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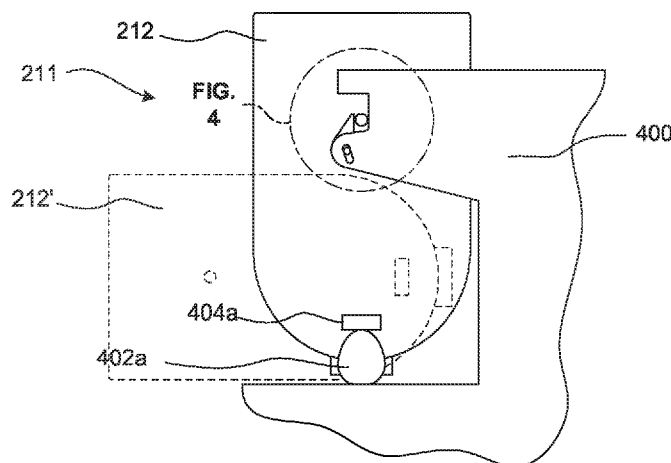


Figure 3

(57) Abstract: A mixer unit is described, comprising a support, a mixing container which includes a mixing device, and first and second load cells mounted on opposed sides of the mixing container between the mixing container and the support. The mixing container is to receive and mix unfused build materials for a 3D printing system from at least two different sources. The mixing container is mounted to the support in a manner constraining to vertical movement and such that all vertical forces from the mixing container pass through the load cells to the support. In this manner, a vertical force of the mixing container acting on the support is measured to weigh the contents of the mixing container. A method of mixing unfused build materials for a 3D printing system in a predefined weight ratio using the mixer unit is also described.



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MIXER UNIT

BACKGROUND

[0001] Additive manufacturing systems that generate three-dimensional objects on a layer-by-layer basis have been proposed as a potentially convenient way to produce three-dimensional objects in small quantities.

[0002] The quality of objects produced by additive manufacturing systems can vary, and can depend on the quality of build materials supplied to a production area. In certain scenarios, it can be desirable to supply a mix of different build materials from different sources. The quality of the produced objects can therefore be dependent on the quality of the mix.

BRIEF DESCRIPTION

[0003] Examples are further described hereinafter with reference to the accompanying drawings, in which:

Figure 1A schematically illustrates an example of a three dimensional (3D) printing system;

Figure 1B schematically illustrates the material management station of the example of Figure 1A;

Figure 1C schematically illustrates a working area of the material management station of the example of Figure 1B;

Figure 2A schematically illustrates an internal circuit diagram of one example of a material management station;

Figure 2B is a table schematically illustrating valve setting information for the material management station internal circuit of Figure 2A;

Figure 2C schematically illustrates a build material trap geometry used in tanks of the material management station internal circuit of Figure 2A;

Figure 3 schematically illustrates a mixer unit according to one example;

Figure 4 is a detail view of a latch portion of the example mixer unit of Figure 3;

Figure 5 is a cross-sectional view through the example mixer unit of Figure 3;

Figure 6 is a top plan view of the example mixer unit of Figure 5;

Figure 7 schematically illustrates the vertical forces acting on an example mixing container of the mixer unit of Figure 3;

Figure 8 schematically illustrates a build material management system according to one example; and

Figure 9 is a flow diagram outlining a method of mixing unfused build materials for a 3D printing system in a predefined weight ratio according to one example.

DETAILED DESCRIPTION

[0004] As shown in Figure 1A, a three dimensional (3D) printing system 100 (or additive manufacturing system) according to one example can include a trolley 102, a 3D printer 104 and a material management system in the form of a

material management station 106. The material management station 106 manages build material.

[0005] The trolley 102 is arranged to slot into a docking position in the printer 104 allow the printer 104 to generate a 3D object within the trolley. The trolley 102 is also arranged to also slot (at a different time) into a docking position 107 in the material management station 106. The trolley 102 may be docked in the material management station 106 prior to a 3D printing process to load the trolley with build material in preparation for a 3D printing process.

[0006] The build material loaded into the trolley may include recycled or recovered build material from a previous printing process, fresh build material or a portion of fresh and recycled build material. Some build materials may be non-recyclable and hence in this case no recovered build material will be used to load the trolley. The build material may be or include, for example, powdered metal materials, powdered composited materials, powder ceramic materials, powdered glass materials, powdered resin material, powdered polymer materials and the like. In some examples where the build material is a powder-based build material, the term powder-based materials is intended to encompass both dry and wet powder-based materials, particulate materials and granular materials. It should be understood that the examples described herein are not limited to powder-based materials, and may be used, with suitable modification if appropriate, with other suitable build materials. In other examples, the build material may be in the form of pellets, or any other suitable form of build material, for instance.

[0007] Returning to Figure 1A, the trolley 102 may also be docked in the docking position 107 in the material management station 106 (shown without the trolley 102 docked in Figure 1A) to clean up at least some components of the trolley 102 after it has been used in a 3D printing production process. The clean-up process may involve recovery and storage in the material management station 106 of unfused build material from the previous print job for subsequent reuse. During a 3D printing process a portion of the supplied build

material may be fused to form the 3D object, whilst a remaining portion of the supplied build material may remain unfused (non-fused) and potentially recyclable, depending on the type of build material used. Some processing of the unfused build material may be performed by the material management station 106 prior to storage for recycling, to reduce any agglomeration for example.

[0008] It will be understood that the material management station 106 may also include an access panel (not shown) to cover the docking position 107 when the trolley 102 is fully docked with the material management station 106 and when the trolley 102 is fully removed from the material management station 106.

[0009] One material management station 106 can be used to service any number of different 3D printers. A given 3D printer may interchangeably use any number of trolleys 102, for example, utilising different trolleys for different build materials. The material management station 106 can purge a trolley 102 of a given build material after a 3D printing production process, allowing it to be filled with a different build material for a subsequent 3D printing production run. Purging of the trolley 102 may also involve purging of the material management station 106 or alternatively, it may involve separation of different build materials in the material management station 106 to prevent contamination of one build material type with another.

[0010] The trolley 102 in this example has a build platform 122 on which an object being manufactured is constructed. The trolley 102 also comprises a build material store 124 (situated beneath a build platform 122 in this example. The build platform 122 may be arranged to have an actuation mechanism (not shown) allowing it, when it is docked in the printer 104 and during a 3D printing production process, to gradually move down, such as in a step-wise manner, towards the base of the trolley 102 as the printing of the 3D object progresses and as the build material store 124 within the trolley 102 becomes depleted. This provides progressively more distance between the build platform 122 and the print carriages (not shown) to accommodate the 3D object being

manufactured. The size of an object being printed may increase progressively as it is build up layer-by-layer in the 3D printing process in this example.

[0011] The 3D printer 104 of this example can generate a 3D object by using a build material depositor carriage (not shown) to form layers of build material onto the build platform 122. Certain regions of each deposited layer are fused by the printer 104 to progressively form the object according to object-specifying data. The object-specifying data are based on a 3D shape of the object and may also provide object property data such as strength or roughness corresponding to the whole object or part(s) of the 3D object. In examples, the desired 3D object properties may also be supplied to the 3D printer 104 via a user interface, via a software driver or via predetermined object property data stored in a memory.

