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(54) **ROAD FINISHER AND METHOD FOR CONTROLLING ITS OPERATION**

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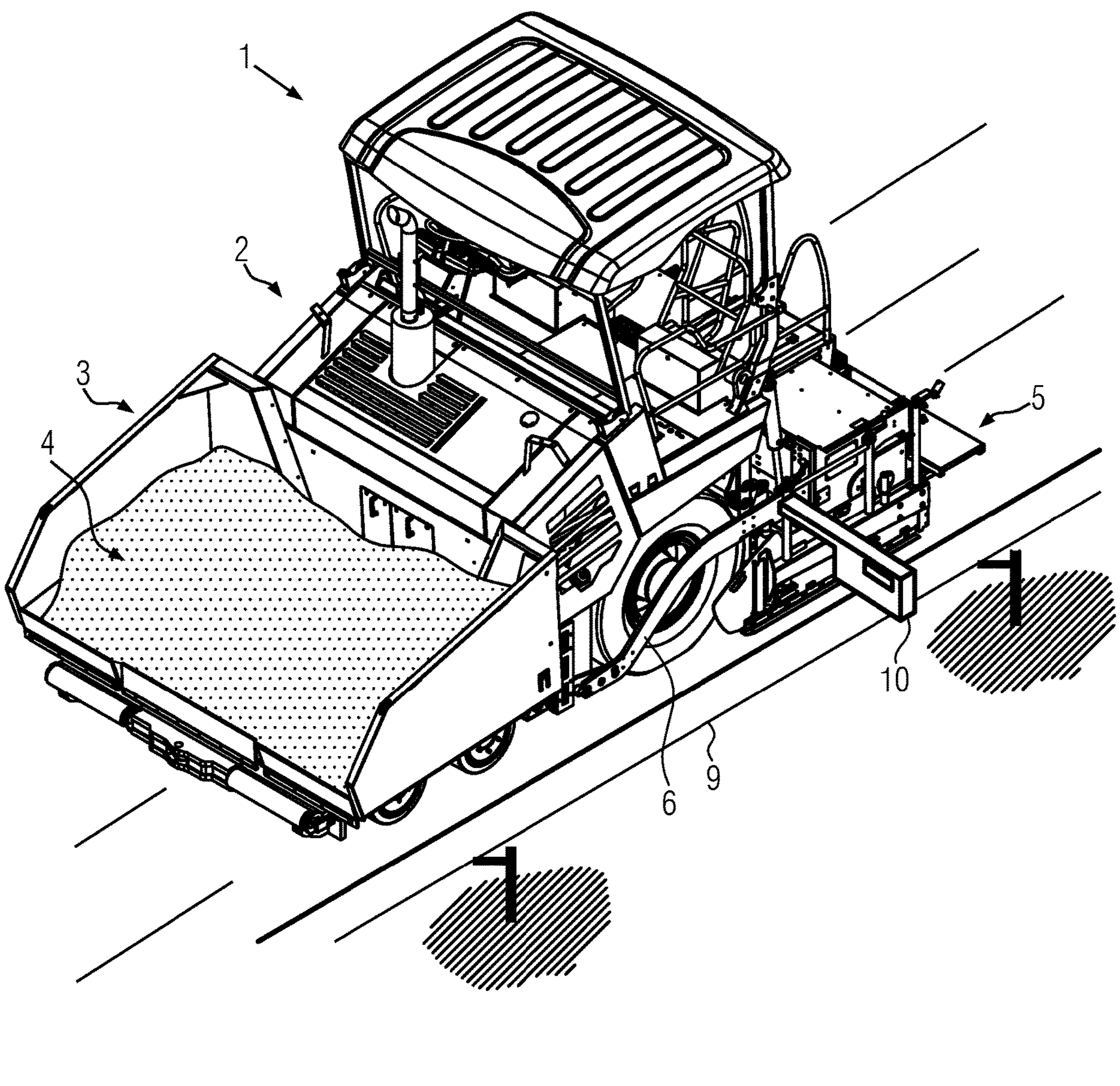
(57) **ABSTRACT**

A road finisher comprises a tractor, a material hopper configured to receive material, and a screed mounted to the tractor by towing arms so as to be pivotable around a towing point. The road finisher further comprises a control system comprising a height detection device configured to detect vertical movements of the screed with respect to a height reference and, to generate a height signal based on the detected movements, and an adjusting cylinder connected to the tractor and one of the towing arms and being configured to adjust a height of the towing point relative to the tractor. The control system is configured to compare the height signal to a target value and thereby calculate a control deviation, to limit an adjustment displacement of the adjusting cylinder to a maximum value based on the control deviation, wherein the maximum value is proportional to the control deviation.



