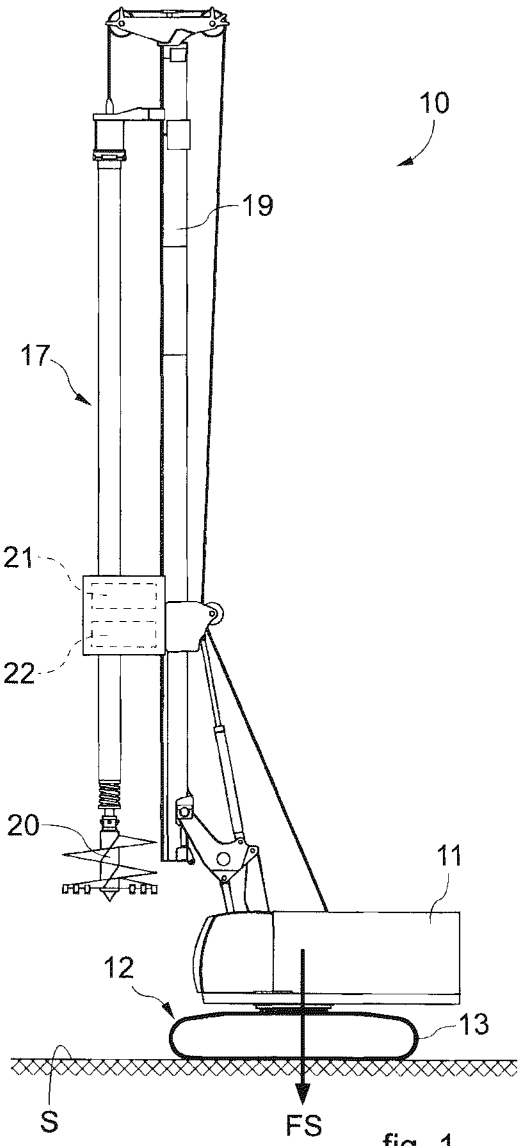


fig. 1

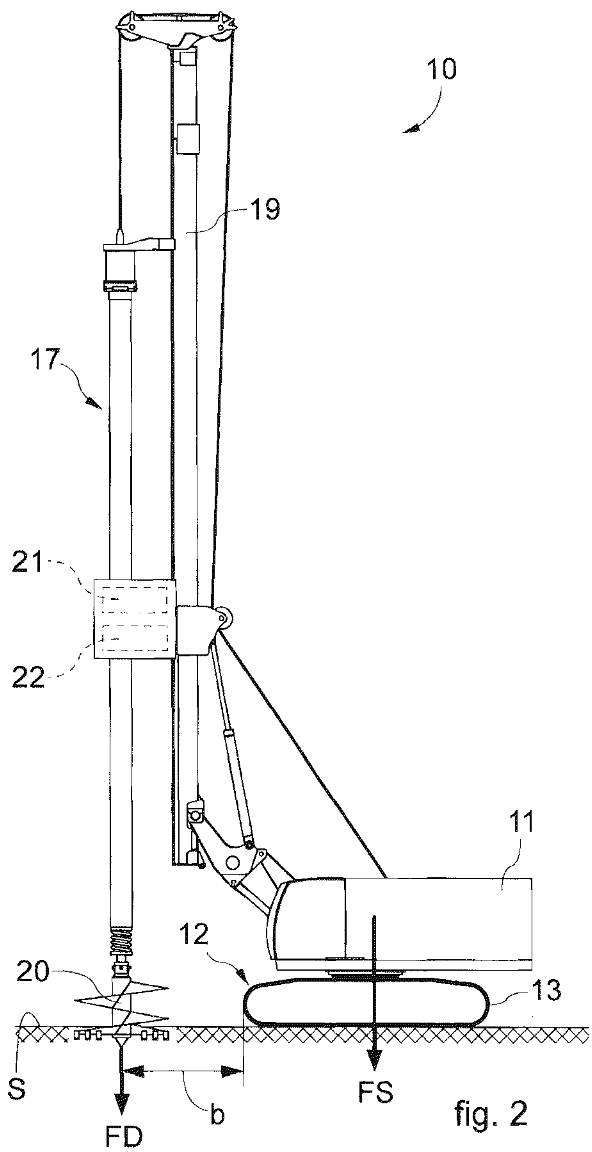


fig. 2

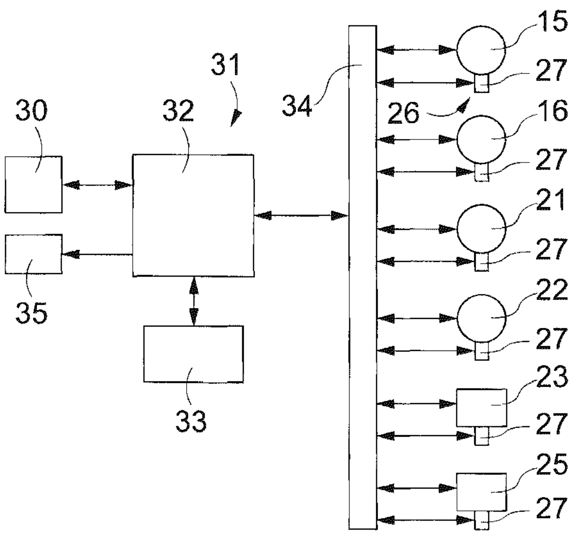


fig. 3

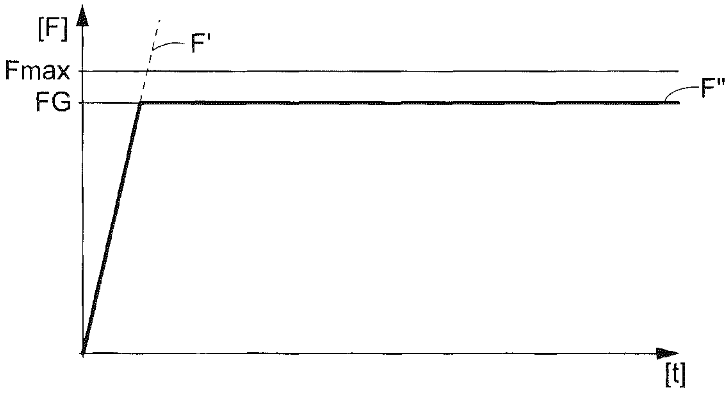


fig. 4

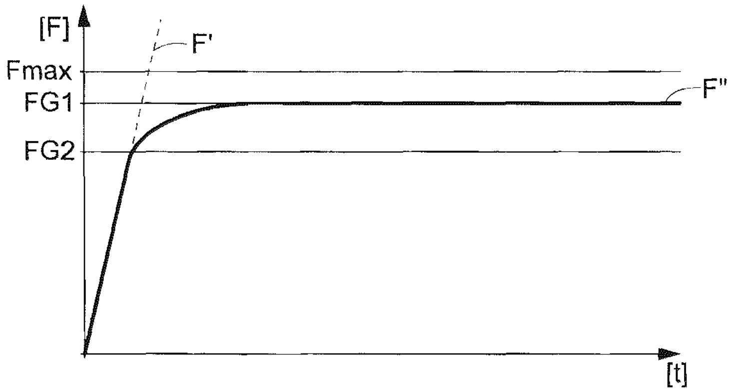


fig. 5

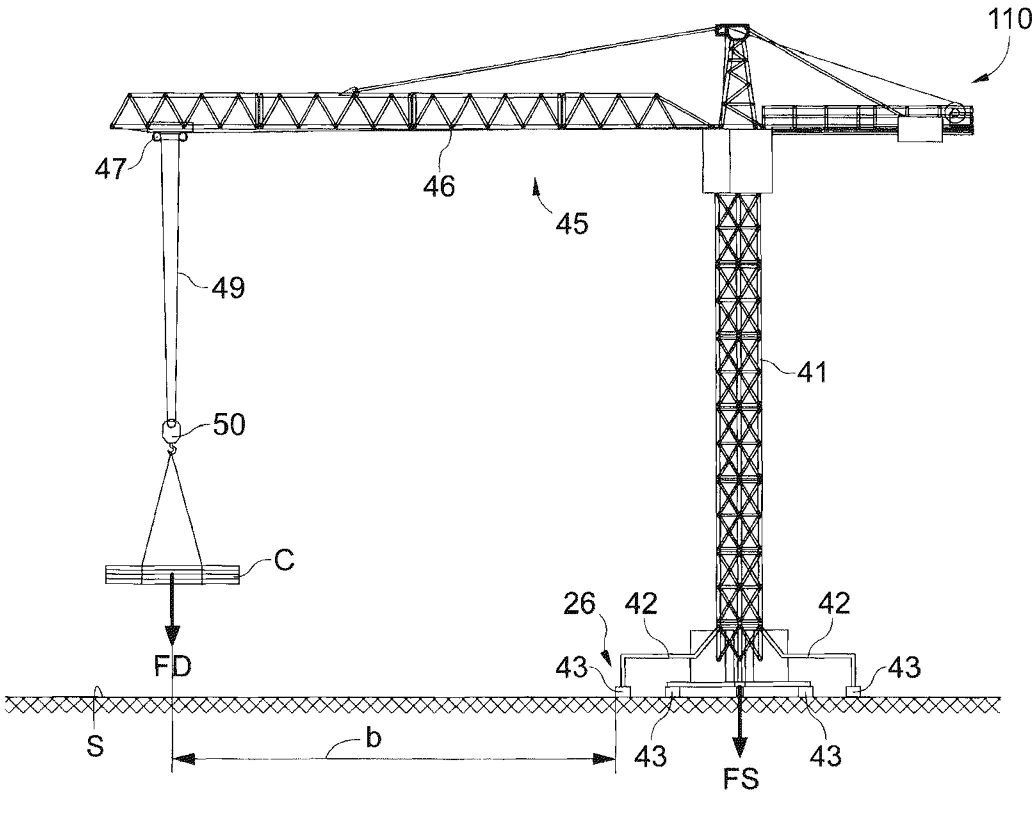


fig. 6

