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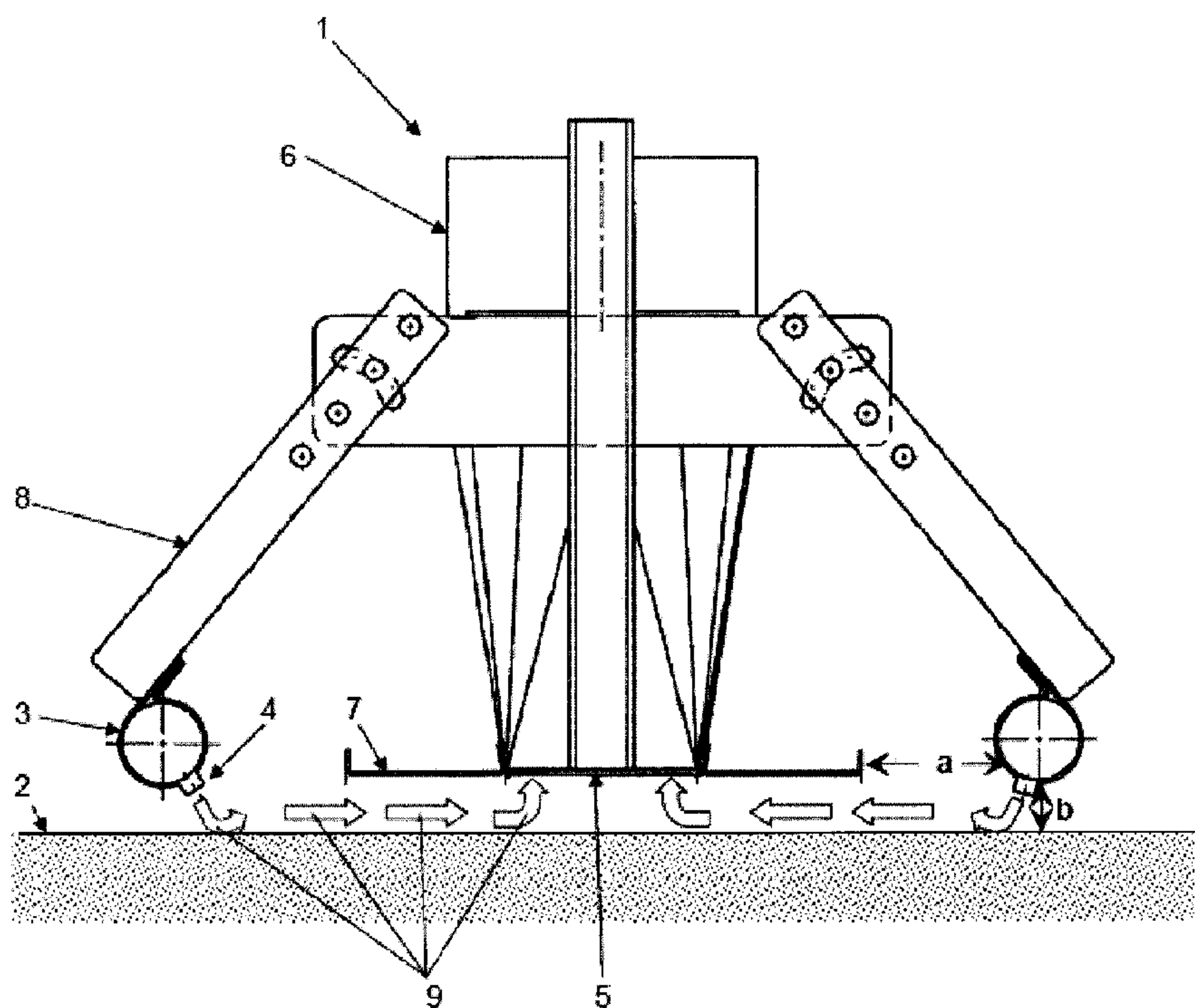
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(54) Titre : APPAREIL ET PROCEDE DE NETTOYAGE DES PAROIS OU DU SOL

(54) Title: DEVICE AND METHOD FOR THE CLEANING OF WALL OR GROUND SURFACES



(57) Abrégé/Abstract:

The invention relates to a device (1), which can be arranged on a railway vehicle, and a method for cleaning of wall or ground surfaces (2), in particular inside tunnels of urban trams. The device (1) has several air nozzles (4) on a common holder (3) for supplyable compressed air arranged on either side of a suction orifice (5), designed as a suction nozzle of a suction hood (6). By setting the respective pressure such that the pressure of the front row of nozzles, with respect to the direction of travel, is less than the pressure of the rear row of nozzles, all kinds of pollutants, for example, objects, dust or other debris are picked up between the rows of nozzles. If these pollutants are not directly picked up by the suction orifice (5) when driving over the same, these may however be moved along in the direction of travel by the relatively strong directed flow of compressed air of the rear row of nozzles, with the front row of nozzles at the same time forming a limit for the transport of the pollutants. The limitation of the wall and ground surface (2) beneath the suction orifice (5) of the suction results in a significant increase in efficiency.