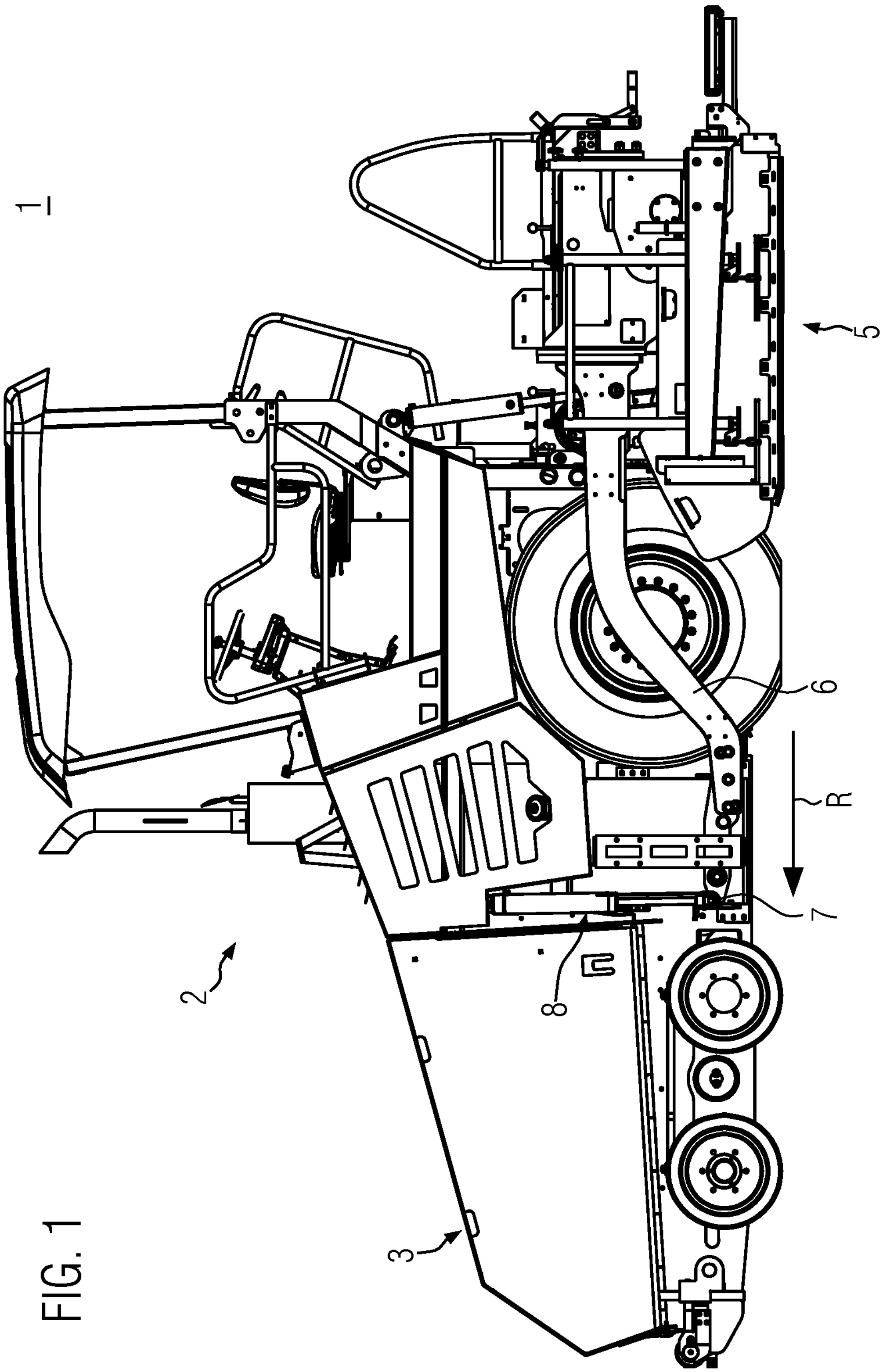


FIG. 1

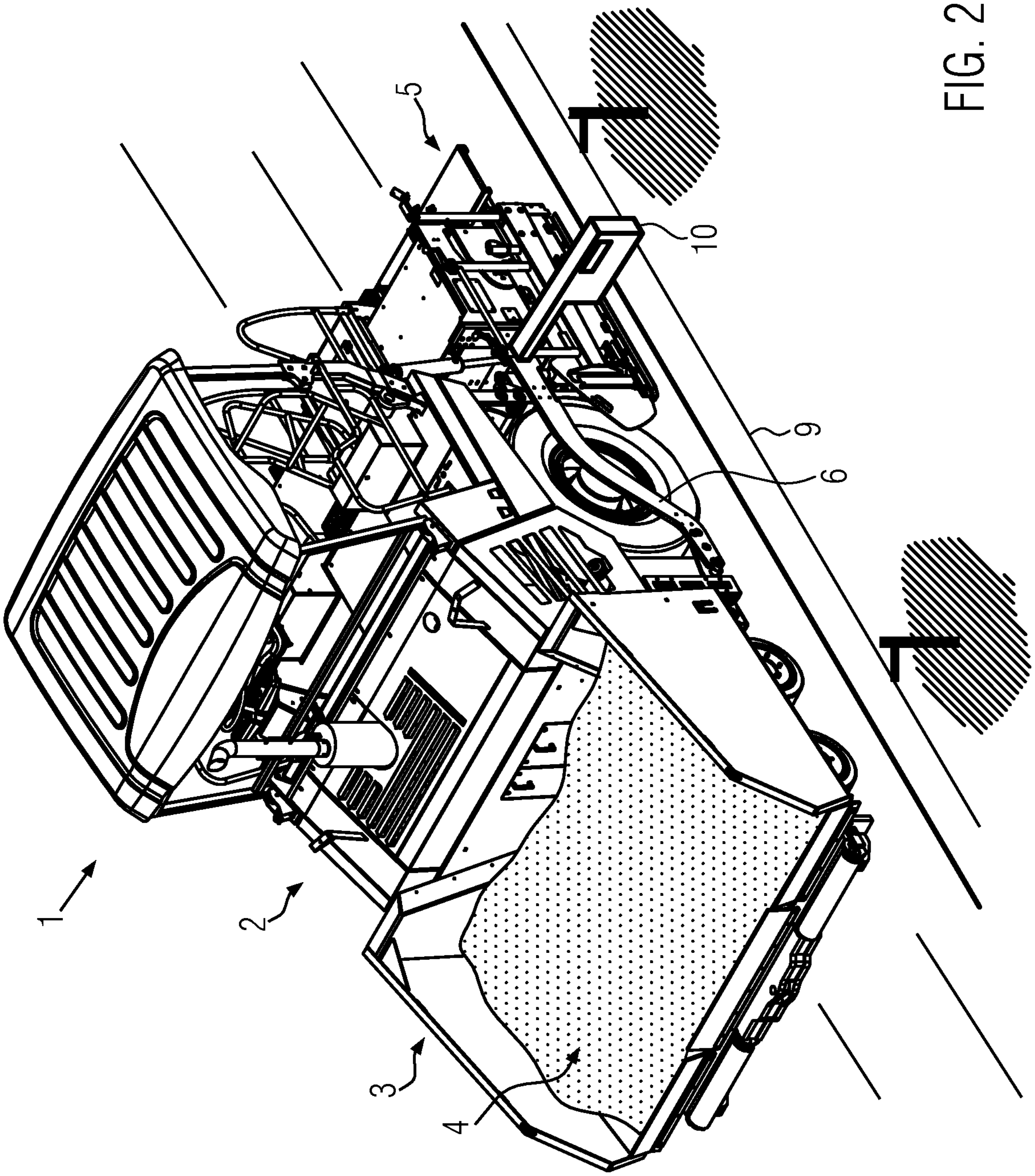


FIG. 2

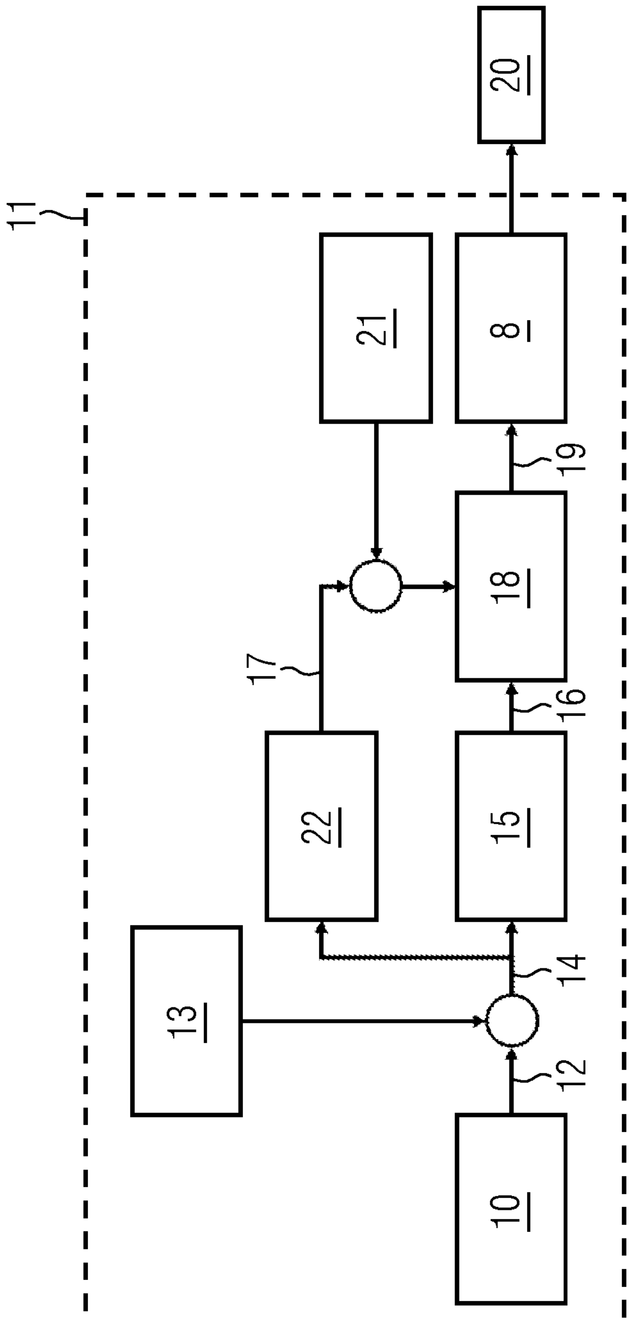


FIG. 3

ROAD FINISHER AND METHOD FOR CONTROLLING ITS OPERATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims foreign priority benefits under 35 U.S.C. § 119(a)-(d) to European patent application number EP 22182719.9, filed Jul. 4, 2022, which is incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The disclosure relates to road finishers having automatic leveling systems and to methods for controlling the operation of such pavers.

BACKGROUND

[0003] Road pavers are known which comprise a screed for compacting paving materials, such as asphalt, and a tractor for towing this screed. The screed is usually mounted on the tractor so as to pivot about a towing point. The height of the towing point can be adjustable, for example, by using a hydraulic cylinder. A so-called tar machine is known from DE 10 2011 001 542 A1. A trowel bar is disclosed, which is attached to the machine at a drag point. The lifting of this drag point can be adjusted by a drag point cylinder. Here, the amount of adjustment that can be made over a distance of 5 m traveled by the machine is to be limited to 3 mm. Furthermore, a calculated lift/lower value is to be adjusted by the cylinder only if it is higher than 1 mm. The disclosed control is based on the assumption that on a travel distance of 5 m the drag point cylinder may never be adjusted by more than 3 mm.

