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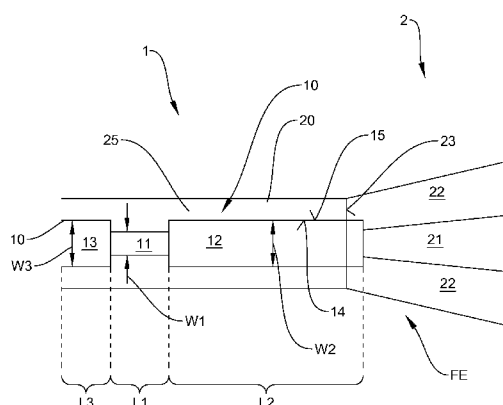


FIG. 1

(57) Abstract: Nozzle system (1) for a powder blasting device comprising a first nozzle element (10) for transporting a powder-gas mixture stream (21) along a transporting direction (T) and a second nozzle element (20), wherein the second nozzle element (20) surrounds the first nozzle element (10) such that at least one channel (25) is formed between the first nozzle element (10) and the second nozzle element (20), wherein the channel (25) is provided for transporting a liquid stream (22), wherein the first nozzle element (10) and the second nozzle element (20) are arranged such that in operation the powder-gas-mixture stream (21) ejected by the first nozzle element (10) is encased by the liquid stream (22) ejected by the channel (25) for forming an output stream (2) of the nozzle system (1), wherein the first nozzle element (10) has an acceleration part (11) having a first cross section and a spreading part (12) having a second cross section, wherein the spreading part (12) is arranged downstream of the acceleration part (11).



Nozzle system, powder blasting device and method for using a nozzle system

The present invention refers to a nozzle system, a powder blasting device, and a
5 method for using the nozzle system.

Nozzle systems in powder blasting devices are well known from the state of the art, for example from US 3 882 638 A or EP 0 294 548 A1. Such nozzle systems are typically used for cleaning teeth, in particular for removing stains, tartar and colorations from teeth and for removing dental biofilms. In particular, the aim of
10 using a powder blasting device is to clean dental surfaces and free them from stains, tartar biofilms and colorations without harming the tooth surface underneath which is enamel or dentine. According to the state of the art the powder is adapted to manipulate or to adjust a functionality of the output stream.

15

Preferably, nozzle systems provide a powder-gas mixture stream being encased by a liquid stream. The outlet stream, formed by the powder-gas mixture encased by the liquid stream, is directed on the tooth surface and causes the removing of stains, tartar coloration and/or dental biofilms. The liquid stream encasing the
20 powder-gas mixture stream is provided for trapping dust generated and to avoid mist during operation of the powder blasting device.

In particular, there are materials being extra prone for abrasion, for example dentine, when the outlet stream is directed to a body formed by this material. In such
25 cases even a “soft” powder might cause a too strong abrasion, disadvantageously.

However, making the powder even “softer” would counteract the main function of the powder blasting device, namely removing stains and various dental deposits.

Starting from that, it was an object of the present invention to provide a nozzle system for reducing abrasivity of an output stream ejected without reducing efficiency of removing stains, tartar dental deposits and/or dental biofilms.

This object is achieved by the nozzle system according to claims 1 and 10 and a powder blasting device according to claim 13 and a method for using a nozzle system according to claim 14. Preferred embodiments are incorporated in the dependent claims, the description and the figures.

According to the invention a nozzle system for a powder blasting device is provided, comprising

- a first nozzle element for transporting a powder-gas mixture stream along a transporting direction and
- a second nozzle element, wherein the second nozzle element surrounds the first nozzle element such that at least one channel is formed between the first nozzle element and the second nozzle element, wherein the channel is provided for transporting a liquid stream, wherein the first nozzle element and the second nozzle element are arranged such that in operation the powder-gas- mixture stream ejected by the first nozzle element is encased by the liquid stream ejected by the channel for forming an output stream of the nozzle system, wherein the first nozzle element has an acceleration part having a first cross section and a spreading part having a second cross section. It is provided that the spreading part is arranged downstream of the acceleration part and for reducing abrasivity of the output stream the second cross section is larger than the first cross section.

In contrast to the state of the art it is provided according to the present invention to modify an inner cross section of the first nozzle element, i. e. to modify an inner geometry of the first nozzle element, along the transporting direction. Thus, it is advantageously possible to reduce the abrasivity of the output stream without ef-

fecting its efficiency on the dental coverings which are to be removed. Thereby, particles of the powder-air mixture are accelerated inside the acceleration part for gaining speed. In the following spreading part the effective flow-cross-section of the powder-gas mixture is increased by the enlarged second cross section of the spreading part. In other words: the cross section of the powder-gas mixture stream is increased inside the first nozzle element in flow direction, in particular inside the spreading part of the first nozzle element. As a result, the envelope of the powder-gas mixture has an enlarged cross section, when it is ejected from the nozzle system, and therefore a larger surface can be treated by the output stream. Consequently, a cleaning surface is enlarged and powder abrasivity is reduced, simultaneously. In addition, a sound shock being generated otherwise outside of the nozzle system, preferably at its front end, is generated inside the nozzle system. Therefore, the noise caused by the nozzle system in operation is advantageously reduced for giving an operator and/or a patient a more comfortable impression/feeling.

Another positive effect is the possibility of enlarging the cross section of the ejected output stream without increasing an air flow rate. Thus, it can be avoided that too much air is used during a treatment, which otherwise would increase an emphysema risk, i. e. pushing air within tissues. Another positive effect of increasing the cross section of the outlet stream, in particular of the cross section of the powder-gas mixture, is an opportunity to create or manipulate different nozzle properties without changing a base unit in charge of supplying the nozzle system with air and/or powder, since the air flow rate remains constant as well as the powder flow rate. For example, it is advantageously possible to adapt an air speed of the ejected output stream as well as its pressure. Another positive effect of the nozzle system of the present invention is that less liquid (e.g. water) is needed and therefore used when using the powder blasting device comprising the nozzle system of the present invention. This may be due to the fact that the liquid stream is better spread and is therefore more efficient in entrapping the powder and/or powder-gas mixture stream.

Preferably, abrasivity defines an efficiency of removing particle from a material surface during a treatment. For example, the abrasivity is specified by the ratio of the crater depth generation rate over powder quantity. The larger -value, the bigger the abrasivity, i. e. more particles of the treated material are removed from the surface.. A reduction of abrasivity is preferably referenced to a first nozzle element having a constant cross section, in particular a constant first cross section of the acceleration part.

Preferably, the first nozzle element and/or the second nozzle element have a sleeve like body, wherein the first nozzle element is arranged inside the second nozzle element, in particular concentrically. In particular, the first nozzle element and the second nozzle element end or terminate at a front end of the nozzle system. Furthermore, it is conceivable that the first nozzle element and the second nozzle element end along the transporting direction simultaneously, i. e. in a plane perpendicular to the transporting direction. Alternatively, the first nozzle element protrudes at the front end of the nozzle system. Especially, the nozzle system is incorporated into a handheld device of a powder blasting device, such that an operator can easily direct the output stream onto the object to be treated. Furthermore, it is provided that the spreading part forms the end of the first nozzle element in transporting direction. Furthermore, the spreading part follows downstream to the acceleration part, preferably directly afterwards.