Abstract

Device And Method For Cleaning Of Wall Or Ground Surfaces

The invention relates to a device (1), which can be arranged on a railway vehicle, and a method for cleaning of wall or ground surfaces (2), in particular inside tunnels of urban trams. The device (1) has several air nozzles (4) on a common holder (3) for supplyable compressed air arranged on either side of a suction orifice (5), designed as a suction nozzle of a suction hood (6). By setting the respective pressure such that the pressure of the front row of nozzles, with respect to the direction of travel, is less than the pressure of the rear row of nozzles, all kinds of pollutants, for example, objects, dust or other debris are picked up between the rows of nozzles. If these pollutants are not directly picked up by the suction orifice (5) when driving over the same, these may however be moved along in the direction of travel by the relatively strong directed flow of compressed air of the rear row of nozzles, with the front row of nozzles at the same time forming a limit for the transport of the pollutants. The limitation of the wall and ground surface (2) beneath the suction orifice (5) of the suction results in a significant increase in efficiency.

Device And Method For The Cleaning Of Wall Or Ground Surfaces

Field of the Invention

The invention relates to a device, which can be arranged on a railway vehicle, for the cleaning of wall or ground surfaces, in particular inside tunnels or divisions of track superstructures or tunnel walls, with said device having several air nozzles for compressed air arranged on either side of a suction orifice. Furthermore, the invention relates to a rail vehicle equipped with such a device and a method for operating the device.

Background

Due to vehicles moving through the tunnel, tunnels, walls and ceilings are subject to a permanent heavy pollution, so periodic cleaning is required.

Suitable for this purpose are devices of the type mentioned above used for surface cleaning in urban rail systems as an integral part of maintenance activities. Due to the increasing pollution of the railway facilities through waste, but also by braking sand, dust and metal abrasion of rails, increasingly measures need to be implemented to solve the problem of surface cleaning, and thereby improve not only the appearance of the railway facilities, but also to maintain the elasticity of the track ballast surface by reducing pollution.

In these cleaning solutions, the dusty air is purified by either dry or wet filters. Such solutions often do not bring the desired performance when pollutants bound between the ballast stones are not carried away by the suction flow.

WO 2010/075828 A1 discloses a device for the cleaning of tunnel walls and tunnel ceilings and for the extraction and cleaning of ballast beds, in which turbulence that is immanent to a cleaning region is produced by inclining air nozzles ensuring the overpressure air curtain required for proper operation. Thereby, the loosened or detached dirt particles are sucked into the suction body in particular due to the inclination of the air nozzles.

DE 92 03 164 U1 relates further to a device mountable on a rail or multi-way vehicle for cleaning the railway track with a lowerable suction box and at least one compressed air nozzle in the suction box, wherein the suction box and the compressed air nozzle are connected to a suction unit and a compressor, respectively, which are arranged on the vehicle.

DE 1 244 221 B discloses a device mountable on a motor vehicle for cleaning railway switches or rails, which has two nozzle boxes, which are mounted on a rail trolley, and thereby are movable along the rails. The approximate center of each nozzle box contains a suction nozzle, which is connected via a flexible hose with a vessel of the vehicle. A suction box laterally extending beyond the two rails features several compressed air nozzles made of an elastic material distributed across its entire width.

In practice, it proves to be disadvantageous that during suction there may be a turbulent mixing of the compressed air that is supplied with the air deflected from the surface and containing the polluting particles. Particularly in cleaning the track bed, in which the jet of compressed air does not hit substantially flat surfaces, but a complex topography, the resulting turbulence may negatively affect the cleaning performance.

Summary of the Invention

It is the object of the invention to provide a means for increasing the cleaning performance that can be implemented at a relatively low cost. In particular, according to the present invention, an increased efficiency is achieved.

According to the invention, this object is achieved with a device according to the features of claim 1. Further embodiments of the invention are defined in the dependent claims.

Thus, according to the invention a device is provided having at least two air nozzles arranged in rows of nozzles adjacent to the suction orifice which enclose the suction orifice between them, and that the rows of nozzles can be pressurized with compressed air, the rows of nozzles dimensioned such that the pressure of the air nozzles of the row of nozzles arranged in the direction of travel of the rail vehicle before the suction orifice is lower than the pressure of the other row of nozzles. The invention is based on the

realization that at least one of the suction orifices is enclosed by a first row of nozzles, which is arranged in front of the suction orifice in the direction of travel of the rail vehicle, and a second row of nozzles arranged behind it such that the suction area is defined and limited by the rows of nozzles. By setting the respective pressure such that the pressure of the front row of nozzles, with respect to the direction of travel, is less than the pressure of the rear row of nozzles, all kinds of pollutants, for example, objects, dust or other debris are picked up between the rows of nozzles. If these pollutants are not directly picked up by the suction orifice when driving over the same, these may, however, be moved along in the direction of travel by the relatively strong directed flow of compressed air of the rear row of nozzles, and are thus carried along, with the front row of nozzles at the same time forming a limit for the transport of the pollutants. In this way, the pollutants are carried quasi synchronously to the traveling movement of the rail vehicle, in particular moved no further than up to the first row of nozzles, and do not escape through the front row of nozzles to the front. The front row of nozzles thus acts as a compressed air wall, which does not displace the pollutants at the first crossing over, and acts as a limit for the pollutants that are transported to the front by the rear row of nozzles. The limitation of the ground surface area beneath the suction orifice of the suction results in a significant increase in efficiency.

