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COATING METHOD AND COATING SYSTEM WITH COMPENSATION OF THE UNSYMMETRICAL THE SPRAY JET

DESCRIPTION

The invention relates to a coating method for coating a component surface of a component with a coating agent, in particular for painting a motor vehicle body part with a paint. Furthermore, the invention relates to a corresponding coating device.

In modern painting installations for the painting of motor vehicle body components, one generally uses as application devices rotary atomizers, which spin off the paint to be applied in the form of droplets from a rapidly rotating bell cup, so that an approximately rotationally symmetrical spray jet results. The rotary atomizers can in this case be guided by multi-axis painting robots with a serial kinematics, which allows for a high application efficiency.

For example, figures 1A to 1C show the conventional application of an idealized spray jet 1 by a rotary atomizer 2 with a bell cup 3 onto a component surface 4 of a component to be coated, wherein it can be, for example, a motor vehicle body component. It is apparent from Figure 1C that the rotary atomizer 2 is guided by the painting robot (not represented) over the component surface 4 in such a manner that the spray jet 1 is oriented with its main axis 5 at right angle to the component surface 5 and thus parallel to a surface normal 6 of the component surface 4. For a curvature of the component surface 4, the rotary atomizer 2 is then respectively oriented in such a manner that the spray jet 1 is oriented with the main axis 5 parallel to the surface normal 6 of the component surface 4 at the point of impact of the spray jet 1. For the idealized, exactly rotationally symmetrical spray jet 1, there is then without any movement of the rotary atomizer 2 an accordingly symmetrical layer thickness distribution 7, as can be seen in Figure 1B. The symmetry of the layer thickness distribution 7 is advantageous when the rotary atomizer 2 sequentially applies several painting paths lying laterally side by side and overlapping laterally onto the component surface 4, since the superimposition of the layer thickness distributions 7 of painting paths laying side by side then leads to an approximately uniform layer thickness. Figure 1A shows for the idealized rotationally symmetrical spray jet 1 a spray pattern 8, which is rotationally symmetrical, wherein the drawing reproduces a boundary line within which the layer thickness d does not fall below a predefined limit value.

In practice, the spray jet 1 is, however, not exactly rotationally symmetrical, but rather is more or less deformed by external forces, as is represented in the figures 2A to 2C. So, for example, the gravitational force, an electrostatic force due to an electrostatic coating agent charging as well as flow forces, which are generated by the movement of the rotary atomizer 2 in the surrounding air or by a downward oriented air flow in a paint cabin act on the spray jet 1 as deformation forces. In Figure 2C, the rotary atomizer 2 is moved by the painting robot with a certain speed V_{PULL} into the drawing plane, wherein the bell cup 3 turns clock-wise, as seen from the rotary atomizer 2. In this case, the spray jet 1 is deflected to the left in Figure 2C due to the disturbing flow forces (i.e. on the right side of the painting path), so that the layer thickness distribution 7 on the left side in Figure 2B (i.e. on the right side of the painting path) is stretched in the sideward direction over a larger surface, which leads on the left side in Figure 2B (i.e. on the right side of the painting path) to a reduced layer thickness. On the right side in Figure 2B (i.e. on the left side of the painting path), the layer thickness distribution 7 is, in contrast, compressed in the sideward direction to a smaller surface, which leads on the right side to an accordingly larger layer thickness. The asymmetry of the spray jet 1 thus generated leads on the component surface 4 to an accordingly asymmetrical layer thickness distribution 7 and to a likewise accordingly asymmetrical spray pattern 8, as is apparent in the figures 2A and 2B. The resulting painting path has therefore on the left side an increased layer thickness and on the right side a reduced layer thickness. This asymmetry of the spray jet 1 leads in each case during application of several painting paths lying side by side and overlapping sidewards to a relatively highly variable layer thickness distribution 9, as is apparent in Figure 4A, wherein the layer thickness distribution 9 consists of a superimposition of layer thickness distributions 10 of the individual painting paths lying side by side.

Figure 2C discloses the coating method according to the preamble of claim 1 and the coating device according to the preamble of claim 9, respectively.

The asymmetries of the spray jet 1 and the resulting problems with respect to the irregularity of the layer thickness distribution 9 were, however, hitherto not yet detected, so that still no solutions are known for this problem.

Reference is also made to EP 1 522 347 A1 concerning the prior art. This document does, however, not concern the technical field of the painting technology, but rather the cooling technology and is therefore remote.

Finally, FR 2 894 599 A1, DE 603 04 914 T2, DE 198 47 258 A1, DE 196 08 754 A1, JP 2003 019451 A, EP 696 582 A1 and EP 2 468 463 A2 have to be mentioned with regard to the state of the art. However, these references also do not disclose any suitable technolgies for the compensation of the asymmetry of the spray jet in a path-bound coating operation in which paint paths are deposited onto the component.

The object of the invention is therefore to improve the known coating methods and coating devices to the effect that the layer thickness is as uniform as possible.

This object is achieved by a coating method according to the invention resp. a coating device according to the independent claims.

The invention is based upon the technical-physical insight that the disturbing irregularity of the layer thickness distribution stems from asymmetries of the spray jet of the atomizer. The invention therefore comprises the general technical teaching to at least partially compensate for the asymmetry of the spray jet, so that the asymmetry of the resulting spray pattern on the component surface is reduced.

According to the invention, the asymmetry of the spray jet is compensated for by the fact that the spray jet is angled with its main axis with respect to the surface normal of the component surface so that the spray jet hits with its main axis slantwise onto the component surface. This can be achieved in such a manner that the atomizer is angled with its spraying axis with respect to the surface normal of the component surface so that an accordingly angled spray jet also results.

According to the invention, the atomizer is moved in a certain painting direction along the component surface in order to apply an elongated painting path along the painting direction onto the component surface. Here, the spray jet is angled with its main axis preferably transverse to the painting direction in order to at least partially compensate for the asymmetry of the spray jet. The angulation of the spray jet with respect to the surface normal of the component surface is therefore done preferably not in or opposite to the painting direction, but rather transversely with respect to the painting direction, namely preferably at right angle to the painting direction.

In this case, it should be mentioned that the atomizer must not be angled exactly at right angle to the painting direction in order to compensate for the asymmetry of the spray jet. Instead, there is also he option within the context of invention for intermediate angles or an angulation in different tilt planes.

It should also be mentioned that the direction of angulation depends on the direction of rotation of the bell cup and on the painting direction of the atomizer. If the bell cup - seen from the rotary atomizer, i.e. from behind - turn clock-wise, the atomizer is preferably angled rightwards with respect to the painting direction. If, in contrast, the bell cup - as seen from the rotary atomizer, i.e. from behind - turns anti-clockwise, the atomizer is preferably angled leftwards with respect to the painting direction.

In general, one can say that the spray jet is deformed in practice due to the external forces (e.g. gravitational force, guide air, cabin air, electrostatic force, air stream due to the movement speed of the atomizer) in a certain deformation direction transversely with respect to the main axis of the spray jet, so that the resulting spray pattern on the component surface is stretched in the deformation direction and compressed opposite to the deformation direction. The spray jet is therefore preferably angled against the deformation direction in order to at least partially compensate for the asymmetry of the spray jet.

The angulation of the spray jet with respect to the surface normal of the component surface therefore reduces the stretching in the resulting spray pattern and the compression on the opposite side of the spray pattern, which leads to a uniform layer thickness distribution on the component surface.

In practice, several painting paths lying side by side and overlapping sidewards are applied onto the component surface in such a way that the atomizer is moved respectively along the painting path over the component surface and delivers in this process the spray jet onto the component surface. Preferably, the atomizer is moved with the asymmetrical spray jet during application of the directly neighboring painting paths in the opposite painting direction along the painting path, so that the asymmetries of the spray jet cancel each other as much as possible out.

