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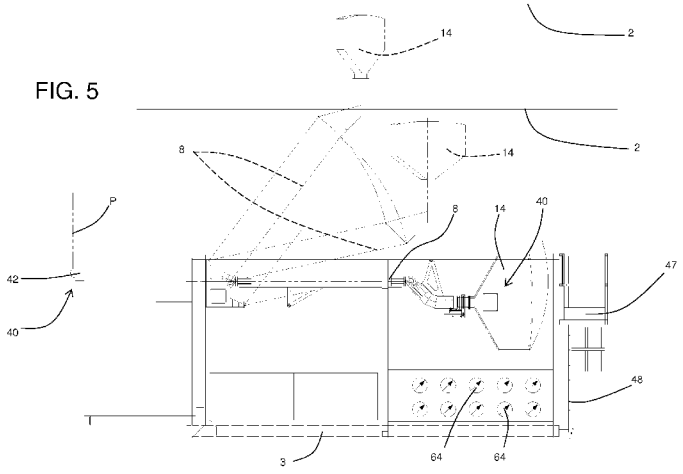
(54) **Title**: APPARATUS FOR SPRAYING LIQUID SUBSTANCES, SUCH AS PAINTS OR WATER, ON THE INNER WALLS OF TUNNELS

FIG. 5



(57) **Abstract**: An apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels, comprising a plurality of arms (8) each able to move in a different radial plane between a home position and a plurality of operating positions and supporting an operating head (14) which can move relative to the respective arm (8). Each operating head (14) comprises one or more sprayers (15) which are arranged and/or shaped in such a way as to create a spraying fan (16) having a cross-section which is elongated along a main direction of extension. Orientation means allow, in practice, variation of the angle of the main direction of extension relative to the surface of the tunnel being treated. A control unit (43) is operatively connected to the orientation means for the various heads and is programmed to vary the orientation of the heads in such a way that, in practice, the portion of surface covered by each spraying fan (16) as the apparatus (1) advances partly overlaps with those covered by the fans adjacent to it.

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APPARATUS FOR SPRAYING LIQUID SUBSTANCES, SUCH AS PAINTS OR WATER, ON THE INNER WALLS OF TUNNELS

* * *

This invention relates to an apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels.

The apparatus was first developed to allow the automation of operations for painting the inner walls of tunnels.

In fact, recently, particularly with the aim of increasing luminosity in tunnels and therefore reducing energy consumption linked to lighting them, there is an increasing need to paint the inside of tunnels in light colours, usually white.

At present, the inside of tunnels are mainly painted by hand by operators equipped with spray guns. It is easy to imagine how that operating method is disadvantageous both in terms of the quality of the painting which can be obtained and, above all, as regards working times. In fact, manual tunnel painting requires extremely lengthy working times, with a consequent negative repercussion on vehicle traffic, especially in the case of repainting existing tunnels, an operation which always involves closing the tunnel.

Moreover, the use of spray guns is also disadvantageous regarding pollution of the working environment. Indeed, part of the nebulised paint does not adhere to the tunnel wall, but is dispersed in the air, more if the distance between the spray guns and the wall deviates from the ideal distance for correct painting.

Patent WO 2005/074527 in contrast describes an apparatus for painting boat hulls, comprising a mobile carriage on which a robotised arm is mounted, equipped with a head for spraying paint and aspirating any volatile excess.

Painting is carried out by moving the arm vertically to create, one after another, a series of painted vertical strips.

Finally, patent JP 6 117197 describes an apparatus for spraying resins inside tunnels, equipped with an arm rotating in a plane perpendicular to the longitudinal axis of the tunnel.

Secondly, this invention was developed relative to the need to wash existing tunnels. That need is particularly felt in the case of painted tunnels where, in a short space of time, smog tends to cover the underlying colour with a blackish coating.

At present, tunnel washing can be carried out either manually, or using means normally intended for washing roads, which have been suitably modified. In this latter case, the rigid bar for spraying the water, normally positioned horizontally in front of or behind the vehicle, is mounted on the side of the vehicle and positioned vertically and facing towards the tunnel wall. The driver then drives through the tunnel, keeping the bar in a position in which it skims the inner wall as far as possible.

Again in this case, the result which can be obtained is certainly not ideal.

In fact, for obvious structural reasons, it is not possible to move the spraying bar beyond a certain point closer to the tunnel wall. Moreover, only the skill and caution of the operator can allow said distance to be kept constant as time passes.

In addition to that, at present it is not possible to recover the dirty washing water, causing consequent pollution of the surrounding environment.

Other washing apparatuses are described in patents CN 201 172 803, FR 2 584 747 and JP 2003 129435. In particular, patent CN 201 172 803 describes a mobile washing apparatus equipped with two arms which can move independently of each other. Patent FR 2 584 747 instead describes an apparatus with a single mobile arm equipped with a system for automatically controlling the distance of the arm from the wall to be cleaned. However, none of the apparatuses described in said patents is described as able to be used for spraying paint or other another substance other than a washing liquid.

In this situation the technical purpose which forms the basis of this invention is to provide an apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels which overcomes the above-mentioned disadvantages.

In particular, the technical purpose of this invention is to provide an

apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels which allows substances to be sprayed in a more reliable way than the prior art solutions.

The technical purpose of this invention is also to provide an apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels which guarantees greater productivity than prior art solutions.

The technical purpose of some embodiments of this invention is also to provide an apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels which allows the minimising of dispersion of polluting substances in the environment.

The technical purpose specified and the aims indicated are substantially achieved by an apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels made as described in the appended claims.

Further features and the advantages of this invention are more apparent in the detailed description, with reference to the accompanying drawings which illustrate several preferred, non-limiting embodiments of an apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels, in which:

Figure 1 is a schematic side view, with some parts cut away to better illustrate others, of a first embodiment of an apparatus according to this invention mounted on a truck with a trailer which, depending on the embodiments, may or may not be part of the apparatus itself;

Figure 2 is a schematic side view, with some parts cut away to better illustrate others, of a second embodiment of an apparatus according to this invention mounted on a road semi-trailer and drawn by a tracked tractor which, depending on the embodiments, may or may not be part of the apparatus itself;

Figure 3 is a schematic plan view of a first part of the apparatus of Figure 1;

Figure 4 is a schematic rear view of the part of the apparatus of Figure 3;

Figure 5 is a schematic side view, with some parts cut away to better

illustrate others, of a second part of the apparatus of Figure 1;

Figure 6 is a rear view of an alternative embodiment of the second part of the apparatus of Figure 5, schematically illustrating a plurality of mobile arms in respective operating positions corresponding to tunnels having a maximum and a minimum diameter;

Figure 7 is a schematic side view of the detail of a mobile arm of the apparatuses of Figures 1 and 2;

Figure 8 is a rear view of the detail of the portion fixing the mobile arm to the supporting structure;

Figure 9 is an enlarged view of the detail IX from Figure 7;

Figure 10 is a schematic view of the projection in a plane of the reciprocal arrangement of the operating heads 14 of three arms of the apparatus of Figure 6, in an operating condition in the case of a tunnel with maximum diameter;

Figure 11 is a schematic view of the projection in a plane of the reciprocal arrangement of the operating heads 14 of three arms of the apparatus of Figure 6, in an operating condition in the case of a tunnel with intermediate diameter;

Figure 12 is a schematic view of the projection in a plane of the reciprocal arrangement of the operating heads 14 of three arms of the apparatus of Figure 6, in an operating condition in the case of a tunnel with minimum diameter;

Figure 13 is an enlarged view, more detailed and partly transparent, of the operating head of the arm of Figure 7;

Figure 14 is a cross-section of the operating head of Figure 13 according to the plane XIV - XIV;

Figure 15 is an enlarged view and partly transparent view of an operating head of a different arm of the apparatus of Figure 6; and

Figure 16 is a hydraulic system diagram of the liquid substance spraying circuit according to this invention.

With reference to the accompanying drawings the numeral 1 denotes in its entirety an apparatus for spraying liquid substances, such as paints or water, on the inner walls 2 of tunnels, made in accordance with this invention.

According to this invention, the apparatus 1 comprises first at least one supporting structure 3 which, during use, can be moved along the length of a tunnel to be treated.

As illustrated in Figures 1 and 2, depending on the embodiments there may be either a single supporting structure 3 (Figure 2), or multiple independent supporting structures 3 for different parts of the apparatus 1 (as in the case of Figure 1 where there are two supporting structures 3).

Moreover, in both of said figures, the supporting structures 3 are in turn positioned on vehicles: in the case in Figure 2 on a single road semi-trailer 4; in the case in Figure 1 part on the back of a truck 5 and part on a road trailer 6.

Depending on requirements, said vehicles may be intended exclusively for transporting the apparatus 1 to the working area, or may also be used during operation 5 of the apparatus 1 to make it advance along the length of a tunnel.

For that purpose, it should in any case be noticed that, according to this invention, the vehicles which transport the supporting structures 3 may also be part of the apparatus 1. In some cases, the chassis of the vehicles may be an integral part of the supporting structures 3.

Indeed, in the most complete embodiments, the lower part of the supporting structure 3 may comprise at least one transport carriage equipped with wheels which allow it to advance on the ground (such as the semi-trailer 4 of Figure 2), just as the apparatus 1 may also comprise at least one tractor unit 7 connected to the carriage to make it advance on the ground (such as the tracked vehicle of Figure 2).

Further details of these aspects are provided below.

Also, according to this invention, the apparatus 1 comprises at least one

mobile arm 8 having a first end 9 connected to the supporting structure 3 and a projecting second end 10 (Figures 5 and 7). The arm 8 can move relative to the supporting structure 3 between a home position in which the second end 10 is close to a central axis of the apparatus 1 (axis not illustrated), and a plurality of operating positions in which the second end 10 of the arm is in contrast distanced from the central axis. In particular, in the embodiment illustrated, in the home position the arm 8 is positioned mainly parallel with the central axis of the apparatus 1 and is within the overall dimensions defined by the supporting structure 3, whilst in the operating positions the arm projects laterally from the supporting structure 3.

Movement of the arm 8 between the various positions is guaranteed by special movement means which, advantageously, may comprise one or more linear actuators (for example hydraulic or electric). In the accompanying drawings, in particular, they comprise a first actuator 11 mounted between a bracket 12 fixed to the arm 8 and a portion 13 for fixing the arm 8 to the supporting structure 3. In fact, the arm 8 is in turn preferably fixed to the supporting structure 3 by means of a fixing portion 13 which is fork-shaped (Figures 7 and 8) in which it is hinged.

Although in the embodiment illustrated the arm 8 has a fixed length, in other embodiments the arm may be extendable (for example by means of a telescopic mechanism).

