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(54) **Bucket for treating excavated soil, earthwork machine equipped with said bucket, and method for treating excavated soil using said bucket.**

(57) Screening bucket (10) for earthworks which has a loading compartment (10a) to collect the soil to be screened and screening devices (24) positioned inside said loading compartment (10a). The screening bucket (10) comprises dosage devices (12) of binder or mixtures of binders, positioned directly inside loading compartment (10a), so as to enable the delivery of the binding material directly into the soil to be screened inside loading compartment (10a).

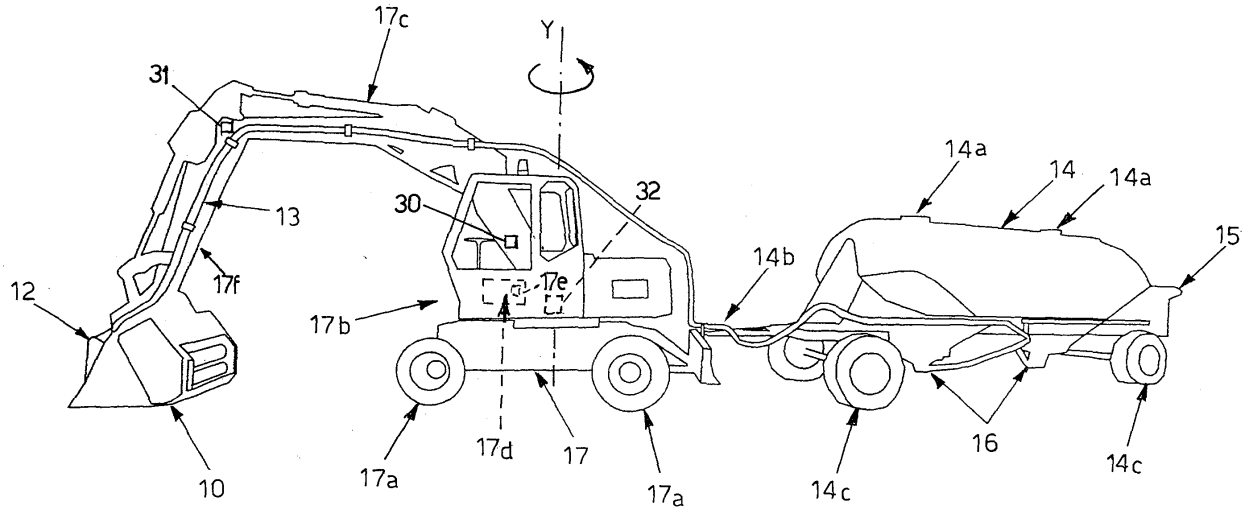

fig. 1

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Description

FIELD OF APPLICATION

[0001] This invention relates to a method for treating excavated soil. Said method is particularly suitable for the laying and underground laying of pipelines, stabilization of road foundations or reclaiming of polluted soils.

[0002] This invention also relates to a special bucket for earthworks necessary to carry out the above-mentioned method and to an earthwork machine including such bucket.

KNOWN TECHNIQUES

[0003] The process of stabilization of soils on which roads, airports and railways are built by means of binding material, usually in powder (for example calcium oxide and cement), is a largely used technique that perfectly substitutes the expensive and environmentally-unfriendly use of quarry dry material.

[0004] Such procedure is usually carried out by laying a certain quantity of binding material onto the soil to treat and the subsequent use of a special machine equipped with a toothed drum that mills and mixes soil with binder. The latter is previously laid off on the surface to a certain depth, on average 40-50 cm, depending on the dimensions and positioning of the drum.

[0005] However, whenever it is necessary to work on limited areas or to treat heaps of excavated soil, not a surface, as in the case of soil deriving from excavations on roadways (for example to lay public utility service pipelines), the said technique cannot obviously be used.

[0006] The known technique, in these specific cases, envisages the laying of binder on top of the excavated heaps and the subsequent working of soil by means of an excavator or a loader, provided with a screening bucket.

[0007] The action of the screening devices positioned inside the bucket results in a good mixing of soil and binder.

[0008] The described known technique presents, however, two major problems which, in most cases, make it necessary to replace the excavated soil with quarry dry material and to carry it to dumps. These problems are:

- the difficulty in obtaining a homogeneous mixture of soil and binder, in that, if we work a heap of soil, not a surface, first we will gather a quantity of binder in excess on top of the heap, and then we will gather only the soil without binder in the inner part of the heap. This will cause inhomogeneous distribution of soil and binder;
- the difficulty in obtaining the correct mixture of binders, according to the characteristics of the soil and its degree of humidity, in that it is difficult to determine the exact quantity of soil to treat.