[0012] After a layer of the build material has been deposited on the build platform 122 by the printer 104, a page-wide array of thermal (or piezo) printheads on a carriage (not shown) of the 3D printer 104 can traverse the build platform 122 to selectively deposit a fusing agent in a pattern based on where particles of the build material are to fuse together. Once the fusing agent has been applied, the layer of build material may be exposed to fusing energy using a heating element (not shown) of the 3D printer 104. The build material deposition, fusing agent and fusing energy application process may be repeated in successive layers until a complete 3D object has been generated. The material management station 106 may be used with any additive manufacturing technique and is not limited to printers using printheads on a carriage to deposit a fusing agent as in the example described above. For example, the material management station 106 may be used with a selective laser sintering additive manufacturing technique.

[0013] Figure 1B schematically illustrates the material management station 106 of the example of Figure 1A, with the trolley 102 of Figure 1A docked therein.

[0014] As shown in the example of Figure 1B, the material management station 106 has two interfaces for receiving two fresh build material supply containers in

the form of tanks (or cartridges) 114a, 114b, which may be releasably insertable in the material management station 106. In this example, each fresh build material supply tank 114a, 114b has a capacity of between about thirty and fifty litres. In one example, the build material may be a powdered semi-crystalline thermoplastic material. The provision of two fresh build material supply tanks 114a, 114b allows “hot swapping” to be performed such that if a currently active tank becomes empty or close to empty of build material when the trolley 102 is being filled with build material by the material management station 106 in preparation for an additive manufacturing process, a fresh build material supply source can be dynamically changed to the other of the two tanks. The material management system 106 may have a weight measurement device to assess how much fresh build material is present at a given time in any of the fresh build material supply tanks 114a, 114b. The fresh build material from the tanks 114a, 114b, may be consumed, for example, when loading the trolley 102 with build material prior to the trolley 102 being installed in the printer 104 for a 3D printing production run.

[0015] Build material is moved around within the material management station 106 in this example using a vacuum system (described below with reference to Figure 2A), which promotes cleanliness within the system and allows for recycling of at least a portion of build material between successive 3D printing jobs where the type of build material selected for use is recyclable. References to a vacuum system in this specification include a vacuum that is partial vacuum or a pressure that is reduced, for example, relative to atmospheric pressure. The vacuum may correspond to “negative pressure”, which can be used to denote pressures below atmospheric pressure in a circuit surrounded by atmospheric pressure.

[0016] A total trolley-use time for printing of a 3D object before the trolley 102 can be reused may depend upon both a printing time of the printer 104 when the trolley 102 is in the printer 104 and a cooling time of the contents of the build volume of the trolley 102. It will be understood that the trolley 102 can be

removed from the printer 104 after the printing operation, allowing the printer 104 to be re-used for a further printing operation using build material within a different trolley before the total trolley-use time has elapsed. The trolley 102 can be moved to the material management station 106 at the end of the printing time. The vacuum system can be used, in some examples, to promote more rapid cooling of the contents of the build volume following a 3D print production process than would otherwise occur without the vacuum system. Alternative examples to the vacuum system such as a compressed air system can create excess dust, potentially making the clean-up process more difficult.

[0017] The material management station 106 in this example has a recovered build material tank 108 (see Figure 1B), located internally, where build material recovered from the printing trolley 102 by the vacuum system is stored for subsequent reuse, if appropriate. Some build materials may be recyclable whilst others may be non-recyclable. In an initial 3D printing production cycle, 100% fresh build material may be used. However, on second and subsequent printing cycles, depending upon build material characteristics and user choice, the build material used for the print job may comprise a proportion of fresh build material (e.g. 20%) and a portion of recycled build material (e.g. 80%). Some users may elect to use mainly or exclusively fresh build material on second and subsequent printing cycles, for example, considering safeguarding a quality of the printed object. The internal recovered build material tank 108 may become full during a post-production clean-up process, although it may become full after two or more post-production clean up processes have been performed, but not before. Accordingly, an overflow container in the form of an external overflow tank 110 can be provided as part of the material management station 106 to provide additional capacity for recovered build material for use once the internal recovered build material tank 108 is full or close to full capacity. Alternatively, the external overflow tank 110 can be a removable container. In this example, ports are provided as part of the material management station 106 to allow for output of or reception of build material to and/or from the external overflow tank 110. A sieve 116 or alternative build material refinement device may be

provided for use together with the internal recovered build material tank 108 to make unfused build material recovered from a 3D printing production process for recycling more granular, that is, to reduce agglomeration (clumping).

[0018] The material management station 106 in this example has a mixing tank (or blending tank) 112 comprising a mixing blade (not shown) for mixing recycled build material from the internal recovered build material tank 108 with fresh build material from one of the fresh build material supply tanks 114a, 114b for supply to the trolley 102 when it is loaded prior to a printing production process. The mixing tank (or blending tank) 112, in this example, is provided on top of the material management station 106, above the location of the build platform 122 when the trolley 102 is docked therein. The mixing tank 112 is connected to a mixer build material trap 113 (described below with reference to Figure 2A) for input of build material into the mixing tank 112.

[0019] The fresh build material supply tanks 114a, 114b, the external overflow tank 110 and the main body of the material management station 106 may be constructed to fit together in a modular way, permitting a number of alternative geometrical configurations for the fully assembled material management station 106. In this way, the material management station 106 is adaptable to fit into different housing spaces in a manufacturing environment.

[0020] The fresh build material supply tanks 114a, 114b may be releasably connected to the main body of the material management station 106 via respective supply tank connectors 134a, 134b. These supply tank connectors 134a, 134b may incorporate a security system to reduce the likelihood of unsuitable build material being used in the 3D printing system. In one example, suitable fresh build material supply tanks 114a, 114b are provided with a secure memory chip, which can be read by a chip reader (not shown) or other processing circuitry on the main body of the material management station 106 to verify the authenticity of any replacement supply tank (cartridge) 114a, 114b that has been installed. In this example, the chip reader may be provided on the supply tank connectors 134a, 134b and upon attachment of the fresh build

material supply tank 114a, 114b to the respective connector 134a, 134b, an electrical connection may be formed. The processing circuitry in the material management station 106 may also be used to write a measured weight of build material determined to be in the respective fresh build material supply tank(s) 114a, 114b onto the secure memory chip of the tank to store and/or update that value. Thus, the amount of authorised build material remaining in the fresh build material supply tank(s) 114a, 114b at the end of a trolley loading process can be recorded. This allows the withdrawal of particulate build material from the fresh build material supply tanks 114a, 114b beyond the quantity with which it was filled by the manufacturer to be prevented. For example, in the case of a fresh build material supply tank 114a, 114b from which the tank manufacturer's authorised fresh build material has previously been completely withdrawn, this limits the withdrawal of further build material that may damage the printer or print quality, if the fresh build material supply tank were re-filled with alternative fresh build material.

[0021] The secure memory chip of the fresh build material supply tanks 114a, 114b can store a material type of the build material contained within the fresh build material supply tanks. In one example, the material type is the material (e.g. ceramic, glass, resin, etc.). In this way, the material management station 106 can determine the material type to be used by the material management station 106.