In a variant of the invention, the spray jet is in this case angled in both opposite painting directions with respect to the surface normal of the component surface, so that the stretchings and compressions of the spray pattern in the opposite painting directions at least partially cancel each other out.

In another variant of the invention, the spray jet is, in contrast, angled only for a movement in one of both opposite painting directions with respect to the surface normal of the component surface. For the movement in the opposite painting direction, the spray jet is in contrast oriented with its main axis essentially parallel to the surface normal of the component surface, so that the stretchings or compressions of the spray pattern in the opposite painting directions are oriented at least in the same direction, which likewise leads to a uniform layer thickness distribution.

A further exemplary embodiment of the invention provides for that, sequentially, at least two superimposed painting paths are applied onto the component surface, namely preferably wet-in-wet. In this case, it is advantageous that the atomizer is moved in another painting direction during application of the first painting path and during application of the second painting path, so that the asymmetries of the spray pattern in both painting paths at least partially compensate for each other, which leads to a more uniform layer thickness distribution.

Preferably, the atomizer is moved during application of both superimposed painting paths, respectively, along a meandrous movement path, which is per se known from the prior art. In a variant of the invention, the meandrous movement path for the upper painting path is mirrored with respect to the meandrous movement path for the lower painting path, wherein the mirror axis preferably runs at right angle to the painting path. In this case, the movement paths of the upper and the lower painting paths are traversed by the atomizer preferably in opposite directions. In another variant of the invention, the meandrous movement paths for the lower and the upper painting paths are, in contrast, essentially similar and are traversed only in opposite painting directions.

Practical trials have shown that it is advantageous, during application of superimposed painting paths, when the painting paths are applied in opposite painting directions, which leads to a more uniform layer thickness distribution.

It was already mentioned briefly at the beginning that the asymmetry of the spray jet is caused by different forces. For example, this includes the following forces:

- A downward oriented gravitational force,
- an electrostatic force, which results from an electrostatic coating agent charging and acts between the electrostatically charged coating agent and the electrically grounded component or vice versa,
- a first flow force, which is caused by a guide air jet that is delivered for shaping of the spray jet from the outside onto the spray jet,
- a second flow force, which is caused by the fact that the atomizer is moved in the surrounding air along the component surface, and
- a third flow force, which is generated by an air flow oriented downwards in a paint cabin.

The previously mentioned forces can vary during the operation of the atomizer, so that also the resulting asymmetry of the spray jet can be subject to fluctuations in operation. It is therefore advantageous if the measures taken to compensate for the asymmetry of the spray jet are adapted accordingly during the operation. Preferably, the forces, which cause the asymmetry of the spray jet, are therefore determined during the operation of the atomizer. The angulation of the atomizer with respect to the surface normal of the component surface can then be adapted depending on the determined forces in order to achieve a layer thickness distribution as uniform as possible. This adaptation can be done within the framework of a closed-loop control (i.e. with a feedback) or an open-loop control (i.e. without any feedback).

It should also be mentioned that the asymmetry of the spray jet increases with the disturbance variables (e.g. the pulling speed of the atomizer). Preferably, the angulation of the atomizer is therefore not constant during the operation, but is rather adapted with respect to the value (tilt angle) and/or the direction of the angulation accordingly, wherein the assignment between the disturbance variables and the associated optimal angulation of the atomizer can be done, for example, through a characteristic field.

Furthermore, it should be mentioned that the atomizer is preferably a rotary atomizer with a bell cup as the application element. The invention can, however, be realized using other types of application devices, which deliver a spray jet of the coating agent.

It should also be mentioned that the atomizer is moved within the context of invention preferably by a multi-axis painting robot with a serial or parallel kinematics, which is per se known from the prior art and must therefore no longer be described. Basically, the invention is, however, also suitable for application in conjunction with so-called rooftop machines or side machines, in as far as the atomizers can be angled as described above in order to compensate for the asymmetry of the spray jet.

Finally, it should be mentioned that the invention also comprises a corresponding coating device, which already results from the previous description, so that a separate description of the coating device according to the invention is not necessary.

Other advantageous developments of the invention are characterized in the subclaims or are explained in more detail below together with the description of the preferred exemplary embodiments of the invention on the basis of the figures. The figures show as follows:

Figure 1A a schematic representation of a spray pattern of a rotary atomizer with an idealized, exactly rotationally symmetrical spray jet,

Figure 1B the layer thickness distribution for an idealized, exactly rotationally symmetrical spray jet,

Figure 1C a schematic representation of a rotary atomizer with an idealized, exactly rotationally symmetrical spray jet, which is oriented at right angle to a component surface,

Figure 2A a schematic representation of a spray pattern of a rotary atomizer with a real, not exactly rotationally symmetrical spray jet,

Figure 2B the layer thickness distribution for the real, not exactly rotationally symmetrical spray jet,

Figure 2C the rotary atomizer with the not rotationally symmetrical spray jet, which is oriented at right angle to the component surface,

Figure 3A an idealized representation of a spray pattern according to the invention, which is created also for a deformed, not rotationally symmetrical spray jet when the asymmetry of the spray jet is compensated for according to the invention,

Figure 3B the layer thickness distribution, which results from the compensation according to the invention for the asymmetry of the spray jet,

Figure 3C a rotary atomizer, which is angled according to the invention with respect to the surface normal of the component surface in order to compensate for asymmetries of the spray jet,

Figure 4A a layer thickness distribution for several painting paths lying side by side and overlapping laterally without any compensation for the asymmetry of the spray jet,

Figure 4B the layer thickness distribution of several painting paths lying side by side and overlapping laterally when the atomizer is angled on each painting path in order to compensate for the asymmetries of the spray jet,

Figure 4C the layer thickness distribution for several painting paths lying side by side and overlapping laterally when either only the stretched or only the compressed side of the spray pattern is compensated for by an angulation of the atomizer,

Figure 5A a meandrous movement path for application of several painting paths lying side by side and overlapping laterally as well as the corresponding angulation of the atomizer on the different painting paths,

Figure 5B the resulting layer thickness distribution on the individual painting paths,

Figure 6A a meandrous movement path of the atomizer for application of several painting paths lying side by side and overlapping laterally and the corresponding angulation of the atomizer on the individual painting paths,

Figure 6B the resulting layer thickness distribution from Figure 6A on the individual painting paths,

Figure 7A a meandrous movement path of the atomizer for application of several painting paths lying side by side and overlapping laterally as well as the corresponding angulation of the atomizer on the different painting paths,

Figure 7B the resulting layer thickness distribution on the individual painting paths according to Figure 7A,

Figure 8 a meandrous movement path of an atomizer for application of a first painting path onto the component surface,

Figure 9A a meandrous movement path of the atomizer for application of a second painting path, wherein both painting paths are superimposed and are traversed in the same painting direction,

Figure 9B the resulting layer thickness distribution of the superimposed painting paths along the line s in Figure 9A,

Figure 10A a mirrored movement path as an alternative to the movement path according to Figure 9A, wherein the superimposed painting paths are traversed in opposite painting directions,

Figure 10B the resulting layer thickness distribution from the painting path according to Figure 10A along the line s in Figure 10A.

Figure 11 a highly simplified schematic representation of a coating device according to the invention, which compensates for asymmetries of the spray jet.

The basic principle of the invention will first be described below with reference to Figures 3A to 3C. Figure 3C shows the rotary atomizer 2 with the spray jet 1 deformed leftwards with respect to the main axis 5, as was already represented in Figure 2C. To avoid misunderstandings, it should be mentioned that in Figures 3A-3C, a deformation to the left means that the spray jet 1 is deflected to the right with respect to the painting path on the component surface.