SUMMARY

[0004] However, in some paving situations, such rigid limits may be impractical. It is therefore an object of the disclosure to provide an improved paver and an improved method for controlling its operation, which permits more flexible operation.

[0005] A road finisher is disclosed, which comprises a tractor and a material hopper, which is disposed at the front of the tractor as seen in the driving direction and which is configured to receive material. The road finisher further comprises a screed, which is mounted to the tractor by towing arms so as to be pivotable around a towing point, such that the screed is towable behind the tractor as seen in the driving direction, and a control system comprising a height detection device, which is configured to generate a height signal, and an adjusting cylinder, the adjusting cylinder being connected to the tractor and one of the towing arms and being configured to adjust a height of the towing point relative to the tractor. The control system is configured to compare the height signal to a target value and thereby calculate a control deviation, to limit an adjustment displacement, in particular an implemented adjustment displacement, of the adjusting cylinder to a maximum value based on the control deviation, wherein the maximum value is proportional to the control deviation, and the control system being further configured to adjust the adjusting cylinder based on the control deviation and taking the maximum value into account.

[0006] Advantageously, the height detection device may be configured to detect vertical movements of the screed with respect to a height reference and preferably generate the height signal based on said detection.

[0007] A wire reference, a curb edge, an edge of a previously laid asphalt layer or a laser beam may be used as a height reference. Correspondingly, the height detection device may be configured to detect the respective height reference and comprise a height sensor, such as a sensing arm, and an ultrasound sensor, a camera or a laser sensor. A height detection device having a laser sensor may be configured to detect a laser beam as a height reference and or to recognize an edge by generating and detecting a line laser. In particular in case of the latter, the height detection device may comprise its own laser source.

[0008] Alternatively or additionally, the height detection device may comprise one or several inclination sensors. The inclination sensor may be configured to detect an inclination, in particular a transverse inclination, of the screed. Several inclination sensors may for example be configured to detect the inclination of screed parts of the screed. When the height signal is generated based on an output of an inclination sensor, a length, in particular a length defined transverse with respect to the driving direction, of the screed or of a screed part of the screed, whose inclination is detected by the inclination sensor, may be taken into account. This may enable to convert an angular signal into a height signal, preferably a vertical height signal. In particular in embodiments, in which the height detection device is not configured to detect vertical movements of the screed relative to a height reference, the height of the screed may be controllable manually on one side. The height on the opposite side of the screed with respect to the driving direction may then be controllable by a height detection device having inclination sensors as explained in more detail further above.

[0009] Alternatively or additionally, the height detection device may comprise a processing unit. The processing unit may be configured to generate the height signal based on an output of one or several of the previously mentioned sensors, in particular of a height sensor, a sensing arm, an ultrasound sensor, a camera, a laser sensor and in inclination sensor. A height signal may in particular be generated based on an output of a height sensor and one or several inclinations sensors, for example by adding the height signals generated according to the above explanations.

[0010] The limiting of the adjustment displacement to a maximum value, which is proportional to the control deviation, may enable an automatic adaption of the maximum value to the respective paving situation. At the same time, undesirable effects of the inertia in the control path, such as overshoot or excessive oscillation, may be prevented. It may occur that a change of the towing point only affects the height as measured by the height detection device after a delay. Without limiting the adjustment displacement, the adjustment displacement may undesirably increase or decrease, respectively, because of a control deviation persisting for a longer time. In addition, in the case of small control deviations, which possibly are caused merely by temporary and or short time disturbances, for example vibrations, the adjustment displacement may also be limited enough to minimize effects on the paving result. In particular for calculating, comparing and generating of signals, the control system may comprise suitable electronic parts. Here, individual assemblies or parts each may execute one or several of the functions mentioned. It is conceivable, that a central control system of the road finisher executes this function.

[0011] It is conceivable that the maximum value is defined relative to a reference value. For example, a certain extension position of the adjusting cylinder may be considered as a reference value. For example, the reference value may be defined as an extension position, which is extended by 160 mm with respect to a completely retracted position of the adjusting cylinder. If, in this case, an adjustment displacement is limited to a maximum value of 5 mm relative to the reference value, the adjustment of the adjusting cylinder may be limited to extension positions in a range between 155 mm and 165 mm.