In a preferred embodiment it is provided that the acceleration part has a first cross section being constant in a direction extending along the transporting direction and/or the spreading part has a second cross section being at least partially constant in a direction extending along the transporting direction. Preferably, the second cross section is constant over its whole extension along the transporting direction. Alternatively, the acceleration part and/or the spreading part have subsections having different cross sections. In particular, the cross section of these subsections increases in transporting direction, such that the subsection at the end of the acceleration part and/or spreading part has the largest cross section of all cross sections assigned to the subsections. Especially, the acceleration part has a

first length being longer than 0.5 mm, preferably longer than 0.75 mm and more preferably longer than 1 mm.

In another preferred embodiment of the present invention it is provided that the
5 first cross section has a first width measured perpendicular to the transporting direction and a second cross section has a second width measured perpendicular to the transporting direction, wherein the second width is up to three times, preferably up to 2.5 times and most preferably up to 2 times, in particular mainly 1.5 times, larger than the first width and/or wherein the first width has a width between 0.1
10 and 2.5 mm, preferably between 0.25 and 1.5 mm and most preferably 0.6 mm. By these dimensions of the acceleration part and the spreading part a significant reduction of the abrasivity can be realized. In the case of several subsections or a varying second cross section within the spreading part, the second cross section and/or a second width of the second cross section is preferably a mean value of all
15 second cross sections or second widths of all subsections along the transporting direction.

Preferably, it is provided that the first nozzle element comprises a collecting part, wherein the collecting part is arranged upstream to the acceleration part, wherein
20 the collecting part has a third cross section being preferably at least partially constant along the transporting direction. In particular, it is provided that the acceleration part follows directly downstream to the collection part. The collection part directs the powder-gas mixture preferably of the acceleration part. For example, a funnel shaped subsection of the collecting part, in particular in a transition area
25 between the collecting part and the acceleration part, directs the powder-gas mixture inside the acceleration part. In particular, the acceleration part, the collecting part and/or the spreading part are arranged adjacent and/or concentrically to each other.

30 In another preferred embodiment, it is provided that the third cross section is larger than the first cross section, wherein
- a third width of the third cross section is up to three times, preferably up to two

times and most preferably up to 1.6 times, in particular mainly 1.2 times, larger than the first width, wherein the first width has a width between 0.1 and 2.5 mm, preferably between 0.25 and 1.5 mm and most preferably 0.6 mm

- 5 In particular, an inner curvature of the first nozzle element in a transition area or in the spreading part has a step-like and/or a cone-like shape. Forming the inner curvature in the spreading part in a step-like and/or cone like manner represents another advantageous possibility to manipulate the form of the cross section of the powder-gas mixture stream being ejected at the front end. In particular, the transition area forms a transition between the collecting part and the acceleration part
10 and/or a transition between the acceleration and the spreading part.

Furthermore, it is preferably provided that the acceleration part has a first length measured along the transporting direction and the spreading part has a second
15 length measured along the transporting direction, wherein the second length is 0.5 to 3.5 times, preferably 1.1 to 2 times and most preferably 1.3 to 1.8 times, longer than the first length. Especially, the acceleration part has a first length being longer than 0.5 mm, preferably longer than 0.75 mm and more preferably longer than 1 mm. By choosing a comparably large spreading part, it is advantageously possible
20 to establish a homogeneous powder density across a plane being perpendicular to the transporting direction at the front end. Alternatively, it is also conceivable that the second length is shorter than the first length.

In another preferred embodiment it is provided that the liquid stream is ejected
25 from the channel via an output surface, wherein the channel is preferably configured such that the liquid stream encasing the powder-gas mixture stream is formed by droplets. By encasing the powder-gas mixture by droplets instead of a closed liquid stream it is advantageously possible to increase an ability of trapping dust powder by the liquid. As a consequence, less liquid, for example water, is
30 needed in operation of the nozzle system, which is beneficial for a comfort of the patient. Another consequence is that less dust is generated and therefore less clogging of the nozzle system channels occur after repeated used. Preferably, the

output surface, in particular a fourth cross section assigned to the output surface, has a structure or profile that supports the droplet formation.

In particular, it is provided that the output surface has a fourth cross section,
5 wherein the fourth cross section preferably has a size between 0.1 and 0.9 mm², preferably between 0.3 and 0.6 mm² and most preferably between 0.3 and 0.4 mm². Thus, a fourth cross section is realized that is smaller than the fourth cross sections typically known from the prior art. The reduction of the fourth cross section supports the formation of the droplets at the front end of the nozzle system
10 advantageously.

According to another aspect of the invention a nozzle system for a powder blasting device is provided, comprising

A nozzle system for a powder blasting device, comprising

- 15 - a first nozzle element for transporting a powder-gas mixture stream along a transporting direction and
- a second nozzle element, wherein the second nozzle element surrounds the first nozzle element such that at least one channel is formed between the first nozzle element and the second nozzle element, wherein the channel is provided for
20 transporting a liquid stream, wherein the first nozzle element and the second nozzle element are arranged such that in operation the powder-gas-mixture stream ejected by the first nozzle element is encased by the liquid stream ejected by the channel via an output surface for forming an output stream of the nozzle system, wherein the output surface has a fourth cross section, wherein the fourth cross
25 section has a size between 0.3 and 0.4 mm².

Preferably, it is provided that the fourth cross section is formed undulated or as a slit, an assembly of holes and/or assembly of grooves. Thus, it is advantageously possible to adapt the fourth cross section profile determining how the liquid is
30 ejected from the nozzle system, in particular from the channel. Thereby, it is preferably provided that the fourth cross section of the output surface comprises six or more openings for ejecting the liquid stream. It is also conceivable that the fourth

cross section comprises less than six openings. Preferably, the holes and/or grooves are distributed homogeneously or statistically along a circumferential direction. The holes might have a circular, rectangular elliptical shape and/or any other shape or a combination thereof.

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In particular, it is provided that an outer curvature of the first nozzle element defines the shape of the fourth cross section, wherein the outer curvature of the first nozzle element comprises at least one recess being curved inwardly. Preferably, the recess is formed arched parabolic and/or circularly in a circumferential direction. In other words: the outer curvature of the first nozzle element is an integral part of the channel, in particular defines the structure / profile of the fourth cross section at the front end. For example, the outer curvature/side of the first nozzle element is configured with regard to the inner surface of the second nozzle element, which is preferably circular, such that a set of sub-channels extending parallel to the transporting direction is realized. In particular, each end of the sub-channels forms an opening being part of the fourth cross section. Preferably the extension of the sub-channels is at least as long as the second length of the acceleration part.

Alternatively, it is provided that an inner curvature of the second nozzle element defines the shape of the fourth cross section, wherein the inner curvature of the second nozzle element comprises at least one recess being curved outwardly. Preferably, the recess is formed arched parabolic and/or circularly in a circumferential direction. In other words: the inner curvature of the second nozzle element is an integral part of the channel, in particular defines the structure / profile of the fourth cross section at the front end. For example, the inner curvature/side of the second nozzle element is configured with regard to the outer surface of the first nozzle element, which is preferably circular, such that a set of sub-channels extending parallel to the transporting direction is realized. In particular, each end of the sub-channels forms an opening being part of the fourth cross section. Preferably the extension of the sub-channels is at least as long as the second length of the acceleration part. Alternatively, the shape of the fourth cross section can be

defined by the insertion of elements between the first and second nozzle elements.

In another embodiment of the present invention it is provided that in a direction parallel to the transporting direction the first nozzle element extends further than
5 the second nozzle element or the first nozzle element and/or the second nozzle element ends at a common plane being perpendicular to the transporting direction. In other words: the first nozzle element protrudes at the front end relative to the second nozzle element along the transporting direction or does not protrudes at the front end. Thus, the form of the output stream can be further manipulated. In
10 particular the first nozzle element does not protrude further than 1 mm, preferably further than 0.8 mm and most preferably 0.5 mm.