The invention therefore provides for that the rotary atomizer 2 is angled with the main axis 5 opposite to the deformation direction of the spray jet 1 with respect to the surface normal 6 of the component surface 4 so that, in the best case, the symmetrical layer thickness distribution 7 according to Figure 3B and the likewise symmetrical spray pattern 3A according to Figure 8 would result. The rotary atomizer 2 is thus angled rightwards in the drawing in order to compensate for the deformation of the spray jet 1 oriented leftwards in the drawing and caused by the disturbing forces (e.g. gravitational force, flow forces, etc.).

The rotary atomizer 2 is in this case guided by a multi-axis painting robot, which is not represented, and which accordingly angles the rotary atomizer 2. In this case, it should be emphasized that, in practice, neither the exactly rotationally symmetrical spray pattern 8 according to Figure 3A nor the exactly rotationally symmetrical layer thickness distribution 7 according to Figure 3B can be realized. The angulation according to the invention of the rotary atomizer 2 leads, however, to a clear reduction in the asymmetry of the spray pattern 8 and the layer thickness distribution 7.

It should also be mentioned that the angle between the main axis 5 of the rotary atomizer 2 and the surface normal 6 of the component surface 4 can be adapted continuously during the operation in order to achieve that the spray pattern 8 and the layer thickness distribution 7 are as symmetrical as possible. In the course of actual operation, the disturbance variables are thus measured, which deform the spray jet 1 and therefore contribute to the disturbing asymmetry of the spray jet 1. These fluctuating disturbance variables include, for example, the pulling speed of the rotary atomizer 2 relative to the component surface 4, the air sinking speed in the paint cabin, the electric voltage of the electrostatic coating agent charging as well as the guide air stream. These disturbance variables can then be used in conjunction with further known data (e.g. location and position of the painting robot, properties of the coating agent used, rotational speed of the rotary atomizer, etc.) to calculate the extent and the direction of the deformation of the spray jet 1. Within the framework of the coating method according to the invention, the direction and the angle of the angulation of the rotary atomizer 2 relative to the surface normal 6 of the component surface 4 are then calculated.

This adaptation of the direction and the angle of angulation of the rotary atomizer 2 with respect to the surface normal 6 of the component surface 4 can, within the context of the invention, be controlled with an open-loop (i.e. without any feedback) or controlled with a closed-loop (i.e. with a feedback).

In the following, with reference to the Figures 4A and 4B, a preferred exemplary embodiment of the invention is now described, for which the rotary atomizer 2 applies several painting paths lying side by side and overlapping laterally onto the component surface 4, which is per se known from the prior art. The individual painting paths have in this case, due to the disturbing deformation of the spray jet 1 described above, respectively an accordingly asymmetrical layer thickness distribution 10, as is apparent in the Figures 4B and 4C. The superimposition of the layer thickness distribution 10 of the individual painting paths then leads to the resulting layer thickness distribution 9.

For the exemplary embodiment according to Figure 4B, the rotary atomizer 2 is angled on each of the painting paths in order to compensate for the asymmetry of the spray jet 1, i.e. in both directions of movement.

For the exemplary embodiment according to Figure 4C, the rotary atomizer 2 is angled on only one of the painting paths in order to compensate for the asymmetry of the spray jet 1.

In both cases, the comparison of the resulting layer thickness distribution 9 with the prior art according to 4A shows, however, that the resulting layer thickness distribution 9 is considerably more uniform than without any compensation for the asymmetry of the spray jet 1.

The figures 5A, 6A and 7A show a meandrous movement path 11 for the rotary atomizer 2, wherein the rotary atomizer 2 is guided along the meandrous movement path 11 over the component surface 4 in order to apply several painting paths lying side by side and overlapping laterally. The figures 5B, 6B and 7B show the respective resulting layer thickness distribution on the individual painting paths.

For the variant according to Figures 5A and 5B, the rotary atomizer 2 is angled on each one of the painting paths in order to compensate for the asymmetry of the spray jet 1.

For the variant according to Figures 6A and 6B, the rotary atomizer 2 is, in contrast, angled only on the painting path, which runs from left to right in the drawing. For a painting direction from right to left, in contrast, there is in this variant no angulation of the rotary atomizer 2 to compensate for the asymmetry of the spray jet 1.

For the variant according to Figures 7A and 7B, the rotary atomizer 2 is, in contrast, angled only for a painting direction from right to left in order to compensate for asymmetries of the spray jet 1.

The figures 8 to 10B illustrate a further exemplary embodiment of the invention in which, sequentially, two superimposed painting paths are applied onto the component surface 4, this resulting in a multi-ply coating.

Figure 8 shows here a first application of coating agent, wherein the rotary atomizer 2 is guided along a meandrous movement path 12 over the component surface 4 so that the spray jet 1 generates several painting paths lying side by side and overlapping laterally on the component surface 4.

Figure 9A then shows a second application of coating agent, which is performed wet-in-wet on the first layer of coating agent, wherein the rotary atomizer 2 is here likewise guided along the meandrous movement path 12 over the component surface 4. In this variant, the painting direction for the first coating agent according to Figure 8 is the same as for the second coating agent according to Figure 9A.

Subsequently, there is a resulting layer thickness distribution 13, which is represented in Figure 9B, wherein the drawing shows the layer thickness distribution 13 along the line s in Figure 9A.

The figures 10A and 10B show an alternative for the second coating agent application, as was described above with reference to the figures 9A and 9B. Thus, the rotary atomizer 2 is guided during the second coating agent application process along a meandrous movement path 14 over the component surface 4, which results in a layer thickness distribution 15 represented in Figure 10B.

The difference between both exemplary embodiments described above according to Figures 9A and 9B on the one hand and Figures 10A and 10B on the other hand consists in that the meandrous movement path 14 for the second coating agent application according to Figure 10A is mirrored with respect to the meandrous movement path 12 for the first coating agent, namely about a mirror axis at right angle to the painting paths. On the other hand, the painting direction for the second coating agent application according to Figure 10A is opposite to the painting direction for the first coating agent application according to Figure 8.

It is apparent from a comparison of the figures 9B and 10B that the second coating agent application with the mirrored movement path 14 and the opposite painting direction leads to a more uniform layer thickness distribution 15 and must therefore be preferred.

A similarly good layer thickness distribution can, however, also be obtained for a non-mirrored movement path for the second coating agent application, in as far as the painting direction for both coating agent applications is opposite.

Figure 11 shows in a strongly schematized form a coating device according to the invention, which can be used for example in a painting installation for painting motor vehicle body components.

Thus, the coating device according to the invention has in this exemplary embodiment a rotary atomizer 16, which is guided by a multi-axis painting robot 17 with a serial kinematics, wherein both the rotary atomizer 16 and also the painting robot 17 can in principle be designed in conventional manner and must therefore not be described in greater detail.

Furthermore, the coating device according to the invention has a robot control apparatus 18, which has at first the conventional task of guiding the rotary atomizer 16 along a programmed movement path over the component surface.

In addition, the coating device according to the invention has a compensation device 19, which has the task of compensating for the disturbing asymmetries of the spray jet 1 of the rotary atomizer 16.

For this purpose, the compensation device 19 receives as input values different disturbance variables, such as the movement speed V_{Pull} of the rotary atomizer 16, a variable guide air speed $V_{Guide\ air}$, a variable cabin air sinking speed $V_{Cabin\ air}$ and a variable electrostatic charging voltage U_{ESTA}. Furthermore, the compensation device 19 receives from the robot control apparatus 18 information about the location and position of the painting robot 17.

The compensation device 19 calculates therefrom the direction and the extent of the deformation of the spray jet 1 delivered by the rotary atomizer 16. Beyond this, the compensation device 19 then calculates the direction in which and at which angle the rotary atomizer 16 must be angled with respect to the surface normal 6 of the component surface 4 in order to compensate for the asymmetries of the spray jet 1 resulting from the disturbance variables. These data are then transmitted from the compensation device 19 to the robot control apparatus 18, which then always accordingly angles the rotary atomizer 16 in the course of actual operation.

