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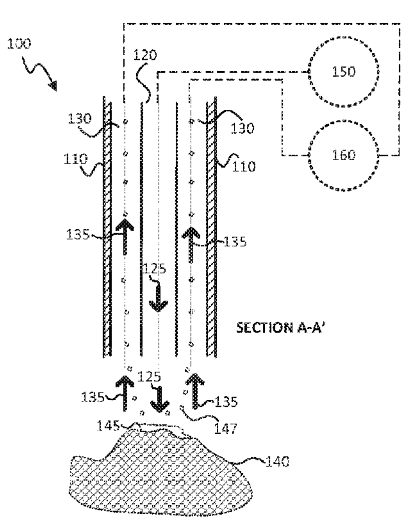

Fig. 1A

(57) Abstract: An example of an apparatus to decake a 3D printed part is disclosed. The apparatus comprises a housing including at least a conduit connectable to a gas source and at least a channel connectable to a vacuum source. The conduit, when in use, is to direct a gas flow to remove un-solidified build material particles from a surface of a 3D printed part. The channel, when in use, is to direct an airflow that generally surrounds the gas flow to extract the removed un-solidified build material particles.

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REMOVING BUILD MATERIAL PARTICLES

BACKGROUND

[0001] Some additive manufacturing or three-dimensional printing systems selectively solidify portions of successive layers of a powdered build material to generate 3D objects. After the generation of the 3D objects a decaking operation may be performed. A decaking operation comprises the separation of the 3D objects from the un-solidified build material that has not been used in the generation of the 3D objects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The present application may be more fully appreciated in connection with the following detailed description of non-limiting examples taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout and in which:

[0003] Fig. 1A is a schematic diagram showing an example of a front view of an apparatus to decake a 3D printed part.

[0004] Fig. 1B is a schematic diagram showing an example of a bottom view of an apparatus to decake a 3D printed part.

[0005] Fig. 1C is a schematic diagram showing another example of a bottom view of an apparatus to decake a 3D printed part.

[0006] Fig. 2 is a schematic diagram showing an example of a 3D cleaning station.

[0007] Fig. 3A is a schematic diagram showing another example of a 3D cleaning station.

[0008] Fig. 3B is a schematic diagram showing an example of a bottom view of a 3D cleaning station.

[0009] Fig. 3C is a schematic diagram showing another example of a bottom view of a 3D cleaning station.

[0010] Fig. 4 is a schematic diagram showing another example of a 3D cleaning station.

[0011] Fig. 5A is a schematic diagram showing another example of a 3D cleaning station.

[0012] Fig. 5B is a schematic diagram showing a bottom view of an example of a 3D cleaning station.

[0013] Fig. 6 is a schematic diagram showing another example of a 3D cleaning station.

[0014] Fig. 7 is a block diagram illustrating an example of a processor-based system to control a 3D cleaning station.

DETAILED DESCRIPTION

[0015] The following description is directed to various examples of additive manufacturing, or three-dimensional printing, apparatus and processes to generate high quality 3D objects. Throughout the present disclosure, the terms “a” and “an” are intended to denote at least one of a particular element. In addition, as used herein, the term “includes” means includes but not limited to, the term “including” means including but not limited to. The term “based on” means based at least in part on.

[0016] For simplicity, it is to be understood that in the present disclosure, elements with the same reference numerals in different figures may be structurally the same and may perform the same functionality.

[0017] Some examples of additive manufacturing use build material to generate 3D objects by selectively solidifying a plurality of layers of build material. Suitable powder-based build materials for use in examples herein may include, where appropriate, at least one of polymers, metal powder, ceramic powder such as for example, polyamides (e.g., PA11, PA12), Thermoplastic Polyurethane (TPU), and stainless-steel. Some additive manufacturing systems use build material in, for example, a powdered or granular form.

[0018] Different powders may have different characteristics, such as different average particle sizes, different minimum and maximum particle sizes, different coefficients of friction, different angle of repose, and the like. In some examples non-powdered build materials may be used such as gels, pastes, and slurries.

[0019] Some 3D printing systems comprise a 3D printer that selectively solidifies portions of a plurality of build material layers in a build chamber. The plurality of build material layers in the build chamber are referred hereinafter as a build bed. The build bed may comprise, after completion of a 3D printing process, solidified portions corresponding to the 3D objects and non-solidified portions corresponding to the build material that is not used for the generation of the 3D objects. In an example, the solidified portions are portions of the build bed that have been melted, coalesced, and cooled. In another example, the solidified portions are portions of the build bed that have been combined with a binder (e.g., thermal curable binder, UV curable binder) in a binder matrix. In some examples, to achieve the above-mentioned solidification, portions in which a binder has been ejected are subject to a curing stage, such as a thermal curing stage, that may be performed either in the printer or outside the printer.

[0020] The 3D objects from the build bed may be separated from the un-solidified build material. The separation of the 3D objects from the un-solidified build material is also known as decaking. In some examples, the decaking is performed in the 3D printer. In other examples, the decaking is performed in a 3D cleaning station. In some of the examples herein, a 3D cleaning station may further include build material processing operations, such as loading a build material store with build material. In other examples herein, the 3D cleaning station may not include the build material processing operations.

[0021] Referring now to the drawings, Fig. 1A is a schematic diagram showing an example of a vertical cross-section of an apparatus 100 to decake a 3D printed part 140. The illustrated example may correspond to the cut plane of the section A-A' of the example bottom view from Fig. 1B.

[0022] The apparatus 100 comprises a housing 110 including a cleaning channel 120 (also referred herein as conduit 120) and a return channel 130 (also referred herein as channel 130). The cleaning channel 120 may be any structure suitable for transporting a gas fluid such as air. The return channel 130 may be any structure suitable for transporting a mix of a gas fluid and build material particles. In some examples, the cleaning channel 120 and/or the return channel 130 may comprise a conduit, a pipe, a hose, or a duct.

[0023] The cleaning channel 120 is connectable to an external gas source 150 and the return channel 130 is connectable to a vacuum source 160. The gas source 150 is any device suitable for generating a gas flow 125 which is directed through the cleaning channel 120 towards a 3D printed part 140. The vacuum source 160 may be any device suitable for generating an airflow 135 through the return channel 130. Examples of the gas source 150 and/or vacuum source 160 may comprise pumps, fans, and the like.

[0024] The 3D printed part 140 (indicated as cross-linear hatching) is not part of the apparatus 100. The 3D printed part 140 is formed by solidified build material particles. Some un-solidified build material particles 145 may stick to a surface of the 3D printed part 140 during its generation.