[0012] It may be advantageous if the reference value is adjustable by an operator. This may in particular be useful at the beginning of a paving drive, for example to provide an initial reference value. It is particularly beneficial, if the control system is configured to automatically adapt the reference value. It may for example be provided that the reference value is automatically adapted, when the control system recognizes that it is in a steady-state. A state, in which the height signal matches the target value and or the control deviation is 0, close to 0 or smaller than 2 mm, may be considered a steady-state. In this way, the reference value may be adapted to a changing extension position.

[0013] It is conceivable that the maximum value is given by multiplication of the control deviation by a proportionality factor, for example 2. The proportionality factor may for example be adjustable by an operator of the road finisher.

[0014] It is conceivable that a top limit is defined for the maximum value. In this way, for example an extension range of the adjusting cylinder may be accounted for, i.e., an extension of the adjusting cylinder to its end stops may be avoided. The top limit may be defined depending from the reference value, in particular the currently set reference value. For example with a maximum possible extension position of the adjusting cylinder of 200 mm and a currently set reference value of 150 mm, the top limit for the maximum value may be 45 mm, in order to prevent the adjusting cylinder being stopped at its end position.

[0015] Further, a method for controlling the operation of a road finisher is disclosed. The road finisher comprises a tractor, a material hopper, which is disposed at the front of the tractor as seen in the driving direction and which is configured to receive material, a screed, which is mounted to the tractor by towing arms so as to be pivotable around a towing point such that the screed is towable behind the tractor as seen in the driving direction, and a control system having a height detection device and an adjusting cylinder connected to the tractor and one of the towing arms. The method comprises generating a height signal by the height detection device, calculating a control deviation by comparing the height signal to a target value, limiting an adjustment displacement of the adjusting cylinder to a maximum value, which is proportional to the control deviation, calculating an adjustment signal based on the control deviation taking the maximum value for the adjustment displacement into account and adjusting a height of the towing point by the adjusting cylinder based on the adjustment signal.

[0016] It may be advantageous, if the method further comprises detecting a movement of the screed with respect to a height reference by the height detection device, wherein the height signal is preferably generated based on the detected movement of the screed with respect to the height reference. All explanations given further above with respect to the disclosed road finisher may be applicable to the disclosed method.

[0017] As mentioned with respect to the road finisher explained above, limiting the adjustment displacement to a maximum value, which is proportional to the control deviation, may enable an automatic adaption of the maximum value to the respective paving situation. At the same time, undesired effects of inertia in the control path, such as an overshoot or excessive oscillation may be avoided. In addition, with small control deviations, which may possibly be merely caused by temporary and or short-term disturbances, for example vibrations, the adjustment displacement may be limited enough such that the effects on the paving result may be minimized. In particular for calculating, comparing or generating signals, the control system may comprise suitable electronic parts and or assemblies. Here, individual assemblies or parts each may execute one or several of the mentioned functions. It is conceivable that a central control of the road finisher executes these functions.

[0018] It is conceivable that the maximum value is defined relative to a reference value. As explained further above, for example a certain extension position of the adjusting cylinder may be considered a reference value.

[0019] It may be advantageous, if the reference value is adjustable by an operator. As explained further above, this may be particularly useful at the beginning of a paving drive, for example in order to provide an initial reference value. It is particularly advantageous, if the method comprises an automatic adaption of the reference value by the control system. For example, it may be provided that the reference value is adapted automatically when the control system recognizes that it is in a steady-state. In this way, the reference value may be adapted to a changing extension position.

[0020] It is conceivable that the maximum value is given by multiplication of the control deviation by a proportionality factor, for example 2. The proportionality factor may, for example, be adjustable by an operator of the road finisher.

[0021] It is conceivable that a top limit of the maximum value is defined. As explained further above, in this way, an extension range of the adjusting cylinder may be accounted for, i.e., an extension of the adjusting cylinder to its end stops may be avoided. The top limit may be defined depending from the reference value, in particular the currently set reference value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The disclosure relates to a road finisher as well as a method of the type explained above. In the following, an advantageous embodiment will be explained as an example using drawings.