[0009] We also have to consider the fact that excavated soil deriving from roadways can vary significantly in its composition and degree of humidity, which can be very different even over limited areas. This requires a constant adjustment of the mixtures of binders to use.

[0010] To solve the above-mentioned drawbacks, one of the known techniques (DE-C-19950435) uses a loader provided with screening bucket inside which the gathered soil is mixed with a binder contained in a pressure container. Furthermore, two pipes, one delivering the binder from the container to bucket and one linking the pressure container to the compressed air unit, brake the loader.

[0011] Such known solution is also equipped with a control system including a time-controlled valve, positioned on the delivering pipe, which injects only a predetermined quantity of binder.

[0012] Nevertheless, this known technique presents an important drawback: the quantity of binder sent to the bucket is not directly linked to the real quantity of soil in the bucket, because it derives from the estimation of the operator on board the loader. Moreover, this technique presents the additional drawback that the binder is placed on top of the material in the bucket. This makes the mixing of the two little effective, if we do not work the material many times by gathering and screening it with several working cycles.

[0013] Yet another drawback of this technique is that the pressure container can contain only one type of binder. Consequently, if several binders are necessary, their mixture must be carried out previously in another container.

[0014] The present invention aims at overcoming the above-mentioned drawbacks pertaining to the known technique.

[0015] In particular, the target of the present invention is to obtain a homogeneous mixture of soil and binder with a unique screening cycle, which would considerably reduce working time.

[0016] Another target of the present invention is the use of the correct quantity of binder, or mixtures of binders, according to the real quantity of soil to treat.

[0017] Yet another target of the present invention is to save more time, compared to the known similar techniques, and to reach a better efficiency, by using a mixture of several types of binders, simultaneously injected, in preset quantities, into the material inside the bucket.

[0018] To overcome the drawbacks of the known technique and to obtain these and additional targets and advantages, the Applicant has studied, experimented and carried out the present invention.

DESCRIPTION OF INVENTION

[0019] The present invention is expressed and characterised in the independent claims, while the related dependent claims describe other characteristics of this invention or variations from the main idea.

[0020] Therefore, according to this invention, the

screening bucket for earthworks is equipped with a loading compartment in which the soil is loaded and with screening devices positioned inside said compartment.

[0021] According to this invention, said bucket includes special devices (dosage devices) which deliver the right quantity of binding material, positioned inside said loading compartment. Said devices deliver the binding material directly into the soil inside the bucket.

[0022] The present invention produces then a homogeneous mixture of soil and binder with a unique screening cycle. This considerably reduces working time. Moreover, it is possible to deliver in a constant way the correct quantity of binder, or mixtures of binders, according to the real quantity of soil.

[0023] In some embodiments of the present invention, the dosage devices include an injection chamber and injection devices of the binder, positioned longitudinally next to the screening devices. Consequently, the binder, or mixtures of binders, is directly injected into the soil, all along the front part of bucket, and is not placed on top of soil, as is the case, on the contrary, for the known technique. Preferably, to obtain a homogeneous delivery of binder, or mixtures of binders, all over the loaded soil, said injection devices are placed in parallel with the screening devices.

[0024] In some embodiments of this invention, the injection chamber presents ribs which make the distribution of binder or binding mixtures more uniform along said injection devices.

[0025] In some embodiments of this invention, the bucket is associated with a computer which communicates with a control unit. Said systems control and regulate the quantity of binder delivered by dosage devices according to the type and/or humidity of the soil.

[0026] In some embodiments of this invention, the bucket includes, or is associated with, primary valve means, controlled by a computer, which regulate the delivery of one or more binders.

[0027] In some embodiments the bucket includes, or is associated with, secondary valve means, controlled by the computer, which regulate the input of a transport fluid, normally compressed air, to transport binders and to enable their mixing.

[0028] In some embodiments of this invention, the bucket is associated with, or envisages, weight measurement devices, which send to the computer the exact weight of soil loaded in the loading compartment of the bucket. In some embodiments, the weight measurement devices are linked to the devices regulating the movements and position of the boom and turret controlling the bucket.

[0029] In some embodiments, said weight measurement devices are regulated by a software loaded in an electronic terminal, positioned in the machine that operates the bucket, normally an excavator, and are in communication with the control unit. The control unit, according to preset parameters, associates to a certain weight certain levels and delivery times of binders and transport fluid. Such data are received and used by the computer operating said valves.

[0030] In some embodiments, said dosage devices are connected to a pressure tank through a totally or partially flexible pipe. The tank contains one or more binders. In some embodiments, part of said pipe delivering binders or binding mixtures is stiff, next to the bucket, to prevent damage when in use. Such stiff part is linked to the remaining pipe through a rapid joint.