List of reference signs

d	Layer thickness
V_{PULL}	Movement speed of the rotary atomizer
U_{ESTA}	Electrostatic charging voltage
$V_{GUIDE\ AIR}$	Guide air speed
$V_{CABIN\ AIR}$	Air sinking speed in the paint cabin
1	Spray jet
2	Rotary atomizer
3	Bell cup
4	Component surface
5	Main axis of the spray jet
6	Surface normal of the component surface
7	Layer thickness distribution
8	Spray pattern
9	Layer thickness distribution
10	Layer thickness distribution of the individual painting paths
11	Meandrous movement path
12	Meandrous movement path
13	Layer thickness distribution
14	Meandrous movement path
15	Layer thickness distribution
16	Rotary atomizer
17	Painting robot
18	Robot control apparatus
19	Compensation device

EP2758181

RÉTEGFELHORDÓ ELJÁRÁS ÉS RÉTEGFELHORDÓ BERENDEZÉS A PORLASZTÓSUGÁR ASZIMMETRIÁINAK KOMPENZÁLÁSÁVAL

SZABADALMI IGÉNYPONTOK

1. Rétegfelhordó eljárás alkatrész egy alkatrészfelületére történő rétegképző anyag felhordásához, különösen gépjármű karosszéria alkatrész lakkal történő lakkozásához, a következő lépésekkel:
a porlasztóanyag porlasztósugarát (1) egy porlasztóval (2) leadjuk a réteggel ellátandó alkatrész alkatrészfelületére (4),
a1) ahol a porlasztósugárnak (1) van egy főtengelye (5), és a sugár a főtengelyhez (5) képest aszimmetrikus, úgy hogy a porlasztósugár (1) az alkatrészfelületen (4) megfelelően aszimmetrikus porlasztási képet (8) mutat, és
b1) ahol a porlasztót (2) meghatározott lakkozási irányban mozgatjuk az alkatrészfelület mentén, hogy a lakkozási irány hossza mentén hosszirányú kiterjedésű lakkozási pályát vigyünk fel az alkatrészfelületre (4), **azzal jellemezve, hogy** a következő lépésaket hajtjuk végre:
a porlasztósugár (1) aszimmetriáját, legalább részben, kompenzáljuk, úgy hogy a létrejövő porlasztási kép (8) aszimmetriáját kizárhassuk az alkatrészfelületen (4),
ahol a porlasztósugarat (1) főtengelyére (5) keresztben, különösen merőlegesen, szögben úgy állítjuk be, hogy a porlasztósugár (1) aszimmetriáját, legalább részben, kompenzáljuk.

2. Az 1. igénypont szerinti rétegfelhordó eljárás, **azzal jellemezve, hogy** a porlasztósugarat (1) egy átalakító irányba, a porlasztósugár (1) főtengelyéhez (5) képest keresztben átformáljuk, úgy hogy az eredményezett porlasztási kép (8) az alkatrészfelületen (4), átformálási irányban megnyújtott és átformálási iránnyal szemben tömörített legyen,
hogy a porlasztósugarat (1), az átformálási iránnyal szemben szögben úgy állítjuk be, hogy a porlasztósugár (1) aszimmetriáját, legalább részben, kompenzáljuk.

3. Az előző igénypontok egyike szerinti rétegfelhordó eljárás, **azzal jellemezve, hogy** egymás után több, egymás mellett fekvő, és oldalt átlapoló lakkozási pályát viszünk fel az alkatrészfelületre (4), mialatt a porlasztót (2), mindig a lakkozási pálya mentén, az alkatrész felület fölé mozgatjuk, és akkor a porlasztósugarat (1) az alkatrészfelületre irányítjuk, és
hogy a porlasztót (2) a közvetlenül szomszédos lakkozási pálya felhordásánál ellenkező lakkozási irányokba mozgatjuk a lakkozási pályák mentén.

4. A 3. igénypont szerinti rétegfelhordó eljárás, **azzal jellemezve, hogy** a porlasztósugarat (1) főtengelyével (5) a két szembefekvő lakkozási irányban, keresztben a lakkozási pályához képest, az alkatrészfelület felületi merőlegesével szemben beállítjuk, úgy hogy a porlasztási kép (8) megnyújtásait és tömörítéseit az ellenkezően elrendezett lakkozási irányokban, legalább részben, megnöveljük,
hogy a porlasztósugarat (1) főtengelyével (5) csak egy lakkozási irányban, keresztben a lakkozási pályához képest, az alkatrészfelület (4) felületi merőlegesével (6) szemben beállítjuk, és az ellenkező lakkozási irányban, főtengelyével (5) lényegében az alkatrészfelület (4) merőlegesével (6) párhuzamosan beszabályozzuk, úgy hogy a porlasztási kép (8) nyújtásait és tömörítéseit a szembefekvő lakkozási irányokban ugyanabba az irányba állítjuk be.

5. Az előző igénypontok egyike szerinti rétegfelhordó eljárás, **azzal jellemezve, hogy** felviszünk egy első lakkozási pályát az alkatrészfelületre (4), mialatt a porlasztót (2) az első lakkozási pálya mentén az alkatrészfelület fölé mozgatjuk, és ennél a porlasztósugarat (1) leadjuk az alkatrészfelületre (4),
hogy egy második lakkozási pályát viszünk fel az alkatrészfelületre (4), mialatt a porlasztót (2) a második lakkozási pálya mentén az alkatrészfelület fölé mozgatjuk, és ennél a porlasztósugarat (1) leadjuk az alkatrészfelületre (4), ahol a második lakkozási pályát felhordjuk az első lakkozási pályára,
hogy a porlasztót az első lakkozási pálya felhordásánál, és a második lakkozási pálya felhordásánál ellenkező irányokban mozgatjuk, úgy hogy a porlasztási kép (8) aszimmetriáit mindkét lakkozási pályán, legalább részben, kompenzáljuk.

6. Az 5. igénypont szerinti rétegfelhordó eljárás, **azzal jellemezve, hogy** a porlasztót (2) a két lakkozási pálya felvitelénél mindig maeander alakú mozgáspálya (12, 14) mentén mozgatjuk, ahol a két lakkozási pálya maeander alakú mozgáspályáit (12, 14) tükrözzük, és a porlasztótól (2) különböző lakkozási irányokban mozgatjuk, vagy

hogy a porlasztót (2) a két lakkozási pálya felvitelénél mindig maeander alakú mozgáspálya (12, 14) mentén mozgatjuk, ahol a két lakkozási pálya maeander alakú mozgáspályái (12, 14) egymással megegyeznek, de egymással szembeni lakkozási irányokban járhatók be.

7. Az előző igénypontok egyike szerinti rétegfelhordó eljárás, **azzal jellemezve, hogy** a porlasztósugár (1) aszimmetriáját a következő erők legalább egyike okozza, amely a porlasztósugárra (1) hat:

a) egy lefelé irányuló gravitációs erő,
b) egy elektrosztatikus erő, amely elektrosztatikus rétegképző anyag feltöltődésén keresztül jön létre és az elektrosztatikusan feltöltött rétegképző anyag és a földelt alkatrész között hat,
c) egy első áramlási erő, amelyet egy szabályozólevegő okozhat, és/vagy
d) egy második áramlási erő, amelyet az okozhat, hogy a porlasztó (2) a körülvevő levegőben, az alkatrészfelület (4) mentén mozog, és/vagy
e) egy harmadik áramlási erő, amely ellenkező irányú légáramlaton keresztül egy lakkozó kabinban keletkezik.