[0023] FIG. **1** shows a schematic side view of a road finisher;

[0024] FIG. **2** shows a schematic perspective view of a road finisher during a paving drive guided by a height reference; and

[0025] FIG. **3** shows a schematic view of components of a control system of a road finisher.

DETAILED DESCRIPTION

[0026] In FIG. **1**, a road finisher **1** is shown in a schematic side view. The road finisher **1** may comprise a tractor **2**. The road finisher **1** may further comprise a material hopper **3**. The material hopper **3** may be disposed at the front of the tractor **2** as seen in a driving direction R. The material hopper **3** may further be configured to receive material **4** (see FIG. **2**). The road finisher **1** may further comprise a screed **5**. The screed **5** may be mounted to the tractor **2** by towing arms **6**. As shown in the illustrated embodiment, the screed **5** may be mounted to the tractor **2** so as to be pivotable around a towing point **7**. The tractor **2** may be configured to tow the screed, preferably floatingly, on an asphalt layer to be compacted. The road finisher **1** may further comprise an adjusting cylinder **8**. The adjusting cylinder **8** may on one side be connected to the tractor **2**. The adjusting cylinder **8** may, on another side, be connected to the towing arms **6**, in particular at the towing point **7**. The adjusting cylinder **8** may be configured to adjust a height of the towing point **7** with respect to the tractor **2**.

[0027] In FIG. **2**, the road finisher **1** is shown in a schematic perspective view from the front and above. Further, FIG. **2** schematically shows a plane, on which an asphalt layer is to be laid, as well as a height reference **9**. As in the present embodiment, the height reference **9** may be a reference wire. The road finisher **1** may comprise a height detection device **10**. As in the present embodiment, the height detection device **10** may be an ultrasound sensor, which may be configured to detect the reference wire **9**. The height detection device **10** may be fixed to the screed **5** and/or the towing arm **6**. In this way, the height detection device **10** may be configured to detect substantially vertical movements of the screed **5** with respect to the height reference **9**. For adjusting the height of the towing point **7** by the adjusting cylinder **8**, the road finisher **1** may comprise a control system **11**, which will be explained in more detail in the following with reference to FIG. **3**.

[0028] FIG. **3** shows a schematic diagram to illustrate the functioning of the control system **11**. The control system **11** may comprise the height detection device **10**. The control system **11** may further comprise the adjusting cylinder **8**. The height detection device **10** may be configured to generate a height signal **12** based on the detection of the height reference **9**. The height signal **12** may represent in particular a height of the screed **5** above the plane. The control system **11** may be configured to compare the height signal **12** to a target value **13**. The control system **11** may further be configured to calculate a control deviation **14** based on the comparison of the target value **13** to the height signal **12**.

[0029] The control system **11** may further comprise a calculation unit **15**. The calculation unit **15** may be configured to calculate a raw adjustment signal **16** based on the control deviation **14**. Further, the control system **11** may be configured to calculate a maximum value **17** based on the control deviation **14**. The control system **11** may further comprise a limiter unit or limiter **18**. The limiter **18** may be configured to adjust an adjustment signal **19** sent to the adjusting cylinder **8** in such a way that an implemented adjustment displacement **20** of the adjusting cylinder **8** is suitably limited, in particular to the calculated maximum value **17**. The limiter may be configured to generate adjustment signal **19** based on the raw adjustment signal **16** as well as the maximum value **17**.

[0030] During generation of the adjustment signal **19**, a reference value **21** may additionally be taken into account. If the reference value **21** is not taken into account during generation of the adjustment signal **19**, the adjustment signal **19** may represent an adjustment displacement to be implemented by the adjusting cylinder **8**. Based on the adjustment signal **19**, the adjusting cylinder **8** may then be adjusted by the adjustment displacement to be implemented. If the reference value **21** is taken into account, the adjustment signal **19** may represent an extension position of the adjusting cylinder **8**. In the latter case, the adjusting cylinder **8** may be configured to implement the extension position to be implemented based on the adjustment signal **19** transmitted to the adjusting cylinder **8**. In both variants, the implemented adjustment displacement of the adjusting cylinder **8** may be limited to the maximum value **17**. A difference is in the kind of control of the adjusting cylinder **8**.