Another aspect of the present invention is a powder blasting device comprising the nozzle system according to the present invention. All features and benefits men-
15 tioned in the context of the nozzle system can be transferred to the powder blasting device and vice versa.

Another aspect of the present invention is a method for using a nozzle system according to the present invention, in particular in a powder blasting device. All features and benefits mentioned in the context of the nozzle system can be trans-
20 ferred to the method and vice versa.

In a preferred embodiment it is provided that the output stream has a fifth cross section that differs from a circularly formed cross section.

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Wherever not already described explicitly, individual embodiments or their individual aspects and features can be combined or exchanged with one another without limiting or widening the scope of the described invention, whenever such a combination or exchange is meaningful and in the sense of this invention. Advantages
30 which are described with respect to one embodiment of the present invention are, wherever applicable, also advantageous of other embodiments of the present invention.

In the drawings:

- Fig. 1 schematically shows a nozzle system according to a preferred
5 embodiment of the present invention,
- Fig.2 schematically shows a first nozzle element according to the
state of the art
- 10 Fig2a to 2d schematically show different preferred embodiments of a first
nozzle element for a nozzle system according to the present in-
vention
- Fig.3 schematically shows a perspective view on a front end of a
15 nozzle system according to the state of the art
- Fig. 3a to 3i schematically show different preferred embodiments for nozzles
systems according to the present invention in a perspective
view directed on the front end of the nozzle system and
20
- Fig.4 a fifth cross section assigned to the output stream.

In **figure 1** a nozzle system 1 according to a preferred embodiment of the present
25 invention is presented in a sectional side view along a transporting direction T.
Such nozzle systems 1 are preferably an essential part of a powder blasting de-
vice. Those power blasting devices are preferably used for removing stains, tartar
or a coloration from a tooth and/or for removing dental biofilms. The nozzle system
1 provides an output stream 2 that is able to remove stains and coloration and/or
30 to remove dental biofilms. In operation, the output stream 2 is ejected by the noz-
zle system 1 at its front end FE.

Besides a powder-gas mixture stream 21 the output stream 2 comprises a liquid stream 22 in order to guide the powder-gas mixture stream 21 and to trap dust generated and to avoid mist during operation. In particular, the powder-gas mixture stream 21 is encased or surrounded at least partially, preferably completely, by the liquid stream 22 in a plane expanding perpendicular to a transporting direction T of the output stream 2. For realizing such an output stream 2 the nozzle system 1 comprises a first nozzle element 10 for transporting a powder-gas mixture stream 21 along the transporting direction T and a second nozzle element 20, wherein the second nozzle element 20 surrounds the first nozzle element 10 such that at least one channel 25 is formed between the first nozzle element 10 and the second nozzle element 20. Preferably, the first nozzle element 10 and/or the second nozzle element 20 have a sleeve – like body, wherein the first nozzle element 10 is arranged inside the second nozzle 20 element, in particular concentrically to each other. Preferably, the output stream 2 is ejected from the nozzle system 1 at a front end FE or a front side of the nozzle system 2. Preferably, the first nozzle element 10 extends further than the second nozzle element 20 in a direction extending parallel to the transporting direction T. Alternatively, the first nozzle element 10 and the second nozzle element 20 end in a common plane that extends perpendicular to the transporting direction T.

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For improving a quality of the output stream 2, in particular regarding a reduced abrasivity in operation, it is provided to adapt a geometry of the first nozzle element 10. In particular, the first nozzle element 10 has an acceleration part 11 having a first cross section and a spreading part 12 having a second cross section, wherein the spreading part 12 is arranged downstream of the acceleration part 11. Thereby, the particles of the powder-gas mixture stream 21 are accelerated inside the acceleration part 11 and thus gain speed during their transport inside the acceleration part 11. The spreading part 12 is configured such that the particles of the powder-gas mixture stream 21 are spread. For realizing the spreading inside the spreading part 21 it is preferably provided that the second cross section is larger than the first cross section. In particular the acceleration part 11 is arranged

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directly next to the spreading part 12 in a direction extending parallel to the transporting direction T.

In particular, it is provided the first cross section has a first width W1 measured
5 perpendicular to the transporting direction T and a second cross section has a
second width W2 measured perpendicular to the transporting direction T, wherein
the second width W2 is up to three times, preferably up to 2.5 times and most
preferably up to 2 times, in particular mainly 1.5 times, larger than the first width
W1 and/or wherein the first width W1 has a width between 0.2 and 1.5 mm, pref-
10 erably between 0.4 and 0.9 mm and most preferably 0.6 mm. By enlarging the
cross section, in particular by using the mentioned dimensions of the first width W1
and the second width W2, it is advantageously possible to reduce the abrasivity of
the output stream 2. Further, a sound shock is generated inside the nozzle system
1 and not at the front end of the nozzle system 1. As a consequence, noises gen-
15 erated by the nozzle system 1 during operation can be reduced for giving an oper-
ator and/or patient a more comfortable impression. Additionally, it is possible to
enlarge an absolute output cross section of the powder-gas mixture stream 12 be-
ing ejected by the first nozzle element 10 without increasing an air flow rate. As a
consequence of the enlarged output cross section of the powder-gas mixture
20 stream 21, an emphysema risk is reduced and a wider range of properties regard-
ing the output stream 2 can be established, for example a thinner or larger output
stream measured in a direction perpendicular to the transporting direction T.

Further, it is provided that in a direction extending parallel to the transporting direc-
25 tion T a curvature / inner side 14 of the first nozzle element 10 has a step-like
shape for forming a transition between the acceleration part 11 and the spreading
part 12. Furthermore, it is provided that the acceleration part 12 is arranged con-
centrically to the spreading part 12. Thus, a homogeneous spreading can be guar-
anteed.

30

Furthermore, the first nozzle element 10 comprises a collecting part 13, wherein
the collecting part 13 is arranged upstream to the acceleration part 11, wherein the

collecting part has a third cross section being preferably constant along the transporting direction T. By using the collecting part 13 it is advantageously possible to prepare particles for entering the acceleration part 11 properly. The third cross section might correspond to the second cross section of the spreading part 12 or might be different from the second cross section, for example regarding size and steps, i. e. a form of the inner side 14 of the first nozzle element 10. In particular, the inner curvature/side 14 of the first nozzle element 10 has another step-like shape forming the transition from the collecting part 13 to the acceleration part 11. It is also conceivable the transition between the collecting part 13 and the acceleration part 11 is funnel shaped. In particular, the third cross section is larger than the first cross section, wherein a third width W_3 of the third cross section is up to three times, preferably up to two times and most preferably up to 1.6, in particular mainly 1.2 times, larger than the first width, wherein the first width has a width between 0.2 and 1.5 mm, preferably between 0.4 and 0.9 mm and most preferably mainly 0.6 mm.

Moreover, the acceleration part 11 has a first length L_1 measured along the transporting direction T and the spreading part 12 has a second length L_2 measured along the transporting direction T, wherein the second length L_2 is 0.5 to 3.5 times, preferably 1.1 to 2 times and most preferably 1.3 to 1.8 times, longer than the first length L_1 . In particular, the first length L_1 should be longer than 0.5 mm.