Moreover, the device may have at least one air baffle adjacent to the suction orifice, which can be positioned as spaced from the cleaning wall or ground surface, and by which the compressed air supplied by means of the rows of nozzles after hitting the wall or ground surface can be deflected substantially parallel to the surface between the wall or ground surface and the air baffle. The invention is based on the realization that the level of efficiency and thus the efficiency of the device in operation can be substantially increased if at least a substantial proportion of the generated air flow is not turbulent, but substantially laminar parallel to the wall or ground surface. According to the invention, such laminar air flow is achieved in a simple manner by a local separation of the air nozzles and the suction orifice in conjunction with a flow zone in which the supplied air flow is guided substantially parallel to the surface of the object to be cleaned by means of the air baffle. As a result, there is a defined flow profile, which is clearly divided into a zone, in particular a deflection zone of the supplied compressed air, parallel to the surface to be cleaned, and another zone in the inlet region of the suction orifice. It thus achieves an easy separation of the supplied and the sucked air flows and avoids an

unwanted mixing zone. As a result, the cleaning performance can be increased or the required power of the aggregate can be reduced. It has been shown already that the uniform air flow can reduce the flow rate necessary for removing the dirt particles. Furthermore, without a change in the position of the device relative to the surface, a much larger surface area can be cleaned, because the cleaning action is not limited to the area that hits the surface first, rather it includes also the areas between the air baffle and the surface of the wall or bottom surface over which the air flows.

It proves to be particularly promising if each row of nozzles, depending on the direction of travel of the rail vehicle which is detected by a control unit, can be pressurized in relation to the other row of nozzles with a higher or a lower pressure, so that the suction function is obtained reliably in both directions of travel.

Furthermore, it is advantageous when the air nozzles have an orientation which is inclined with respect to the ground surface, in particular form an acute angle with the ground surface, and when the air nozzles are inclined such that at least the rear row of nozzles is directed to a ground surface area beneath the suction orifice. By this inclination, the air flow is directed with an orientation to the ground surface such that pollutants can be transported in the direction of travel and can be carried to the suction.

Moreover, by an inclined arrangement of the air baffles relative to the surface, in particular, a continuous approaching of the ground surface, starting from an outer periphery of the air baffles up to a suction orifice, an acceleration of the air flow can be achieved through a nozzle effect.

Another, also especially practical embodiment of the invention is achieved when the air baffles can be positioned parallel to the wall or ground surface to be cleaned, ensuring a constant flow rate of the compressed air over the entire area covered by the respective baffle.

Likewise, in another particularly advantageous modification of the device of the invention, the air nozzles or air baffles are jointly pivotably adjustable for setting the orientation, in particular, arranged movably or pivotably in order to be able to make a quick adaptation to a different condition of the surface to be cleaned. For example, in the

area of an expanded track bed, such as those found in a station, a corresponding positioning motion may be initiated so as to achieve complete suction.

Furthermore, a modification is particularly relevant to practice, in which the device can be positioned at different distances relative to the surface. Here, the advantageous effect is based on the flow rate between the suction and the surface which is adjustable in the desired manner at the same time as the distance. Based on the determined degree of pollution, the flow may be adjusted to the required cleaning performance simply by lowering or raising the device or the air baffles.

The geometry and cross-sectional shape of the suction is easily adaptable to the particular conditions of operation. For example, a suction orifice can be realized with a circular inlet opening, which is enclosed by a single concentric air baffle. In an advantageous variant of the invention, the suction orifice is enclosed by the rows of nozzles at at least two opposite sides, so as to define a substantially strip-shaped suction area. By omitting air nozzles from at least one peripheral region of the suction orifice, in conjunction with a movable arrangement of the device, difficult to access areas, such as corners, can be reached by the suction area, without the air nozzles being a hindrance.

Further, the area of air baffle may be adjustable, that is, it may be enlarged or reduced in order to be able to achieve optimum adaptation to the respective conditions of operation without a change to the system technology.

The air nozzles may be arranged on or connected to an outer edge region of the air baffles. It is particularly advantageous, however, if several air nozzles are arranged on a common holder, where the air nozzles are preferably arranged next to each other, for example along a straight line and at a constant distance to each other. According to the invention, naturally, it is not excluded that, for individual control, different air nozzles of the same row of nozzles are pressurized with a different pressure.

Furthermore, it is of considerable advantage when the holder can be positioned in an orientation parallel to the main extension of the area, so that the distance of the air

nozzle from the surface is constant for at least a substantial part of it, and therefore, the pressure distribution due to the compressed air hitting the surface is homogeneous.

An effective suction performance is achieved also, even when the rows of nozzles have an adjustable angle of inclination and/or distance to the surface, so as to achieve a removal rate that is optimally adapted to the respective kind of pollution by changing the flow angle in relation to the main extension of the surface. Naturally, the change may be made even while compressed air is supplied so as to pressurize adhering dirt particles with varying pressures.

Moreover, also the distance between the air nozzles and the suction orifice in the plane parallel to the surface may be varied, so as to be able to adapt to the area of impact accordingly. Particularly practical, however, is an embodiment in which the air nozzles are at a distance from the suction orifice transversely to the direction of suction of at least 50 mm, in particular at least 150 mm. Here, the air nozzles can may join directly, i.e., substantially without gaps, peripherally to the respective air baffle, or may be at a suitable distance therefrom. For example, the air baffle may be at a distance from the suction orifice transversely to the direction of suction of between 50 and 300 mm, preferably between 80 and 120 mm, where the direction of suction runs parallel to the surface normal of the surface to be cleaned.

In principal, the device is suitable for almost any chassis. Preferably, the device together with a dirt collecting container and a drive unit form an autonomous mobile unit, which can easily be used in the area of local underground railways.