[0022] Figure 1C schematically illustrates a working area of the material management station 106 of the example of Figure 1B, showing the build platform 122 of the trolley 102 and a build material loading hose 142, which provides a path between the mixing container 112 of Figure 1B and the build material store 124 of the trolley 102. The loading hose 142 is used for loading the trolley 102 with build material prior to the trolley 102 being used in the printer 104. Figure 1C also shows a recycling hose 144 for unpacking manufactured 3D objects, cleaning the build platform 122 of the trolley 102 and a surrounding working area within the material management station 106. In one

example, the recycling hose 144 operates by suction provided via a pump 204 (see Figure 2A) and provides an enclosed path to the recovered build material tank 108 (see Figure 1B) for receiving and holding build material for re-use in a subsequent 3D printing process. The recycling hose 144 may, in one example, be operated manually by a user to recover recyclable build material from and/or to clean up a working area of the material management station 106.

[0023] Figure 2A schematically illustrates an internal circuit diagram 200 of one example of a build material management system in the form of a material management station 106. The material management station 106 can be used in conjunction with the trolley 102 of Figure 1A.

[0024] As previously described, printed parts along with unfused build material can be transported from the 3D printer 104 to the material management station 106 via the trolley 102. The material management station 106 can then be used to process build material and printed parts from the trolley 102.

[0025] In another example, printed parts along with unfused build material can be transported from the 3D printer 104 to the material management station 106 via another suitable container, e.g. a box or cartridge (not shown) instead of the trolley 102. The material management station 106 may then be used to process the powder-based material and printed parts from the container.

[0026] The material management station circuit 200 includes a conduit (or guide-channel) network and a pump 204 to provide a pressure differential across the conduit network to transport unfused build material between different components, as described below with reference to Figure 2A. In this example, the pump 204 is a suction pump which operates to create a pressure differential across the suction pump to produce air flow from an air inlet at substantially atmospheric pressure through the conduit network towards an upstream side of the suction pump (at a pressure below atmospheric or at "negative pressure"). The pump 204 may be provided as an integral part of the material management station 106 in one example, but in another example, the material management station 106 provides a negative/reduced pressure interface, via which a suction

pump may be detachably coupled or coupled in a fixed configuration. Although the description below refers to first conduit, second conduit, third conduit etc. of the conduit network, there is no implied ordering in the number of the conduits other than to distinguish one conduit from another.

[0027] A collection hose 206 is connected to a recovered build material tank (RBMT) 208 via a working area port in a working area 203 in the form of a working area inlet port 273 and a first conduit (hose-to- RBMT conduit) 272 of the conduit network. The recovered build material tank 208 includes a recovered build material tank (RBMT) inlet area comprising a recovered build material tank (RBMT) build material trap 218b and a recovered build material tank (RBMT) material outlet. The RBMT inlet area is where a fluidised flow of build material is received for storage in the recovered build material tank 208. The first conduit 272 provides a path between the working area inlet port 273 and the RBMT inlet area. The working area inlet port 273 is to receive build material from the collection hose 206 and is provided at an end of the first conduit 272 connected to the collection hose 206. In other examples, the RBMT inlet area may communicate directly with the working area 203 or the collection hose 206 without a first conduit 272 between.

[0028] The recovered build material tank 208 in this example is provided internally to the material management station 106. A hose-to-RBMT valve 242 is positioned along the first conduit 272 for opening and closing the path through the first conduit 272. The collection hose 206 extends from the working area inlet port 273 into the working area 203. The working area 203 includes at least a portion of the trolley 102 (or other container) and can be maintained at substantially atmospheric pressure. Build material from the trolley 102 can be collected by the collection hose 206 and transported to the recovered build material tank 208 through the first conduit 272. In this way, build material collected in the working area 203 and/or the trolley 102 can be considered to be from a collection source. The recovered build material tank 208 can be used for storing any unfused build material from the trolley 102 that is suitable for being

used again in a further 3D printing (additive manufacturing) process. In this way, the recovered build material tank 208 can be used as a buffer storage tank to temporarily store unfused build material prior to supplying the unfused build material for use in a further 3D printing (additive manufacturing) process.

[0029] A second conduit 274 (hose-to-overflow conduit) of the conduit network connects the collection hose 206 to an overflow tank 210. The overflow tank 210 includes an overflow inlet area and the second conduit 274 provides a path between the collection hose 206 and the overflow inlet area comprising, in this example, an overflow build material trap 218a (a filter). An overflow tank port in the form of an overflow tank outlet port 275 may also be provided at an end of the second conduit 274. The overflow tank 210 can be selectively sealed by an openable lid (not shown). In a sealed configuration, the overflow tank 210 is in fluid communication with overflow inlet ports and overflow outlet ports of the conduit network. Furthermore, in the sealed configuration, the overflow tank 210 is not directly open to the atmosphere. Build material from the working area 203 can be transported through the second conduit 274 and overflow tank outlet port 275 into the overflow tank 210. A hose-to-overflow valve 244 is positioned along the second conduit 274 for opening and closing a path through the second conduit 274. Unfused build material from the trolley 102 (or other container) can be collected by the collection hose 206 and transported to the overflow tank 210 through the first conduit 272. The overflow tank 210 is an external container that is removable and that can be used for storing excess recoverable (recyclable) build material when the recovered build material tank 208 is full. Alternatively, the overflow tank 210 can be used as a waste storage tank to store unfused build material from the trolley 102 that is not suitable for recycling. In this example, the overflow tank port can be referred to as a waste port and the overflow tank outlet port 275 can be referred to as a waste outlet port. In a further alternative, the overflow tank 210 can be used as a purged build material storage tank to store unfused build material from the trolley 102 and from elsewhere in the material management station 106 when the material management station is purged of un-fused build material.

[0030] The pump 204 is connected via a third conduit 276 (pump-to-RBMT conduit) of the conduit network to the recovered build material tank 208. The third conduit 276 provides a path between the pump 204 and the RBMT inlet area. A RBMT-to-pump valve 246 is positioned along the third conduit 276 for opening and closing the path through the third conduit 276.

[0031] The pump 204 is also connected to the overflow tank 210 via a fourth conduit 278 (pump-to-overflow conduit) of the conduit network. The fourth conduit 278 provides a path between the pump 204 and the overflow inlet area. An overflow tank port in the form of an overflow tank vacuum port 279 may also be provided at an end of the fourth conduit 278. Fluid, e.g. air, can transmit through the overflow tank vacuum port 279 from the overflow inlet area towards the pump 204. An overflow-to-pump valve 248 is positioned along the fourth conduit 278 for opening and closing a path through the fourth conduit 278.

[0032] Unfused build material in the trolley 102 can be collected using the collection hose 206 and transported either to the recovered build material tank 208 or to the overflow tank 210, or both. The tank to be used at a given time can be selected by opening appropriate valves along the conduits of the circuit of Figure 2A.

[0033] The valves described herein with reference to Figure 2A may be controlled by a controller 295, which may be, for example a programmable logic controller forming a part of processing circuitry of the build material management station 106. The controller 295 may electronically open any number of valves to open any number of corresponding paths in respective conduits based on the material transport operation being performed. The controller 295 may also electronically close one or more valves to close any number of corresponding paths in respective conduits. The valves may be, for example, butterfly valves and may be actuated using compressed air. In another example, any number of valves may be opened and closed manually by a user.