[0031] The maximum value **17** may be proportional to the control deviation **14** and may preferably be calculated by multiplying the control deviation **14** by a proportionality factor **22**. The proportionality factor **22** may be adjustable, in particular by an operator of the road finisher **1**. In particular, the maximum value **17** may for example be twice the control deviation **14**. The reference value **21** may be adjustable by an operator. Alternatively or additionally, the control system **11** may be configured to adapt the reference value **21** automatically. For example, it is conceivable that at the beginning of a paving drive, the reference value **21** is set by an operator and is continuously autonomously adjusted by the control system **11**.

[0032] Except for the adjusting cylinder **8**, any units or devices shown in FIG. **3** may be understood as logical units. These may be implemented as electronic circuits, in software or as a mix of the two. In particular, the height detection device **10** may be implemented as a combination of electronic circuits and software.

What is claimed is:

1. A road finisher, comprising:

a tractor;

a material hopper, which is disposed at a front of the tractor as seen in a driving direction and which is configured to receive material;

a screed, which is mounted to the tractor by towing arms so as to be pivotable around a towing point, such that the screed is towable behind the tractor as seen in the driving direction; and

a control system comprising a height detection device, which is configured to generate a height signal, and an adjusting cylinder, the adjusting cylinder being connected to the tractor and one of the towing arms and being configured to adjust a height of the towing point relative to the tractor;

wherein the control system is configured to compare the height signal to a target value and thereby calculate a control deviation, to limit an adjustment displacement of the adjusting cylinder to a maximum value based on the control deviation, wherein the maximum value is proportional to the control deviation, and the control system is further configured to adjust the adjusting cylinder based on the control deviation and taking the maximum value into account.

2. The road finisher according to claim **1**, wherein the height detection device is configured to detect vertical movements of the screed with respect to a height reference and generate the height signal based on the detected movements.

3. The road finisher according to claim **1**, wherein the maximum value is defined relative to a reference value.

4. The road finisher according to claim **3**, wherein the reference value is adjustable by an operator.

5. The road finisher according to claim **3**, wherein the control system is configured to automatically adapt the reference value.

6. The road finisher according to claim **1**, wherein the maximum value is given by multiplication of the control deviation by a proportionality factor.

7. The road finisher according to claim **6**, wherein the proportionality factor is adjustable.

8. The road finisher according to claim **1**, wherein a top limit is defined for the maximum value.

9. The road finisher according to claim **1**, wherein the height detection device is configured to detect a movement of the screed with respect to a height reference and generate the height signal based on the detected movement.

10. A method for controlling operation of a road finisher, which comprises a tractor, a material hopper disposed at a front of the tractor as seen in a driving direction and which is configured to receive material, a screed mounted to the tractor by towing arms so as to be pivotable around a towing point, such that the screed is towable behind the tractor as seen in the driving direction, a control system having a height detection device and an adjusting cylinder connected to the tractor and one of the towing arms, the method comprising:

generating a height signal by the height detection device;

calculating a control deviation by comparing the height signal to a target value;

limiting an adjustment displacement of the adjusting cylinder to a maximum value, which is proportional to the control deviation;

calculating an adjustment signal based on the control deviation taking the maximum value for the adjustment displacement into account; and

adjusting a height of the towing point by the adjusting cylinder based on the adjustment signal.

11. The method according to claim **10**, further comprising detecting a movement of the screed with respect to a height reference by the height detection device, wherein the height signal is generated based on the detected movement of the screed with respect to the height reference.

12. The method according to claim **10**, wherein the maximum value is defined relative to a reference value.

13. The method according to claim **12**, wherein the reference value is adjustable by an operator.

14. The method according to claim **12**, further comprising automatically adapting the reference value by the control system.

15. The method according to claim **10**, wherein the maximum value is given by multiplication of the control deviation by a proportionality factor.

16. The method according to claim **15**, wherein the proportionality factor is adjustable.

17. The method according to claim **10**, wherein a top limit is defined for the maximum value.

* * * * *