Naturally, the device is not limited to the cleaning of ground surfaces. Instead, through an arrangement that is movable into several horizontal or vertical positions, the device is equally suited for wall or ceiling surfaces. In this way, therefore, the entire tunnel cross section may be treated appropriately by means of multiple devices in a single cleaning pass. Provided only partial areas are to be cleaned, the devices associated with the remaining areas, if necessary, may be assigned to the surfaces to be cleaned in order to improve the cleaning performance further.

If the device is used for cleaning wall or ground surfaces, in particular inside tunnels or other lateral or upper boundary surfaces, for example, of track ballast surfaces and tunnel walls, said device having several air nozzles for compressed air arranged on either side of a suction orifice and several suction orifices covering at least approximately the entire opening cross section of a tunnel or an underpass, in particular track bed, wall surface and ceiling surface, it is also particularly advantageous if the device comprises a controller and sensors to detect the respective distance or obstacles that restrict the free space in a timely fashion. For this purpose, the device may be equipped with corresponding distance measuring sensors, such as laser, ultrasound, sonar or lidar, detecting, in the direction of travel of the device, an area in front of the suction orifice, thus detecting potential collision hazards already in advance. The suction orifices can then easily be moved into an appropriate position, in particular a recessed avoidance position, to allow unhindered passage.

Furthermore, it is advantageous if the suction power of the suction orifice and/or the power of the compressed air supply of the air nozzles are variably adjustable, because thereby the energy efficiency can be further optimized. For this purpose, the suction performance is reduced to such an extent that the cleaning result is achieved reliably without providing an unnecessarily high suction performance.

Additionally, a further optimization of the suction performance may be achieved, if a suction hood enclosing the suction orifice or the air baffle are arranged movably, in particular pivotably, for setting a variable width of the area covered by the suction hood. For this purpose, it may be pivotable about a substantially vertical axis, which has a distance to the center of the longitudinal axis, so that a pivoting motion will lead to an increase of the lateral extension of the suction orifice.

Brief Description of the Drawings

The invention provides for various embodiments. To further illustrate the basic principle, one embodiment is shown in the drawing and will be described below.

Fig. 1 shows a rail vehicle with several devices of the invention in use inside a tunnel having a rounded cross-sectional shape;

Fig. 2 shows the rail vehicle shown in Figure 1 in a tunnel with a polygonal cross-sectional shape;

Fig. 3 is a perspective view of the device of the invention;

Fig. 4 shows a side view of the device shown in Figure 3;

Fig. 5 shows a plan view of the device shown in Figures 3 and 4.

Description of the Embodiments

The device 1 according to the invention for cleaning a surface 2 formed by a wall or a track base, preferably in the underground area of urban trams will be explained in more detail below with reference to Figures 1 to 5.

Several devices 1 are arranged on a rail vehicle 10 in such a manner that they may be easily adapted to almost all of the usual cross-sections, in conjunction with a motion kinematics 11 (not shown), in particular in accordance with a rounded cross-sectional shape shown in Figure 1 as well as a substantially rectangular cross-sectional shape shown in Figure 2. The motion kinematics 11 also permits an adaptation to channel-shaped depressions 12 in the track ballast surface 13 or on line supports 14 on the tunnel sidewalls 15.

As seen in Figures 3 to 5, the device 1 comprises several air nozzles 4 for suppliable compressed air arranged at a common holder 3, which are arranged on either side of a suction orifice 5, designed as suction nozzle, of a suction hood 6 and directed obliquely to the surface 2. The suction orifice 5 is enclosed by two air baffles 7 adjacent parallel and without gaps to the suction orifice 5 in the horizontal direction, which are implemented by one component each that is detachably connected to the suction hood 6.

The receptacles 3 for the air nozzles 4 are arranged, relative to an outer edge of the respective air baffle 7, positionably at a variable distance at a respective pivotably

movable support arm 8 that is length-adjustable in different locking positions, such that the air nozzles 4 are inclined in the direction of the suction orifice 5. As a result, the air nozzles 4 may be positioned in particular at a distance b to the surface 2 which is decreased relative to the suction orifice 5.

The arrangement of the air baffles 7 parallel to the surface 2, in conjunction with the horizontal deflection of the flow of the air supplied, results in that the compressed air of the air nozzles 4, after hitting the surface 2 to be cleaned, is initially deflected parallel to the surface 2 between the respective air baffle 7 and the surface 2 in the direction of arrow 9, and, after a further deflection, enters into the suction orifice 5. As a result, in operation, an almost laminar flow forms between the air baffle 7 and the surface 2, which results in significantly better cleaning performance compared to the turbulent air flow which is deflected at the surface to be cleaned in an undefined manner disclosed in the prior art.