[0034] The controller 295 controls the general operation of the material management system 200. The controller may be a microprocessor-based

controller that is coupled to a memory (not shown), for example via a communications bus (not shown). The memory stores machine executable instructions. The controller 295 may execute the instructions and hence control operation of the build material management system 200 in accordance with those instructions.

[0035] Figure 2B is a table schematically illustrating for each of a number of different build material source locations and build material destination locations, an appropriate valve configuration corresponding the valves as labelled in Figure 2A. A tick in an appropriate column of the table indicates that the corresponding valve is controlled to be open by the controller 295 for the particular build material transport operation. For example, when transporting build material from the recovered build material tank 208 to the mixing tank 212, the valves 256, 258 and 254 are set by the controller 295 to be open, whereas the valves 250, 244, 276, 248, 242, 262, 260, 252a and 252b are set to be closed. In alternative examples, some valves may be set to be open by simultaneity.

[0036] In an example, a recyclability indicator is determined by processing circuitry of the build material management station 106. The recyclability indicator can be indicative of whether the build material in the trolley 102 (or container) includes recyclable or recoverable material. When it is determined that the unfused build material in the trolley 102 is not recyclable or when the recovered build material tank 208 is full, the unfused build material can be transported to the overflow tank 210.

[0037] To transport the unfused build material from the trolley 102 to the overflow tank 210, the hose-to-overflow valve 244 in the second conduit 274 between the collection hose 206 and the overflow tank 210 and the overflow-to-pump valve 248 in the fourth conduit 278 between the pump 204 and the overflow tank 210 can be opened, e.g. electronically by the controller 295. When the pump is active, a differential pressure is provided from the pump to the collection hose 206. That is, a pressure at the pump 204 is lower than a

pressure at the collection hose 206. The differential pressure enables build material from the trolley 102 (or container) to be transported to the overflow tank 210. Build material (and air) in proximity with an end of the collection hose 206 (at approximately atmospheric pressure) is transported from the collection hose 206, along the second conduit 274 and through the hose-to-overflow valve 244 to overflow tank 210. The overflow tank 210 is provided in the sealed configuration. At the overflow tank 210, build material separates from air flow and drops from the overflow inlet area into the overflow tank 210. Air (and any residual build material) continues along the fourth conduit 278 and through the overflow-to-pump valve 248 towards the pump 204, which is at a reduced pressure.

[0038] In an example, a storage tank fill level indicator is determined by processing circuitry of the build material management station 106. The storage tank fill level indicator can be indicative of an availability of a further capacity in a storage tank in the form of the recovered build material tank 208. When it is determined that the recovered build material tank 208 is full or nearly full, the unfused build material to be recovered from the trolley 102 can be transported through the overflow tank port in the form of the overflow tank outlet port 275 to the overflow tank 210. When it is determined that there is further capacity in the recovered build material tank 208, the unfused build material to be recovered from the trolley 102 can be transported to either or both of the recovered build material tank 208 and the overflow tank outlet port 275. In this way, processing circuitry of the build material management station 106 can control a routing of the unfused building material from a collection source (e.g., the trolley 102 and/or the collection area 203) to at least one of the recovered build material tank 208 and the overflow tank outlet port 275. In an example, the storage container (e.g., the recovered build material tank 208) is provided with a fill level sensor to output a fill level value indicative of an amount of unfused build material in the storage tank. The fill level sensor can be a load cell, or any other type of sensor such as a laser-based sensor, a microwave sensor, a radar, a sonar, a capacitive sensor, etc., to output a fill level value indicative of an

amount of unfused build material in the storage tank. The fill level indicator can be determined based on the fill level value from the fill level sensor. When the fill level sensor is a load cell, the fill level value can be an electrical signal indicative of a mass of the unfused build material in the storage tank.

[0039] To help prevent unfused build material traveling through the overflow inlet area of the overflow tank 210 into the fourth conduit 278 towards the pump 204, the overflow inlet area can include an overflow build material trap 218a (e.g. a powder trap). The overflow build material trap 218a is arranged to collect build material from the second conduit 274 and divert the build material (e.g. powder) into the overflow tank 210. Thus, the overflow build material trap 218a helps prevent build material conveying past the overflow inlet area of the overflow tank 210 and entering the fourth conduit 278 via the overflow tank vacuum port 279 to travel towards the pump 204.

[0040] The overflow build material trap 218a may include a filter (e.g. a mesh), which collects build material transported from the overflow tank 210. Thus, the filter separates build material from air flow in the overflow inlet area. Holes in the filter are small enough to prevent the passage of at least 95% of build material but allow relatively free flow of air through the filter. Holes in the filter may be small enough to prevent the passage of at least 99% of build material, whilst still allowing relatively free flow of air through the filter. Build material collected by the filter may drop from the overflow inlet area into the overflow tank 210.

[0041] Recoverable unfused build material in the trolley 102 can be transported to the recovered build material tank 208 in a similar way. To transport the unfused build material from the trolley 102 to the recovered build material tank 208, the hose-to-RBMT valve 242 in the first conduit 272 between the collection hose 206 and the recovered build material tank 208 and the RBMT-to-pump valve 246 in the third conduit 276 between the pump 204 and the recovered build material tank 208 can be opened electronically by the controller 295 as described above. When the pump is active, a differential pressure is provided from the pump to the collection hose 206. That is, a pressure at the pump 204 is

lower than a pressure at the collection hose 206. The differential pressure enables build material from the trolley 102 (or container) to be transported to the recovered build material tank 208. Build material (and air) in proximity with an end of the collection hose 206 (at approximately atmospheric pressure) is transported from the collection hose 206, along the first conduit 272 and through the hose-to-RBMT valve 242 to the recovered build material tank 208. At the recovered build material tank 208, build material separates from air flow and drops from the RBMT inlet area into the recovered build material tank 208. Air (and any residual build material) continues along the third conduit 276 and through the RBMT-to-pump valve 246 towards the pump 204, which is at reduced pressure relative to atmospheric pressure.

[0042] Each of the recovered build material tank 208, the overflow tank 210, and the mixing tank 212 has a build material trap 218b, 218a and 218c respectively. These build material traps 218a, 218b, 218c perform cyclonic filtration of an incoming fluidised flow of build material and air as schematically illustrated in Figure 2C. An inlet 296 of the build material trap 218 receives the fluidised flow of build material and the build material is pushed by a centrifugal force created by suction of the pump 204 to an outer wall 297 of the build material trap 218. In one example, the outer wall 297 of the build material trap 218 has a circular cross-section and the incoming build material migrates via a cyclonic action to the outer wall 297 of the build material trap 218 until the incoming air reaches an exit below, whereupon the build material particles drop down into a vacuum sealed recipient 299 in the build material trap 218. Thus the build material trap 218 separates a fluidised flow of build material into a powder component, which is deposited in the associated tank and an air component, which is sucked towards the pump 204 via an air outlet 298 in the build material trap 218 providing an interface to the pump 204. A filter (not shown) may be provided in the air outlet 298 of the build material trap 218 to reduce the likelihood of any remaining build material reaching the pump 204 in the separated air flow. The build material trap 218 provides efficient powder separation via its geometry that promotes formation of a cyclone within the build

material trap in use. It offers transportation of build material in an air flow and storage of the powder in a tank, whilst diverting an air flow out of the tank towards the pump 204. The build material trap provides a filter to capture residual powder in an air flow emerging from the cyclone to prevent it from reaching the pump 204. The build material trap 218 is one example of a build material filter having a function of separating an air from a build material flow at a corresponding tank inlet area. In other examples, the air flow is separated from the fluidised build material upon arrival at a destination tank using a filter other than a cyclonic filter. For example, a diffusion filter may be used.