Furthermore, it is provided that the channel 25 is configured such that a small/thin liquid jet is generated for the output stream 2. In particular, an output surface 23 from which the liquid jet is ejected preferably has comparable small fourth cross section. Preferably, the fourth cross section is measured in a plane extending perpendicular to the transporting direction T at the front end FE. Hereby, all openings used and/or being available for ejecting the liquid stream preferably form the fourth cross section, i. e. the fourth cross section might be formed by sub-cross sections assigned to several separated or individual openings at the front end for ejecting the liquid stream 22. In particular, the fourth cross section has a structure or profile formed by a plurality of openings that for example are arranged circumferential at

the front end FE of the channel 25, preferably uniformly along a circle. In particular, the fourth cross section preferably has a size between 0.1 and 0.8 mm², preferably between 0.6 and 0.3 mm² and most preferably between 0.3 and 0.4 mm². In contrast to that, the forth cross section according to the state of the art is larger
5 than 0.8 mm².

In particular, the fourth cross section is preferably configured such that the liquid stream 22 encasing the powder-gas mixture stream 12 is formed by droplets. Due to the use of droplets it is advantageously possible to increase a probability of the
10 liquid to trap dust powder. Furthermore, a controlled liquid stream 22 supports directing or guiding of the powder – gas mixture stream 21.

Such geometry of the channel 25 allows by itself to reduce the abrasivity of the output stream. Therefore, a nozzle system (1) for a powder blasting device is provided, comprising
15 - a first nozzle element (10) for transporting a powder-gas mixture stream (21) along a transporting direction (T) and
- a second nozzle element (20), wherein the second nozzle element (20) surrounds the first nozzle element (10) such that at least one channel (25) is formed
20 between the first nozzle element (10) and the second nozzle element (20), wherein the channel (25) is provided for transporting a liquid stream (22), wherein the first nozzle element (10) and the second nozzle element (20) are arranged such that in operation the powder-gas-mixture stream (21) ejected by the first nozzle element (10) is encased by the liquid stream (22) ejected by the channel (25)) via
25 an output surface (23) for forming an output stream (2) of the nozzle system (1), wherein the output surface (23) has a fourth cross section, wherein the fourth cross section has a size between 0.3 and 0.4 mm² for reducing abrasivity of the output stream.

30 In **Figure 2** a first nozzle element 10 according to the prior art is presented for comparing it to the geometries of the first nozzle elements 10 of the **figures 2a to 2d** representing different exemplary embodiments of first nozzle elements 10 for a

nozzle system 1 according to the present invention. In particular, figure 2a shows a first nozzle element 10, assigned to a nozzle system 1 being named EA-5698 in the following, which has no collecting part. Further, the first nozzle element 10 has a comparable long acceleration part 11 compared to the spreading part 12. The elements 17, such as struts or ribs, extending at an outer side 15 of the first nozzle element 10 are intended for realizing sub-channel and a structured output surface 23 of the channel 25 ejecting the liquid stream 22. Preferably, the struts and/or ribs have a length longer than the second length L2. Moreover, the second width W2 is about 0.8 mm, whereas the inner diameter of the first nozzle element 10 according to the prior art is about 0.65 mm. The first nozzle element 1 in figure 2b has a collecting area 13 and refers to a nozzle system 1 named EA 5682 in the following. Its second width W2 is about 0.7 mm. The first length L1 is about 3 to 5 mm and the second length L2 about 2 to 3 mm. A third length L3 assigned to the collecting part 13 is about 0.3 to 0.7 mm and the third width is about 1 mm. Furthermore, it is provided that the transition between the collecting part 13 and the acceleration part 11 is funnel shaped. Moreover, the third width W3 being for example about 1 mm is larger than the second width being for example about 0.7 mm. The first width is about 0.61 mm.

The first nozzle element 10 of figure 2c is for example part of a nozzle system 1 assigned to the name EA-5701. The first nozzle element 10 of figure 2c differs from that of figure 2b by the design of the inner curvature/side 14 of the spreading part 12, wherein the inner curvature/side along the transporting direction T has a step like shape. In the illustrated embodiment, several subsection, in particular three subsection 25, are provided, wherein the sub-sections 25 have the same length measured along the transporting direction T. For example, the length of each subsection is about 1.5 mm, consequently forming a second length L2 of about 4.5 mm. Furthermore, it is preferably provided that a respective second width W2 assigned to each of the subsection increases along the transporting direction T. For example the second width W2 is increased by 0.2 mm by each transition from one subsection 26 to the next subsection 26 in transporting direction T. Alternatively, it is also conceivable that the enlargement of the second width W2

between adjacent subsections 26 and/or the length of each subsection 26 differs along the transporting direction T.

5 In figure 2d a further first nozzle element 10 is presented and this first nozzle element is part of the nozzle system called EA-5697 in the following. Compared to the embodiment of figure 2b, a longer collecting part 13 is provided. Furthermore, it is provided that the third width W3 being for example about 0.8 mm is smaller than the second with W2 being for example about 1 mm.

10 In **Figure 3** a front end FE of a nozzle system 1 according to the prior art is presented in a perspective view for comparing it to front ends FE of nozzle systems 1 of the **figures 3a to 3i** representing different exemplary embodiments of nozzle system 1 according to the present invention. In particular, the view at the front end FE shows the fourth cross section formed at the end of the channel 25 for ejecting
15 the liquid stream 22. The nozzle system 1 representing the prior art is called in the following EMS. This nozzle system 1 is ring-shaped and has no structures included in the channel 25 for forming a profiled fourth cross section. In contrast to that, the channel 25 of the nozzle systems 2 illustrated by the figure 3a to 3h is formed by several sub-channels, in particular groove like sub-channels, between the first
20 nozzle element 10 and the second nozzle element 20. The sub-channels extend preferably parallel to the transporting direction T and their ends at the front end of the nozzle system 1 form the fourth cross section. In particular, the sub-channels have a fourth length L4 measured in a direction extending parallel to the transporting direction T. Preferably, the fourth length L4 is determined by the length of rip
25 elements and/or strut elements 17 protruding from the first nozzle element 10 radially. For example, the fourth length L4 is longer than the second length L2. In particular, a ratio of the second length L2 to the fourth length L4 is larger than 1, preferably larger than 2 and most preferably larger than 3.

30 In particular, the strut elements 17 are part of the first nozzle element 10. Moreover, it is provided that the outer surface/side 15 of the first nozzle element 10 has an arched shape between two adjacent strut elements 17. In particular the first

nozzle element 10 includes grooves 35 for forming the sub-channels. Thereby the outer surface/side 15 of the first nozzle element 10 is shaped/curved inwardly. In the nozzle systems of the figure 3a to 3d the arched shape is mainly parabolic and six different sub-channels are formed by six radially extending strut elements 17.

- 5 The nozzle system of the figures 3a to 3d mainly differs from each other by the thickness of a wall assigned to the first nozzle element 10.

In the figures 3e and 3f more than six sub-channels are realized. In the figure 3f and 3g are less than six sub-channels formed and the arched shape is mainly like
10 a circular arc. In figure 3i the fourth cross section is formed by a slit 36.