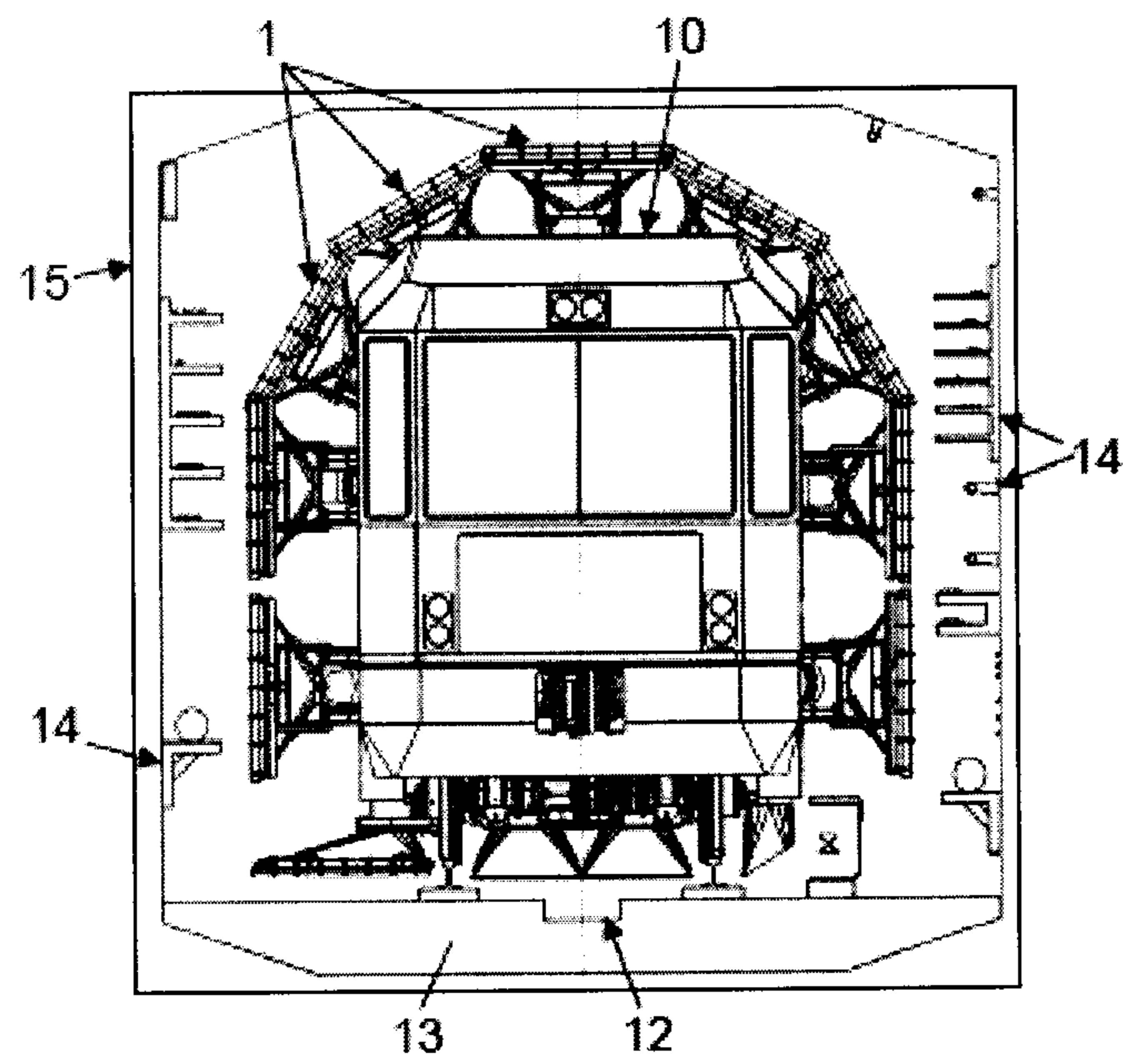
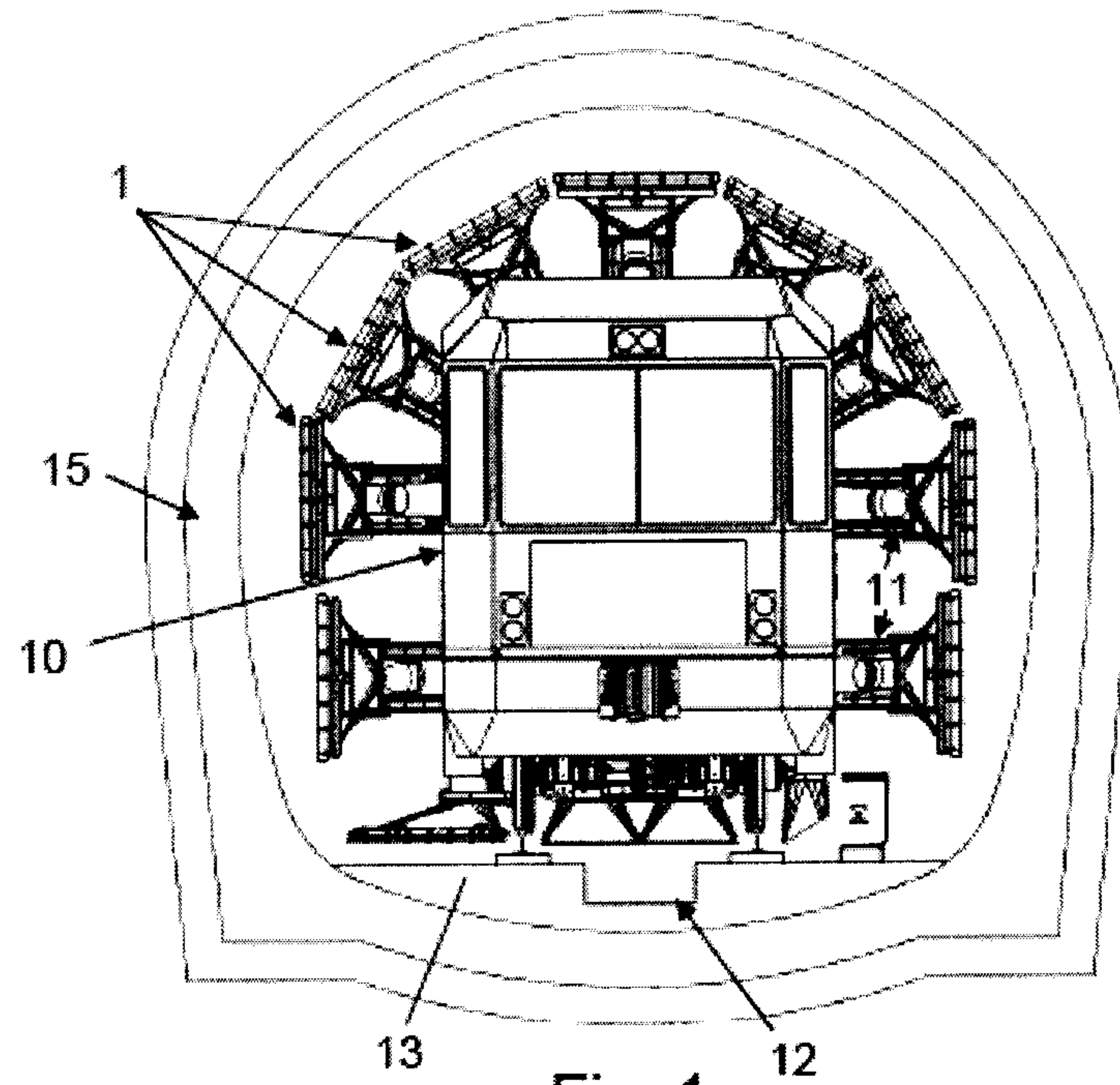
PATENT CLAIMS