[0043] Returning to Figure 2A, the RBMT inlet area of the recovered build material tank 208 may also include the RBMT build material trap 218b (e.g. a powder trap) or another type of RBMT build material filter to separate build material and air from an incoming fluidised flow of build material. The RBMT build material trap 218b operates in the same or a similar way as the overflow build material trap 218a in the overflow tank 210, to help collect and divert build material into the recovered build material tank 208 to help prevent build material from traveling through the third conduit 276 towards the pump 204.

[0044] When collecting material from the trolley 102 via the collection hose 206, as described above, a user can move the end of the collection hose 206 around the working area 203 including the trolley 102 to collect as much build material from the trolley 102 as possible.

[0045] The recovered build material tank 208 is also connected via a fifth conduit (overflow-to-RBMT conduit) 280 of the conduit network. An overflow tank port in the form of an overflow tank inlet port 281 may also be provided at an end of the fifth conduit 280. Build material from the overflow tank 210 can be transported through the fifth conduit 280 and overflow tank inlet port 281 into the recovered build material tank 208.

[0046] The fifth conduit 280 between the recovered material tank 208 and the overflow tank inlet port 281 includes an overflow-to-RBMT valve 250 in the path leading to the RBMT build material trap. In the event that the recovered build

material tank 208 needs to be refilled with recovered build material, the overflow-to-RBMT valve 250 in the fifth conduit 280 between the recovered build material tank 208 and the overflow tank 210 can be opened, along with the RBMT-to-pump valve 246 in the third conduit 276 between the recovered build material tank 208 and the pump 204. Each of the valves can be opened electronically by the controller 295, as described above. When the pump is active, a differential pressure is provided from the pump to the overflow tank 210. That is, a pressure at the pump 204 is lower than a pressure at the overflow tank 210. In this example, the overflow tank 210 is provided in an unsealed configuration and includes an air inlet (not shown) open to atmosphere to maintain approximately atmospheric pressure within the overflow tank 210. The differential pressure enables build material from the overflow tank 210 to be transported to the recovered build material tank 208. Air flows into the overflow tank 210 through the air inlet. Build material (and air) in the overflow tank is transported from the overflow tank 210, along the fifth conduit 280 and through the overflow-to-RBMT valve 250 to the recovered build material tank 208. At the recovered build material tank 208, build material separates from air flow and drops from the RBMT inlet area into the recovered build material tank 208. Air (and any residual build material) continues along the third conduit 276 and through the RBMT-to-pump valve 246 towards the pump 204, which is at a reduced pressure.

[0047] The material management station circuit 200 also includes a mixer unit 211 that includes a mixing container in the form of a mixing tank 212 and a support 400 as described in greater detail with reference to Figures 3 to 7 in particular. The mixing tank 212 can be used to mix recovered build material from the recovered build material tank 208 with fresh build material from a fresh build material supply tank 214a or 214b, ready to be used in a 3D printing process.

[0048] Although two fresh build material supply tanks 214a, 214b are shown in this example, in other examples, any number of fresh build material supply

tanks 214a, 214b may be used. More fresh build material supply tanks 214a, 214b may be used when appropriate.

[0049] Each fresh build material supply tank 214a, 214b is connected to the mixing tank 212 via a sixth conduit (a fresh build material conduit) 282 of the conduit network and a fresh build material supply tank port 283a, 283b. The fresh build material supply tank port 283a, 283b is to output build material from the respective fresh build material supply tank 214a, 214b. Each fresh build material supply tank 214a, 214b has an associated material supply tank cartridge-to-mixer valve 252a, 252b in the sixth conduit 282 between the respective fresh build material supply tank 214a, 214b and the mixing tank 212. Each fresh build material supply tank 214a, 214b also includes an air inlet valve whereby to ensure air can enter the fresh build material supply tanks 214a, 214b to maintain air pressure within the fresh build material supply tanks 214a, 214b at approximately atmospheric pressure.

[0050] The mixing tank 212 is connected via a seventh conduit (pump-to-mixer conduit) 284 of the conduit network to the pump 204. The seventh conduit 284 between the mixing tank 212 and the pump 204 includes a mixer-to-pump valve 254, which may be opened or closed to open and close the passage through the seventh conduit 284.

[0051] To transport fresh build material from the fresh build material supply tank 214a or 214b to the mixing tank 212, the material supply tank cartridge-to-mixer valve 252a or 252b and the mixer-to-pump valve 254 in the seventh conduit 284 between the mixing tank 212 and the pump 204 are opened. Each of the valves can be opened electronically by the controller 295, as described above. When the pump 204 is active, a differential pressure is provided from the pump 204 to the fresh build material supply tank 214a or 214b. That is, a pressure at the pump 204 is lower than a pressure at the fresh build material supply tank 214a or 214b. The differential pressure enables build material from the fresh build material supply tank 214a or 214b to be transported to the mixing tank 212. Build material (and air) in the fresh build material supply tank 214a or

214b is transported from the fresh build material supply tank 214a or 214b, along the sixth conduit 282 and through the cartridge-to-mixer valve 252a or 252b to the mixing tank 212. At the mixing tank 212, build material separates from air flow and drops from the mixer inlet area into the mixing tank 212. Air (and any residual build material) continues along the seventh conduit 284 and through the mixer-to-pump valve 254 towards the pump 204, which is at a reduced pressure.

[0052] The mixer inlet area of the mixing tank 212 can include a mixer build material trap 218c (e.g. a powder trap) or any type of mixer build material filter to separate an air flow from a build material flow, which operates in the same or similar manner to as the overflow build material trap 218a and the RBMT build material trap 218b. The mixer build material trap 218c helps to collect and divert build material into the mixing tank 212, and help prevent the build material from travelling through the seventh conduit 284 towards the pump 204.

[0053] The mixing tank 212 is also connected to the recovered build material tank 208 via an eighth conduit (RBMT-to-mixer conduit) 286 of the conduit network and a ninth conduit 288 of the conduit network extending sequentially from the recovered build material tank 208 to the mixing tank 212. The ninth conduit 288 may be part of the RBMT-to-mixer conduit 286.

[0054] A sieve 216 may, in some examples, be located in the RBMT to mixer conduit 286 or between the eighth and ninth conduits 286 and 288 between the recovered build material tank 208 and the mixing tank 212. The sieve 216 may be used to separate agglomerates and larger parts of material from the recycled build material that is transported from the recovered build material tank 208. Often, agglomerates and larger parts of material are not suitable for recycling in a further 3D printing process, so the sieve may be used to remove these parts from the build material. The sieve 216 includes an air inlet (not shown) to ensure air can enter the sieve 216 to maintain air pressure within the sieve 216 at approximately atmospheric pressure. In some examples, the RBMT-to-mixer conduit 286 may not be connected to a build material outlet of the recovered

build material tank 208. In other examples a conduit connecting an outlet of the recovered build material tank 208 to a build material inlet in the mixer build material trap 218c of the mixing tank 212 may form a closed circuit.