Furthermore, the nozzle system of figure 3a refers to EA 5682, the nozzle system of figure 3b to EA 5701, the nozzle system of figure 3c to EA 5698 and the nozzle system of figure 3d to EA 5697. For those nozzle systems an abrasivity of the out-
15 put stream 1 was measured and compared to the abrasivity of the nozzle system named EMS. Abrasivity test is carried out by using a test bench where the nozzle is placed at 45° and 2 mm of projected distance. A shutter in front of the nozzle is used to determine the exposure time. To determine the abrasivity, the test material is a PMMA plate. 16 abrasion points are made for each test using the same appli-
20 cation time. In order to avoid experimental bias, the exposure time is adjusted to get abrasion holes of 20 to 200 microns. The exposure time is mostly between 1 and 5 seconds. This exposure time is not a key parameter as the outcome is normalized according to the powder amount used. Therefore the abrasivity is defined as the crater depth generation rate over powder quantity. Abrasivity = Crater depth
25 [μm] / powder quantity used [g]

The abrasivity of EMS had a value between 1700 and 2333 μm/g, EA-5682 had a value between 1300 and 1600 μm/gm, EA-5701 had a value between 900 and 1100 μm/g, EA-5698 had a value between 700 and 1100 μm/g and ES 5697 had a value between 400 and 600 μm/g.

30

In **figure 4** a fifth cross section Q5 assigned to the output stream realized by EA-5701 is shown. The fifth cross section of the output stream is visualized by direct-

ing the output stream 2 on a painted steel surface located at a distance of 2.2 mm from the front end FE of the nozzle system 1. It can be seen that the fifth cross section differs from a circularly formed cross section.

5

Reference signs:

	1	nozzle system
	2	output stream
10	10	first nozzle element
	11	acceleration part
	12	spreading part
	13	collecting part
	14	inner side
15	15	outer side
	17	strut elements
	20	second nozzle element
	21	powder-gas mixture stream
	22	liquid stream
20	23	output surface
	25	channel
	26	subsection
	35	groove
	36	slit
25	T	transporting direction
	FE	front end
	L1	first length
	L2	second length
	L3	third length
30	W1	first width
	W2	second width
	W3	third width
	Q5	fifth cross section

Claims

1. Nozzle system (1) for a powder blasting device comprising
5 a first nozzle element (10) for transporting a powder-gas mixture stream (21) along a transporting direction (T) and
a second nozzle element (20), wherein the second nozzle element (20) surrounds the first nozzle element (10) such that at least one channel (25) is
10 formed between the first nozzle element (10) and the second nozzle element (20), wherein the channel (25) is provided for transporting a liquid stream (22), wherein the first nozzle element (10) and the second nozzle element (20) are arranged such that in operation the powder-gas-mixture stream (21) ejected by the first nozzle element (10) is encased by the liquid stream (22) ejected by the channel (25) for forming an output stream (2) of the nozzle
15 system (1),
wherein the first nozzle element (10) has an acceleration part (11) having a first cross section and a spreading part (12) having a second cross section, wherein the spreading part (12) is arranged downstream of the acceleration part (11), characterized in that the second cross section is larger than the first
20 cross section.
2. Nozzle system (1) according to claim 1, wherein the acceleration part (11) has a first cross section being constant in a direction extending along the transporting direction (T) and/or the spreading part (12) has a second cross
25 section being at least partially constant in a direction extending along the transporting direction (T).
3. Nozzle system (1) according to one of the preceding claims, wherein the first cross section has a first width (W1) measured perpendicular to the transport-
30 ing direction (T) and a second cross section has a second width (W2) measured perpendicular to the transporting direction (T), wherein the second width

(W2) is up to three times, preferably up to 2.5 times and most preferably up to 2 times, in particular mainly 1.5 times, larger than the first width (W1) and/or wherein the first width (W1) has a width between 0.1 and 2.5 mm, preferably between 0.25 and 1.5 mm and most preferably 0.6.

5

4. Nozzle system (1) according to one of the preceding claims, wherein the first nozzle element (10) comprises a collecting part (13), wherein the collecting part (13) is arranged upstream to the acceleration part (11), wherein the collecting part (13) has a third cross section being preferably at least partially constant along the transporting direction (T).
10
5. Nozzle system (1) according to claim 4, wherein the third cross section is larger than the first cross section, wherein
 - a third width (W3) of the third cross section is up to three times, preferably up to two times and most preferably up to 1.6 times, in particular mainly 1.2 times, larger than the first width (W1), wherein the first width (W1) has a width between 0.1 and 2.5 mm, preferably between 0.25 and 1.5 mm and most preferably 0.6 and/or
15
6. Nozzle system (1) according to one of the preceding claim, wherein an inner curvature (14) of the first nozzle element (10) in a transition area or in the spreading part (11) has a step-like and/or a cone-like shape.
20
7. Nozzle system (1) according to one of the preceding claims, wherein the acceleration part (11) has a first length (L1) measured along the transporting direction (T) and the spreading part (12) has a second length (L2) measured along the transporting direction (T), wherein the second length (L2) is 0.5 to 3.5 times, preferably 1.1 to 2 times and most preferably 1.3 to 1.8 times, longer than the first length (L1).
25
8. Nozzle system (1) according to one of the preceding claims, wherein the liquid stream (22) is ejected from the channel (25) via an output surface (23),
30

wherein the channel (25) is preferably configured such that the liquid stream (22) encasing the powder-gas mixture stream (21) is formed by droplets.

- 5 9. Nozzle system (1) according to claim 8, wherein the output surface (23) has a fourth cross section, wherein the fourth cross section preferably has a size between 0.1 and 0.9 mm², preferably between 0.3 and 0.6 mm² and most preferably between 0.3 and 0.4 mm².
- 10 10. A nozzle system (1) for a powder blasting device, comprising
- a first nozzle element (10) for transporting a powder-gas mixture stream (21) along a transporting direction (T) and
- a second nozzle element (20), wherein the second nozzle element (20) surrounds the first nozzle element (10) such that at least one channel (25) is formed between the first nozzle element (10) and the second nozzle element (20), wherein the channel (25) is provided for transporting a liquid stream (22), wherein the first nozzle element (10) and the second nozzle element (20) are arranged such that in operation the powder-gas-mixture stream (21) ejected by the first nozzle element (10) is encased by the liquid stream (22) ejected by the channel (25) via an output surface (23) for forming an output stream (2) of the nozzle system (1), wherein the output surface (23) has a fourth cross section, wherein the fourth cross section has a size between 0.3 and 0.4 mm².
- 15 11. Nozzle system (1) according to claim 8 to 10, wherein the fourth cross section is formed as a slit (36), an assembly of holes and/or assembly of grooves (35).
- 20 12. Nozzle system (1) according to one of the claims 8 to 10, wherein an outer curvature (15) of the first nozzle elements (10) defines the shape of the fourth cross section, wherein the outer curvature of the first nozzle element (10) comprises at least one recess being curved inwardly.
- 25 30

13. Nozzle system (1) according to one of the preceding claims, wherein in a direction parallel to the transporting direction (T) the first nozzle element (10) extends further than the second nozzle element (20) or the first nozzle element (10) and/or the second nozzle element (20) ends at a common plane
5 being perpendicular to the transporting direction (T).
14. Powder blasting device comprising the nozzle system (1) according to one of the preceding claims.
- 10 15. Method for using a nozzle system (1) according to one of the preceding claims, in particular in a powder blasting device.
16. Method according to claim 15, wherein the output stream (5) has a fifth cross section that differs from a circularly formed cross section