[0031] In some embodiments of this invention, envisaging the use of binding mixtures, said tank can be divided into several compartments to contain different binders separately. Therefore, the different binders are premixed, through above-mentioned transport fluid, in the delivery pipe before being injected into the soil. In some embodiments, the bucket includes devices delivering a fluid which reduces the amount of dust caused by injection of binding materials into the loading compartment.

[0032] This invention also includes an earthwork machine equipped with a screening bucket, as illustrated above.

[0033] In some embodiments, the earthwork machine is linked to a tank which contains one or more binding materials.

[0034] Moreover, this invention includes one method for treating excavated soil which envisages the following phases:

- a first phase in which the soil is gathered by means of a screening bucket;
- a second phase in which a certain quantity of binder or mixtures of binders is directly injected into the soil gathered in the bucket;
- a third phase in which the soil is mixed with the binder, injected into it, and at the same time the soil is screened.

[0035] In some embodiments of the above-mentioned method, a pre-mixing of several different binders inside the delivery pipe linked to the bucket is envisaged.

[0036] In some embodiments of the above-mentioned method, the mixtures of binders are injected in the bucket simultaneously with the mixing of different types of binders, contained in a tank, directly inside the pipe delivering binders into the bucket.

[0037] In some embodiments of the above-mentioned method, between the first and second phase there is an automatic weighing operation of the gathered soil and, in the second phase, the injection of the binder into bucket is proportional to the real weight of the soil measured during the weighing operation.

[0038] The injection of binder into the soil results in a homogeneous mixing of both during the whole screening cycle and, consequently, the two processes can be carried out simultaneously. Therefore, once the screening cycle is over, it is not necessary to gather and screen the material another time to obtain a homogeneous mixing.

DESCRIPTION OF DRAWINGS

[0039] The above-mentioned characteristics together with other characteristics of this invention will become clear by the following description of one possible embodiment of this invention, given here just as an example, not restrictive, with reference to the enclosed drawings where:

- fig. 1 represents a machine equipped with the bucket of invention;
- fig. 2 represents a detail of bucket in fig. 1;
- fig. 3 represents a detail of machine in fig. 1.

DESCRIPTION OF ONE POSSIBLE EMBODIMENT OF THIS INVENTION

[0040] With reference to the enclosed figures, according to this invention, a bucket 10 is particularly suitable for a hydraulic excavator 17, equipped with wheels 17a for linear movement and with a turret 17b rotating around a vertical axis Y, as shown by arrow in fig. 1. Said turret 17b is linked to a boom 17c equipped with a stick 17f to operate bucket 10. Hydraulic excavator 17 could also be equipped with tracks instead of wheels 17a.

[0041] This invention could also be applied to a loader. However, hydraulic excavator 17 is more efficient in that it reduces obstruction and can be used on limited areas, given its 360° rotating capacity.

[0042] Bucket 10 presents internally a loading compartment 10a open on top in which, normally, the soil (generally heaps of excavated soil) is gathered to be screened.

[0043] Inside loading compartment 10a, particularly in its inferior part, bucket 10 includes screening devices 24, for example rollers equipped with blades and counter blades, operated by a motor rotating around axis X to screen soil. The soil, once screened, comes out from the inferior opening of loading compartment 10a of bucket 10.

[0044] The above-mentioned bucket is equipped with a dosage device 12 of binding material, positioned directly inside loading compartment 10a.

[0045] Bucket 10 is associated with pipe 13, totally or partially flexible to follow the movements of boom 17c and stick 17f which deliver the binder itself. Said pipe is linked to boom 17c and in communication with above-mentioned dosage device 12.

[0046] As can be noted in detail of fig. 2, dosage device 12 of binding material includes, inside loading compartment 10a, an injection chamber 12a, delimited by two plates, one at the front and one at the back. Said chamber is adjacent to the part of bucket 10 nearest to hydraulic excavator 17. Pipe 13 delivering binder is then connected into superior part.

[0047] Dosage device 12 includes also an injection mouth 18 opening on the inferior part of injection chamber 12a, through which binder is directly injected into soil, not on its surface, during the screening process. As a result, the mixture soil-binder is more homogeneous.

[0048] In some embodiments of this invention, injection mouth 18 develops all along the length of bucket 10, in parallel with rotation axis X, that is with the screening devices 24.

[0049] Injection chamber 12a is characterised by internal ribs 23 on its internal walls in order to distribute the injected material homogeneously all along the length of injection mouth 18. Moreover, said internal ribs 23 make the whole structure more rigid.

[0050] The width of injection mouth 18, in some embodiments 4-6 mm wide, is sufficiently narrow to prevent stoppage of dosage device 12 and is protected by two projecting elements.