[0055] A RBMT-to-sieve valve 256 is located in the eighth conduit 286 between the recovered build material tank 208 and the sieve 216, and a sieve-to-mixer valve 258 is located in the ninth conduit 288 between the sieve 216 and the mixing tank 212. The RBMT-to-sieve valve 256 and sieve-to-mixer valve 258 may be opened or closed to open and close the passages through the eighth and ninth conduits 286, 288 between the recovered build material tank 208 and the mixing tank 212. The valves may be opened or closed electronically by the controller 295. To transport build material from the recovered build material tank 208 to the mixing tank 212 both the RBMT-to-sieve valve 256 and the sieve-to-mixer valve 258 in the eighth and ninth conduits 286, 288 between the recovered build material tank 208 and the mixing tank 212 can be opened as well as the mixer-to-pump valve 254 in the seventh conduit 284 that connects the mixing tank 212 to the pump 204. Build material in the recovered build material tank 208 may drop down into the sieve 216 through the eighth conduit 286 by gravity, for example. When the pump 204 is active, a differential pressure is provided from the pump 204 to the sieve 216. That is, a pressure at the pump 204 is lower than a pressure at the sieve 216. The differential pressure enables build material from the recovered build material tank 208 to be transported to the sieve 216 by gravity and to the mixing tank 212 by suction. Build material in the recovered build material tank 208 is transported through the RBMT material outlet, along the eighth conduit 286 and through the RBMT-to-sieve valve 256 to the sieve 216. Build material (and air) in the sieve 216 is transported from the sieve 216, along the ninth conduit 288 and through the sieve-to-mixer valve 258 to the mixing tank 212. At the mixing tank 212, build material separates from air flow and drops from the mixer inlet area into the mixing tank 212. Air (and any residual build material) continues along the seventh conduit 284 and through the mixer-to-pump valve 254 towards the pump 204, which is at a reduced (negative) pressure.

[0056] A currently selected ratio of recovered build material from the recovered build material tank 208 and fresh build material from the fresh build material supply tank 214a or 214b can be transported to the mixing tank 212 as described above. The ratio of fresh build material to recovered build material may be any selected ratio. The ratio may depend on the type of build material and/or the type of additive manufacturing process. In a selective laser sintering process the ratio could be, for example 50% fresh to 50% recovered build material. In one example of a printhead cartridge 3D printing process, the ratio may be 80% recovered to 20% fresh build material. For some build materials 100% fresh build material may be used, but for other build materials up to 100% recovered build material may be used. The fresh build material and the recovered build material can then be mixed together within the mixing tank 212 using, for example, a rotating mixing blade 213.

[0057] Once the fresh build material and the recovered build material are sufficiently mixed, the mixed build material can be transported from the mixing tank 212 through a mixer-to-trolley valve 260, a tenth conduit (mixer-to-trolley conduit) 290 of the conduit network, a working area port in the form of a working area outlet port 291, to the working area 203 and into the trolley 102. Build material from the mixing tank 212 can pass through the working area outlet port 291 into the working area 203. The trolley 102 (or container) can be located substantially beneath the mixing tank 212 so that gravity can aid the transport of mixed build material from the mixing tank 212, through the mixer-to-trolley valve 260, the tenth conduit 290, the working area outlet port 291 and the working area 203 to the trolley 102.

[0058] Once the trolley 102 is filled with enough build material for a given 3D print run, the trolley 102 can be returned to the 3D printer 104. An appropriate quantity of build material to fill the trolley 102 for a print job may be controlled by the controller 295 of the material management station 106 based on the material management station 106 sensing how much build material is in the trolley when the trolley is docked in the material management station 106 at the

beginning of a trolley fill workflow. The controller may then fill the trolley with a particular quantity (dose) of build material requested by a user for a particular print job intended by the user. The dosing is achieved by using a fill level sensor (not shown) such as a load cell in the mixing tank 212 to output a fill level value indicative of an amount of non-fused build material in the mixing tank. The fill level sensor can include a load cell, or any other type of sensor such as a laser-based sensor, a microwave sensor, a radar, a sonar, a capacitive sensor, etc.,. When the fill level sensor is a load cell, the fill level value can be an electrical signal indicative of a mass of the non-fused build material in the storage container.

[0059] A number of different workflows may be implemented in the material management station 106. These workflows are managed by the user, but some level of automation may be provided by a data processor on the material management station 106. For example, the user may select a workflow from a digital display on the material management station 106. For users having one material management station 106 and one printer 104 an example workflow cycle may be filling the trolley 102, followed by printing a 3D object, followed by unpacking the object from a build volume in the material management station 106 followed by a subsequent print operation and a corresponding unpacking of the build volume and so on. However, the material management station 106 may serve two or more printers so that successive unpacking and trolley filling operations may be performed by the material management station 106. The user may also choose to perform the trolley filling, printing and unpacking functions in a random order.

[0060] For each of the workflow operations, a user interface of the material management station 106 may guide the user to undertake particular manual operations that may be performed as part of the workflow operation. For example, to perform an unpack operation, the user interface may instruct the user to move the collection hose 206 around the collection area 203 as described previously. In addition, the material management station 106 can

automatically initiate other functions of the workflow operation. For example, to perform the unpack operation, the material management station 106 can automatically operate the pump 204 whilst the user moves the collection hose 206 around the collection area 203 to recover build material from the trolley 102. Any workflow operations the material management station 106 can perform fully automatically may be signalled to the user through the user interface without requiring user confirmation to proceed. If the workflow operation could present a potential safety risk, the otherwise fully automatic workflow operation may require user confirmation to proceed.

[0061] For example, to load the trolley 102 with build material, the user sets this workflow operation then the material management station 106 automatically launches the different operations required sequentially. The material management station 106 is controlled to send build material from the recovered build material tank 208 to the mixing tank 212. The material management station 106 is further controlled to send fresh build material from at least one of the fresh build material supply tanks 214a, 214b to the mixing tank 212. The material management station 106 is subsequently controlled to blend the mixture in the mixing tank 212. The mixed build material in the mixing tank 212 can then be discharged to the trolley 102. In an example, this workflow operation is completed as a batch process, and so the cycle may be continuously repeated to completely fill the trolley 102.

[0062] In some processes, a small portion (e.g. 1%) of build material can pass through the build material traps 218a, 218b, 218c (e.g. the powder traps) and can travel towards the pump 204.

[0063] An additional RBMT build material trap 220 (e.g. a powder trap) may, in some examples, be located in an eleventh conduit (pump feed conduit) 292 of the conduit network that connects each of the third, fourth and seventh conduits 276, 278 and 284 to the pump 204. The additional RBMT build material trap 220 is connected to the RBMT inlet area. The additional RBMT build material trap 220 collects build material that may have passed through any of the overflow

build material trap 218a, RBMT build material trap 218b or mixer build material trap 218c to help prevent it from reaching the pump 204. Build material collected in the additional RBMT build material trap 220 can be transported into the recovered build material tank 208 by opening a trap-to-RBMT valve 262. The trap-to-RBMT valve 262 may be opened electronically by the controller 295. The RBMT build material trap 220 may operate in the same or similar way to each of the overflow, RBMT, and mixer build material traps 218a, 218b and 218c. Build material can be transported from the RBMT build material trap 220 to the recovered build material tank 208 by gravity.