Mounted on the second end 10 of the arm 8 there is at least one operating head 14, equipped with at least one sprayer 15 designed to spray the liquid substance on the walls 2 of tunnels. However, in the preferred embodiments, each head 14 is equipped with a plurality of sprayers 15 arranged side by side and spaced as shown, for example, in Figures 7 and 13 to 15. Preferably, the sprayers 15 (whether one or more) are arranged and/or shaped in such a way as to create a spraying fan 16 without axial symmetry (in Figure 7 each spraying fan 16 is schematically illustrated by two lines made up of dashes alternated with two dots which diverge from each sprayer 15). In fact, advantageously, the

spraying fan 16 has a cross-section which is elongated along its own main direction of extension which, in Figure 7 is parallel with the plane of the drawing. In other words, in the embodiment illustrated each spraying fan 16 has a cross-section which is substantially rectangular (increasing with the gradual increase in the distance from the sprayer 15). As illustrated in Figure 7, moreover, the sprayers 15 of an operating head 14 are arranged relative to each other in such a way that the respective spraying fans 16 partly overlap at the tunnel wall 2 (whose distance from the sprayer 15, as explained in more detail below, is advantageously kept within a predetermined range).

In the preferred embodiment illustrated in the accompanying drawings, the operating head 14 is in turn able to move relative to the second end 10 of the arm 8 to which it is fixed. In fact, advantageously, the head 14 is hinged to the second end 10 of the arm 8 by a shaped connecting element 17 which is interposed between the two. In the embodiment illustrated, the hinging axis of the shaped element to the arm 8 is perpendicular to the plane of movement of the arm 8 (plane determined by the hinging axis of the arm 8 to the fixing portion 13).

Preferably, there are also means for orientation of the head 14 relative to the arm 8. In more detail, to guarantee controlled rotation of the connecting element 17 relative to the arm 8, the orientation means comprise first rotation means 18 which cause the rotation of the connecting element 17 between a home position (illustrate with a continuous line in Figure 7) and an operating position (partly illustrated using a dashed line in Figure 7), and which advantageously comprise a second linear actuator 19 (for example hydraulic or electric), which, in the preferred embodiment illustrated in the accompanying drawings, is in turn hinged, on one side, to the fixing portion 13 and, on the other, to a projection 20 of the shaped connecting element 17. Moreover, as shown in Figure 7, to allow on one hand movement of the arm 8, and on the other the possibility of always keeping the shaped connecting element 17 parallel with itself during operation, when the connecting element 17 is in its operating

position, the hinging points of the arm 8 (respectively to the fixing portion 13 and to the connecting element 17) and of the second actuator 19 (respectively to the fixing portion 13 and to the projection 20) constitute the vertices 21 of a four-bar linkage. In this way, the first rotation means 18 allow the head 14 to be kept parallel with itself during movement of the arm 8. That situation is schematically illustrated in Figure 5 where the apparatus 1 illustrated is equipped with a single arm 8 able to move in the vertical plane: the arm 8 illustrated with a continuous line corresponds to the arm 8 in the home position with the connecting element 17 also in the home condition, whilst the two arms illustrated with dashed lines indicate two different operating positions of the arm 8 which correspond to inner walls 2 of tunnels having different radii (both with the connecting element 17 in its operating position).

In light of the above, it therefore seems clear that, with the arm 8 in the home position, each head 14 can be positioned in such a way that both the arm 8 and the head 14 are within the dimensions of the apparatus 1 for circulation on the roads.

Also, advantageously, irrespective of the presence or absence of the first rotation means 18 (if the embodiment allows it), the orientation means may, in practice, allow a variation of the angle of the main direction of extension of the spraying fan 16 relative to the surface of the inner wall 2 of the tunnel (the different orientation of the head 14 can be seen three-dimensionally in the three positions of the arm 8 illustrated in Figure 5).

For that purpose, as shown in Figure 9, the orientation means preferably comprise second means 22 for rotation of the head 14 about itself (in the embodiment illustrated relative to the shaped connecting element 17). In fact, in the preferred embodiment, the operating head 14 is fixed to the connecting element 17 by means of an annular bearing 23 (in other embodiments the fixing method described here may however be used directly between the operating head 14 and the arm 8). The head 14 is also equipped with a gear wheel 24 coaxial with the bearing 23, connected (by a chain not illustrated in the accompany

drawings for the sake of clarity) to a pinion 25 driven by a motor 26 fixed to the connecting element 17. Advantageously, interposed between the motor 26 and the pinion 25 there is both a reduction unit 27 and a brake 28.

The latter is designed to keep the head 14 stationary once the predetermined angular position has been reached. Also fitted, coaxially to the bearing 23 and to the gear wheel 24, there is an annular cam element 29 which, interacting with a mechanical limit switch 30 fixed to the motor 26, determines the angle of possible rotation of the head 14.

Said second rotation means 22 are designed to adapt the apparatus 1 to tunnels having different diameters if multiple mobile arms 8 are provided, as described in more detail below.

It should also be noticed that, in the embodiment illustrated, the shape of the connecting element 17 is designed in such a way that, when it is in the operating position and therefore the head 14 is connected to the supporting structure 3 by means of a four-bar linkage, the axis of rotation of the head 14 on itself lies in a plane which is substantially perpendicular to the direction of advancement of the apparatus 1 along the tunnel (therefore, also to a longitudinal axis 31 of the axis 1).

In the preferred embodiment, the apparatus 1 also comprises extractor means 32 operatively associated with the operating head 14. The extractor means 32 are designed to aspirate, during operation, at least part of what is sprayed at the portion of the tunnel affected by the spraying with the liquid substance. In particular, in the case of an apparatus 1 designed for painting or for similar applications, the extractor means 32 are designed to aspirate, as far as possible, the nebulised paint which is not deposited on the tunnel wall 2. The embodiment illustrated relates to that application. In contrast, for an apparatus 1 designed for washing, the extractor means 32 may be designed to recover, as far as possible, the dirty water.

As shown in the accompanying drawings, the extractor means 32 comprise an extractor inlet 33 mounted on the operating head 14 (Figures 13, 14), an

extraction and filtering chamber 34 mounted on the supporting structure 3 (Figures 1 and 2; the chamber being of the known type and therefore not described in further detail) and at least one tube 35 extending between the extraction chamber 34 and the extractor inlet 33 (Figures 7 and 8; the latter figure shows only the dimensions of the tube 35 at a through-hole 36, made in the fixing portion 13, which allows communication with the inside of the extractor chamber 34). Advantageously, the tube 35 is at least partly inserted in the mobile arm 8 which is hollow for that purpose.

In more detail, the operating head 14 is shaped, in its entirety, like an extractor hood. Consequently, the extractor inlet 33 is formed by the entire open side of the head 14 which in practice is facing towards the tunnel wall 2. Advantageously, at least at the main sides of the extractor inlet 33, the head 14 is also equipped with projecting flexible plates 37 which, during operation, delimit the aspiration area. As shown in Figure 14 (where there are only two plates 37 on the main sides of the extractor inlet 33), preferably the plate 37 which in practice is positioned upstream relative to the direction of advancement of the apparatus 1 in the tunnel, projects more than the other. In this way, the upstream plate 37 can also be placed in contact with the wall 2 for improved closing of the aspiration space, whilst the downstream plate remains distanced from the wall 2, preventing it from ruining the paint just applied. Moreover, preferably, the plates 37 may comprise an arched outer edge so that they can get as close as possible to the tunnel wall 2 (advantageously, the radius of curvature of said edge may be a mean radius amongst the various possible radii of the tunnels in which the apparatus 1 can operate).

It should also be noticed that the flow of aspirated air moves against the flow of the sprays. Inside the head 14, the aspirated air is made to pass through filtering means 38 (two panel filters in the accompanying drawings). In particular, the inside of the operating head 14 illustrated is divided in such a way as to create a path for the air (indicated by the arrow in Figure 14) which mainly skims the head 14 outer panels from the extractor inlet 33 as far as

the filters, and is substantially central relative to the head 14 downstream of the panel filters. In contrast, the air passes through the latter in a direction transversal to the first two. In this way, although keeping the thickness of the head 14 limited (dictated by the dimensions of the spraying fans 16) it is possible to significantly increase the filtering cross-section and therefore reduce the consequent pressure losses, the filtering effect being equal.

In contrast, in the case of an apparatus 1 designed for washing, the extractor inlet 33 will advantageously be shaped in such a way that it can collect at least most of the water which is sprayed. For that purpose, for example, the inlet may be equipped with flexible plates designed to rest on the tunnel along their entire lower part. However, alternatively, in other embodiments, the water collecting means may also be made independent of the operating heads 14. Furthermore, in the case of an apparatus designed for washing, mounted inside the extractor inlet 33 there may also be a motor-driven rotating brush sized in such a way that it projects from the extractor inlet 33 so as to be able to interact with the tunnel wall to maximise the cleaning effect.

According to this invention, the apparatus 1 also comprises means 39 for feeding the liquid substance to be sprayed to the sprayer 15 or sprayers 15 (means described below with reference to Figure 16), and detection means 40 for detecting during operation the position of the operating head 14 relative to the tunnel wall 2.

As schematically illustrated in Figures 7 and 13, the detection means 40 may comprise at least one distance detector 41 (for example of the laser or ultrasound type) which is operatively coupled to the operating head 14 for measuring the distance of the head from the tunnel wall 2. Alternatively, the detection means 40 may comprise a laser detector 42 of the type described below, as well as means for controlling the position of the head 14 relative to the rest of the apparatus 1, for measuring the distance in an indirect way.

Finally, the apparatus 1 according to this invention comprises a control unit 43 which is operatively connected at least to the movement means, to the

feed means 39, to the detection means 40 and, advantageously, if present, to the orientation means and to the extractor means 32.

The control unit 43 is programmed firstly to control operation of the movement means depending on the position detected by the detection means 40. However, advantageously, the control unit 43 is operatively connected to all of the devices of the apparatus 1 for controlling their relative operation.

In particular, the control unit 43 is programmed to maintain, during operation, the distance of each operating head 14 from the inner wall 2 of the tunnel within a predetermined range. Consequently, when through the detection means 40 the control unit 43 receives the indication that the distance has gone outside, or is about to go outside, the predetermined range (due to variations in the cross-section of the tunnel, deviations in the direction of advancement along the tunnel relative to the ideal direction, etc.) it issues the command to operate the movement means to suitably return the distance within the range allowed.

In the embodiment illustrated, before moving the arm 8 from the home position, the control unit 43 checks whether or not the connecting element 17 is in its own operating position. If not, the control unit operates the first rotation means 18 to move it there, thus forming the above-mentioned four-bar linkage.

Moreover, advantageously, as already indicated, the detection means 40 may also comprise at least one laser detector 42 mounted on the supporting structure 3 for detecting in practice the inner shape of the tunnel and/or the presence of obstacles inside it. In particular, the laser detector 42 (of the known type and therefore not described in detail) may emit either a plurality of coplanar laser beams, arranged in a plane P which is substantially perpendicular to a longitudinal axis 31 of the apparatus 1, for simultaneously detecting the shape of the entire tunnel wall 2 involved, or a single mobile beam with predetermined frequency in said perpendicular plane. In this way, the control unit 43 can identify both the position of the apparatus 1 relative to the wall 2 (information which, combined with identification of the position of the

arms 8 relative to the rest of the apparatus 1 may also allow the distance detector 41 to be dispensed with), and the presence of any fixed obstacles such as road signs, service columns, etc. Consequently, knowing the position of the obstacles, the control unit 43 can automatically issue the command to retract the arms 8 which could make contact with them.