[0025] The cleaning channel 120, when in use, is to direct the gas flow 125 towards the 3D printed part 140. The gas flow 125 is to remove, at least in part, un-solidified build material particles 145 from a surface of the 3D printed part 140. The particles from the un-solidified build material particles 145 which are removed by the gas flow 125 are referred hereinafter as particles 147. In some examples, the particles 147 may become airborne and form a particle cloud between the apparatus 100 and the 3D printed part 140.

[0026] The gas flow 125 may be formed from a gaseous fluid with high levels of purity (i.e., low amount of impurities flowing therein). In an example, the gas flow 125 has a purity level of above 98%. In another example, the gas flow 125 has a purity level of above 95%. In another example, the gas flow 125 has a purity level of above 90%. In another example, the gas flow 125 has a purity level of above 80%. In another example, the gas flow 125 has a purity level of above 70%.

[0027] When the gas flow 125 is directed towards a 3D printed part 140 through the cleaning channel 120, any impurities in the gas flow 125 may damage the 3D printed part 140 by, for example, causing erosion thereon. Therefore, a gas flow 125 with high levels of purity reduces damage caused to the 3D printed part 140 during the decaking operation.

[0028] The return channel 130, when in use, is to direct the airflow 135 to extract any removed un-solidified build material particles 147 through the return channel 130.

[0029] The airflow 135 extracts the particles 147, previously removed by the gas flow 125, to the return channel 130. In some examples, the airflow 135 may further extract un-solidified build material particles 145 not removed by the gas flow 125. The particles 147 in the return channel 130 are directed to the opposite end of the return channel 130 where they may be stored for recycling or may be discarded. The airflow 135 surrounding the gas flow 125 ensures that most of the particles 147 are extracted by the airflow 135 through the return channel 130, thereby preventing the removed particles from eroding the surface of the 3D printed part 140 and from reaching other areas from the working area.

[0030] Fig. 1B illustrates a bottom view example of the housing 110 from the apparatus 100. As shown, the cleaning channel 120 and a return channel 130 are axially concentric. In an example, the output nozzle of the cleaning channel 120 may be located at the center of the bottom of the apparatus. The airflow 135 generally surrounds the gas flow 125 around the axis of the gas flow 125. In the illustrated example, the airflow 135 fully surrounds the gas flow 125 around the axis of the gas flow 125.

[0031] In a different example, illustrated in Fig. 1C, a plurality of return channels 130A-F may be provided around the cleaning channel 120. In the example, six return channels 130A-F are shown, however in other examples other numbers of return channels may be used. In this example, return channels 130A-F are radially aligned around the axis of the cleaning channel 120. The cleaning channel 120 may be located at the center of the apparatus.

[0032] When the apparatus 100 is in use, the gas flow 125 and the airflow(s) 135 may be generated to generally surround the gas flow 125. In some examples, the airflow 135 partially surrounds the gas flow 125 with regards to the vertical axis (e.g., there may be gaps in between two consecutive return channels 130A-F).

[0033] In other examples, the relative position between the cleaning channel 120 and the return channel 130 may be different than the relative position depicted in the examples above. In an example, the return channel 130 may surround, at least partially, the cleaning channel 120. In other examples, the return channel 130 may not surround the cleaning channel 120, but the airflow 135 directed from the return channel 130 surrounds, at least in part, the gas flow 125 directed from the cleaning channel 120.

[0034] In an example, the gas flow 125 is controllable independently from the airflow 135 (by e.g., different controllers, different inlet valves). In other examples, however, the airflow 135 is controlled based on the gas flow 125. The speed of the gas flow 135 and the airflow 135 may depend on the size and geometry of the section in which the gas flow 135 or the airflow 135 flows through. For example, the gas flow 125 at the cleaning channel 120 may flow at a lower speed than the gas flow 125 at a nozzle at the end of the cleaning channel 120, given that the nozzle has a smaller section than the cleaning channel 120. The gas flow 125 speed and the airflow 135 speed may be controlled to be any suitable combination of speeds that allow each of the flows to perform the respective functionality described herein.

[0035] In some examples, the gas flow 125 in the cleaning channel 120 flows at a higher speed than the airflow 135 in the return channel 130. In another example, the airflow 135 in the return channel 130 flows at a higher speed than the gas flow 125 in the cleaning channel 120. In yet other examples, the gas flow 125 in the cleaning channel 120 flows at about the same speed than the airflow 135 in the return channel 130.

[0036] In an example, the gas flow generator 150 is controlled to generate a gas flow 125 in the cleaning channel 120 to have an average speed from about 0.01 m/s to about 1 m/s, for example 0.7 m/s. In another example, the gas flow generator 150 is controlled to generate a gas flow 125 in the cleaning channel 120 to have an average speed from about 0.1 m/s to about 0.5 m/s, for example 0.25 m/s. In yet another example, the gas flow generator 150 is controlled to generate a gas flow 125 in the cleaning channel 120 to have an average speed from about 0.2 m/s to about 0.4 m/s, for example 0.38 m/s.

[0037] Fig. 2 is a schematic diagram showing an example of a cross-section of a portion of a 3D cleaning station 200 comprising the apparatus 100 shown in Figure 1.

[0038] The 3D cleaning station 200 comprises a transport module 270 to transport at least one 3D printed part 140 with attached un-solidified build material 145 through the 3D cleaning station 200. For clarity reasons, the illustrated example comprises un-solidified build material particles 145 on the top portion of the 3D printed part 140, however it is to be understood that the 3D printed part 140 may be covered in un-solidified build material particles 145. The 3D printed part 140 may be moved along the 3D cleaning station 200 as indicated by the arrow 275 by the transport module 270. The transport module 270 may be implemented in a number of different ways, for example, as a conveyor belt, a moveable tray, or any other suitable mechanism that enables the transportation of the 3D printed part 140 through the 3D cleaning station 200.

[0039] The 3D cleaning station 200 includes the housing 110 including the cleaning channel 120 removably connected to the gas source 150 and a return channel 130 removably connected to the vacuum source 160. When in use, the cleaning channel 120 is to direct the gas flow 125 to remove, at least in part, un-solidified build material particles 145 from a surface of the 3D printed part 140 (e.g., particles 147). The return channel 130 is to direct the airflow 135, that generally surrounds the gas flow 125, to extract the particles 147.

[0040] In some examples, the 3D cleaning station 200 may comprise at least one of the gas source 150 and the vacuum source 160. In other examples, however, the gas source 150 and the vacuum source 160 are external to the cleaning station 200 but are respectively connectable to the cleaning channel 120 and the return channel 130.