1. A device (1), which can be arranged on a railway vehicle (10), for the cleaning of wall or ground surfaces (2), of track ballast surfaces (13) or tunnel walls (15), said device (1) having several air nozzles (4) for compressed air arranged on either side of a suction orifice (5) of a suction having at least one nozzle orifice, **characterized in that** said device (1) has at least two air nozzles (4) arranged in rows of nozzles adjacent to the suction orifice (5) which enclose the suction orifice between them, and that the rows of nozzles can be pressurized with compressed air, the rows of nozzles dimensioned such that the pressure of the air nozzles (4) of a row of nozzles arranged in a direction of travel of the rail vehicle (10) before the suction orifice (5) is lower than the pressure of the other row of nozzles.
2. The device (1) according to claim 1, **characterized in that** the air nozzles (4) of each row of nozzles may be pressurized with a high or a low pressure, depending on the direction of travel of the rail vehicle (10), which is determined by means of a control unit.
3. The device (1) according to claims 1 or 2, **characterized in that** the air nozzles (4) have an orientation which is inclined with respect to the ground surface (2) such that it and a surface normal to the wall or ground surface (2) define an acute angle, and that the air nozzles (4) are inclined such that at least the rear row of nozzles is directed to an area of the wall or ground surface (2) below the suction orifice (5).
4. The device (1) according to any one of claims 1 to 3, **characterized in that** the air nozzles (4) are pivotably arranged for setting an orientation of a row of nozzles.
5. The device (1) according to at any one of claims 1 to 4, **characterized in that** a suction hood (6) enclosing the suction orifice (5) and/or the rows of nozzles are

arranged movably, for setting a variable width of the wall or ground surface (2) covered by the suction hood (6) and rows of nozzles, respectively.

6. The device (1) according to any one of claims 1 to 5, **characterized in that** the suction hood (6) and/or the rows of nozzles are moveable, by means of a frictional force transmission element by a drive.
7. The device (1) according to any one of claims 1 to 6, **characterized in that** at least some of the suction device are translationally movable by a sliding guide or slotted guide.
8. The device (1) according to any one of claims 1 to 7, **characterized in that** the rows of nozzles are aligned transversely to the direction of travel.
9. The device (1) according to any one of claims 1 to 8, **characterized in that** the air nozzles (4) have an adjustable angle of inclination and/or distance (a, b) with respect to the suction orifice (5) and/or the wall or ground surface (2).
10. The device (1) according to any one of claims 1 to 9, **characterized in that** the device (1) has a controller and sensors to detect the respective distance (b) of the air nozzles (4) with respect to the wall or ground surface (2) and/or obstacles which restrict the free space in a timely fashion.
11. The device (1) according to any one of claims 1 to 10, **characterized in that** the device (1) is equipped with distance measuring sensors.
12. The device (1) according to any one of claims 1 to 11, **characterized in that** the suction power of the device (1) and/or the power of the compressed air supply of the air nozzles (4) is variably adjustable.
13. A rail vehicle (10) having a device (1) according to any one of claims 1 to 12.
14. A method for operating the device (1) according to any one of claims 1 to 12, **characterized in that** the pressure of the compressed air supplied to the air

nozzles (4) of the different rows of nozzles is adjusted differently from one another depending on the direction of travel of the rail vehicle (10).