Also, knowing the shape of the entire cross-section of the tunnel thanks to a special laser detector 42 with an operating angle of at least 180° (but preferably greater), in the most complete embodiments equipped with a tractor unit 7, allows the control unit 43 to also control the advancement of the apparatus 1 along the tunnel, through direct control of the tractor unit 7, which may therefore be an automatic unit without a driver, as schematically illustrated in Figure 2.

As already indicated, in the preferred embodiment of this invention the apparatus 1 is equipped with not just one arm 8 and one head 14, but with a plurality of mobile arms 8, as illustrated in Figure 6. With regard to this, it should first be noticed that the arrangement of the arms 8 illustrated in Figure 6 is also provided for application to the apparatuses of Figures 1 and 2. It is only for the sake of clarity that said Figures illustrate only one arm 8.

Advantageously, each arm 8 of Figure 6 is structurally the same as the single arm described above. Moreover, each arm 8 can move relative to the supporting structure 3 in such a way that the respective operating head 14, during operation, can spray the liquid substance at a zone of the surface of the tunnel which is at least partly separate from those covered by the other operating heads 14. In other words, after advancing along the tunnel, each head 14 sprays the liquid product on a longitudinal band of the tunnel wall 2 partly overlapping those covered by the other heads.

That situation is schematically illustrated in Figure 6 where continuous lines indicate the road surface, the inner walls 2 of two tunnels with different radii (maximum and minimum), the supporting structure 3 and the fixing portions 13 of the various arms 8. In contrast, the arms are only schematically illustrated with dashed lines at the operating position they adopt for a tunnel

with maximum radius. In contrast, at the tunnel wall 2 with minimum radius only dashed lines indicate the end edges of each operating head 14 in the corresponding operating position. As shown, in the operating position corresponding to the tunnel with minimum radius, the apparent width of the operating heads 14 is less than the apparent width at the tunnel with maximum radius. That is because the heads, to avoid interfering with each other and to guarantee correct overlapping of the respective spraying fans 16, are arranged at a different angle relative to the plane of the drawing (and angle obtained through the second rotation means 22).

By way of explanation only, Figures 10 and 12 schematically illustrate a projection in a plane, on the tunnel wall 2 respectively with maximum diameter and minimum diameter, of the extractor inlets 33 of three adjacent operating heads 14 of the apparatus 1 of Figure 6. In contrast, Figure 11 shows the similar case for a tunnel with intermediate diameter.

As shown, in all cases the angle of the heads 14 is such that it maintains a similar reciprocal alignment (horizontally in the drawings) of the upper and lower ends of the various heads. In this way, even the overlapping of the spraying fans 16 of the various heads is guaranteed as the apparatus 1 advances along the tunnel.

As can also be seen in Figure 6, in the preferred embodiment the arms 8 (except the lowest one, as described below) can each move in a different radial plane which substantially passes through a longitudinal axis 31 of the apparatus 1. Said longitudinal axis 31, during apparatus 1 operation, is positioned substantially parallel with the longitudinal axis of the tunnel. Moreover, in the embodiment illustrated in the accompanying drawings, preferably, during operation, the longitudinal axis 31 of the apparatus 1 is made to coincide as far as possible with the longitudinal axis of the tunnel.

Figure 6 also shows the positioning of the various operating heads 14 when the related arm 8 and the related connecting element 17 are in the home position: the related rectangular shapes are in fact drawn with dashed lines

over the fixing portions 13 and extend radially towards the longitudinal axis 31 until they almost touch each other.

To avoid any accidental contact of the heads 14 in the home position, due to any unwanted oscillations of the arms 8 during apparatus 1 transfer, each arm 8 in the home position may engage with slight interference in a respective containment seat fixed to the supporting structure 3 close to the second end 10 of the arm 8 (embodiment not illustrated). Advantageously, to avoid damage to the arm 8, the seat is covered with self-lubricating material.

As indicated, the only arm 8 which in the embodiment illustrated is different to the others is the lower one which is designed for spraying at the lower base 44 of the tunnel wall 2 and the pavement 45 if present. In fact, said arm 8 can move in a horizontal plane. Even the related head 14, illustrated in Figure 15, has differences compared with the others as regards the number and positioning of the sprayers 15. Rather than four sprayers 15 facing towards the wall 2 it only has two, but it also has an auxiliary sprayer 46 located outside the extractor hood and facing towards the pavement 45. Otherwise, although its shape is different to that of the other heads 14, structurally it is the same as them and therefore is not described in further detail. However, depending on the embodiments, the number of auxiliary sprayers 46 may be greater than one, thus allowing spraying even on relatively wide pavements. Moreover, in some preferred embodiments not illustrated, it may also be the case that, if there are two or more auxiliary sprayers, either they may be activated independently of each other, or their distance may be varied in such a way as to adapt the apparatus to pavements of different sizes.

Finally, the embodiment in Figure 6 shows the case of an apparatus 1 able to carry out with a single pass the spraying of the liquid substance on half of the tunnel. Therefore, in this embodiment the arms 8 move substantially like the spokes of an umbrella. However, in other embodiments there may be a different number of arms 8, so as to cover a greater or smaller portion of the tunnel. With regard to this, it should be noticed that if the number of arms 8 is such that it

does not cover at least half of the tunnel, it is appropriate that it should also be possible to move them about the longitudinal axis 31 of the apparatus 1 so that on each occasion they can be positioned opposite the portion of tunnel wall 2 required.

The control unit 43 (which is operatively connected to all of the arms 8) can control operation of the movement means relative to each arm 8 independently, as it can control the orientation means, the feed means 39, the extractor means 32 and the detection means 40. In particular, the control unit 43 is operatively connected to the orientation means for the various heads for varying their orientation in such a way that, in practice, the portion of surface covered by each spraying fan 16 as the apparatus 1 advances partly overlaps with those covered by the fans 16 adjacent to it.

Figures 1 and 2 show how on the back of the supporting structure 3 there is a platform 47 for an operator and a related access ladder 48. At the zone surrounded by the arms 8 in the home position, the apparatus 1 comprises both the control panels 49 and the pumps of the feed means 39. Advantageously, the control panels 49 may comprise at least one interface (not illustrated) connected to the control unit 43 and which allows the operator to set the apparatus 1 operating parameters (such as the distance of the heads from the wall 2, the movement speed of the arms 8, the advancing speed, etc.).

Relative to the feed means 39, it should be noticed that in Figures 1 to 15, to improve understanding of the drawings, no hydraulic or pneumatic ducts are shown, ducts which in contrast are shown in Figure 16 which illustrates the system layout relative to the embodiment of Figure 6 (that is to say, equipped with nine arms 8).

Therefore, with reference to said figure, it can be seen how the feed means 39 comprise a hydraulic circuit and a pneumatic circuit.

The hydraulic circuit firstly comprises a plurality of tanks for the various liquid substances to be sprayed or in any case to be used. For example, it may comprise a first tank 50 for the water, a second tank 51 for water-based paint

(normally used for painting the tunnel), a third tank 52 for a siloxane paint (normally transparent and used for covering a previous layer of water-based paint with a protective layer), and a fourth tank 53 for a solution of water and solvent (for cleaning the feed means 39).

Each of these tanks is connected to an initial pipe 54 by means of a check valve 55 and a first on-off solenoid valve 56. Along the initial pipe 54, which is connected to a first centrifugal pump 57, there is also a first filter 58, a first flow rate measuring device 59 and a check valve 55. The delivery side of the first pump 57 is connected by a first pipe 60 to a main manifold 61 from which there extend in parallel ten identical branches 62 each equipped with a first on-off valve 63, a second pump 64 (advantageously of the diaphragm type) and a second filter 65. The various branches 62, in groups of five, converge in two second manifolds 66 which can be put in communication with each other by means of a second on-off valve 67. However, it should be noticed that the two second manifolds 66 are put in communication with each other only if one of the second pumps 64 of a group develops a fault, so as to compensate for its absence by means of the second pumps 64 of the other group. The two second manifolds 66 are designed, one to feed the sprayers 15, 46 of the five lower arms 8, and the other to feed the sprayers 15 of the four upper arms 8 (since these sprayers 15 are positioned higher up, the use of a second pump 64 relative to the number of arms 8 to be fed guarantees the necessary additional head compared with the other group of arms 8). In particular, except for the first arm 8, all of the sprayers 15 of each arm 8 are preferably fed by a related second pipe 68 extending from the second manifold 66 and on which a pneumatically-controlled third on-off valve 69 is mounted. For simplicity, the accompanying drawings only show one sprayer 15 per arm 8, representing all four of those present which, therefore, in reality are connected in parallel downstream of the third on-off valve 69.

Regarding the first arm 8 (corresponding to the second highest pipe 68 in Figure 16), in order to make the painting of the pavement 45 independent

of that for the walls 2, the feed means 39 comprise two separate second pipes 68 designed to independently feed the auxiliary sprayers 46 facing the pavement and the sprayers 15 facing towards the wall 2.

Moreover, as can be seen, each second pipe 68, immediately upstream of the third on-off valve 69 is connected to a fourth pipe 70, intercepted by a pneumatically-controlled fourth on-off valve 71, which is connected to a recovery 72. In fact, it is sufficient to close the third on-valves 69, open the fourth on-off valves 71 and feed a washing liquid (pure water or water with solvent) to the first pump 57 to completely wash the feed means 39 except for the final stretch of the second pipe 68 (which in contrast may be cleaned with a brief spray of water or water and solvent), recovering practically all of the washing residues.

Therefore, all of that constitutes means for washing the feed means 39.

The recovery tank 72 is also connected, by a fifth pipe 73 and a sixth pipe 74 to the main manifold 61. In particular, the fifth pipe 73 connects the main manifold 61, by means of a second solenoid valve 75, to a first way of a three-way valve 76, another way of which is also connected to the recovery tank 72 by the sixth pipe 74. Finally, the third way of the three-way valve 76 is connected to a drain 77.

Advantageously, each second pump 64 comprises its own secondary outfeed connected, by a seventh pipe 78 equipped with a fifth on-off valve 79, to a third manifold 80 in turn connected, by an eighth pipe 81 to the initial pipe 54 downstream of the various tanks and upstream of the first pump 57. A ninth pipe 82 equipped with a check valve 55 connects the third manifold 80 to the fifth pipe 73.

Also connected to the initial pipe 54, by a tenth pipe 83, there is a fifth tank 84 for any catalyst. Mounted on the tenth pipe 83 there is a third pump 85, a second flow rate measuring device 86, a sixth on-off valve 87 and a check valve 55.

The pneumatic part of the feed means 39 comprises first a compressor 88

which supplies a first duct 89 on which a sixth tank 90 for pressurised air is mounted. A second duct 91 connects the sixth tank 90 to a first line 92 and a second line 93. The first line 92 is split into a third line 94 and a fourth line 95. The third line 94, designed for controlling the third on-off valves 69, is in turn split into as many fifth lines 96 as there are third on-off valves 69 to be controlled. Each fifth line 96 is equipped with a first two-state solenoid valve 97 which can be switched between a first condition in which it puts in fluid communication the third line 94 and the respective third on-off valve 69, and a second condition in which it closes the fifth line 96, putting its downstream stretch in communication with the environment (therefore, allowing closure of the third on-off valve 69).