[0041] In some examples, the 3D cleaning station 200 may comprise a plurality of the housings 110 located at different positions relative to the advancement location (i.e., axis X) of the transport module. The plurality of housings 110 are to remove and extract un-solidified build material particles 145 from the 3D printed part 140 as the 3D printed part 140 moves through the 3D cleaning station 200.

[0042] Additionally, the distance in which the distal end of the housing 110 is positioned relative to, for example, a 3D printed part 140 may be adjustable. Adjusting the height between the distal end of the housing 110 and the 3D printed part 140 may enable the housing 110 to be located at a preset distance from the 3D printed part 140.

[0043] A number of different mechanisms may be used to adapt the distance of the housing 110 with regards of the vertical axis. In an example, the distance in which the housing 110 is positioned may be adjusted by a manual mechanism operated by a user. A manual mechanism may include at least one of a ramp, a pin, a lever, a piston, or any suitable mechanism to adjust manually the distance between the distal end of the housing 110 and the 3D printed part 140. In another example, the distance in which the distal end of the housing 110 is positioned may be adjusted by an automatic driving mechanism including, for example, a motor. In some of the examples herein, the distal end of the housing 110 is to be adjusted to be at a distance from the 3D printed part from about 5mm to about 100mm. In other examples, the distal end of the housing 110 is to be adjusted to be at a distance from the surface of a portion of the 3D printed part being cleaned from about 5mm to about 50mm. In yet other examples, the distal end of the housing 110 is to be adjusted to be at a distance from the 3D printed part from about 10mm to about 40mm.

[0044] Additionally, the 3D cleaning station 200 may comprise a positioning mechanism (not shown) to move the housing 110 with respect to the 3D cleaning station 200. In an example, the positioning mechanism may move the housing 110 with regard to the vertical axis (i.e., Z axis). Additionally, or alternatively, the positioning mechanism may move the housing 110 with regard to the transportation movement axis (i.e., X axis). Additionally, or alternatively, the positioning mechanism may move the housing 100 with respect to the width (e.g., Y axis, not shown) from the transport module. In some additional examples, the positioning mechanism may be automatically adjusted to be located at a preset distance from the uppermost surface of the 3D printed part 140 as the 3D printed part 140 moves through the 3D cleaning station 200 by means of, for example, a height sensor connectable to the positioning mechanism.

[0045] Fig. 3A is a schematic diagram showing another example of a cross-section of a section of a 3D cleaning station 300. In some examples, the 3D cleaning station 300 may include the apparatus 100 from Fig. 1A. In other examples, the 3D cleaning station 300 may include elements from the 3D cleaning station 200 from Fig. 2.

[0046] The housing 110 comprises a cleaning channel 120 (visible in Figure 3B) and a plurality of return channels, for example a first return channel 130M and a second return channel 130N. The return channels 130M and 130N may be the same as or similar to the return channel 130 from Fig. 1A. The cleaning channel 120 from the 3D cleaning station 300 forms an airknife that spans substantially the full width of the transport module 270 (i.e., axis Y). In an example, the airknife has a length of from about 250mm to about 400mm. In another example, the airknife has a length of from about 100mm to about 500mm. In yet another example, the airknife has a length of from about 275mm to about 350mm.

[0047] In the examples herein, the term airknife should be regarded to include any suitable device to provide a uniform sheet of laminar gas flow. Some examples of airknifes are regarded to be a pressurized air plenum containing a plurality of holes or continuous slots through which the gas flow 125 is ejected in a laminar flow pattern.

[0048] Additionally, to increase the decaking speed, the 3D cleaning station 300 may further comprise a plurality of the housings 110 located at different positions relative to the length (axis X) of the transport module 270 to remove and extract un-solidified build material particles 145 from the 3D printed part 140 as the 3D printed part 140 moves along the 3D cleaning station.

[0049] Fig. 3B illustrates a bottom view example of the housing 110 from Fig. 3A. The illustrated example may correspond to the cut plane of the section B-B' of the example vertical cross-section view from Fig. 3A. In the bottom-view example of Fig. 3B the housing 110, at the middle portion, comprises a strip formed from an elongated cleaning channel aperture 120. The housing 110 further comprises a first elongated return channel aperture 130M located at a first side of the elongated cleaning channel aperture 120, and a second elongated return channel aperture 130N located at a second side of the elongated channel aperture 120. In the illustrated examples, the return channel apertures 130M and 130N generally surround the cleaning channel 120.

[0050] Fig. 3C illustrates a bottom view example of an alternative rearrangement of the cleaning channel 120 and plurality of return channels of the housing 110 from Fig. 3A. In the bottom-view example of Fig. 3C, at the middle portion, the housing 110 comprises a strip formed from a plurality of cleaning channel nozzles 120A-F. The housing 110 further comprises a first additional strip of a first plurality of return channel nozzles 130A-F located at a first side of the cleaning channel nozzles 120A-F, and a second additional strip of a second plurality of return channel nozzles 130G-L located at a second side of the cleaning channel nozzles 120A-F.

[0051] Fig. 4 is a diagram showing a cross-section of another example of a cleaning apparatus 400.

[0052] The 3D cleaning station 400 comprises the housing 110 including the cleaning channel 120 that is at least partially surrounded by the return channel 130. The cleaning channel 120 and the return channel 130 are located around a central axis 490. In an example, the distal end of the cleaning channel 120 is a nozzle structure which corresponds with the central axis 490. The distal end from the return channel 130 is, at least partially, coaxially concentric to the distal end of the cleaning channel 120. Thereby, the return channel 130 generally surrounds the cleaning channel 120. The cleaning channel 120 surrounding the return channel 130 ensures that most part of the particles 147 are driven by the airflow 135 through the return channel 130, thereby preventing the removed particles from eroding the surface of the 3D printed part 140. Additionally, since most part of the particles 147 are driven by the airflow 135, it may prevent the particles 147 from reaching other areas from the working area of the apparatus 110, thereby providing a cleaner working environment.

[0053] Additionally, to increase the decaking speed, the 3D cleaning station 400 may further comprise a plurality of the housings 110 located at different positions relative to the transport module 270 to remove and extract un-solidified build material particles 145 from the 3D printed part 140 as the 3D printed part 140 moves along the 3D cleaning station.

[0054] Fig. 5A is a schematic diagram showing another example of a 3D cleaning station 500. Respectively, Fig. 5B illustrates a bottom-view of a housing 510 from the 3D cleaning station 500.