[0051] Injection chamber 12a gradually widens in order to inject binder all along length of bucket 10.

[0052] Pipe 13 presents, in some embodiments, a rigid element 11 linked to bucket 10 on one side and to the remaining part of pipe 13 on the other, through a rapid joint 20. Said element 11 connects injection chamber 12a to delivery pipe 13.

[0053] Dosage device 12 described above is positioned inside loading compartment 10a of bucket 10 and linked to this through fixing devices, specifically gussets 19 and bolts, to remove it if not in use and to clean it.

[0054] Thanks to the particular shape of dosage device 12 and the position of injection mouth 18, as shown in fig. 2, the binder is directly injected into the material inside bucket 10 next to screening devices 24. This helps to obtain a homogeneous mixing of soil and binder during the whole screening cycle.

[0055] As results clear from fig. 1, pipe 13 is linked to boom 17c and stick 17f of hydraulic excavator 17.

[0056] Hydraulic excavator 17 is linked to a pressure tank 14 with several compartments 25, in this case only two, preferably but not necessarily positioned on wheels 14c in order to be hooked and towed by excavator 17. Delivery pipe 13 comes out from tank 14.

[0057] Said tank 14 is linked to a compressor unit 15 which is structured to guarantee a binder flow towards bucket 10 of approximately 3-7% in weight proportionally to the flow of screened soil (for example 6,000 l/min). Such percentage can obviously vary depending on the characteristics and degree of humidity of soil and on the result we want to obtain in terms of stabilization or simply improvement of the soil.

[0058] The above-mentioned flow capacity enables the simultaneous injection of the binder and the screening of the soil, which is considerably time-saving if compared to the known technique.

[0059] Tank 14 is also equipped with valves 16 in every compartment 25 in which it is divided, with electrical servo control system with stepper motor, operated by the electronic control unit 27. This unit is radio controlled by means of a transceiver antenna 27a and of a radio unit 27b and can be linked to tank 14 (fig. 3). Through antenna 27a and the radio unit 27b the control unit 27 can be in

communication with computer 17d positioned in the rotating turret 17b where the operator operates bucket 10 and hydraulic excavator 17.

[0060] Excavator 17 is equipped with a weight measurement system for the soil gathered in bucket 10. It includes a weight measurement device 30, positioned on cylinders of boom 7c, which measures the pressure of cylinder oil. Then, it sends a signal, proportioned to the weight of material inside bucket 10, to computer 17d.

[0061] In some embodiments, two other devices are envisaged: one which measures position 31 and one movement 32. Device 31 is positioned on pivot 17f and device 32 is positioned in correspondence with joint between boom 17c and turret 17b. Said devices measure respectively the reciprocal inclination of stick 17f with boom 17c and of boom 17c with turret 17b.

[0062] The computer 17d is equipped with a software to process signals received by above-mentioned devices 30, 31 and 32.

[0063] In particular, the signals taken by devices 31 and 32 and sent to computer 17d are elaborated with the oil pressure signal of the cylinders, taken by weighing device 30, and computer 17d calculates the weight of the gathered material by a series of algorithms. Such values are then used to control valves 16 that deliver binder. Such computer 17d is equipped with memory devices 17e and a special software which calculate the weight of gathered material and manage the injection process. The above-mentioned software, according to preset values memorized by said memory devices 17e, controls the opening levels and times of valves 16, according to the weight inside the bucket 10.

[0064] The weight measuring device 30 interacts, through said software and a radio control, with control unit 27 which controls the opening of valves 16 in tank 14. This way we constantly obtain the right quantity of binder, or mixtures of binders, according to the real quantity of soil to work.

[0065] As results clear in fig.3, illustrating a tank 14 with two compartments 25, the delivering valves 16 are operated independently by computer 27.

[0066] This way, the level and opening period of each valve 16 is determined autonomously according to preset values loaded in the software, according to the real weight of soil inside bucket 10.

[0067] The separate delivering pipes 16a, positioned under valves 16, converge in a point 28 together with another pipe 26a delivering compressed air, shown by arrow A. This pipe is controlled by valve 26 which is servo controlled and linked to computer 27. The compressed air transports binders to dosage device 12. Thanks to the compressed air flow and the simultaneous opening of valves 16 and 26, the binders contained in the compartments of tank 14 are mixed in the right percentages, according to the different opening levels of valve 16, directly inside pipe 13 which delivers the binder to bucket 10.

[0068] The binders, in the case of a stabilization process, can be in powder (such as calcium oxide and/or cement) and the different mixing percentage is determined by the type of soil and its humidity degree. So, according to preset values loaded in the software, we will have different opening levels and opening times of valves 16 and 26.