8. A 7. igénypont szerinti rétegfelhordó eljárás, **azzal jellemezve, hogy** a következő lépéseket alkalmazzuk a porlasztósugár (1) aszimmetriájának kompenzálására:
a) meghatározzuk azoknak az erőknek legalább egyikét, amelyek a porlasztósugár aszimmetriáját (1) okozzák,
b) beforgatással beállítjuk a porlasztót (2) az alkatrészfelület (4) felületi merőlegesével (4) szemben, a megállapított erő, vagy erők függvényében.

9. Rétegfelhordó berendezés alkatrész alkatrészfelületének (4) rétegképző anyaggal történő, réteggel való ellátásához, különösen gépjármű karosszéria alkatrészének lakkal való lakkozásához,
porlasztóval (2), rétegképző anyag porlasztósugarának (1) az alkatrészfelületre (4) történő leadásához, ahol a porlasztósugárnak (1) főtengelye (5) van, és a főtengelyre (5) vonatkozó aszimmetriája van, úgy hogy a porlasztósugár (1) az alkatrészfelületen (4) megfelelő aszimmetriájú porlasztási képet képez,
manipulátorral (17) a porlasztó (2) mozgatásához,
vezérlőegységgel (18) a manipulátor (17) irányításához,
ahol a vezérlőegység (18) a manipulátort (17) úgy irányítja, hogy a porlasztó (2) egy meghatározott lakkozási irányban az alkatrészfelület (4) mentén úgy mozoghasson, hogy egy hosszanti irányú lakkozási pályát hordjon fel lakkozási irány mentén az alkatrészfelületre, **azzal jellemezve,**
hogy van egy kompenzációs berendezés, amely a porlasztósugár (1) aszimmetriáját, legalább részben, kompenzálja, úgy hogy a keletkező porlasztási kép (8) aszimmetriája az alkatrészfelületen (4) kizárható legyen,
ahol a vezérlőegység (18) a manipulátort (17) úgy irányítja, hogy a porlasztósugár (1) főtengelyével (5) keresztben, különösen merőlegesen, a lakkozási irányhoz beálljon, hogy a porlasztósugár (1) aszimmetriáját, legalább részben, kompenzálja.

10. A 9. igénypont szerinti rétegfelhordó berendezés, **azzal jellemezve, hogy** a porlasztósugár (1) egy átalakítási irányban, a porlasztósugár (1) főtengelyéhez (5) képest keresztben, deformált, úgy hogy a keletkező porlasztási kép (8) az alkatrészfelületen (4), az átalakítási irányban megnyújtott, és ellenkezően tömörített,
hogy a vezérlőegység (18) a manipulátort úgy irányítja, hogy a porlasztó (2) a deformálási iránnyal szemben beállítható legyen, hogy a porlasztósugár (1) aszimmetriáját, legalább részben, kompenzálja.

11. A 9.-10. igénypontok egyike szerinti rétegfelhordó berendezés, **azzal jellemezve,**
a) **hogy** a vezérlőegység (18) a manipulátort (17) úgy irányítja, hogy egymás után több, egymás melletti és oldalt átlapoló lakkozási pálya felhordásra kerüljön az alkatrészfelületre (4), mialatt a porlasztó (2), mindig a lakkozási pályák mentén, az alkatrészfelület (4) fölé mozog, és ennél a porlasztósugarat (2) az alkatrészfelületre (4) leadja, és
b) **hogy** a vezérlőegység (18) a manipulátort (17) úgy irányítja, hogy a porlasztó (2), a közvetlenül szomszédos lakkozási pályák felhordásánál, ellenkezően elhelyezett lakkozási irányokban mozog a lakkozási pályák mentén.

12. A 11. igénypont szerinti rétegfelhordó berendezés, **azzal jellemezve,**

a) **hogy** a vezérlőegység (18) a manipulátort (17) úgy irányítja, hogy a porlasztó (2) mindkét, ellenkezően elrendezett lakkozási irányban, a lakkozási pályához képest ellenkezően, a felület merőlegeséhez (6) képest szemben legyen beállítva, úgy hogy a porlasztási kép nyújtásai és tömörítései a szembe beállított lakkozási irányokban, legalább részben, megnövekedjenek, vagy
b) **hogy** a vezérlőegység (18) a manipulátort (17) úgy vezérelje, hogy a porlasztó (2) csak egy lakkozási irányban, a lakkozási pályához képest ellentétesen legyen beforgatva, és az ellentétesen beállított lakkozási irányban, lényegében párhuzamosan az alkatrészfelület (4) merőlegeséhez képest beállítva, úgy hogy a porlasztási kép (8) nyújtásai, vagy tömörítései az ellenkezően elrendezett lakkozási irányokban, ugyanabba az irányba vannak beállítva.

13. A 9.-12. igénypontok egyike szerinti rétegfelhordó berendezés, **azzal jellemezve,**
a) **hogy** a manipulátor (17) többtengelyes lakkozórobot (17), különösen szabadon programozható lakkozórobot (17) soros kinematikával, vagy
b) **hogy** a manipulátor lakkozógép, különösen tető felsőrész lakkozó gép, vagy oldallakkozó gép.