Regarding the fourth line 95, designed for opening the fourth on-off valves 71, since the latter may be opened simultaneously, in the embodiment illustrated there is a single second two-state solenoid valve 98 of the type described above, connected in parallel with all of the fourth on-off valves 71. However, in alternative embodiments, each fourth on-off valve 71 may also be controlled independently by a related second solenoid valve 98, similarly to what happens for the third on-off valves 69 and the related first solenoid valves 97. In this way, during the apparatus initial set-up procedure, it is possible to optimise the pre-loading of liquid substance in the various second pipes 68 to be used (identification of the latter depends on each occasion on which arms must actually be used). Once the arms selected for the processing and the related second pipes 68 have been identified, the pre-loading process involves starting the first pump 57, using the first flow rate measuring device 59 to monitor the quantity of liquid substance fed to the main manifold 61 until it is full, and then starting the second pumps 64 involved and simultaneously opening the related fourth on-off valve 71 by means of the second solenoid valve 98 dedicated to it.

Finally, the second line 93 is connected, by a three-state third solenoid valve 99 of the type described, a pressure reduction unit 100 and a check valve

55, directly to the initial pipe 54 of the hydraulic part of the system. The second line 93 is designed to allow recovery of at least part of the paint present in the feed means 39 at the end of the work. In fact, by opening all of the passages leading to the drain 77 or to the recovery tank 72, it is possible to use the pressurised air to drain off the paint contained in the hydraulic circuit.

All of the various tanks described above are advantageously positioned on the portion of the supporting structure 3 illustrated in Figures 3 and 4, which, as indicated, do not show the various pipes. Also on said structure there may be a generator 101 if present, designed to supply electricity to the entire apparatus 1. Alternatively, the apparatus 1 may be supplied either electrically by a direct connection to the mains or by an external generator 101, or hydraulically by an external hydraulic motor if present (for example, of a work vehicle designed for drawing the apparatus 1).

Operation of the apparatus 1 derives immediately from the description of the structure above.

Once the apparatus 1 has been put in the conditions to be able to move along the length of the tunnel to be treated, it is put in the correct position (for example with the longitudinal axis 31 coinciding with the centre of the cross-section of the tunnel). At that point the control unit 43 activates the first orientation means for forming the four-bar linkage and then the movement means for bringing the various operating heads 14 to the required distance from the tunnel wall 2. At the same time, depending on the radius the heads are set to, the control unit 43 issues the command to the second rotation means 22 for orienting the heads in the most suitable way to guarantee correct overlapping of the spraying fans 16.

At that point, after charging the hydraulic circuit if necessary, on one hand the feed means 39, the sprayers 15 and the extractor means 32 (if present) are activated, and on the other hand advancement of the apparatus 1 along the tunnel is activated (at a speed of several kilometres per hour). Advantageously, the advancing speed is varied depending on the tunnel radius: the greater the

radius, the slower the speed. In fact, the greater the radius, the less the spraying fans 16 are angled and therefore the lower the paint yield. Alternatively, it would also be possible to keep the advancing speed the same and instead modify the flow rate of the feed means 39.

Moreover, as indicated, advancing may be more or less directly managed by the electronic control unit 43 thanks to the laser detector 42.

When the laser detector 42 detects the presence of an obstacle, the control unit 43, at the appropriate moment activates the movement means to retract the arms 8 affected and then make them return to the operating position once the obstacle has been passed.

However, at all times the control unit 43 controls the distance of the heads from the wall 2 to keep it within the predetermined range.

This invention brings important advantages.

First, thanks to this invention it is possible to spray liquid substances on the walls of tunnels in a more reliable way than the prior art solutions.

Second, at least in the most complete embodiments, this invention guarantees greater productivity than the prior art apparatuses.

Third, at least the most complete embodiments of this invention allow the dispersion of any polluting substances in the environment to be minimised.

Finally, it should be noticed that this invention is relatively easy to produce and that even the cost linked to implementing the invention is not very high compared with the benefits it offers.

The invention described above may be modified and adapted in several ways without thereby departing from the scope of the inventive concept.

Moreover, all details of the invention may be substituted with other technically equivalent elements and the materials used, as well as the shapes and dimensions of the various components, may vary according to requirements.

Claims

1. An apparatus for spraying liquid substances, such as paints or water, on the inner walls of tunnels, comprising:

at least one supporting structure (3) which can be moved along a tunnel;

a plurality of arms (8) each having a first end (9) which is connected to the supporting structure (3) and a second end (10); each arm (8) being able to move relative to the supporting structure (3) between a home position in which the second end (10) is close to a central axis of the apparatus (1) and a plurality of operating positions in which the second end (10) of the arm (8) is distanced from the central axis;

means for moving the arm (8) between the home position and the operating positions;

an operating head (14) mounted on the second end (10) of each arm (8); each operating head (14) being equipped with at least one sprayer (15) and being able to move relative to the second end (10) of the respective arm (8);

means for orientation of each head (14) relative to the related arm (8);

means (39) for feeding a liquid substance to be sprayed to the sprayer (15);

detection means (40) for detecting, during operation, the position of the operating head (14) relative to the wall (2) of the tunnel;

a control unit (43) which is operatively connected at least to the movement means, to the feed means (39), to the detection means (40) and the orientation means, the control unit (43) being programmed to control operation of the movement means depending on the position detected by the detection means (40);

each arm (8) also being able to move relative to the supporting structure (3) in such a way that the respective operating head (14), during operation, can spray the liquid substance at a zone of the surface of the tunnel which is at least partly separate from those covered by the other operating heads (14);

characterised in that:

the arms (8) can each move in a different radial plane which substantially passes through a longitudinal axis (31) of the apparatus (1); during operation said longitudinal axis (31) of the apparatus (1) being positioned substantially parallel with a longitudinal axis of the tunnel;

each operating head (14) comprises one or more sprayers (15) which are arranged and/or shaped in such a way as to create a spraying fan (16) having a cross-section which is elongated along a main direction of extension;

for each head (14) the orientation means allow, in practice, variation of the angle of the main direction of extension relative to the surface of the tunnel being treated; and

the control unit (43) is operatively connected to the orientation means for the various heads and programmed to vary the orientation of the heads in such a way that, in practice, the portion of surface covered by each spraying fan (16) as the apparatus (1) advances partly overlaps with those covered by the fans adjacent to it.

2. The apparatus according to claim 1, characterised in that the control unit (43) is programmed to increase the angle of the main direction of extension of each head (14) relative to the longitudinal axis of the apparatus (1), as the distance separating the second end (10) of the related arm (8) from the longitudinal axis itself increases.

3. The apparatus according to claim 1 or 2, characterised in that the control unit (43) is programmed to maintain, with variations in the orientation of the heads (14), a horizontal alignment between the upper end of one head (14) and the lower end of the head (14) above.

4. The apparatus according to claim 1, 2 or 3, characterised in that the control unit (43) is programmed to maintain, during operation, the distance of

each operating head (14) from the inner wall (2) of the tunnel within a predetermined range.

5. The apparatus according to any of the foregoing claims, characterised in that the orientation means comprise first means (18) for rotation of the head (14) relative to the arm (8) and/or second means (22) for rotation of the head (14) about itself.

6. The apparatus according to claim 5, characterised in that the first rotation means (18) are structured in such a way as to allow the head (14) to be kept parallel with itself during movement of the arm (8).

7. The apparatus according to any of the foregoing claims characterised in that the detection means (40) comprise at least one distance detector (41) which is operatively coupled to the operating head (14) for measuring the distance of the head from the surface of the tunnel.

8. The apparatus according to any of the foregoing claims, characterised in that it also comprises extractor means (32) which are operatively associated with the operating head (14) for aspirating, during operation, at least part of what is sprayed at the portion of the tunnel affected by the spraying with the liquid substance.

9. The apparatus according to claim 8, characterised in that the extractor means (32) comprise an extractor inlet (33) mounted on the operating head (14), an extraction and filtering chamber (34) mounted on the supporting structure (3) and at least one tube (35) extending between the extraction chamber (34) and the extractor inlet (33) and being at least partly inserted in the mobile arm (8).

10. The apparatus according to any of the foregoing claims, characterised in that the control unit (43) may control operation of the movement means relative to each arm (8) independently.

11. The apparatus according to any of the foregoing claims, characterised in that the detection means (40) comprise at least one laser detector (42) mounted on the supporting structure (3) for detecting in practice the inner shape of the tunnel and/or the presence of obstacles inside it.

12. The apparatus according to any of the foregoing claims, characterised in that the lower part of the supporting structure (3) comprises at least one transport carriage equipped with wheels which allow it to advance on the ground.

13. The apparatus according to claim 12, characterised in that it also comprises at least one tractor unit (7) which is connected to the carriage to make the carriage advance on the ground.

14. The apparatus according to claim 13, characterised in that the detection means (40) comprise at least one laser detector (42) mounted on the supporting structure (3) for detecting in practice the inner shape of the tunnel and/or the presence of obstacles inside it, and also being characterised in that the tractor unit (7) is operatively connected to the control unit (43) and in that the control unit (43) controls operation of the tractor unit (7) based on what is detected by the detection means (40).

15. The apparatus according to any of the foregoing claims, characterised in that it also comprises means for washing the feed means (39).

16. The apparatus according to any of the foregoing claims, characterised in that with the related arm (8) in the home position, each head (14) can be positioned in such a way that both the arm (8) and the head (14) are within the dimensions of the apparatus (1) for circulation on the roads.