[0069] Once the compressor unit 15 has been operated, hydraulic excavator 17 gathers the soil to be screened in the bucket 10.

[0070] Automatically, by means of weight measuring device 30, computer 17d calculates the weight of the collected material and calculates, according to the type of soil and its degree of humidity, the opening levels and opening times of valves 16 and 26 which are sent to control unit 27. Said unit then operates and coordinates valves 16 and 26.

[0071] Once the bucket 10 has been positioned, the screening devices 24 and the injection of binders directly into the gathered soil are operated, either simultaneously or in a sequence.

[0072] In just one operation the material is screened, mixed homogeneously to the correct quantity of binder and laid down in the digging, ready to be tamped.

[0073] This technique is considerably time saving compared to similar known techniques and improves their efficiency through the mixing of several binders, according to predetermined values, simultaneously with their injection into the gathered material in bucket 10. It also avoids the need for another tank to premix the binders.

[0074] Moreover, the height of tank 14 and the form and position of the loading openings, as shown in fig. 1 (reference number 14a), can enable the loading of the binders directly under the loading mouths for silotrailers in traditional stocking plants. This avoids the need for special silotrailers on the workplace to transport binders.

[0075] Furthermore, the fact that tank 14, as shown in fig. 1, is positioned on wheels and towed by a machine (in our case a hydraulic excavator 17) can guarantee its operating autonomy for the whole working day. This further improves the efficiency of the system, compared to the known methods.

[0076] According to what described so far, when the material is gathered by bucket 10 of invention it is weighed by the system through weighing device 30. Said device then calculates the opening levels and times of each valve 16 and 26, according to preset values based on type of soil and its degree of humidity.

[0077] At this point the operator on board turret 17b has only to press the push button to operate the system and at the same time to start the screening cycle and keep it pressed for all the screening cycle. Said button is preferably, but not necessarily, positioned on one of the two joysticks which enable the operator to control the movements of hydraulic excavator 17 from turret 17b. Said joysticks are associated with computer 17d.

[0078] This way, with just one operation, the material is screened, homogeneously mixed with the right quantity of binder(s) and laid down in the correct point, ready to

be tamped.

[0079] The described method to treat excavated soil can be conveniently used to fill diggings, by recycling directly on place the excavated soil, for example in the case of road foundations, or to lay pipes underground.

[0080] Moreover, said method is suitable for the reclamation of lands containing polluting agents, if said agents are to be treated with binders to inhibit the polluting agents, such as calcium oxide.

[0081] From the description given above, we can deduce that the invention reaches all its fixed goals.

[0082] In particular, the homogeneous mixture of soil and binder can be carried out with only one screening cycle. This considerably reduces working time compared to the known techniques.

[0083] The binder is constantly injected in the right proportion, according to the real quantity of soil to work and not following the estimation of the operator, as in the case of the known techniques.

[0084] Through the mixing of several types of binders and their simultaneous injection, we save more time and we do not need the use of other tanks to premix the binders and to transport them from stocking plants to the workplace.

[0085] In some embodiments of the invention, it is also envisaged a high pressure water circuit which delivers, by means of nebulising nozzles 29 (fig. 2), pressure water to reduce dust generated by the injection of the binder. Said nozzles are positioned on the bucket 10, in particular inside loading compartment 10a, preferably on its upper part. Such water can also be used in case of particularly dry soil to have always the right humidity percentage suitable for stabilization process.

[0086] Pressurized water is regulated by a delivering valve controlled by the software which manages valves 16 and valve 26. The pump which lets in the pressurized water is linked to the compressor unit 15. Said pump can be equipped with pistons, for example, with a capacity between 15 and 25 l/min and a pressure between 100 and 300 bar.

[0087] Nozzles 29 are equipped with blades in order to create a water blade which covers the upper opening of bucket 10 uniformly. Moreover, other types of nozzles can be envisaged, for example on the exit mouth of bucket 10 we can have traditional nozzles to eliminate the remaining dust produced when the bucket is emptied. The use of nozzles is particularly suitable when working in open spaces, such as the countryside, or where there is no traffic.

[0088] In case of inhabited areas or areas with traffic, bucket 10 can also include a closing cover, better if removable and made of plastic, hinged to the back side of bucket 10. This way dirty water generated by nozzles produces only little dripping along the external walls of bucket 10.

Claims

1. Screening bucket for earthworks, which presents a loading compartment (10a) where to put the soil to be screened and screening devices (24) positioned inside said loading compartment (10a), **characterized in that** it comprises dosage devices (12) of binder or mixtures of binders, positioned directly inside said loading compartment (10a), so as to allow the delivery of said binding material directly into the soil to screen inside loading compartment (10a).