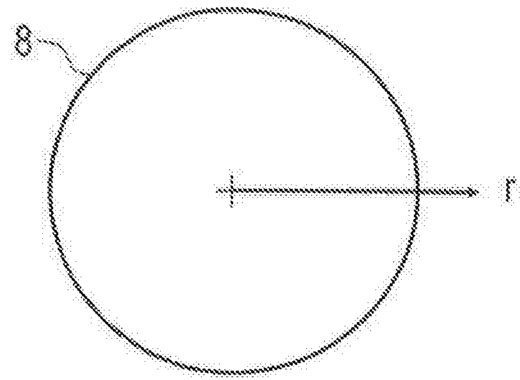


Fig. 1A
Prior Art

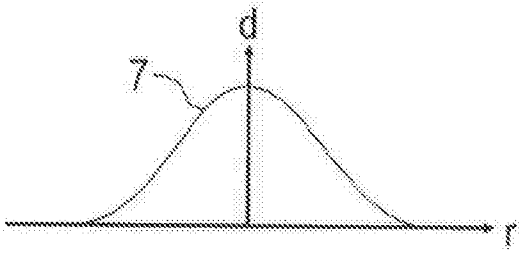


Fig. 1B
Prior Art

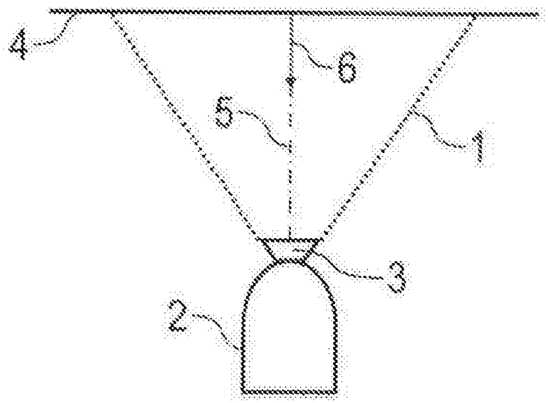


Fig. 1C
Prior Art

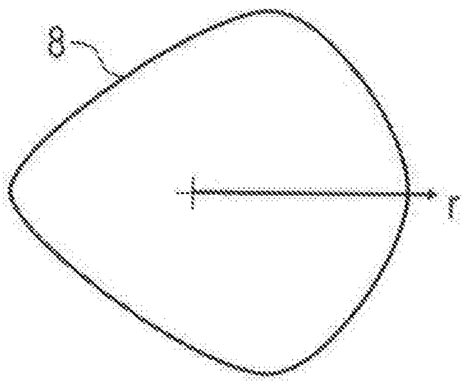


Fig. 2A
Prior Art

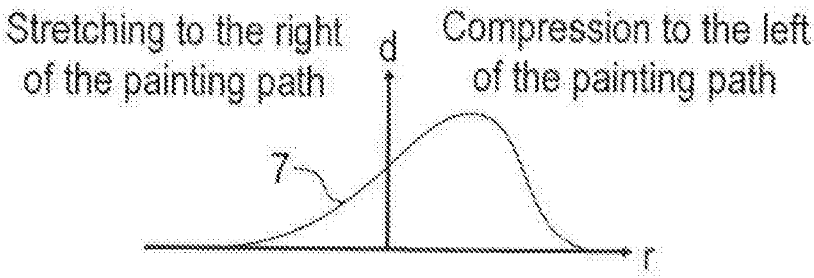


FIG. 2B
Prior Art

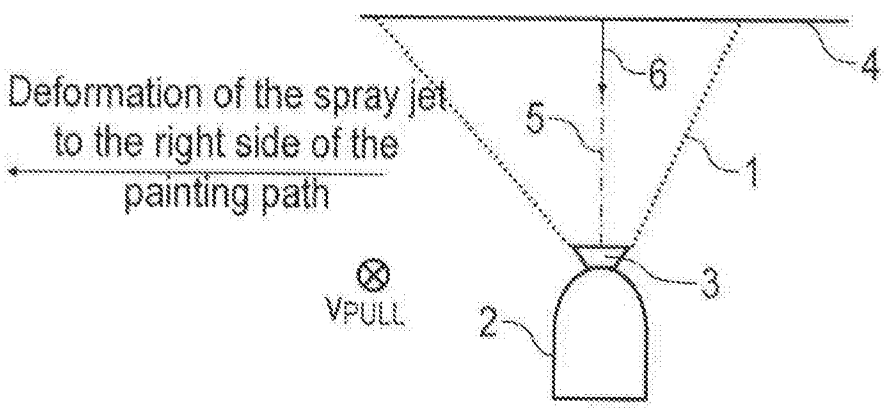


Fig. 2C
Prior Art

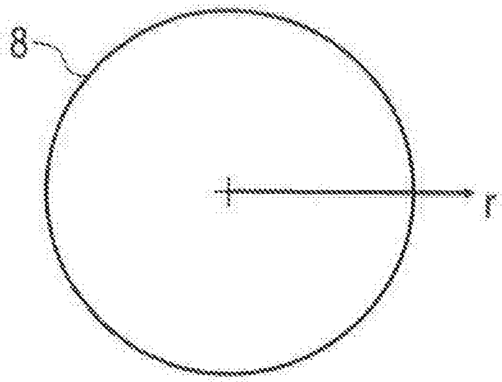


Fig. 3A

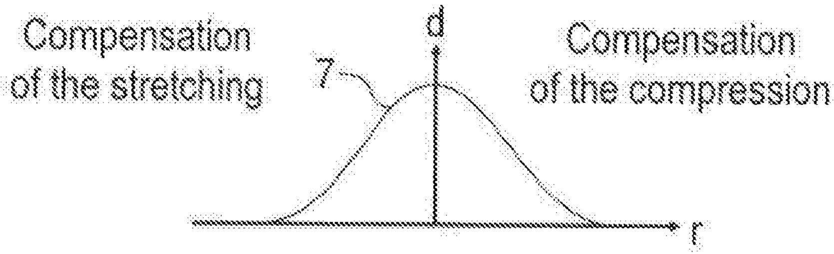


Fig. 3B