* * *

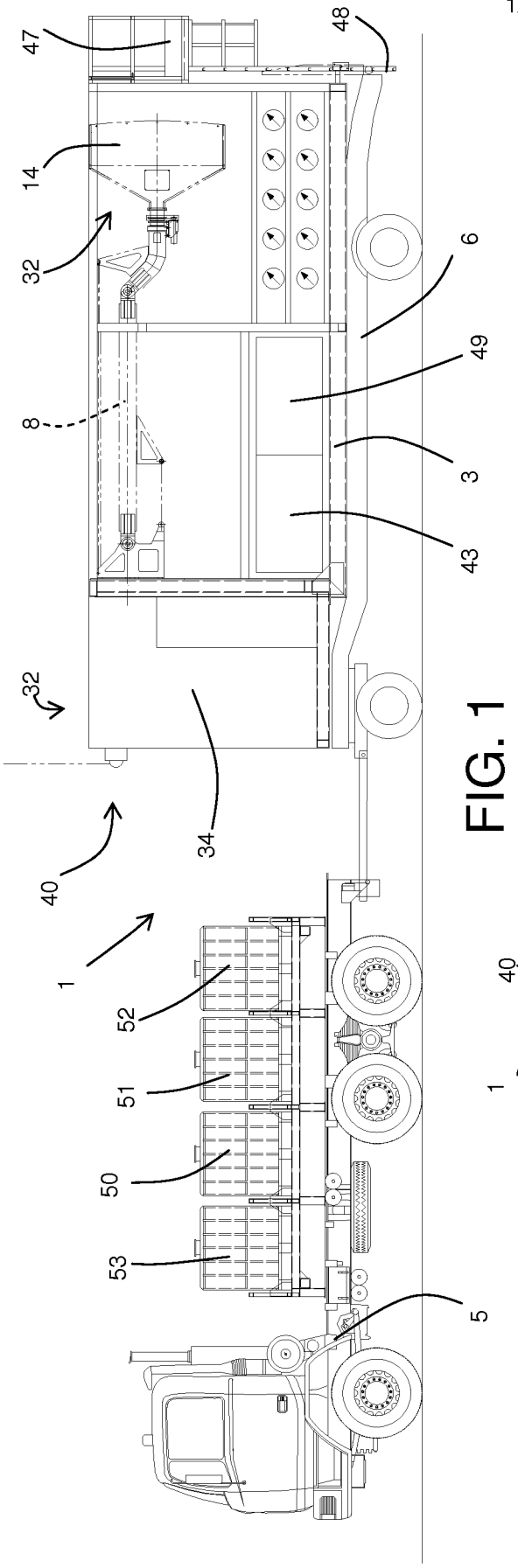
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FIG. 1

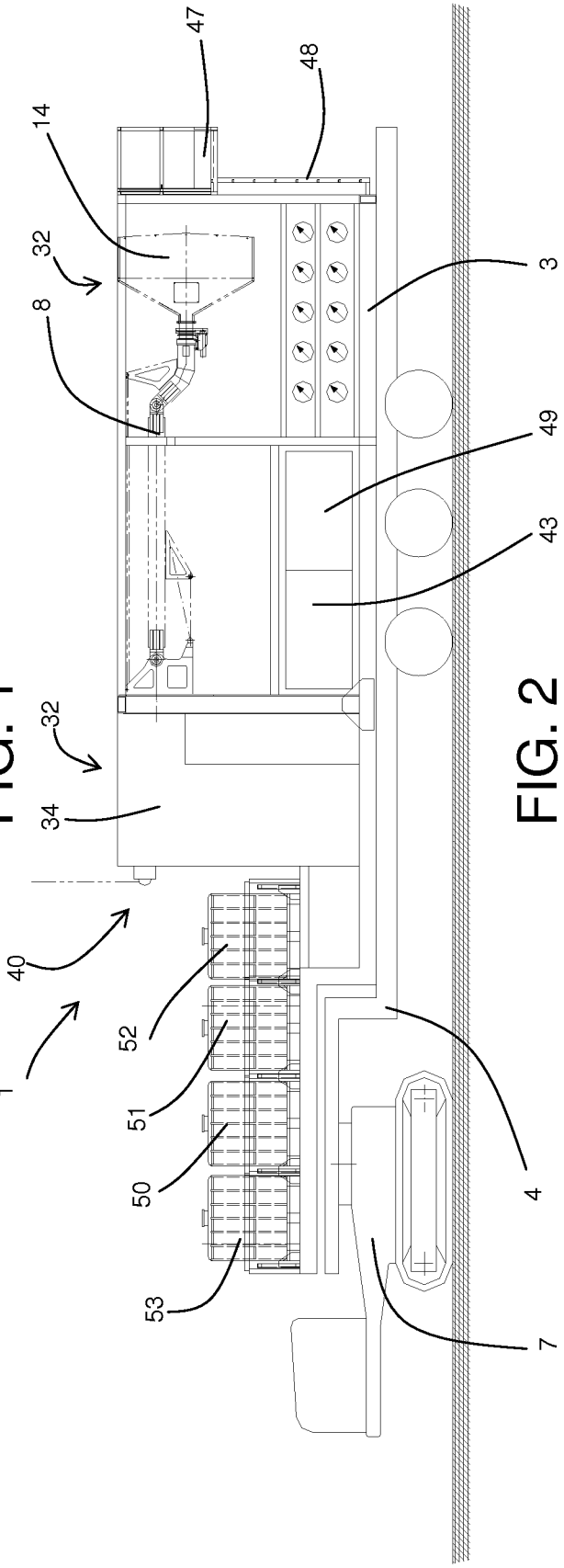
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FIG. 2

FIG. 3

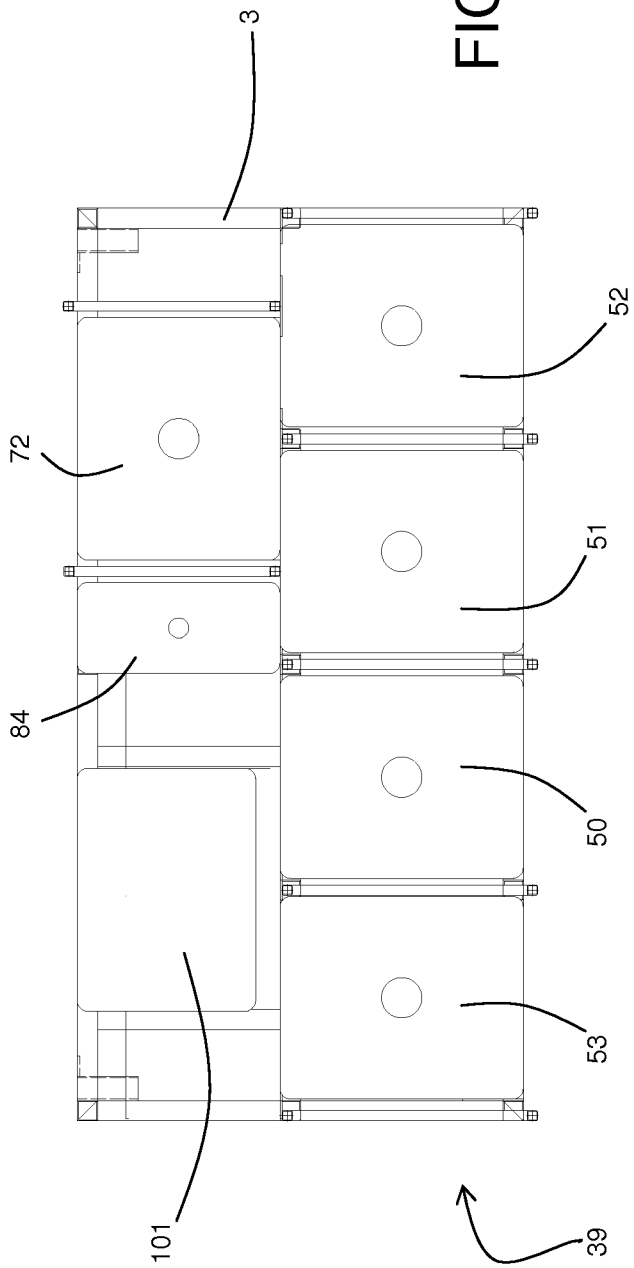
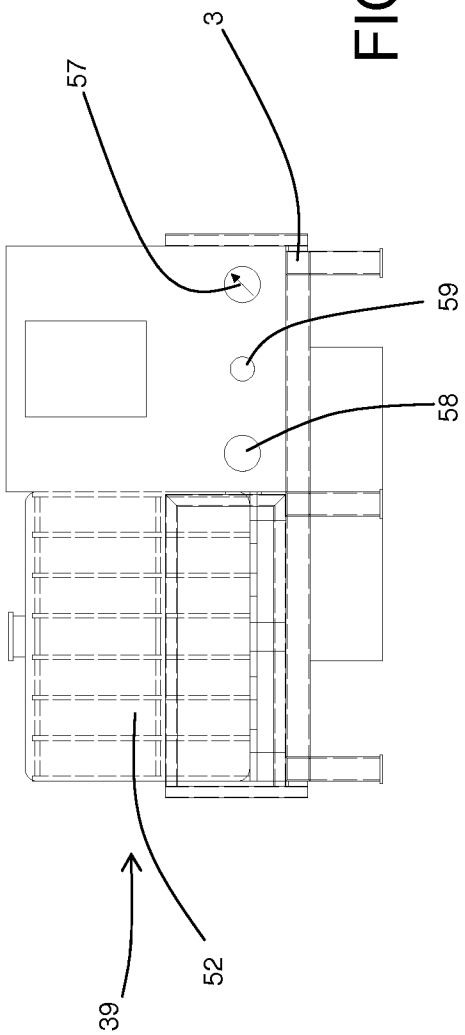