15

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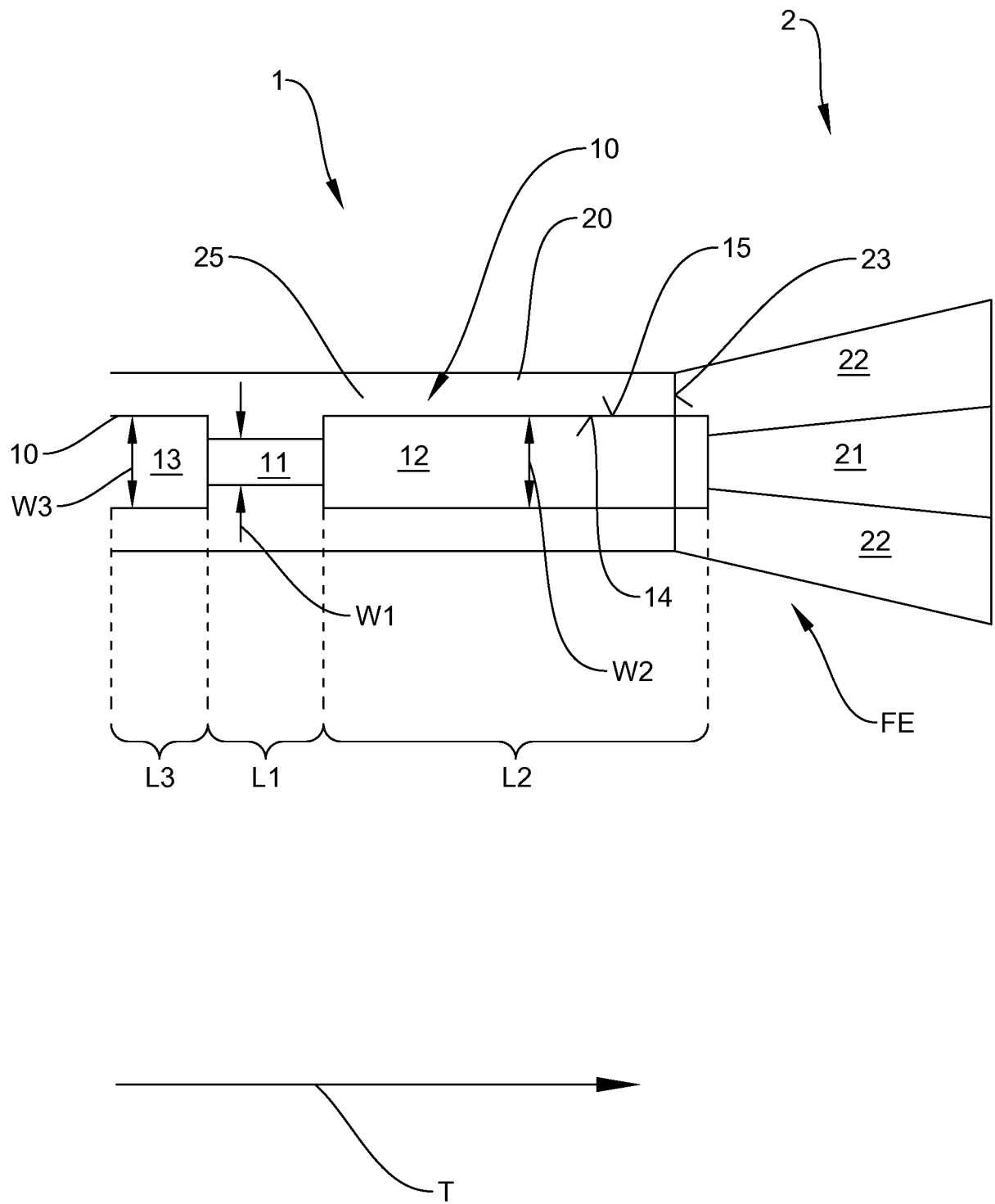


FIG. 1

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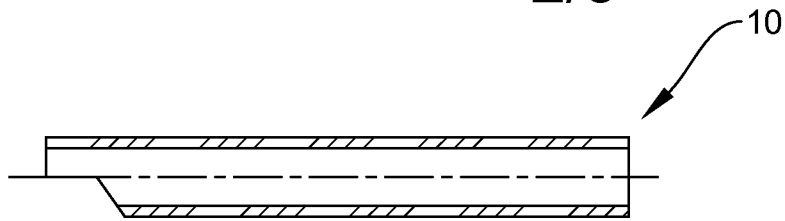


FIG. 2

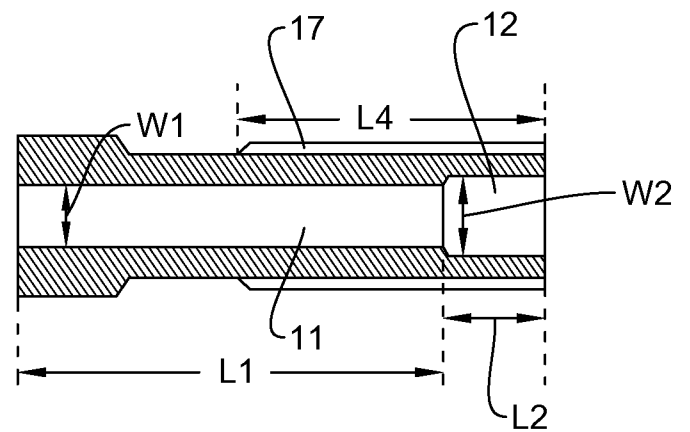


FIG. 2A

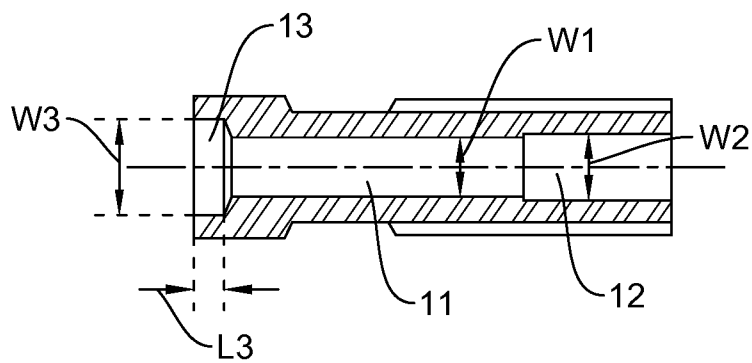


FIG. 2B

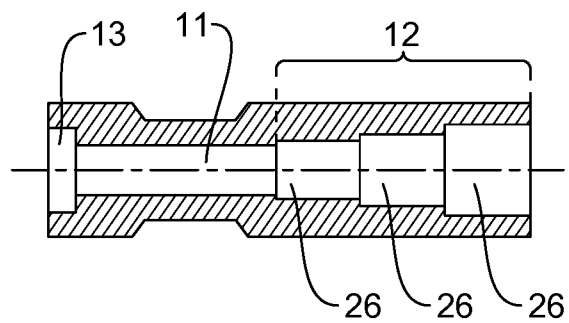


FIG. 2C

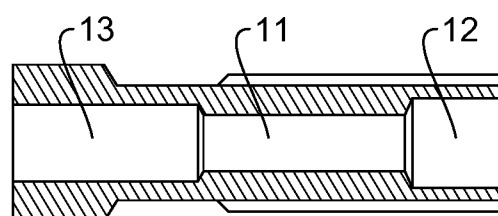


FIG. 2D

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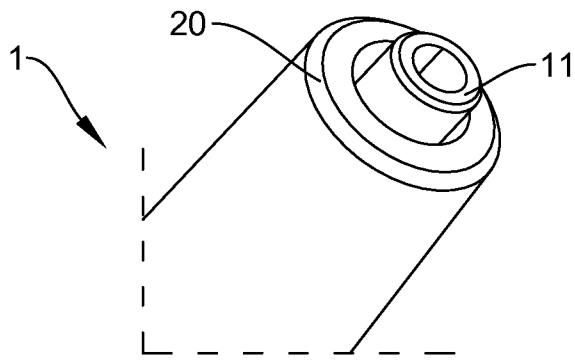