[0055] The housing 510 from the 3D cleaning station 500 further comprises a skirt 330. In the examples herein, a skirt is a part from the housing 510 that increases from a constant width for most of the housing 510, and then expands the width of the housing 510 as it approaches to the distal end of the housing 510. In an example, the skirt 330 is located at the lower position of the housing 510. The distal end of the housing 510 including the skirt 330 may correspond to the return channel 130 extension from the bottom-view illustrated in Fig. 5B. The skirt 330 defines an aperture around the cleaning channel 120. In an example, the aperture of the skirt

330 is from about 200mm to about 400mm. In another example, the aperture of the skirt 330 is from about 100mm to about 200mm. In another example, the aperture of the skirt 330 is from about 50mm to about 100mm. In yet another example, the aperture of the skirt 300 is less than about 50mm.

[0056] The skirt 330 provides a wider surface in which the gas flow 125 and/or airflow 135 operate. In some examples, however, a wider skirt 330 may involve a higher vacuum power from the vacuum source 160 (not shown) to counterpart the loss of airflow 135 speed caused by the wider aperture of the skirt 330. The skirt 330 may ensure that most of the particles 147 are transported by the airflow 135 into the apparatus 510, thereby enhancing the efficiency with which the return channel 130 prevents the removed particles from eroding the surface of the 3D printed part 140. Additionally, since most part of the particles 147 are driven by the airflow 135, it may prevent the particles 147 from reaching other areas from the working area of the apparatus 510, thereby providing a cleaner working environment.

[0057] In some examples, the skirt 330 may be removable and interchangeable with a different skirt 330 with a different aperture. Additionally, some examples of the skirt 330 may be generated through 3D printing means in order to accurately span, at least in part, to the surface of subsequent 3D objects to be printed. Alternatively, some examples of skirt 330 may be generated through other technologies, such as injection molding.

[0058] Fig. 6 is a diagram showing another a cross-section of a 3D cleaning station 600 according to one example.

[0059] The 3D cleaning station 600 comprises a series of housings 610A-610D. Each housing 610A-D constitutes an individual cleaning element. The series of cleaning elements 610A-D collectively span up to substantially the full width (axis Y) of the transport module 270. Each cleaning element comprises a cleaning channel 120 and a return channel 130 with respective functionalities as described above, to enable the 3D cleaning station 600 to perform decaking operations.

[0060] Additionally, to increase the decaking speed, the 3D cleaning station 600 may comprise a plurality of series of cleaning elements (e.g., cleaning elements 610A-610D) located at different positions relative to the length of the transport module (i.e., X axis) to remove and extract un-solidified build material particles 145 from the 3D printed part 140, as the 3D printed part 140 moves along the 3D cleaning station.

[0061] FIG. 7 is a block diagram illustrating a processor-based system 700 that includes a machine-readable medium 720 encoded with instructions to control a 3D cleaning station (e.g., 3D cleaning station 200 from Fig. 2). In some implementations, the system 700 is a processor-based system and may include a processor 710 coupled to a machine-readable medium 720. The processor 710 may include a micro-controller.

[0062] The machine-readable medium 720 may be any medium suitable for storing executable instructions, such as a random-access memory (RAM), electrically erasable programmable read-only memory (EEPROM), flash memory, hard disk drives, optical disks, and the like. In some example implementations, the machine-readable medium 720 may be a tangible, non-transitory medium, where the term “non-transitory” does not encompass transitory propagating signals. The machine-readable medium 720 may be disposed within the processor-based system 700, as shown in FIG. 7, in which case the executable instructions may be deemed “installed” on the system 700. Alternatively, the machine-readable medium 720 may be a portable (e.g., external) storage medium, for example, that allows system 700 to remotely execute the instructions or download the instructions from the storage medium. In this case, the executable instructions may be part of an “installation package”. As described further herein below, the machine-readable medium may be encoded with a set of executable instructions 721-723.

[0063] Instructions 721, when executed by the processor 710, may cause the processor 710 to control a transport module (e.g., transport module 270) to move through a 3D cleaning station (e.g., 3D cleaning station 200 from Fig. 2). In an example, the transport module may move in a continuous manner. In other example, the transport module may move periodically.

[0064] Instructions 722, when executed by the processor 710, may cause the processor 710 to control a gas source (e.g., gas source 150) to generate a gas flow (e.g., gas flow 125) which is directed through the conduit (e.g., channel 120) towards the transport module to remove un-solidified build material particles (e.g., un-solidified build material particles 145) from a 3D printed part (e.g., 3D printed part 140) placed thereon.

[0065] Instructions 723, when executed by the processor 710, may cause the processor 710 to control a vacuum source (e.g., vacuum source 160) to direct an airflow (e.g., airflow 135) through the channel (e.g., channel 130) that generally surrounds the gas flow to extract the removed un-solidified build material particles (e.g., particles 147).

[0066] As used herein, the terms “about” and “substantially” are used to provide flexibility to a numerical range endpoint by providing that a given value may be, for example, an additional 20% more or an additional 20% less than the endpoints of the range. The degree of flexibility of this term can be dictated by the particular variable and would be within the knowledge of those skilled in the art to determine based on experience and the associated description herein.

[0067] The drawings in the examples of the present disclosure are some examples. It should be noted that some units and functions of the procedure may be combined into one unit or further divided into multiple sub-units. What has been described and illustrated herein is an example of the disclosure along with some of its variations. The terms, descriptions and figures used herein are set forth by way of illustration. Many variations are possible within the scope of the disclosure, which is intended to be defined by the following claims and their equivalents.

[0068] There have been described example implementations with the following sets of features:

[0069] Feature set 1: A 3D cleaning station comprising:

a transport module to transport at least one 3D printed part with un-solidified build material through the 3D cleaning station;

a housing including at least a conduit connectable to a gas source and at least a channel connectable to a vacuum source;

the conduit, when in use, to direct a gas flow to remove un-solidified build material particles from a surface of the 3D printed part; and

the channel, when in use, to direct an airflow that generally surrounds the gas flow to extract the removed un-solidified build material particles.

[0070] Feature set 2: A 3D cleaning station with feature set 1, further comprising a plurality of the housings located at different positions relative to the transport module to remove and extract un-solidified build material particles from the 3D printed part as the 3D printed part moves through the 3D cleaning station.

[0071] Feature set 3: A 3D cleaning station with any preceding feature set 1 or 2, further comprising a positioning mechanism to move the housing with respect to the 3D cleaning station.

[0072] Feature set 4: A 3D cleaning station with any preceding feature set 1 to 3, further comprising the gas source and the vacuum source respectively connected to the conduit and the channel.