FIG. 4



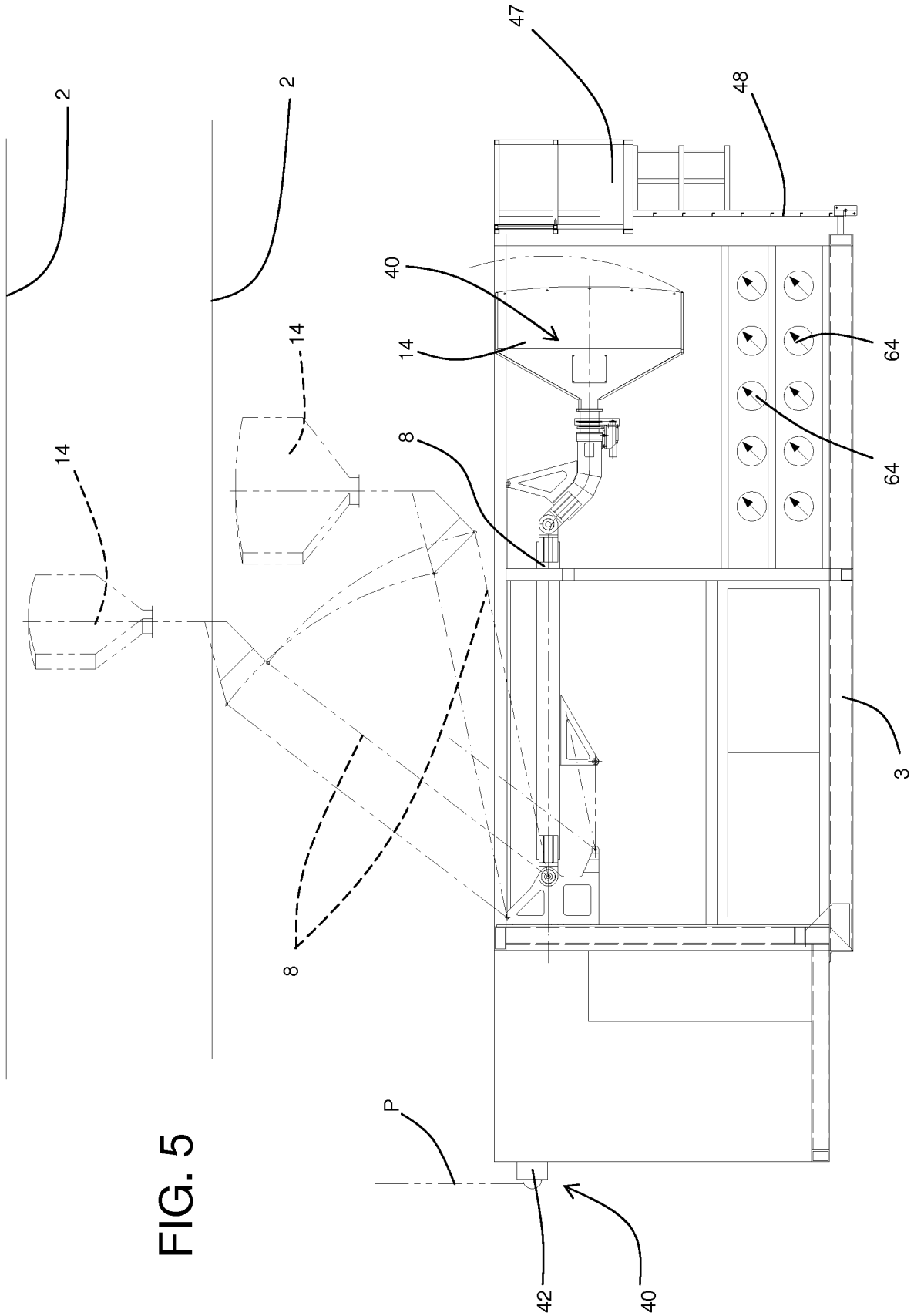


FIG. 5

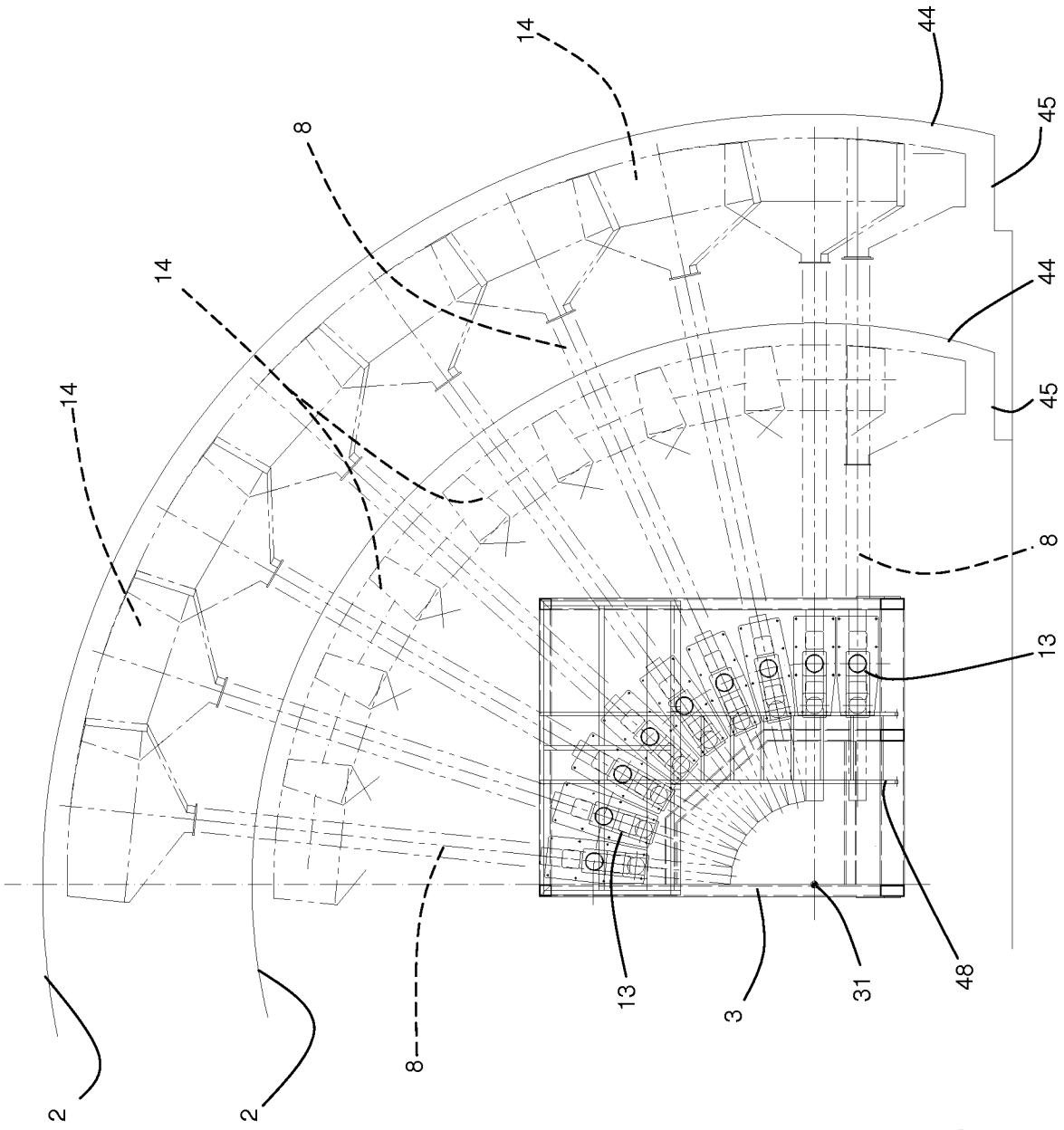


FIG. 6

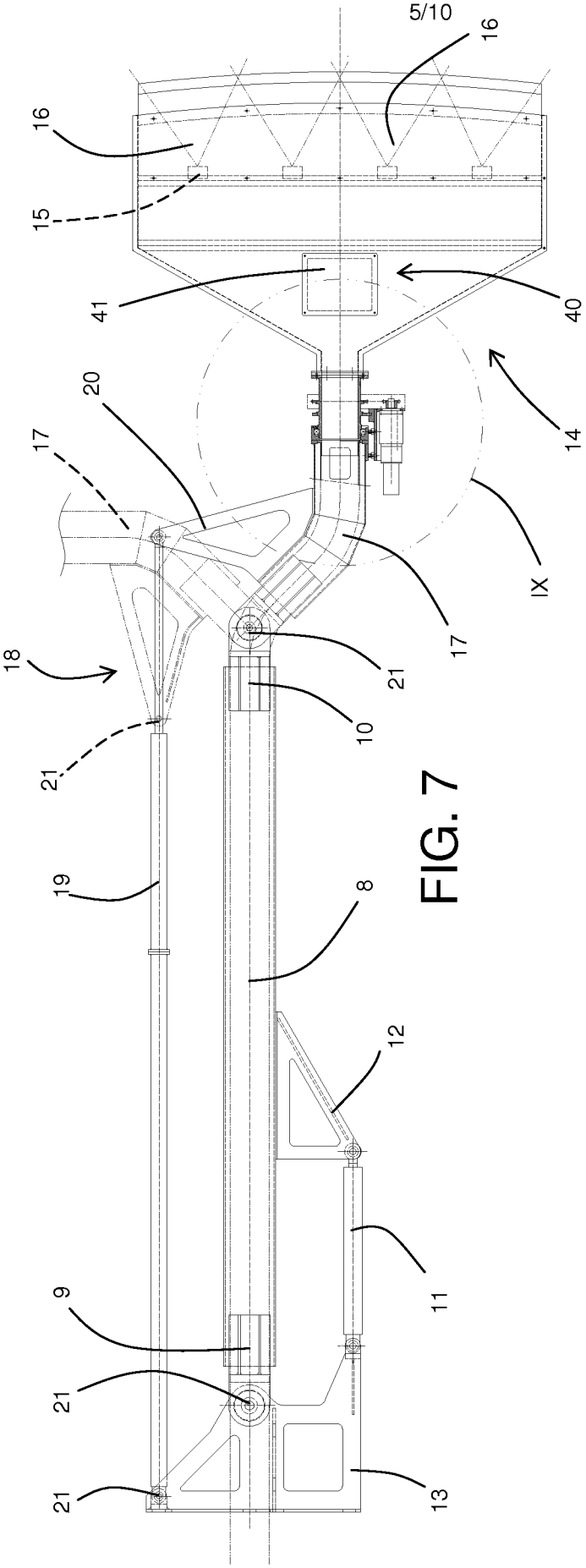


FIG. 7

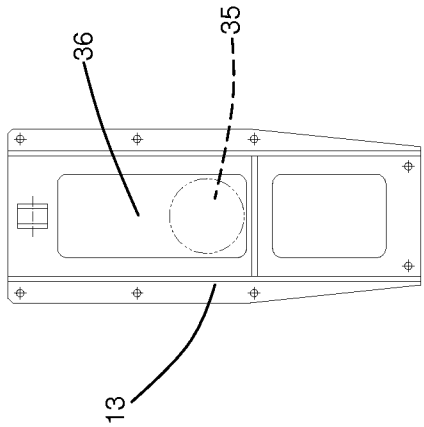


FIG. 8

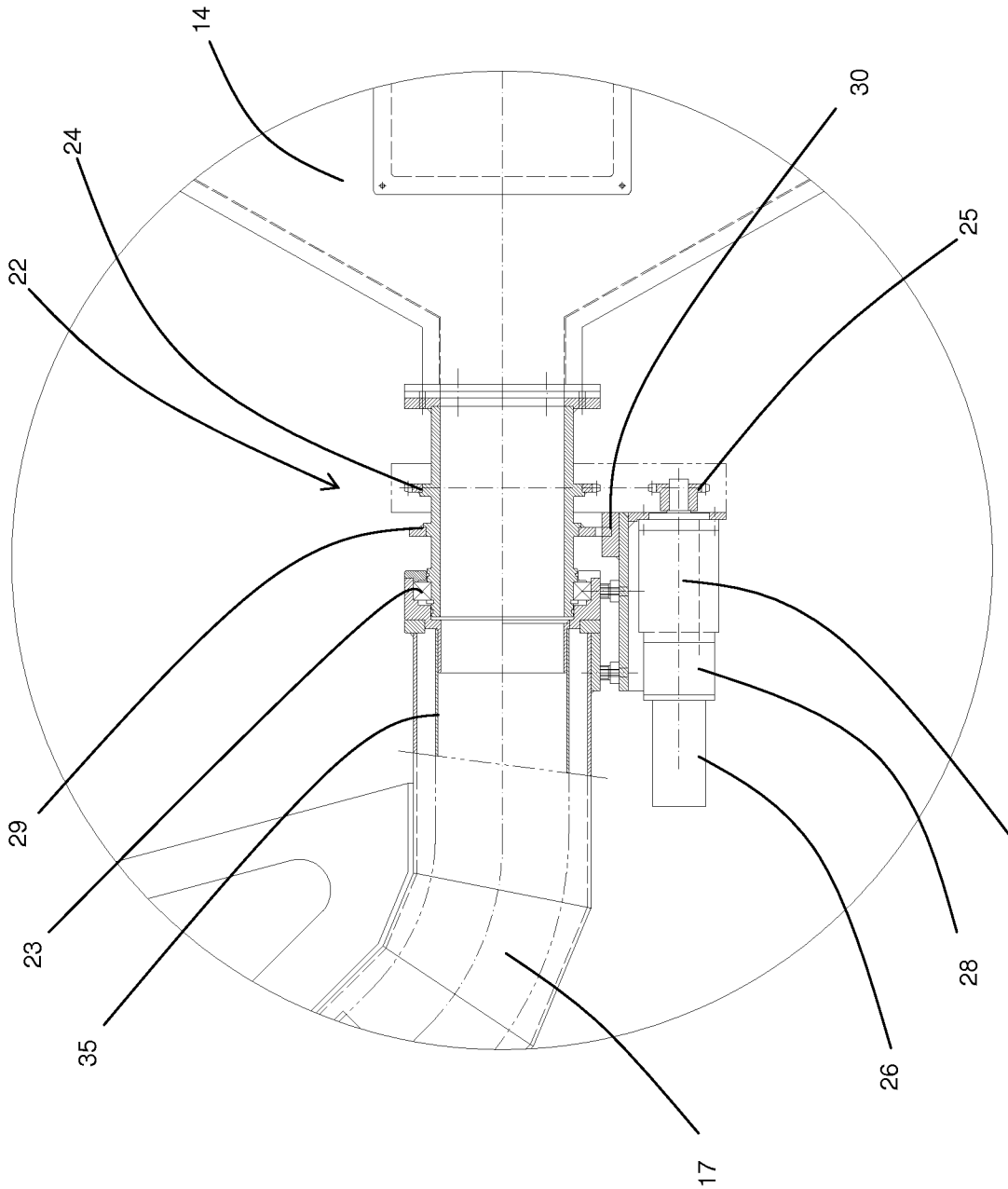


FIG. 9

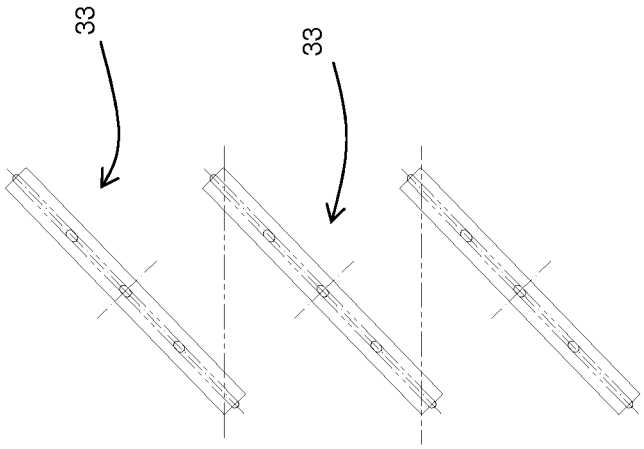


FIG. 12

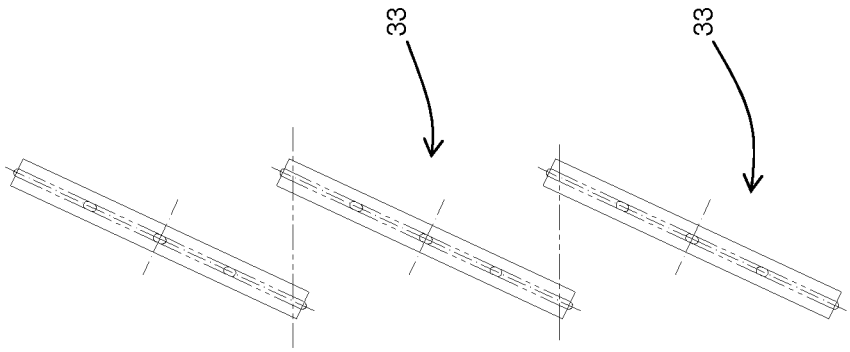


FIG. 11

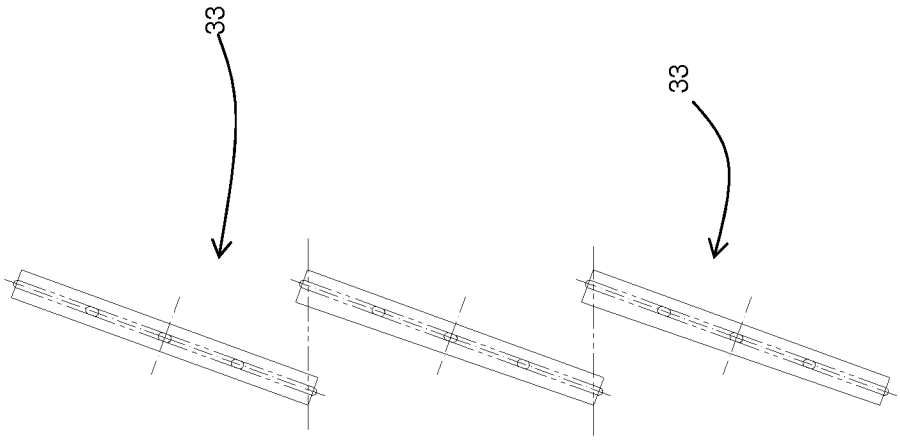


FIG. 10

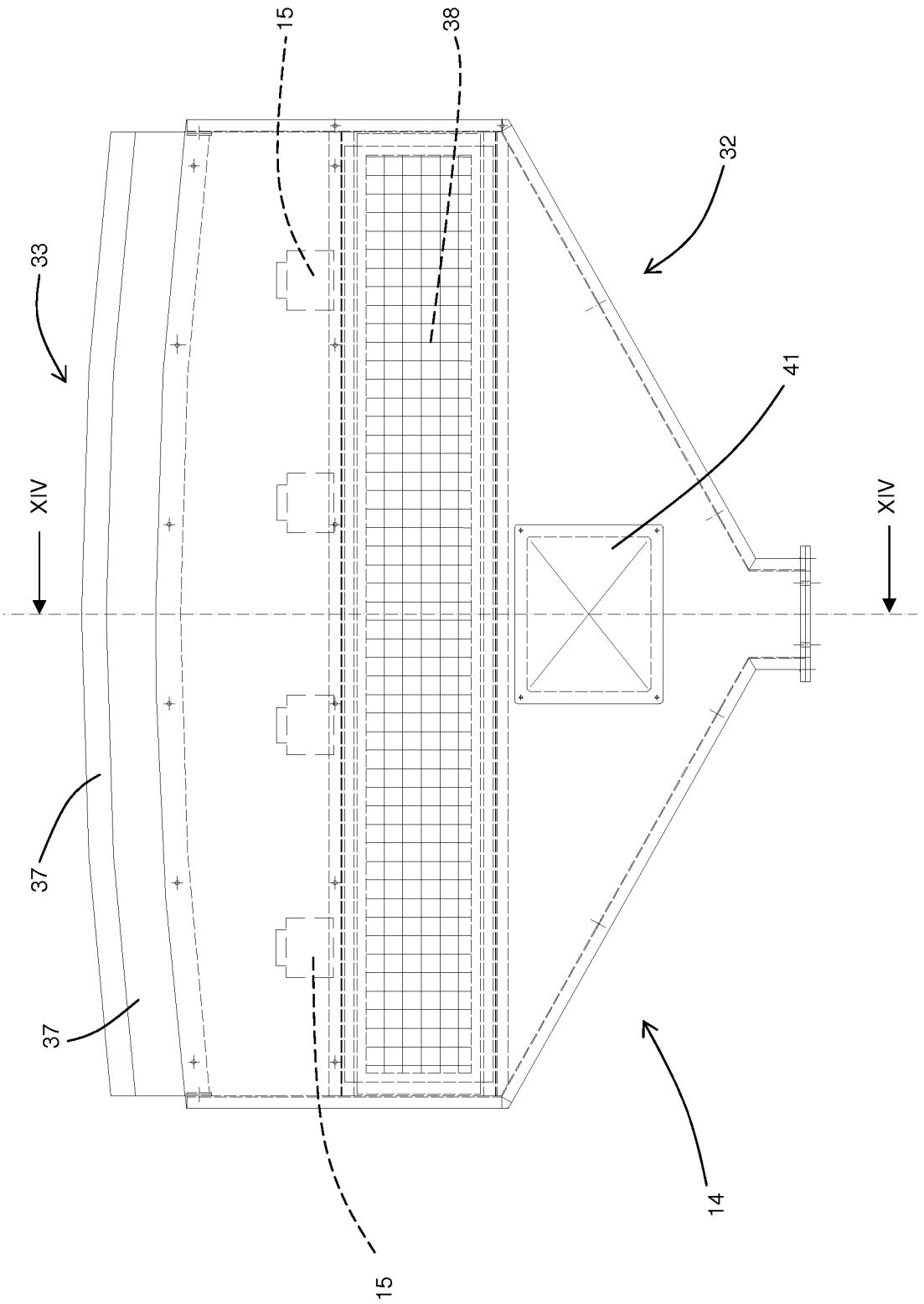


FIG. 13

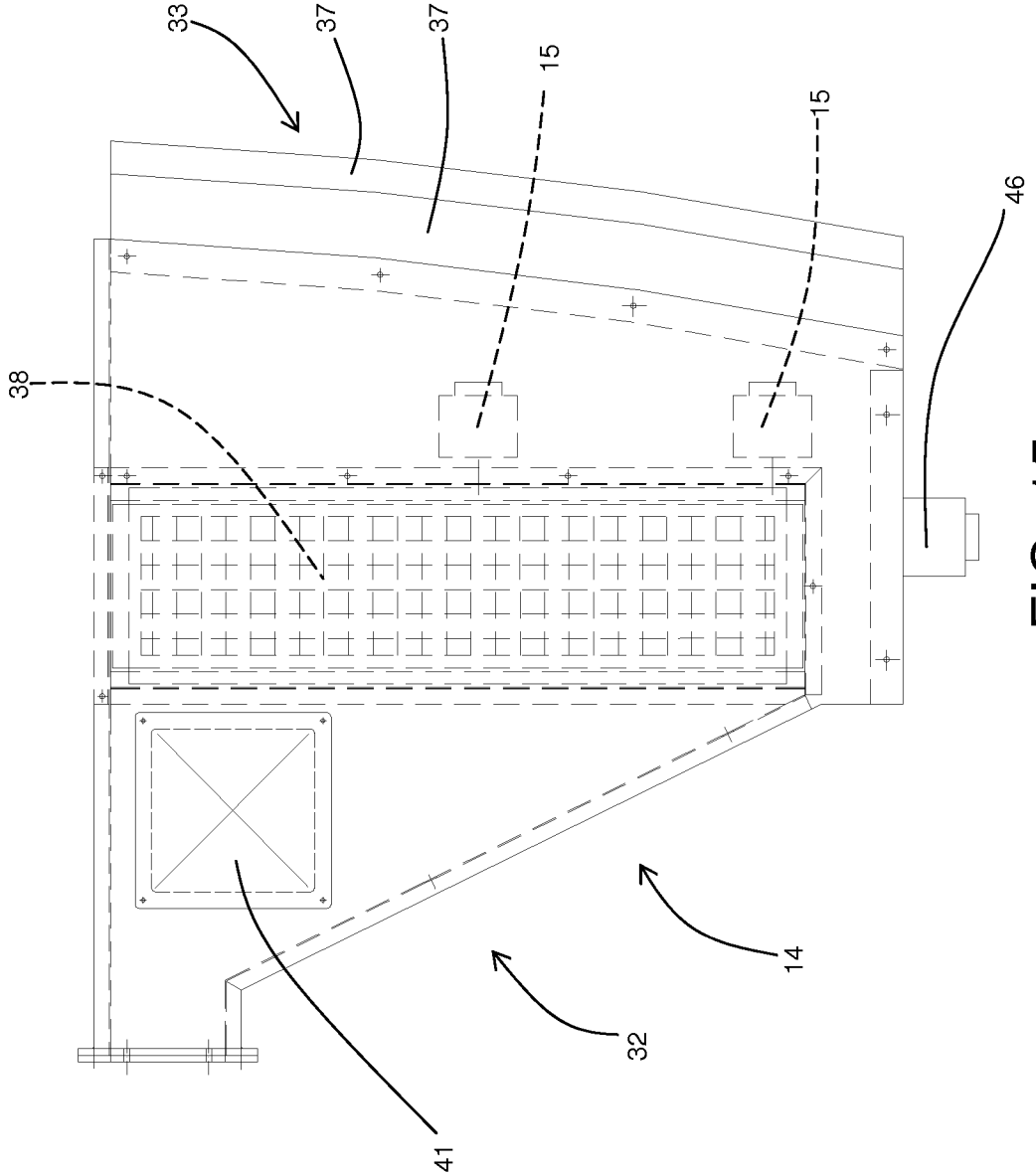


FIG. 15

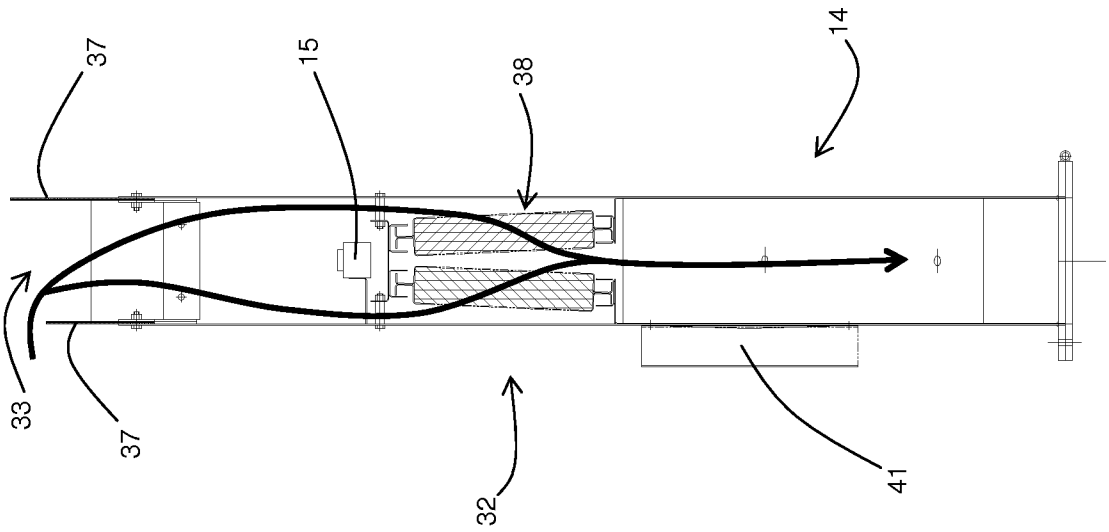


FIG. 14

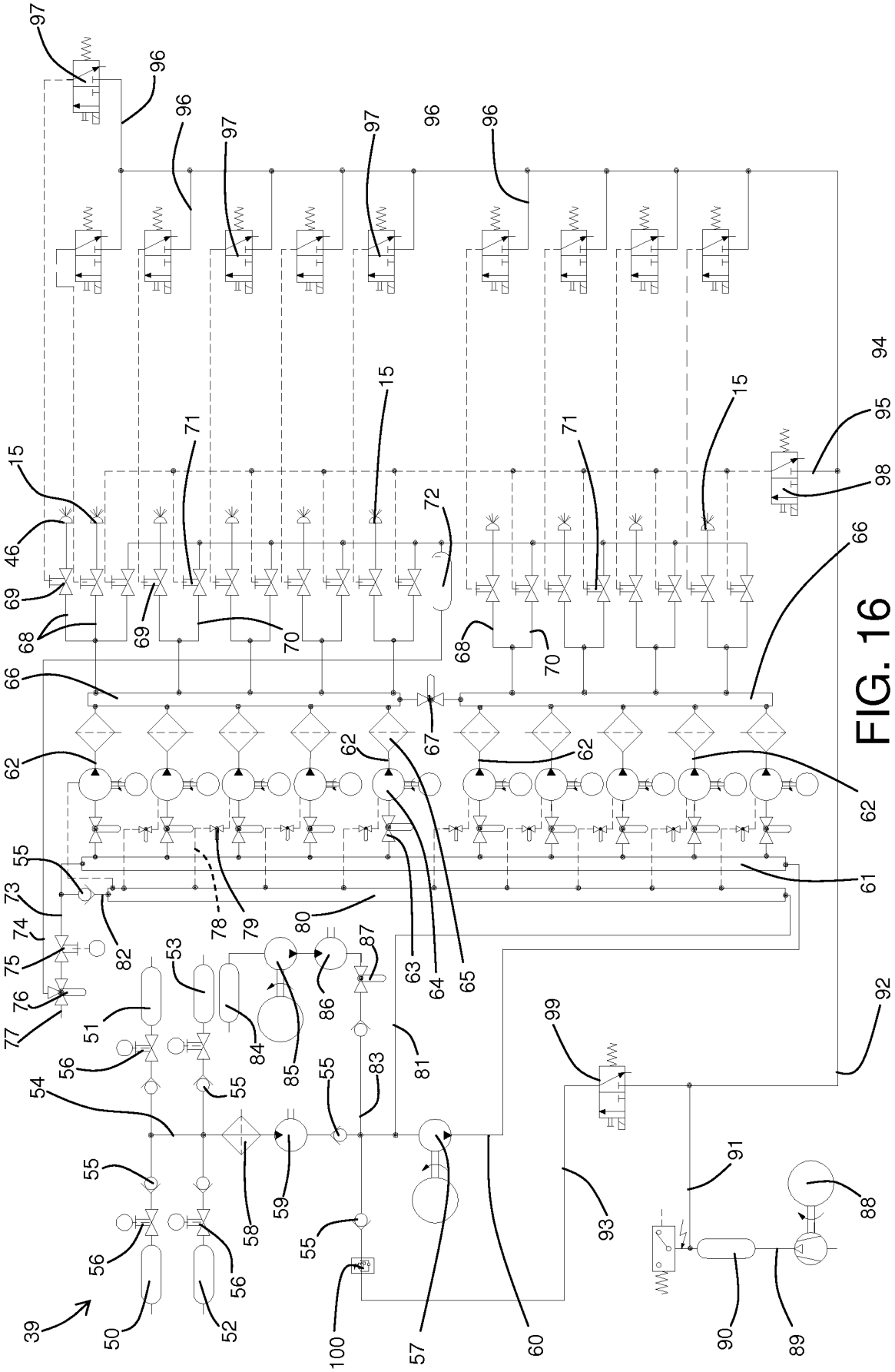


FIG. 16

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2011/054863

A. CLASSIFICATION OF SUBJECT MATTER
INV. E01H1/00 B05B12/12 B05B13/00 B05B13/04 B05B15/02
E01C23/12 B08B3/02 B05B15/04 E21D9/00
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E01H B05B E01C B08B E21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 201 172 803 Y (XIAODONG LI [CN]) 31 December 2008 (2008-12-31) cited in the application page 2; claims; figures	1
A,P	DE 20 2011 001292 U1 (MULAG FAHRZEUG WOESSNER [DE]) 10 March 2011 (2011-03-10) paragraphs [0023], [0035] - [0036]; figures	1