FIG. 3

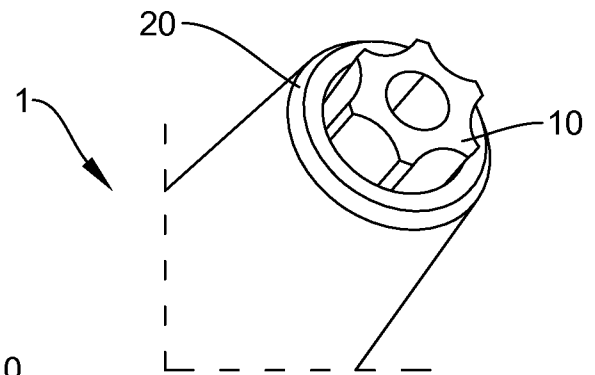


FIG. 3A

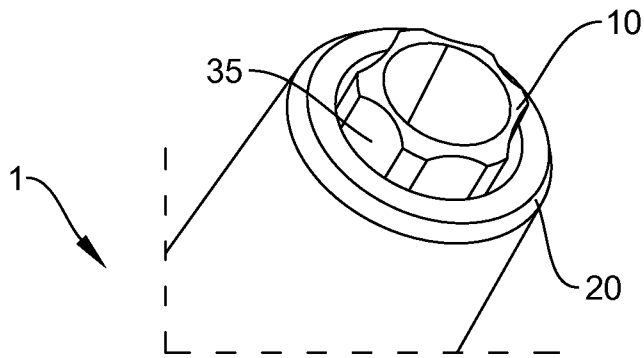


FIG. 3B

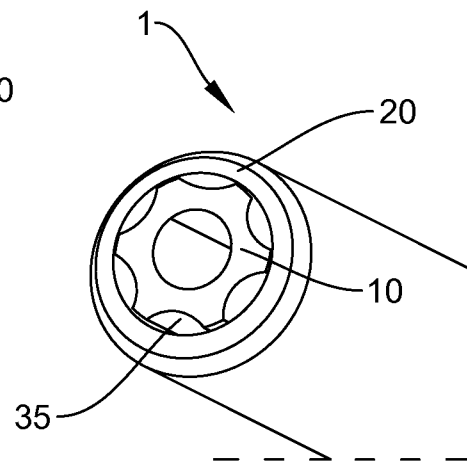


FIG. 3C

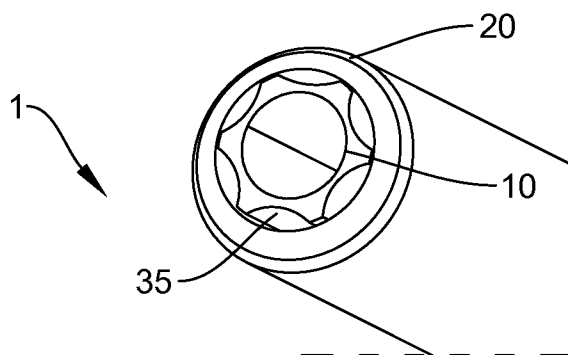


FIG. 3D

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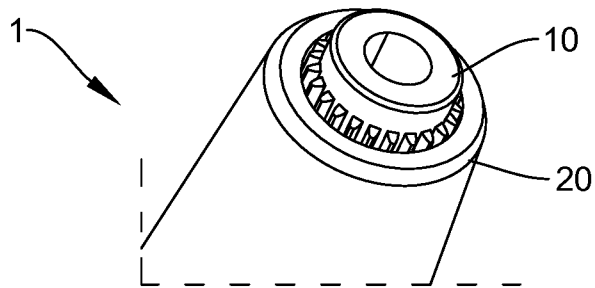