[0073] Feature set 5: A 3D cleaning station with any preceding feature set 1 to 4, wherein the conduit forms an airknife that spans substantially the full width of the transport module.

[0074] Feature set 6: A 3D cleaning station with any preceding feature set 1 to 5, wherein the gas in the conduit flows at a higher speed than the airflow in the channel.

[0075] Feature set 7: A 3D cleaning station with any preceding feature set 1 to 6, wherein the conduit and the channel are located around a central axis.

[0076] Feature set 8: A 3D cleaning station with any preceding feature set 1 to 7, wherein at least one of a conduit end and a channel end comprises a nozzle opening.

[0077] Feature set 9: A 3D cleaning station with any preceding feature set 1 to 8, further comprising an array of conduits and channels to span substantially a full width of the transport module.

[0078] Feature set 10: A 3D cleaning station with any preceding feature set 1 to 9, wherein the housing further comprises a skirt defining an aperture that spans, at least in part, a surface of the 3D printed part.

[0079] Feature set 11: An apparatus comprising:

a housing including at least a conduit connectable to a gas source and at least a channel connectable to a vacuum source;

the conduit, when in use, to direct a gas flow to remove un-solidified build material particles from a surface of a 3D printed part; and

the channel, when in use, to direct an airflow that generally surrounds the gas flow to extract the removed un-solidified build material particles.

[0080] Feature set 12: An apparatus with preceding feature set 11, wherein the conduit and the channel are located around a central axis.

[0081] Feature set 13: An apparatus with any preceding feature set 11 to 12, wherein the gas flow in the conduit is to have an average speed from about 0.01 m/s to about 1 m/s.

[0082] Feature set 14: An apparatus with any preceding feature set 11 to 13, wherein the distance in which the housing is positioned relative to the 3D printed part is adjustable.

[0083] Feature set 15: A non-transitory machine-readable medium storing instructions executable by a processor, the non-transitory machine-readable medium comprising:

instructions to control a transport module to move through a 3D cleaning station;

instructions to control a gas source to generate a gas flow towards the transport module to remove un-solidified build material particles from a 3D printed part placed thereon; and

instructions to control a vacuum source to direct an airflow that generally surrounds the gas flow to extract the removed un-solidified build material particles.

CLAIMS

WHAT IT IS CLAIMED IS:

1. A 3D cleaning station comprising:
   a transport module to transport at least one 3D printed part with un-solidified build material through the 3D cleaning station;
   a housing including at least a conduit connectable to a gas source and at least a channel connectable to a vacuum source;
   the conduit, when in use, to direct a gas flow to remove un-solidified build material particles from a surface of the 3D printed part; and
   the channel, when in use, to direct an airflow that generally surrounds the gas flow to extract the removed un-solidified build material particles.

2. The 3D cleaning station of claim 1, further comprising a plurality of the housings located at different positions relative to the transport module to remove and extract un-solidified build material particles from the 3D printed part as the 3D printed part moves through the 3D cleaning station.

3. The 3D cleaning station of claim 1, further comprising a positioning mechanism to move the housing with respect to the 3D cleaning station.

4. The 3D cleaning station of claim 1, further comprising the gas source and the vacuum source respectively connected to the conduit and the channel.

5. The 3D cleaning station of claim 1, wherein the conduit forms an airknife that spans substantially the full width of the transport module.

6. The 3D cleaning station of claim 1, wherein the gas in the conduit flows at a higher speed than the airflow in the channel.

7. The 3D cleaning station of claim 1, wherein the conduit and the channel are located around a central axis.

8. The 3D cleaning station of claim 1, wherein at least one of a conduit end and a channel end comprises a nozzle opening.

9. The 3D cleaning station of claim 8, further comprising an array of conduits and channels to span substantially a full width of the transport module.

10. The 3D cleaning station of claim 1, wherein the housing further comprises a skirt defining an aperture that spans, at least in part, a surface of the 3D printed part.

11. An apparatus to decake a 3D printed part comprising:

a housing including at least a conduit connectable to a gas source and at least a channel connectable to a vacuum source;

the conduit, when in use, to direct a gas flow to remove un-solidified build material particles from a surface of a 3D printed part; and

the channel, when in use, to direct an airflow that generally surrounds the gas flow to extract the removed un-solidified build material particles.

12. The apparatus of claim 11, wherein the conduit and the channel are located around a central axis.

13. The apparatus of claim 11, wherein the gas flow in the conduit is to have an average speed from about 0.01 m/s to about 1 m/s.

14. The apparatus of claim 1, wherein the distance in which the housing is positioned relative to the 3D printed part is adjustable.

15. A non-transitory machine-readable medium storing instructions executable by a processor, the non-transitory machine-readable medium comprising:

instructions to control a transport module to move through a 3D cleaning station;

instructions to control a gas source to generate a gas flow towards the transport module to remove un-solidified build material particles from a 3D printed part placed thereon; and

instructions to control a vacuum source to direct an airflow that generally surrounds the gas flow to extract the removed un-solidified build material particles.