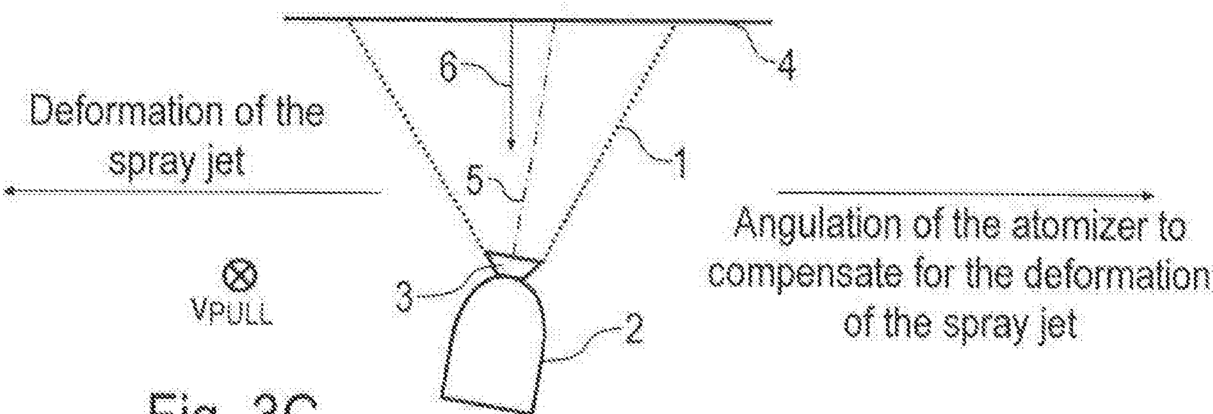


Fig. 3C

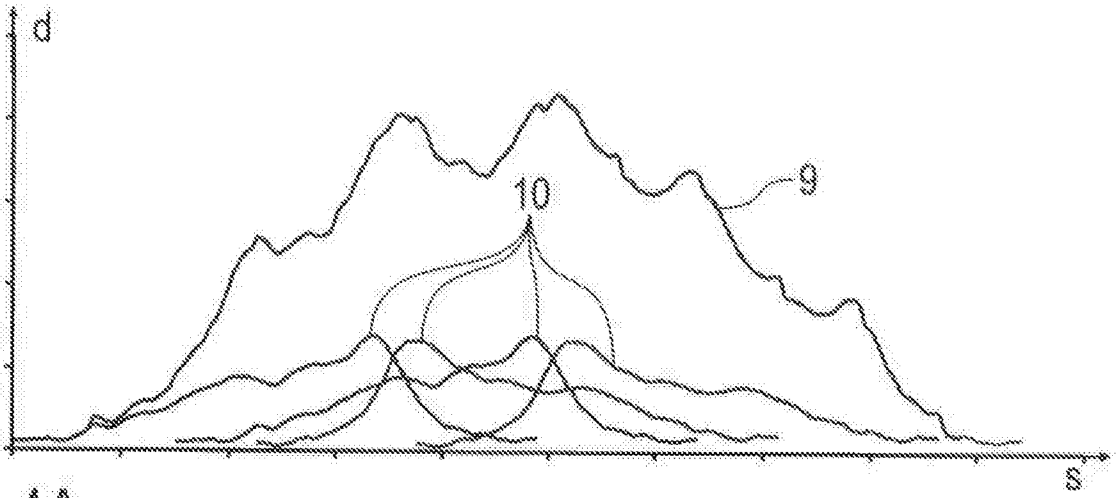


Fig. 4A
Prior Art

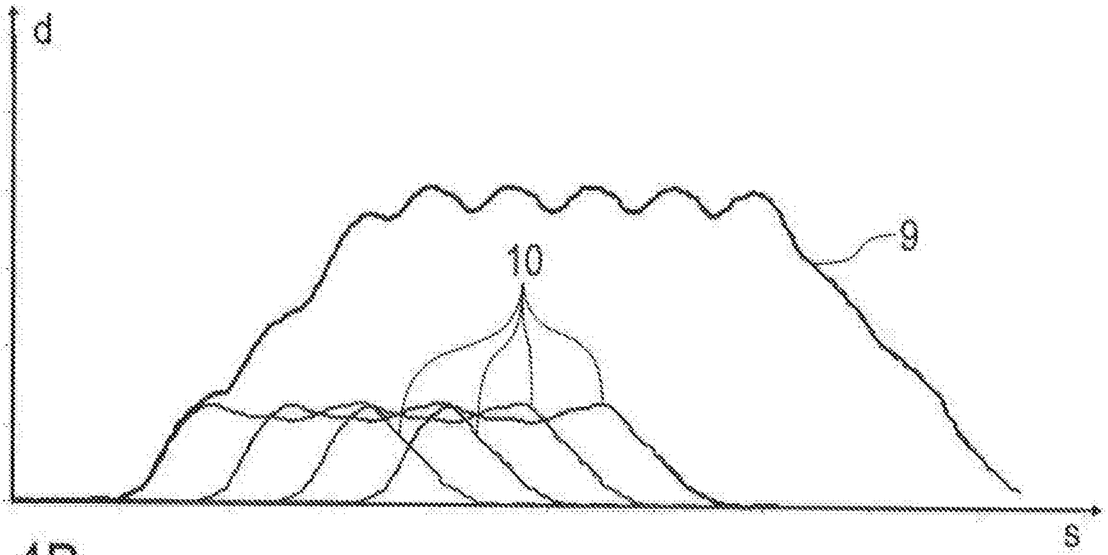


Fig. 4B

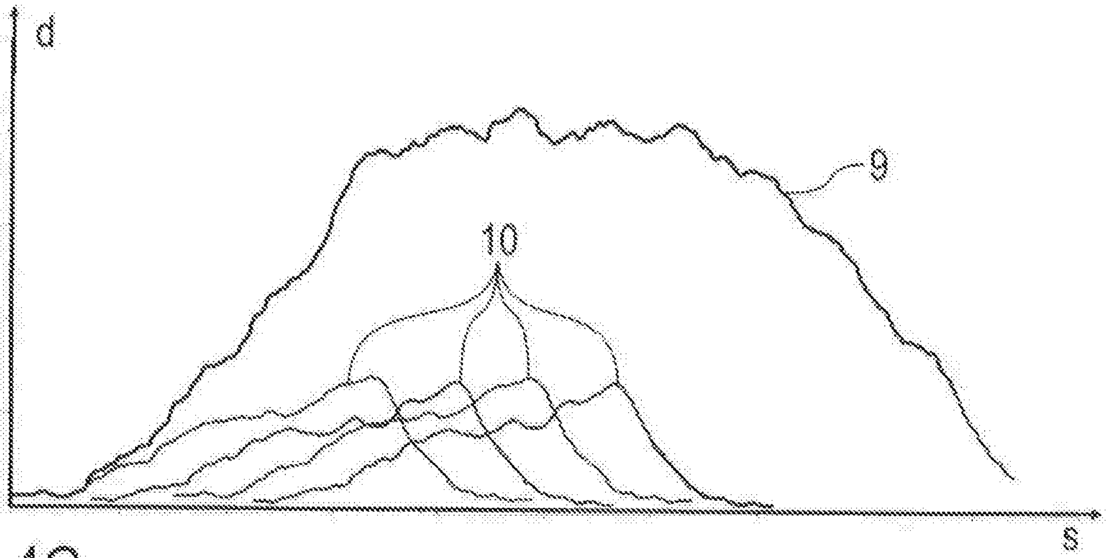


Fig. 4C

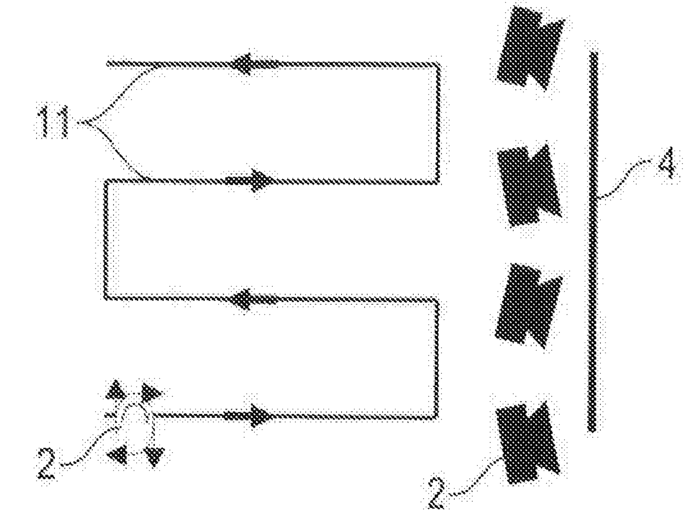


Fig. 5A

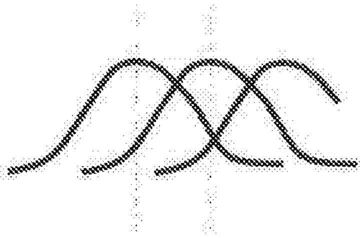


Fig. 5B

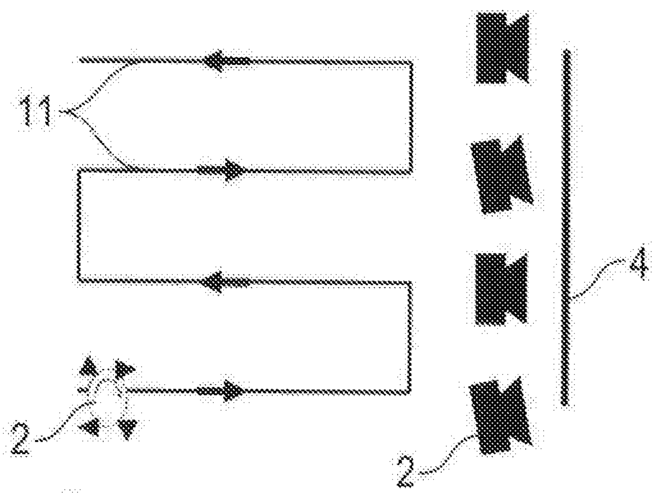


Fig. 6A

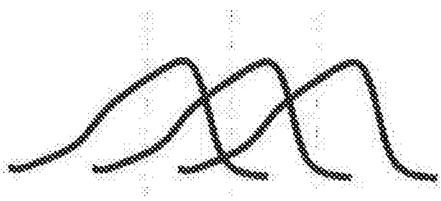


Fig. 6B

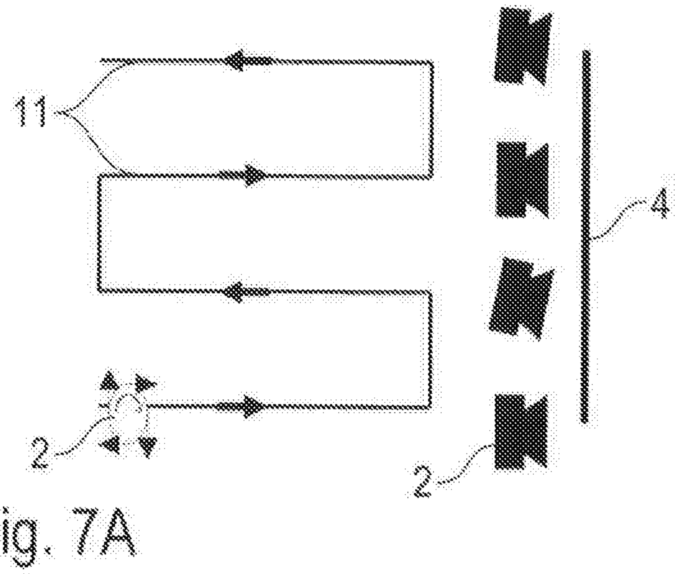
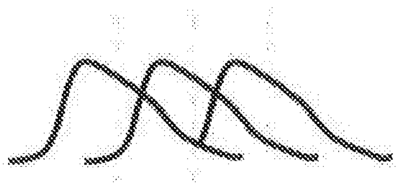