2. Bucket according to claim 1, **characterized in that** dosage devices (12) include an injection chamber (12a) and injection devices (18) of binder or mixtures of binders, which develop longitudinally, usually positioned next to screening devices (24).

3. Bucket according to claim 2, **characterized in that** the injection chamber (12a) has ribs (23) which allow a more uniform distribution of the binder along said injection devices (18).

4. Bucket according to claim 1, 2 or 3, **characterized in that** it is controlled by a computer (17d) linked to a control unit (27) which set the right binder quantity delivered by dosage devices (12) according to type and /or humidity of soil to screen.

5. Bucket according to claim 4, **characterized in that** it includes primary valve means (16), controlled by said control unit (27), and which regulate the input of one or more binders by means of said dosage devices (12).

6. Bucket according to claim 5, **characterized in that** it includes secondary valve means (26), controlled by said control unit (27), and which regulate the input of the transport fluid, usually compressed air, to transport the binder or mixtures of binders.

7. Bucket according to claim 4, 5 or 6, **characterized in that** it envisages weight measurement devices (30) which send to control unit (27) a signal in function of the weight of loaded soil inside loading compartment (10a).

8. Bucket according to claim 6 and 7, **characterized in that** said weight measurement devices (30) are linked to a software in computer (17d) which, according to preset values memorized by means of memory devices (17e), associates to a certain weight measured by said weight measurement devices (30) set levels and opening times of primary valve means (16) and secondary valve means (26) which are controlled by the control unit (27).

9. Bucket according to claim 7 or 8, **characterized in**

that it envisages movement and position control devices (31, 32) of the boom (17c, 17f) and of a turret (17b) which control the bucket and cooperate with said weight measurement devices (30).

10. Bucket according to any of the previous claims, **characterized in that** it comprises delivery devices (29) of a liquid which reduces dust generated by the injection of binding materials into loading compartment (10a).

11. Earthwork machine, equipped with a screening bucket (10) according to any of the previous claims.

12. Method for treating excavated soil, **characterized in that** it comprises the following phases:

- collecting the excavated soil by means of screening bucket (10);
- injecting a set quantity of binder or mixtures of binders directly into the collected soil inside bucket (10);
- mixing soil with injected binder simultaneously with the screening of the soil itself.

13. Method according to claim 12, **characterized in that** it envisages a pre-mixing operation of several different binders inside a delivery pipe (13) linked to bucket (10).

14. Method according to claim 13, **characterized in that** the injection of mixtures of binders into bucket (10) is simultaneous with the mixing of different types of binders, contained in a tank (14), directly inside binders delivery pipe (13).

15. Method according to claims 12, 13 or 14, **characterized in that** between the first and second phase there is an automatic weighing operation of the collected soil and in the second phase the binder injection into bucket (10) is proportioned to the real weight of the soil collected inside the bucket (10) measured during the weighing operation.

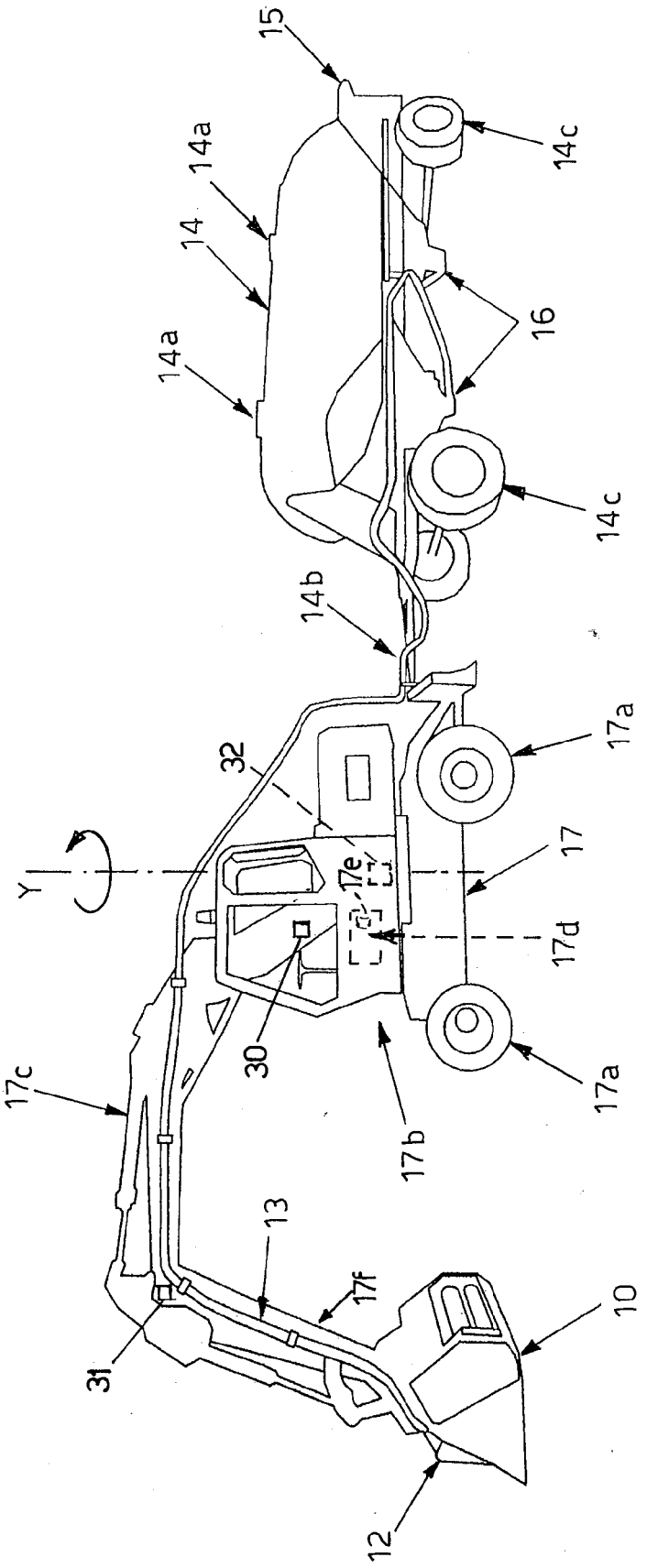
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fig. 1