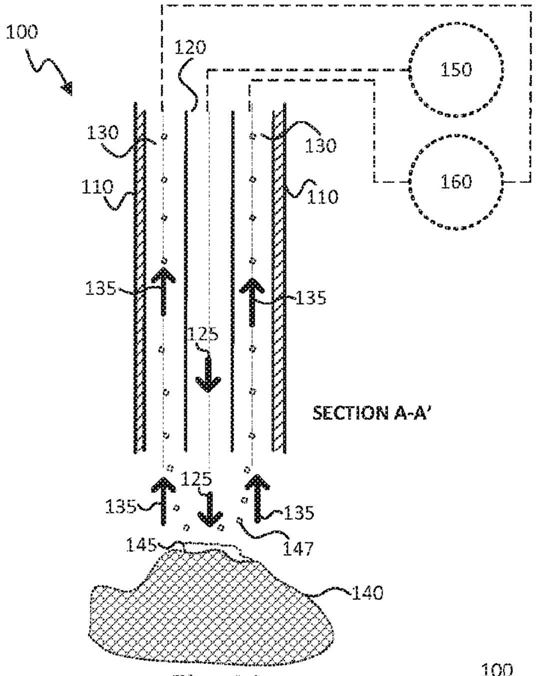

Fig. 1A

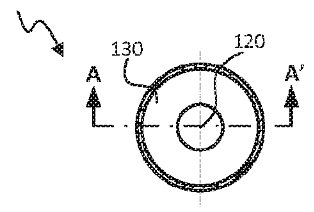

Fig. 1B

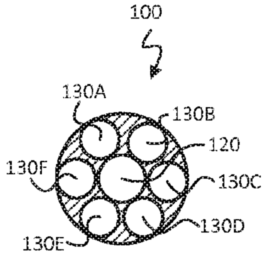

Fig. 1C

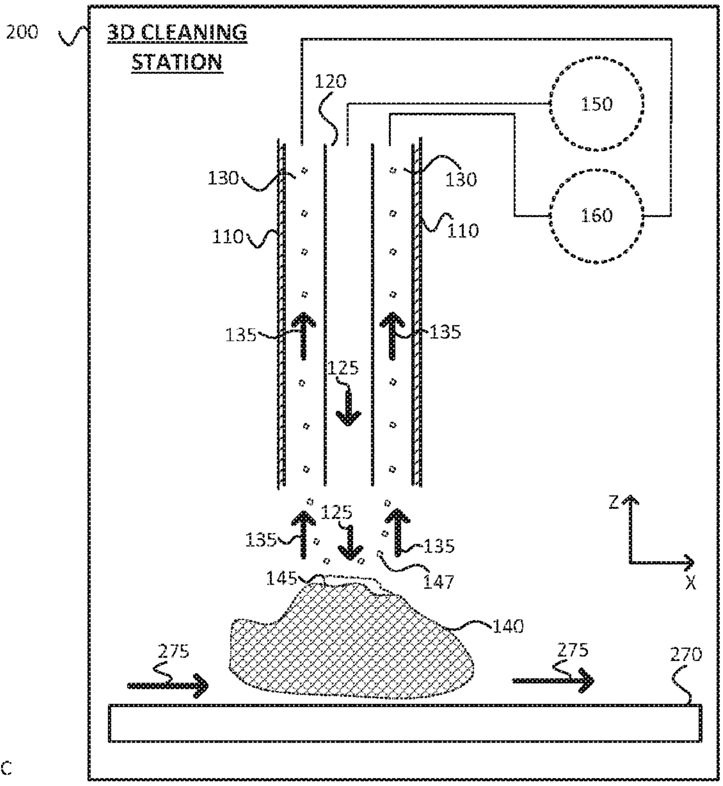

Fig. 2

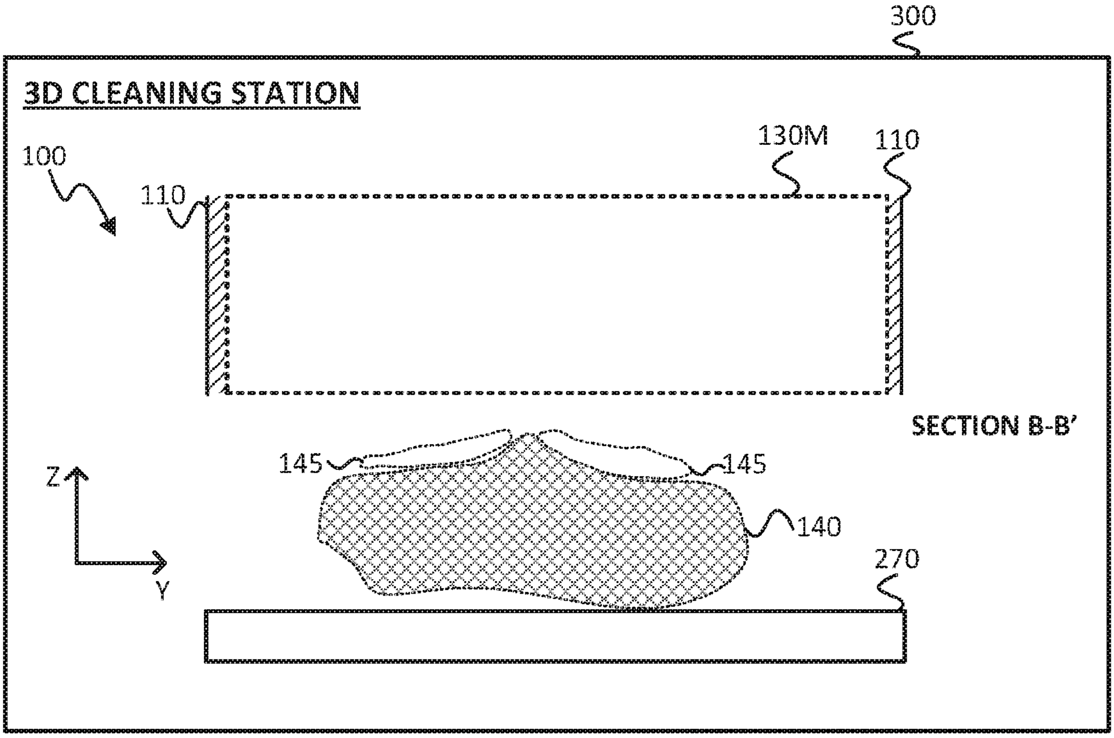

Fig. 3A

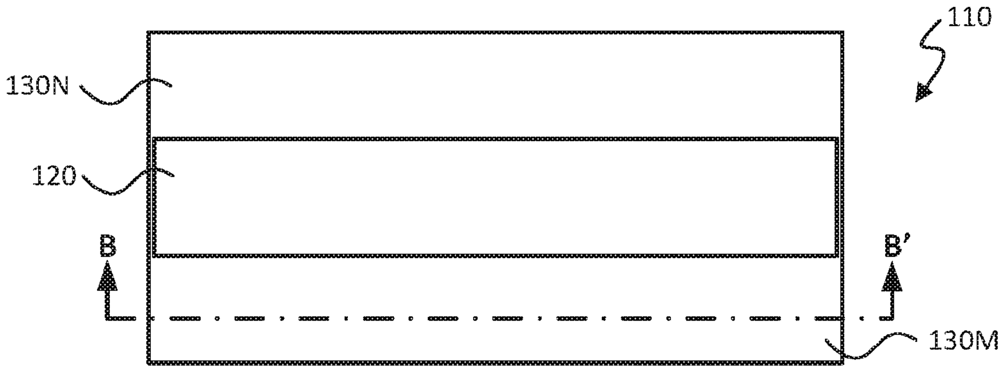

Fig. 3B

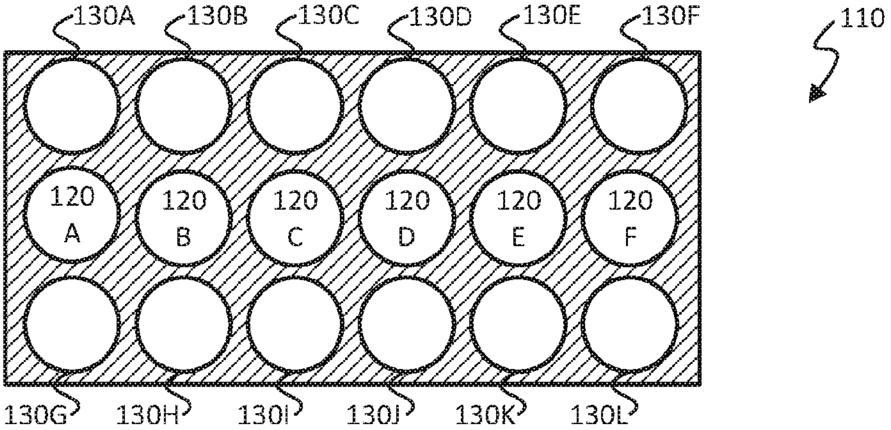

Fig. 3C

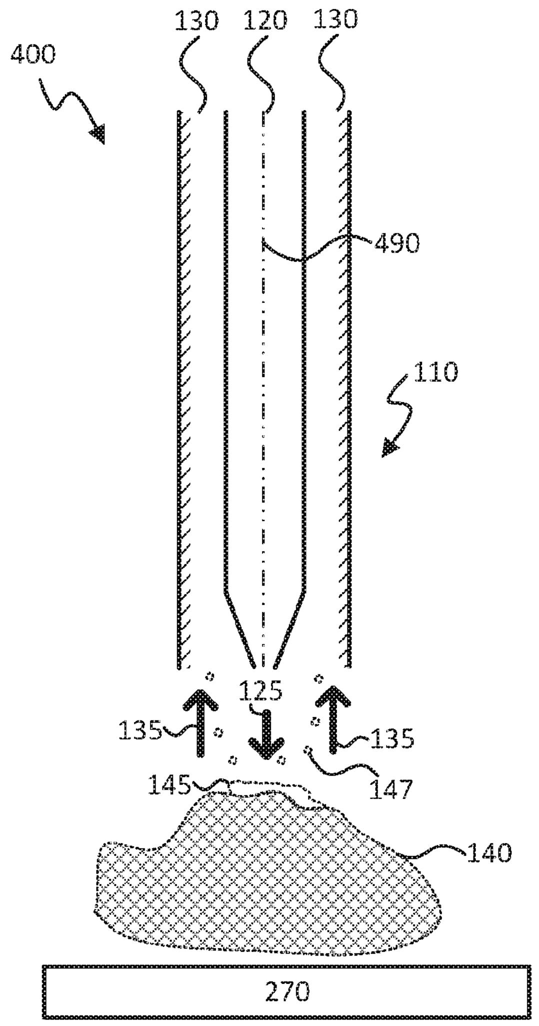

Fig. 4

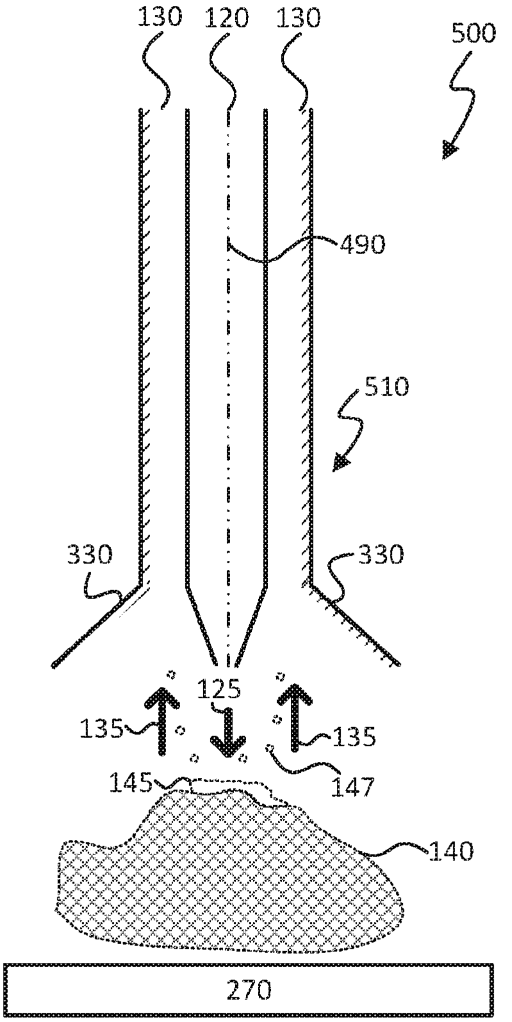

Fig. 5A

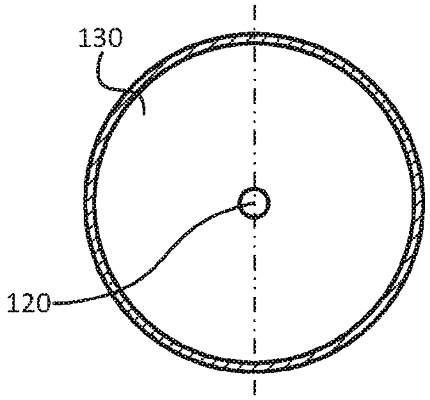

Fig. 5B

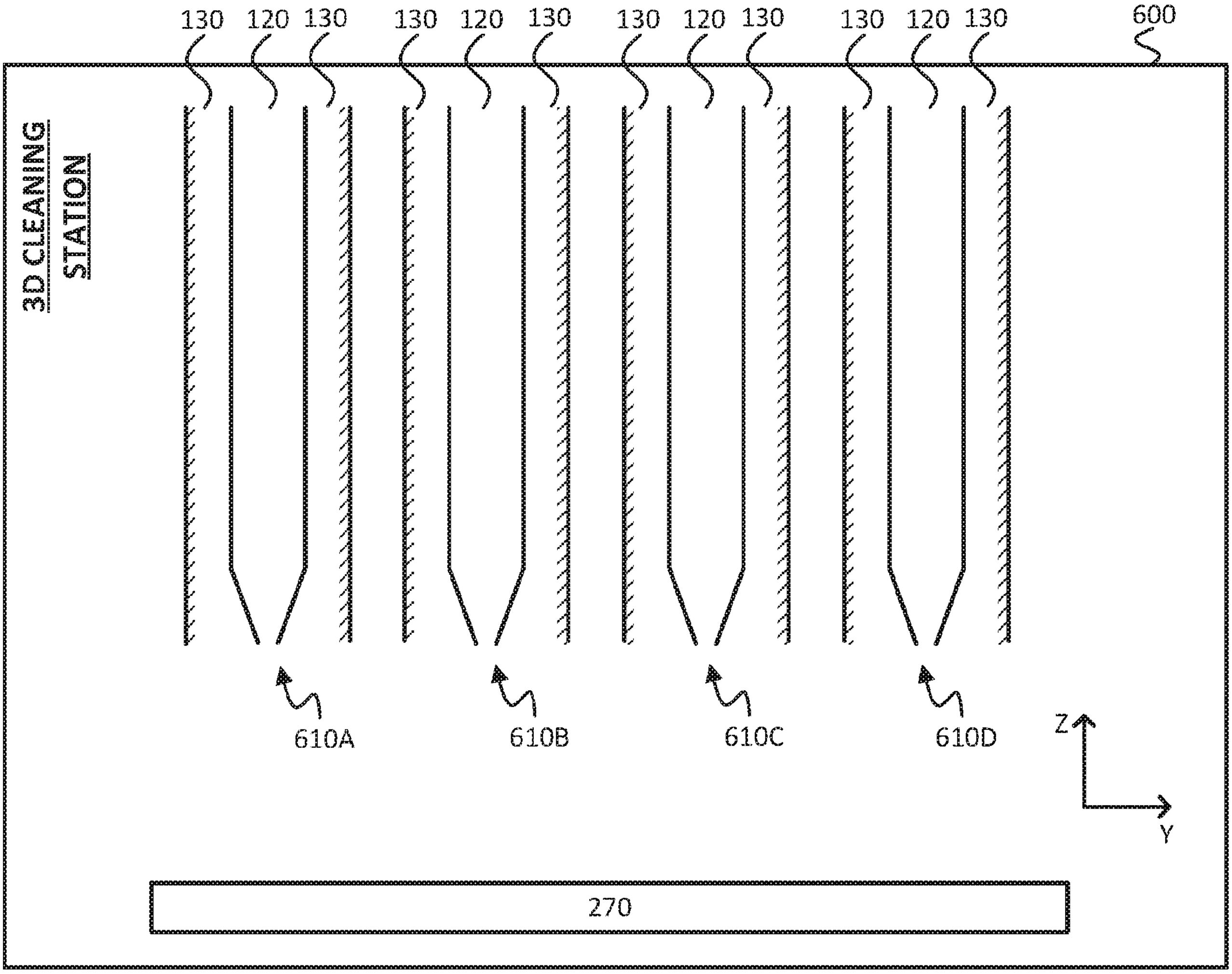
130
120
130
130
120
130
130
120
130
130
120
130
600
3D CLEANING STATION
610A
610B
610C
610D
Z
Y
270

Fig. 6

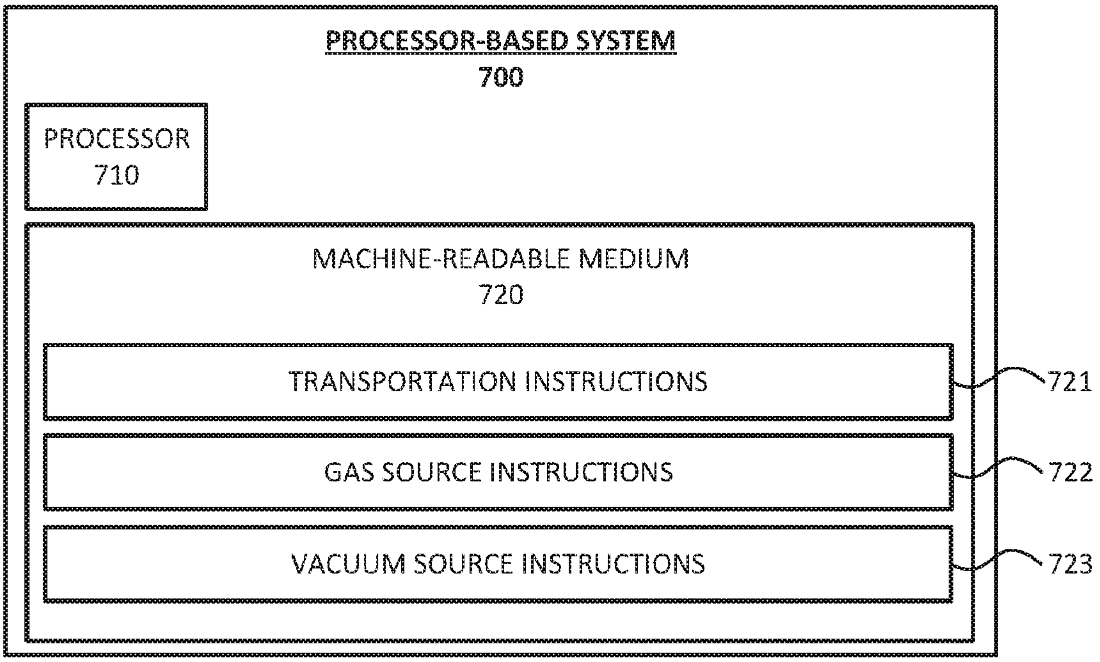
PROCESSOR-BASED SYSTEM
700
PROCESSOR
710
MACHINE-READABLE MEDIUM