Fig. 7A



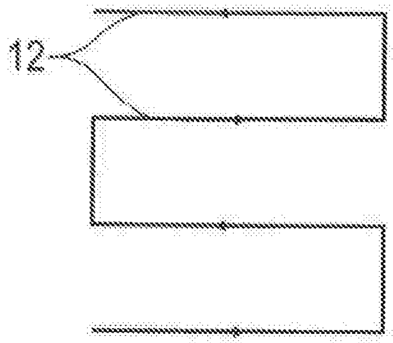


Fig. 8

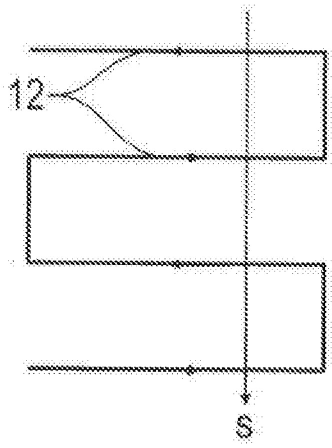


Fig. 9A

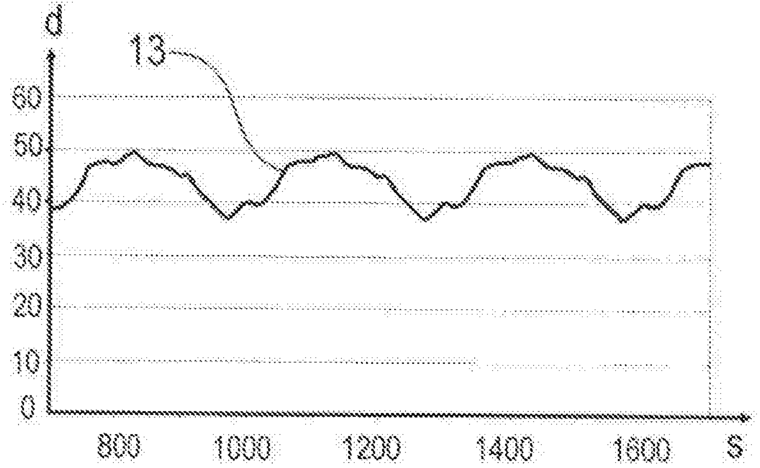


Fig. 9B

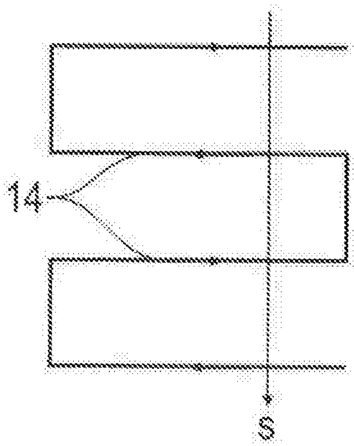


Fig. 10A

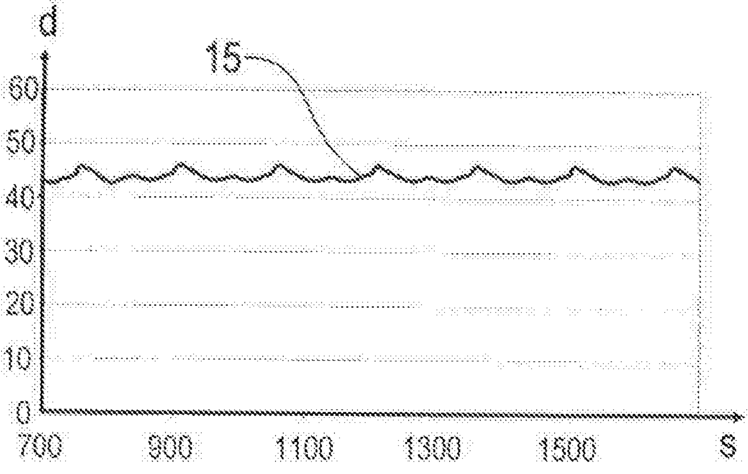


Fig. 10B

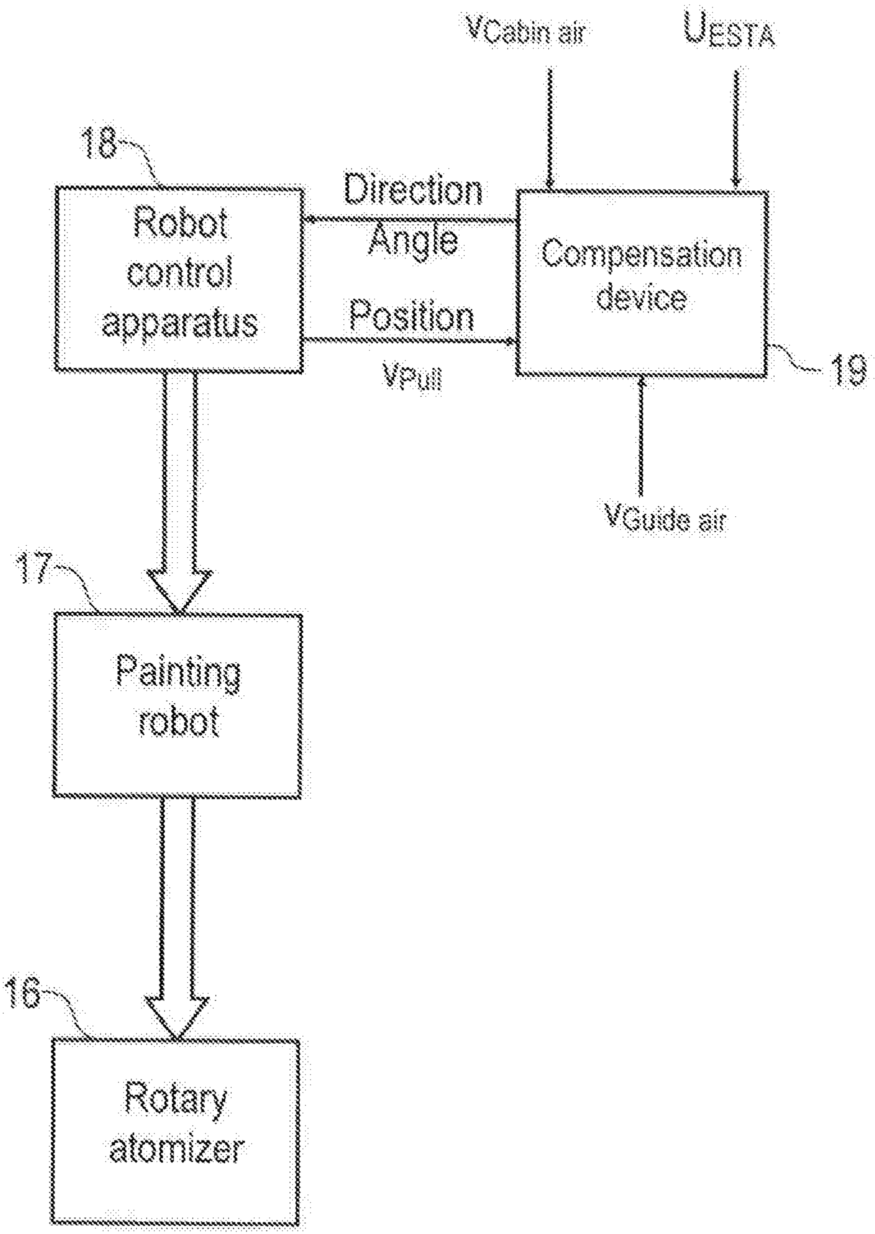

VCabin air
UESTA
18
Robot control apparatus
Direction
Angle
Position
VPull
Compensation device
19
VGuide air
17
Painting robot
16
Rotary atomizer

Fig. 11