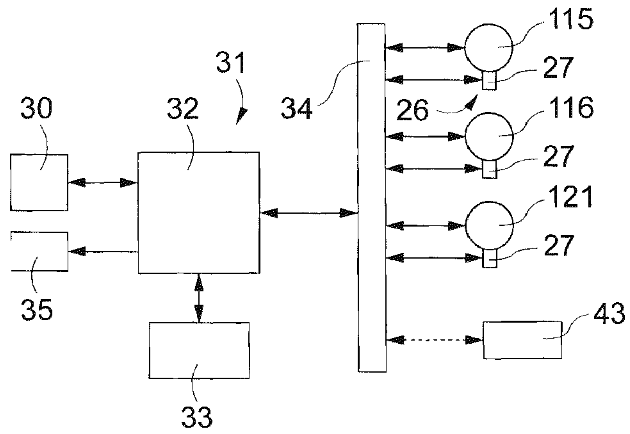
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fig. 7

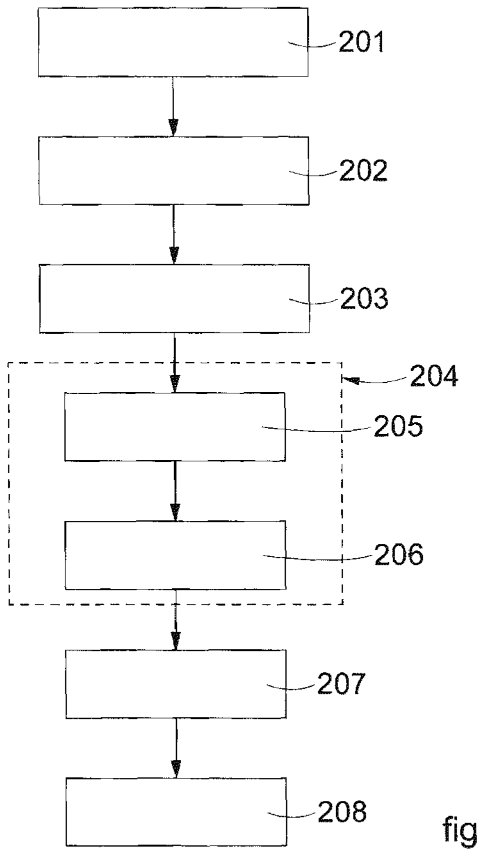
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fig. 8

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# EUROPEAN SEARCH REPORT

Application Number
EP 23 17 1787

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The present search report has been drawn up for all claims

1

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 5 July 2023 | Altamura, Alessandra |

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EPO FORM 1503 03.82 (P04C01)

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