[0064] A pump filter 222 may also be located in a twelfth conduit 294 of the conduit network adjacent the pump 204. This pump filter 222 helps to collect any build material that may have passed through any of the overflow build material trap 218a, RBMT build material trap 218b or mixer build material trap 218c as well as the additional RBMT build material trap 220. This helps prevent the build material from reaching the pump 204, thereby reducing the likelihood of the function of the pump 204 being impaired, which could happen if large quantities of build material were to reach it. At any time, when the material management station 106 is to be used to process build material of a different material type, for example of a different material, the material management station circuit 200 can be controlled to implement a purging process to purge substantially all build material (e.g., greater than 90% of the build material) of a current material type from the material management station circuit 200 to the overflow tank 210. The fresh build material supply tanks 214a, 214b can be disconnected from the build material station circuit 200 and stored to prevent wastage of fresh building material of the current material type.

[0065] In one example, the purging process is carried out when unfused build material in the trolley 102 has already been collected using the collection hose 206 and transported either to the recovered build material tank 208 or to the overflow tank 210, or both. Alternatively, the purge process can include using

the collection hose 206 to transport any unfused build material in the trolley 102 to the overflow tank 210, as described previously.

[0066] The purge process includes transporting any unfused build material in the recovered build material tank 208 to the overflow tank 210. To transport unfused build material from the recovered build material tank 208 to the overflow tank 210, the RBMT-to-sieve valve 256 and the sieve-to-mixer valve 258 in the eighth and ninth conduits 286, 288 between the recovered build material tank 208 and the mixing tank 212 can be opened as well as the mixer-to-trolley valve 260 in the tenth conduit 290 and the hose-to-overflow valve 244 in the second conduit 274 between the collection hose 206 and the overflow tank 210 and the overflow-to-pump valve 248 in the fourth conduit 278 between the pump 204 and the overflow tank 210. Any build material in the recovered build material tank 208 drops down into the sieve 216 through the eighth conduit 286 by gravity. The collection hose 206 can be connected directly to the tenth conduit 290 before or after any cleaning of the unfused build material in the trolley 102 has been completed. When the pump 204 is active, a differential pressure is provided from the pump 204 to the sieve 216 via the overflow-to-pump valve 248, the overflow tank 210, the hose-to-overflow valve 244, the collection hose 206, the mixer-to-trolley valve 260, the mixing tank 212 and the sieve-to-mixer valve 258. Build material in the recovered material tank 208 is transported to the sieve 216 by gravity via the eighth conduit 286 and the RBMT-to-sieve valve 256. That is, a pressure at the pump 204 is lower than a pressure at the sieve 216. The differential pressure enables build material from the recovered build material tank 208 to be transported to the sieve 216 and on to the overflow tank 210. At the overflow tank, build material separates from air flow and drops from the overflow inlet area into the overflow tank 210. Air (and any residual build material) continues along the fourth conduit 278 and through the overflow-to-pump valve 248 towards the pump 204, which is at a reduced pressure. It can be seen that any unfused build material in the sieve 216, the mixing tank 212 or in any of the eighth conduit 286, the ninth conduit 288, the tenth conduit 290 or the second conduit 274 will also be transported to the

overflow tank 210. In this way, substantially all unfused build material in the material management station circuit 200 can be transported to the overflow tank 210.

[0067] Alternatively, the unfused build material in the recovered build material tank 208 can be transported to the trolley 102 as described previously. Subsequently, the unfused build material in the trolley 102 can be transported to the overflow tank 210, also as described previously. Thus, an alternative way to transport unfused build material from the recovered build material tank 208 to the overflow tank 210 can be provided without directly connecting the collection hose 206 to the tenth conduit 290.

[0068] The purge process can also include further purging process elements where a sacrificial material is transported through any part of the conduit network of the material management station circuit 200 which may still contain at least an amount of unfused build material of a current material type. The sacrificial material can act to dislodge at least some of the current build material remaining in the material management station circuit 200. The sacrificial material in one example may be the build material of the different build material type to be subsequently used in the material management station 106. The sacrificial material may alternatively be an inert material (e.g. silica) which is not a build material. In this way, any small amount of sacrificial material remaining in the material management station 106 at the end of the purging process is unlikely to interfere with the further operation of the material management station 106.

[0069] After the purge process is completed, and substantially all the unfused build material in the material management station circuit 200 is in the overflow tank 210, the overflow tank 210 can then be removed from the material management station 106, for example for storage or disposal and a further overflow tank (not shown) can be connected to the material management station 106. The further overflow tank can be empty or the further overflow tank

can contain build material previously purged from the (or another) material management station 106.

[0070] Figures 3 to 7 show the mixer unit 211 which includes a support 400, which may be in the form of a frame, and which may comprise a part of a housing of the material management station 106. The mixing tank 212 is mounted to the support 400 via first and second load cells 402a, 402b at opposite ends of the mixing tank, each disposed between the support 400 and a respective bracket 404a, 404b projecting outwardly from the mixing tank. The mixing tank 212 also includes first and second pegs 406a, 406b projecting outwardly from the opposite ends of the mixing tank and retained within respective vertical slots 408a, 408b in the support 400 to constrain movement of the mixing tank 212 within the support to just vertical movement. In this manner, all vertical forces between the mixing tank 212 and the support 400 pass through the load cells 402. Accordingly, because the weight of the mixing tank itself will be known, the contents 450 can be weighed by measuring the forces passing through the load cells 402.

[0071] As shown in Figure 6, the load cells 402a, 402b are disposed along a line 410 passing through the centre of gravity 412 of the mixing tank 212 (plus contents 450). The mixer 213 may have an axis of rotation that is horizontal and parallel with the line 410. If the centre of gravity is central in the mixing tank 212, then the load cells may be disposed symmetrically. In this case, the sum of the forces f_1 , f_2 registered at the respective load cells 402a, 402b will be equal to the weight W of the mixing tank and contents (see Figure 7). However, in certain scenarios the centre of gravity may be off-centre and thus the load cells 402 may be asymmetrically disposed. Moreover, although having the load cells disposed along a line 410 passing through the centre of gravity can keep the calculations simple, it will be understood that the load cells may be disposed in any suitable arrangement and that the weight of the contents 450 can be calculated using geometrically-corrected algorithms.

[0072] Because the top of the mixing tank 212 extends beyond the top of the support 400, it can be advantageous, for ease of transport and installation, to provide for the mixing tank 212 to be rotated between an upright position and a lowered position.

[0073] This can be achieved by providing a moveable latch 420 on a common side of each slot 408. The vertical slot 408 hence comprises a first side 409 defined by a vertical edge in the support 400 and a facing second side defined by an edge 422 on the latch member 420. The latch member 420 is moveable between a closed position, in which said edge 422 thereof is parallel to the corresponding vertical edge 409 in the support 400, and an open position, in which said second side is opened, allowing passage of the associated peg 406 away from the first side 409. The movement of the latch member 420 is guided by a peg 424 on the latch received to slide within a corresponding slot 426 in the support 400. Thus, moving the latches 420 to the open position enables the mixing tank 212 to be pivoted, about a pivot point (not explicitly shown), from an upright position to the lowered position 212' as shown in Figure 3.