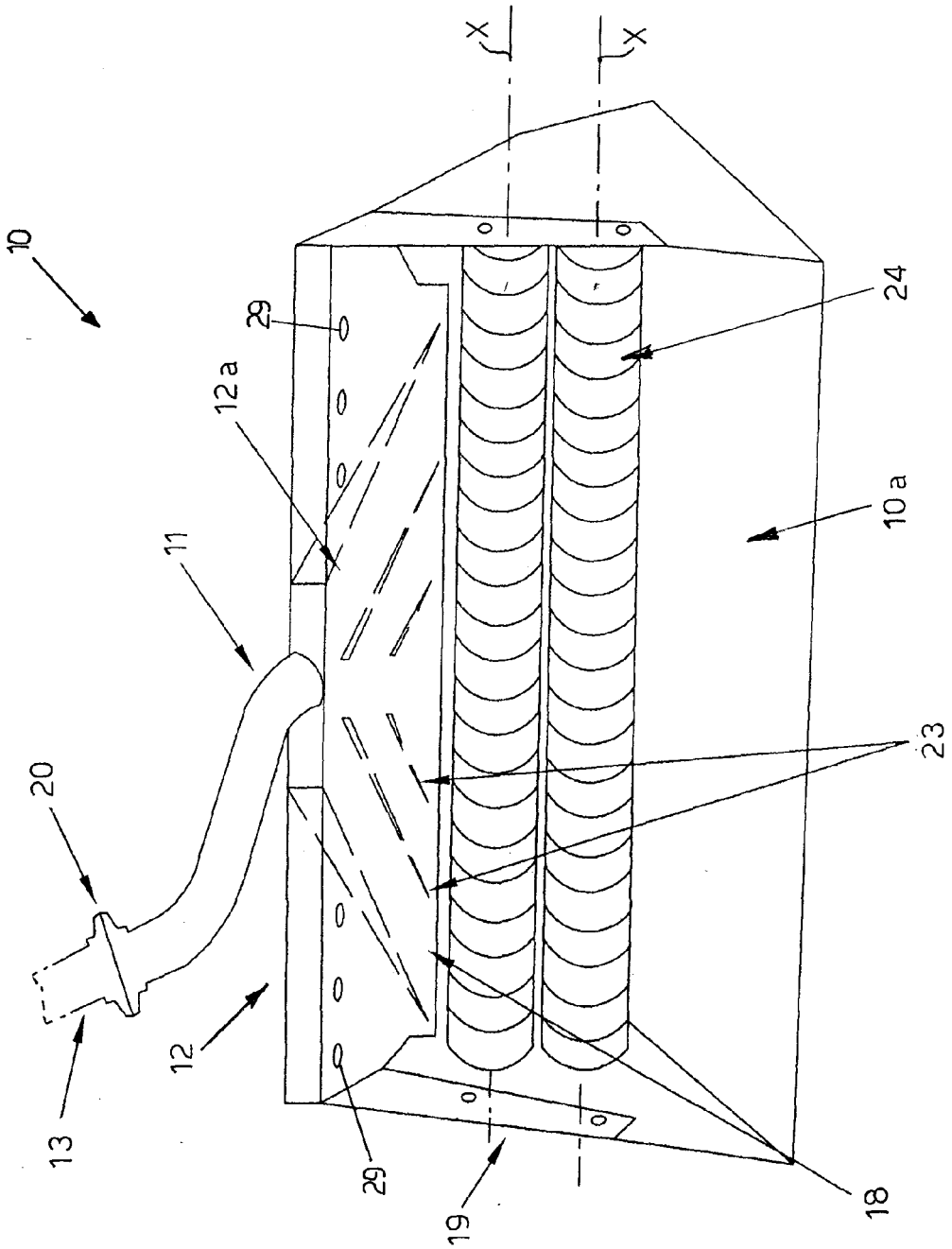

fig. 2

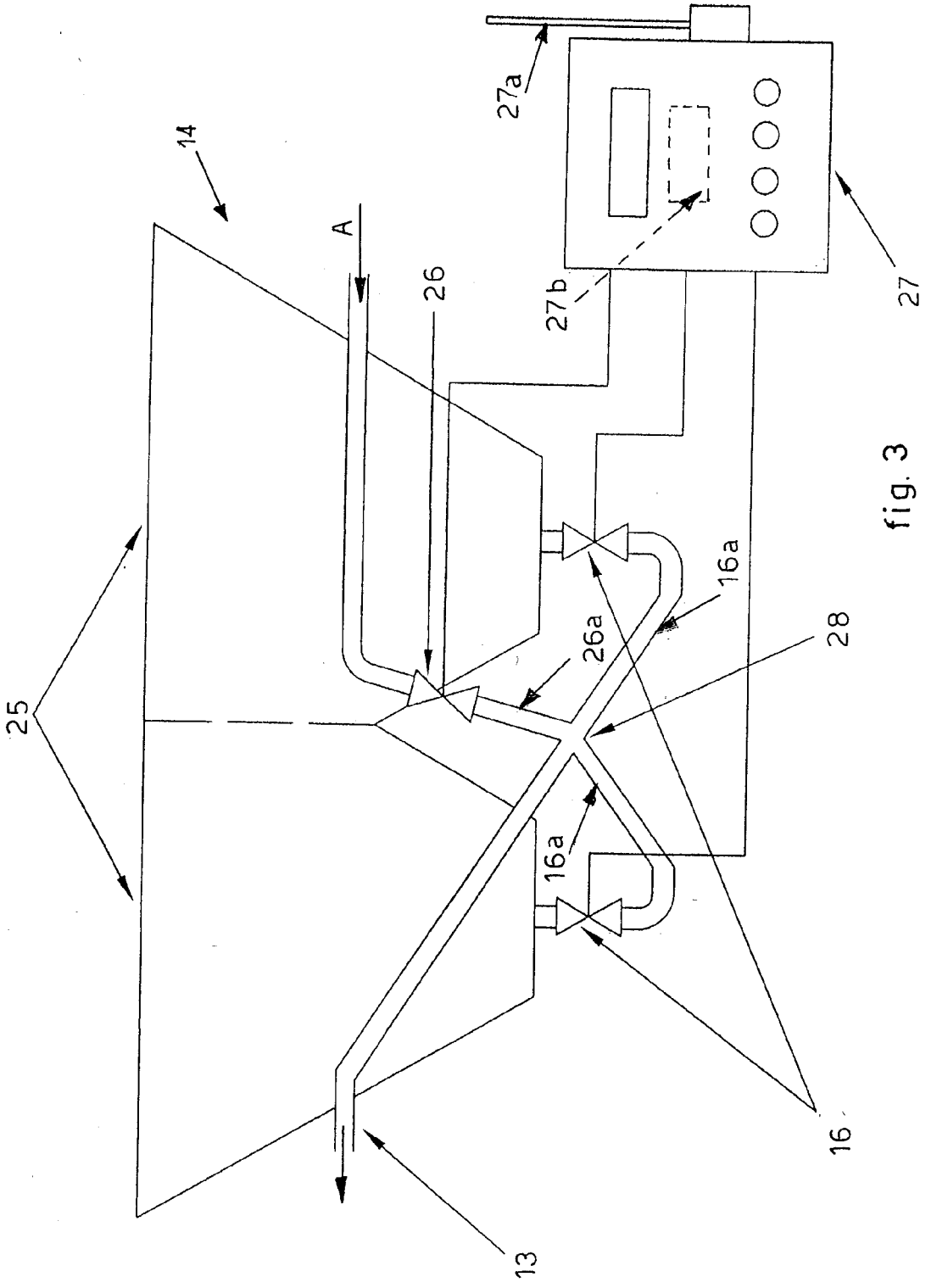

fig. 3

REFERENCES CITED IN THE DESCRIPTION

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