A	WO 2005/074527 A2 (MORTON JOHN STEPHEN [US]) 18 August 2005 (2005-08-18) cited in the application page 6, paragraph 4 page 8, paragraph 3 - page 11, line 1 page 12, paragraph 3 - page 18, paragraph 1 figures	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 March 2012	14/03/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Endrizzi, Silvio

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2011/054863

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 2010 0094011 A (HITECHSERVICE CO LTD [KR]) 26 August 2010 (2010-08-26) paragraphs [0013], [0024], [0025]	1
A	FR 2 584 747 A1 (MATERIEL DE VOIRIE [FR]) 16 January 1987 (1987-01-16) cited in the application page 1, line 1 - line 15 page 6, line 29 - page 15, line 34 figures	1
A	JP 2003 129435 A (ISHIKAWAJIMA HARIMA HEAVY IND) 8 May 2003 (2003-05-08) cited in the application abstract; figures paragraphs [0027] - [0033]	1
A	EP 0 874 086 A1 (VILLANUEVA SAUIU JOSE ANTONIO [ES]) 28 October 1998 (1998-10-28) page 4, line 15 - page 5, line 26; figures	1
A	KR 100 835 301 B1 (UNIV CHUNGJU NAT IND ACAD COOP [KR]) 12 June 2008 (2008-06-12) abstract; figures	1
A	EP 0 668 400 A1 (PENNATINI CARLO [IT]) 23 August 1995 (1995-08-23) abstract; figures	1
A	JP 6 117197 A (MITSUI FUDOSAN KENSETSU; FUKAZAWA KUNIO) 26 April 1994 (1994-04-26) abstract; figures	1