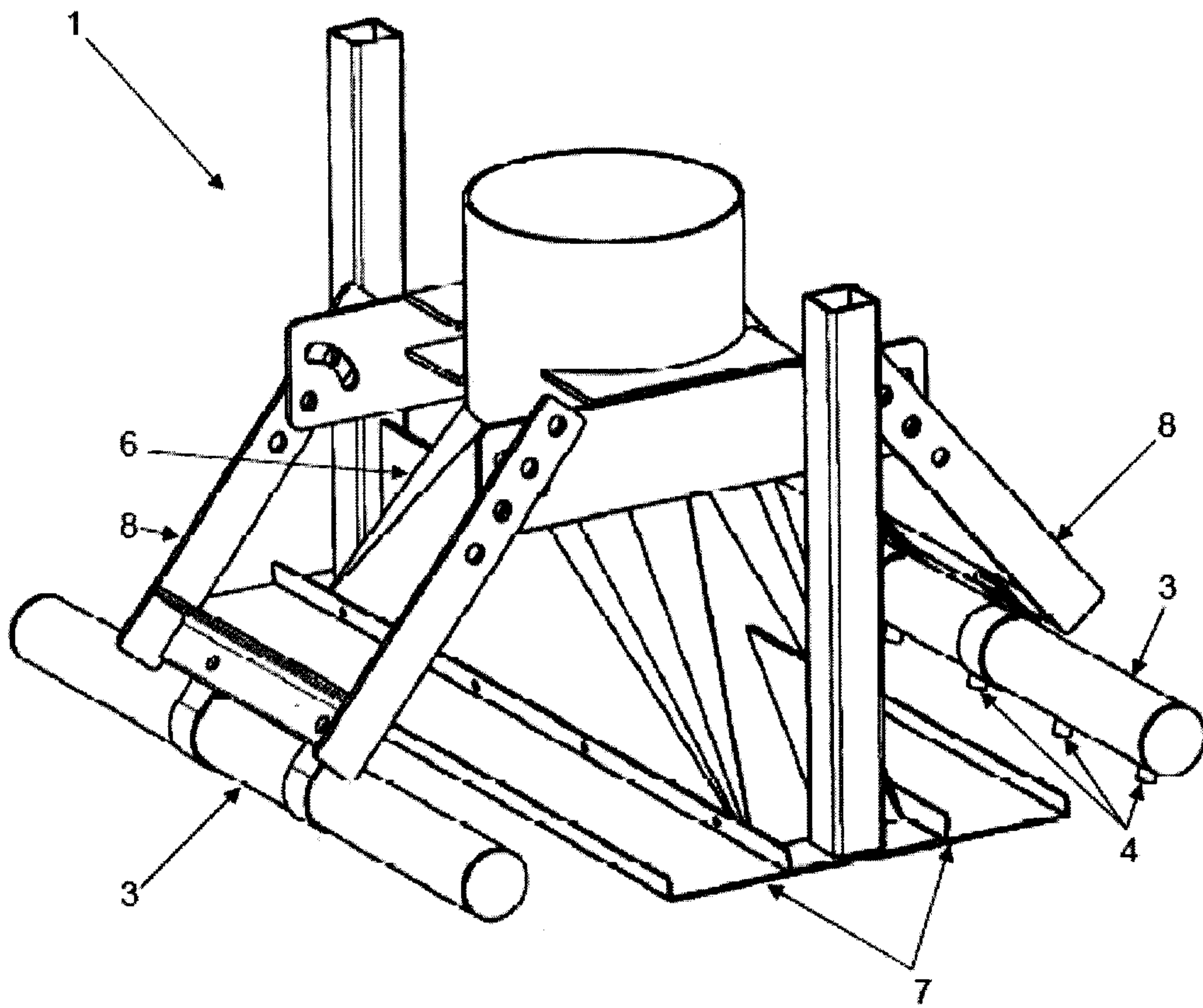


Fig. 3

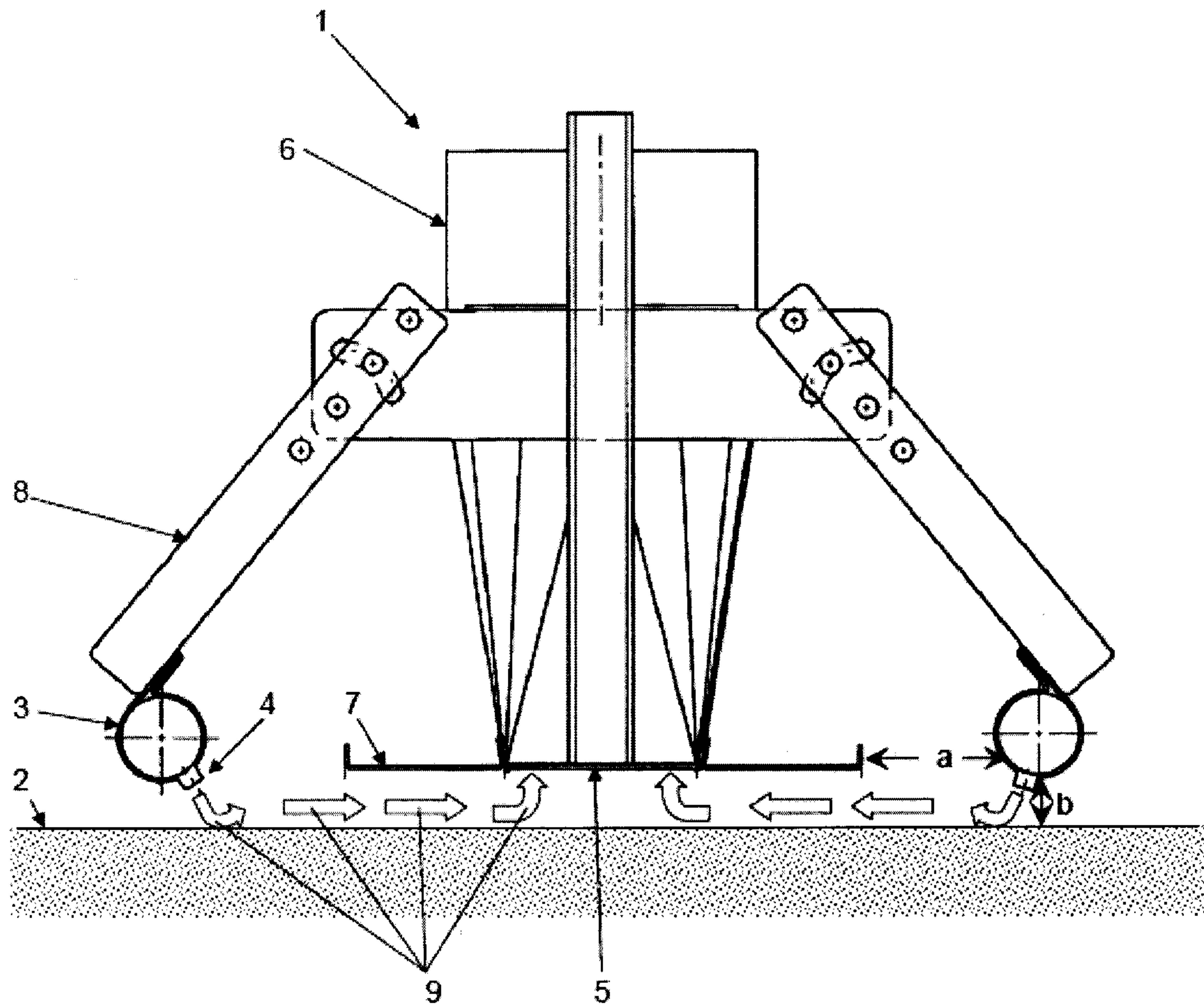