FIG. 3E

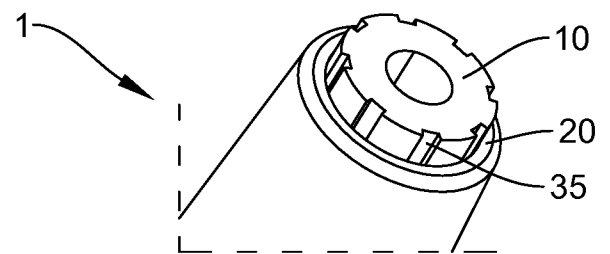


FIG. 3F

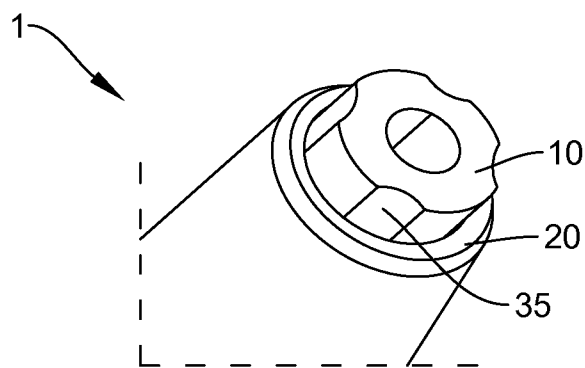


FIG. 3G

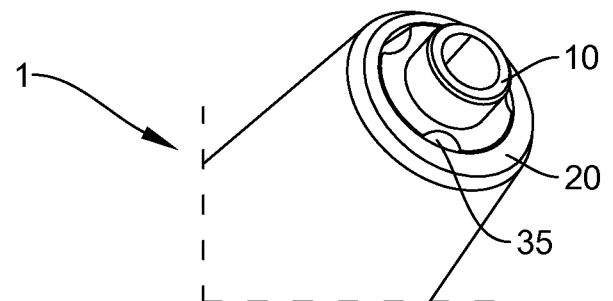


FIG. 3H

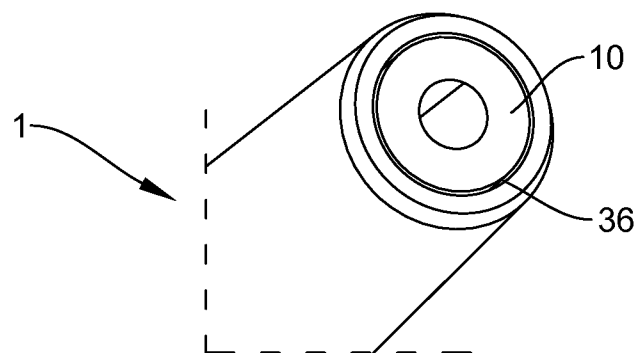


FIG. 3I

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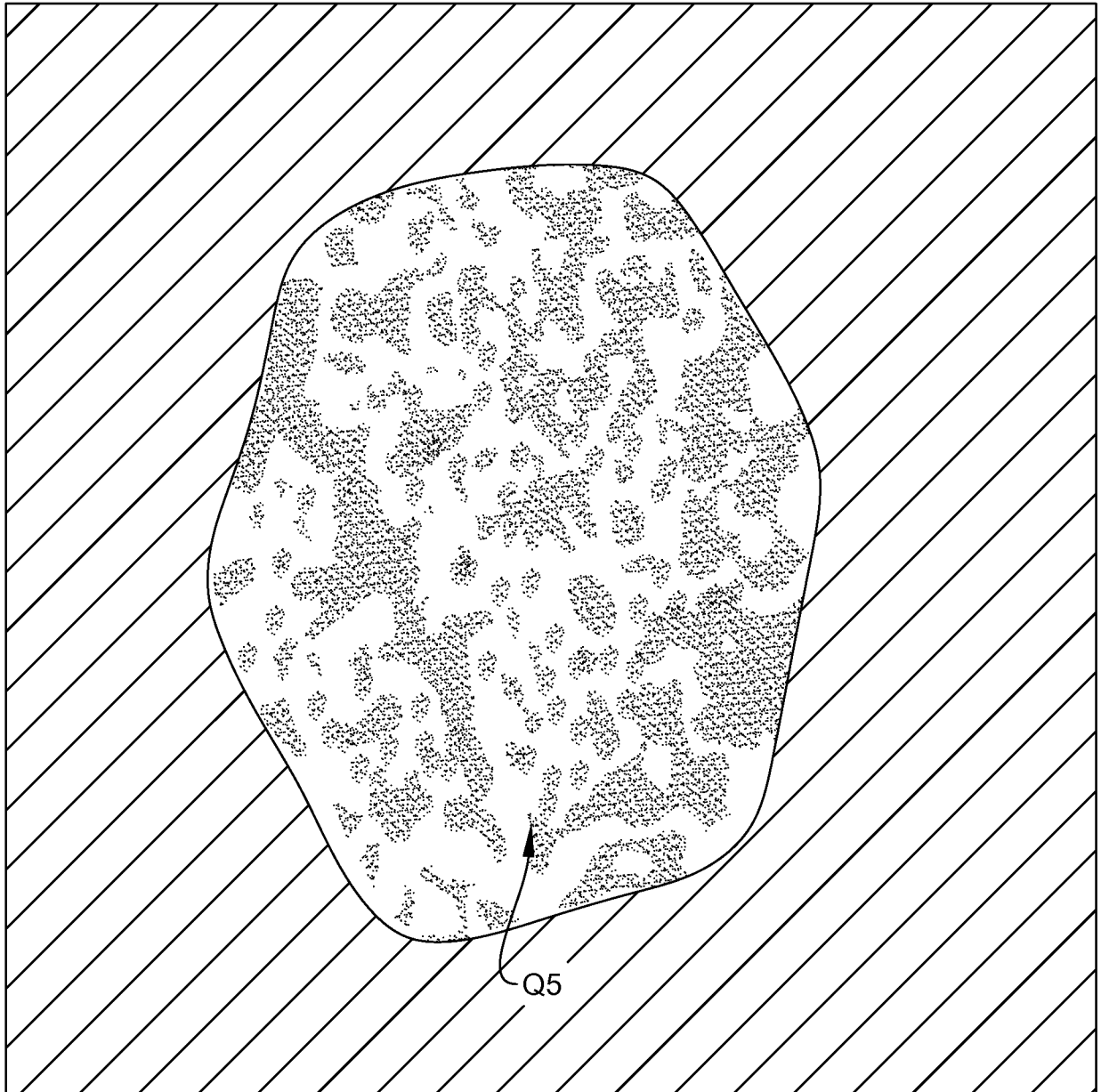


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/071217

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61C17/02 A61C3/025
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)
A61C

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 practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 882 638 A (BLACK ROBERT B) 13 May 1975 (1975-05-13) cited in the application figures -----	1-9,14
X	JP 2008 093080 A (SHOFU KK) 24 April 2008 (2008-04-24) paragraphs [0012], [0016]; figures -----	1,3-8,14
X	EP 0 248 638 A2 (MELLER MOSHE) 9 December 1987 (1987-12-09) column 9, line 62 - column 11, line 14; figure 17 -----	1-9,14
A	US 5 957 760 A (LASALLE RICHARD TODD [US] ET AL) 28 September 1999 (1999-09-28) figures -----	1-9,14



Further documents are listed in the continuation of Box C.



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 application or patent 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

20 September 2019

Date of mailing of the international search report

30/09/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Fouquet, Michèle

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2019/071217

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 10-13, 15, 16
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 10-13, 15, 16

The present application contains 16 claims, of which 4 claims are independent. Independent claims 1 and 10 relate both to a Nozzle system. However, the subject-matter of independent claim 10 is unclear (Art. 6 PCT) to such an extent, that no meaningful search of the whole claimed subject-matter can be carried out. The reason therefore is that in independent claim 10 "a fourth cross section" with a size is claimed, without a. defining the precise location of that fourth cross section (as defined on p. 13, line 23- p. 14, line 5) and b. no first, second and third cross sections have been defined in that independent claim 10. As such claim 10 and its depending claims are unclear.

Moreover, there is no unity between the subject-matter of independent claims 1 and 10 as the common concept linking both claims is part of the preamble of claim 1, being: a nozzle system for a powder blasting device comprising a first nozzle element for transporting a powder-gas mixture stream along a transporting direction (T) and a second nozzle element, wherein the second nozzle element surrounds the first nozzle element such that at least one channel is formed between the first nozzle element and the second nozzle element, wherein the channel is provided for transporting a liquid stream, wherein the first nozzle element and the second nozzle element are arranged such that in operation the powder-gas-mixture stream ejected by the first nozzle element is encased by the liquid stream ejected by the channel for forming an output stream/surface of the nozzle system.

Claim 1 does not comprise the feature of claim 10, reading "wherein the output surface has a fourth cross section, wherein the fourth cross section has a size between 0.3 and 0.4 mm²" and claim 10 does not comprise the features of claim 1, reading "wherein the first nozzle element has an acceleration part having a first cross section and a spreading part having a second cross section, wherein the spreading part is arranged downstream of the acceleration part, characterized in that the second cross section is larger than the first cross section". The common concept linking together the subject-matter of claims 1 and 10 is already disclosed in US3882638 (cited in the application on p. 1, lines 7-14) as following a nozzle system for a powder blasting device (fig. 3, title) comprising a first nozzle element (11) for transporting a powder-gas mixture stream along a transporting direction (T, 10) and a second nozzle element (13), wherein the second nozzle element surrounds the first nozzle element (fig. 4) such that at least one channel is formed between the first nozzle element and the second nozzle element, wherein the channel is provided for transporting a liquid stream, wherein the first nozzle element and the second nozzle element are arranged such that in operation the powder-gas-mixture stream ejected by the first nozzle element is encased by the liquid stream ejected by the channel for forming an output stream/surface of the nozzle system (fig. 3). EP0294548, also cited in the application on p. 1, discloses also this common concept in fig. 4.

The problem solved by the subject-matter of

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

claim 1 is as defined on p. 2, lines 4-6 and p. 2, line 29- p. 3, line 31, being reducing abrasivity of an output stream ejected without reducing efficiency or removing stains, tartar dental deposits and/or dental biofilms.

The problem solved by the subject-matter according to claim 10 is as defined on p. 14, lines 7-11, being forming droplets which increase a probability of the liquid to trap dust powder.

Consequently,
The application lacks unity within the meaning of Rule 13 PCT.

Claims

15 and 16 can not be searched as a. claim 15 does not comprise any method steps or any restricting use feature and b. because also claim 16 does not comprise any method steps but further defines a "fifth cross section" of the output stream (without defining a first, second, third and fourth cross section".

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/071217

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
US 3882638	A	13-05-1975	JP	S5037468 B2		02-12-1975
			JP	S5076883 A		23-06-1975
			US	3882638 A		13-05-1975

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			JP	2008093080 A		24-04-2008

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			US	4776794 A		11-10-1988

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			US	6273789 B1		14-08-2001