A	US 6 349 249 B1 (CUNNINGHAM PETER D [CA]) 19 February 2002 (2002-02-19) abstract; figures column 2, line 1 - line 16	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2011/054863

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 201172803 Y	31-12-2008	NONE	
DE 202011001292 U1	10-03-2011	NONE	
WO 2005074527 A2	18-08-2005	AU 2005211365 A1	18-08-2005
		BR PI0507042 A	13-11-2007
		CA 2554992 A1	18-08-2005
		EP 1740313 A2	10-01-2007
		JP 2007519524 A	19-07-2007
		US 2005196543 A1	08-09-2005
		US 2011212254 A1	01-09-2011
		WO 2005074527 A2	18-08-2005
KR 20100094011 A	26-08-2010	NONE	
FR 2584747 A1	16-01-1987	NONE	
JP 2003129435 A	08-05-2003	NONE	
EP 0874086 A1	28-10-1998	AU 3095397 A	14-01-1998
		EP 0874086 A1	28-10-1998
		ES 1034481 U	01-01-1997
		WO 9749868 A1	31-12-1997
KR 100835301 B1	12-06-2008	NONE	
EP 0668400 A1	23-08-1995	EP 0668400 A1	23-08-1995
		IT FI940032 A1	17-08-1995
JP 6117197 A	26-04-1994	JP 2108939 C	21-11-1996
		JP 6117197 A	26-04-1994
		JP 7122399 B	25-12-1995
US 6349249 B1	19-02-2002	AT 261108 T	15-03-2004
		AU 757632 B2	27-02-2003
		AU 2398299 A	04-11-1999
		CA 2269957 A1	24-10-1999
		CN 1233706 A	03-11-1999
		DE 69915156 D1	08-04-2004
		DE 69915156 T2	28-10-2004
		EP 0952427 A2	27-10-1999
		JP 3049053 B1	05-06-2000
		JP 2000275045 A	06-10-2000
		NO 991939 A	25-10-1999
		US 6349249 B1	19-02-2002
		ZA 9902905 A	26-10-1999