Fig. 4

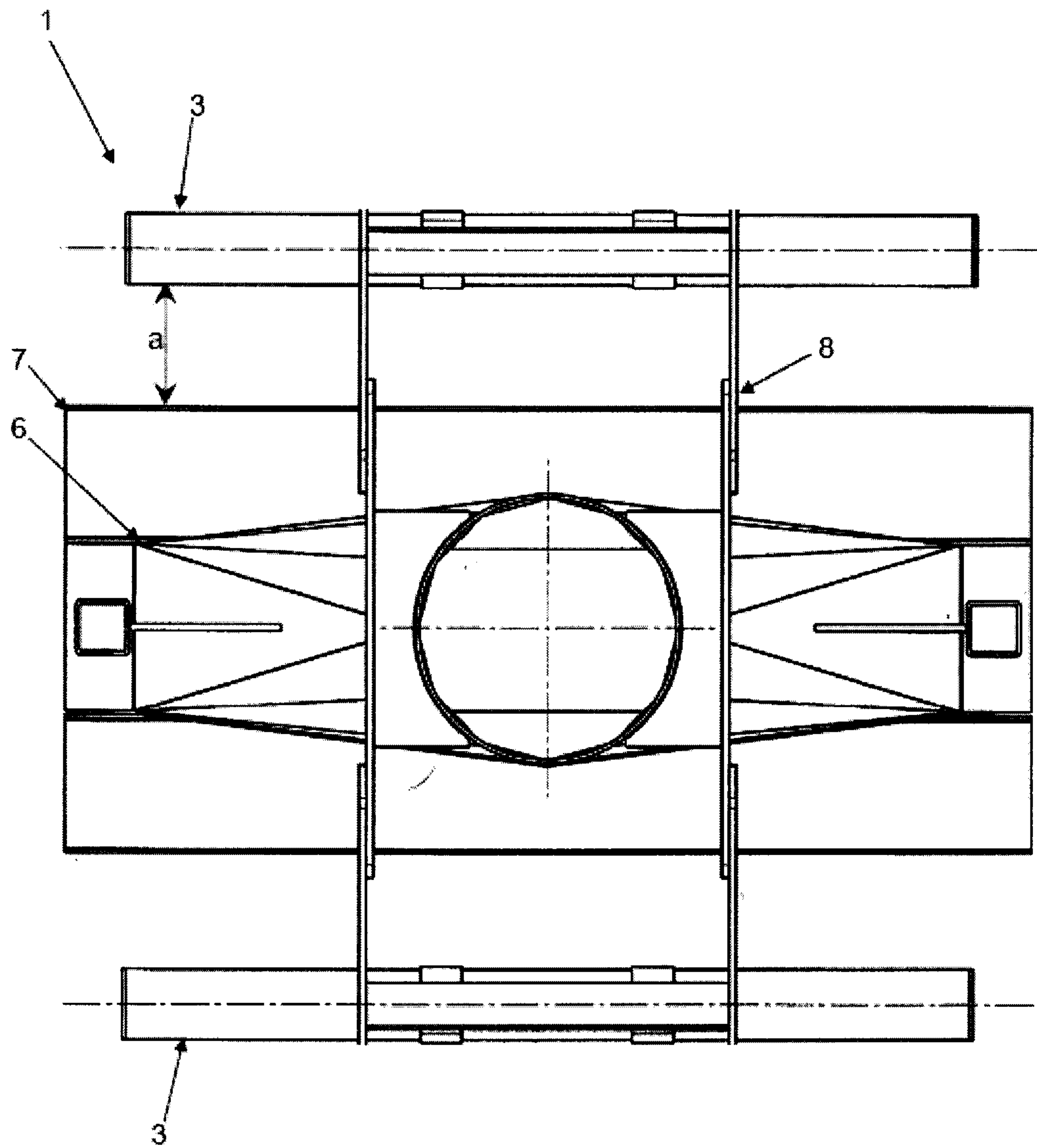


Fig. 5