720
TRANSPORTATION INSTRUCTIONS
721
GAS SOURCE INSTRUCTIONS
722
VACUUM SOURCE INSTRUCTIONS
723

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2019/052909

A. CLASSIFICATION OF SUBJECT MATTER

***B33Y 44/00** (2015.01)*
***B08B 5/04** (2006.01)*
***B29C 64/379** (2017.01)*

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)

B08B 3/02, 5/02, B29C 64/35, 64/379, B33Y 44/00, B08B 5/04

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)

PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 10391712 B2 (XEROX CORPORATION) 27.08.2019, col. 3, line 14 - col. 4, l line 36, fig. 1	1-9, 11-14 15 10
Y	US 1772492 A (THE TABULATING MACHINE COMPANY) 12.08.1930	15
A	US 5782252 A (THE MART CORPORATION) 21.07.1998	1-15
A	RU 2524603 C2 (MAMONTOV MIKHAIL OLEGOVICH et al.) 27.07.2014	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"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
"A"	document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier document but published on or after the international filing date		
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"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
"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	"&"	document member of the same patent family

Date of the actual completion of the international search 18 February 2020 (18.02.2020)	Date of mailing of the international search report 23 April 2020 (23.04.2020)
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer V. Podshibikhin Telephone No. 8(495) 531-64-81