[0074] Figure 8 shows a schematic illustration of a build material management system 800 according to an example of the present disclosure. The system 800 comprises a controller 802 that controls the general operation of the build material management system 800. In the example shown in Figure 8 the controller 802 is a microprocessor-based controller that is coupled to a memory 804, for example via a communications bus (not shown). The memory stores processor executable instructions 806. The controller 802 may execute the instructions 806 and hence control operation of the build material management system 800 in accordance with those instructions.

[0075] In one example, the controller 802 controls the material management station circuit 200 to implement the mixing process described herein.

[0076] It will be appreciated that examples described herein can be realised in the form of hardware, or a combination of hardware and software. Any such software may be stored in the form of volatile or non-volatile storage such as,

for example, a storage device like a ROM, whether erasable or rewritable or not, or in the form of memory such as, for example, RAM, memory chips, device or integrated circuits or on an optically or magnetically readable medium such as, for example, a CD, DVD, magnetic disk or magnetic tape. It will be appreciated that the storage devices and storage media are examples of machine-readable storage that are suitable for storing a program or programs that, when executed, implement examples described herein. Accordingly, examples provide a program comprising code for implementing a system or method as claimed in any preceding claim and a machine readable storage storing such a program.

[0077] Figure 9 is a flow diagram outlining a method of mixing unfused build materials for a 3D printing system in a predefined weight ratio according to one example. In the method of Figure 9, at 902, a quantity of a first unfused build material to be delivered to a mixing chamber according to a predefined weight ratio is specified. By way of example, if the objective is to produce a 5 kg batch of build material at a mix ratio of 70% recovered (or recycled) build material to 30% fresh build material by weight, then the specified quantity of fresh build material to be supplied will be 1.5 kg (which can be mixed with 3.5 kg of recovered build material). At 904, the first material is delivered to the mixing chamber 212 according to the specified quantity (for example the nominal 1.5 kg of fresh build material). At 906, the mixing tank 212 is weighed to determine the weight of an actual delivered quantity of the first material. The actual quantity of material delivered can vary from that specified due to build material becoming lodged in the material management station circuit 200 between the source of the build material (e.g. the fresh build material tanks 214a, 214b and the recovered build material supplies 208 and/or 210) and the mixing tank 212 and due to inaccuracies in the routing process. By way of example, if the timing of the valve openings is calculated to deliver a specified volume of build material, then variations in build material density (and material to air ratio) at the source could lead to variations in delivered weight of build material at the mixing tank 212. At 908, a quantity of a second unfused build material to be delivered to the mixing tank is calculated based on the delivered quantity of the first

material and according to the ratio. So, following the example given above, if only 1.4 kg of the intended 1.5 kg of fresh build material has been delivered to the mixing chamber 212, then to ensure the correct 70:30 ratio, 3.27 kg of recycled build material should be delivered. At 910, the second material is delivered to the mixing chamber 212 according to the corresponding quantity (i.e. the calculated 3.27 kg). Note that if the nominal 3.5 kg of recovered build material were to be delivered then the mix ratio would be inaccurate and accordingly the quality of parts produced in a subsequent 3D print process might be inferior.

[0078] As described in the example above, the fresh build material is delivered first because the density (material to air ratio) of the material in the fresh supplies 214a, 214b can be less homogeneous than that of the recovered build material from the recovered build material tank 208 or the overflow tank 210. In general, it may be better to deliver to the mixing tank 212 material from the least predictable or accurate source first (and verify the delivered amount by weighing) before delivering the material from the second, more accurate source. This is for several reasons, including: the less accurate source is more likely to have a discrepancy between the actual delivered quantity and the nominal quantity; and the more accurate source is more likely to be able to deliver the calculated quantity to keep the desired mix ratio.

[0079] Although the examples above describe mixing fresh and recovered build materials, the disclosure extends to any mixtures of two or more different materials.

[0080] Throughout the description and claims of this specification, the words “comprise” and “contain” and variations of them mean “including but not limited to”, and they are not intended to (and do not) exclude other components, integers or steps. Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be

understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers or characteristics, described in conjunction with a particular example are to be understood to be applicable to any example described herein unless incompatible therewith. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. The invention is not restricted to the details of any foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A mixer unit comprising:

a support;

a mixing container to receive unfused build materials for a 3D printing system from at least two different sources, the mixing container including a mixing device to mix said materials, wherein the mixing container is mounted to the support in a manner constraining to vertical movement; and

a first load cell and a second load cell mounted on opposed sides of the mixing container between the mixing container and the support to measure a vertical force of the mixing container acting on the support to weigh the contents of the mixing container;

wherein all vertical forces from the mixing container pass through the load cells to the support.

2. The mixer unit of claim 1, wherein the load cells are disposed symmetrically with respect to the centre of gravity of the mixing container.

3. The mixer unit of claim 2, wherein the load cells are disposed on a line passing through the centre of gravity of the mixing container.

4. The mixer unit of claim 1, wherein the mixing unit and the support include mating guide members to constrain movement of the mixing container with respect to the support to just vertical movement.

5. The mixer unit of claim 4, wherein the mating guide members comprise pegs projecting from opposite sides of the mixing chamber received in corresponding vertical slots in the support.

6. The mixer unit of claim 5, wherein the vertical slots each comprise a first side defined by a vertical edge in the support and a facing second side defined by an edge on a latch member, the latch member being moveable between a closed position, in which said edge thereof is parallel to the corresponding vertical edge in the support, and an open position, in which said second side is opened, allowing passage of the peg away from the first side.

7. The mixer unit of claim 6, wherein the mixing container is pivotably mounted to the support and can be moved from an upright position to a lowered position by opening the latch members and passing the pegs through the open sides of the slots.

8. The mixer unit of claim 1, wherein the mixing device has an axis of rotation and wherein the load cells are located in line with the axis of rotation.

9. A build material management system, for a 3D printing system, the build material management system comprising:

- an unfused build material transportation system;

- a source of a first unfused build material;

- a source of a second unfused build material;

- a mixer unit according to claim 1; and

- processing circuitry to control a routing of specified quantities of the first and second unfused build materials from the respective sources to the mixing

container of the mixing unit dependent at least in part on the weight of the contents in the mixing container.

10. The build material management system of claim 9, wherein the source of the second unfused build material is a container to which the build material transportation system has routed recovered unfused build material.

11. A method of mixing non-fused build materials for a 3D printing system in a predefined weight ratio, the method comprising:

- specifying a quantity of a first unfused build material to be delivered to a mixing chamber according to the ratio;

- delivering the first material to the mixing chamber according to the specified quantity;

- weighing the mixing chamber to determine the weight of an actual delivered quantity of the first material;

- calculating a corresponding quantity of a second unfused build material to be delivered to the mixing chamber based on the delivered quantity of the first material and according to the ratio; and

- delivering the second material to the mixing chamber according to the corresponding quantity;

- wherein the first unfused build material is supplied from a first source and the second unfused build material is supplied from a second source that is different from the first.

12. The method of claim 11, wherein the first unfused build material is fresh and wherein the second unfused build material is recovered.

13. A non-transitory machine-readable storage medium encoded with instructions executable by a processor, the machine-readable storage medium comprising:

instructions to mix unfused build materials for a 3D printing system in a predefined weight ratio, including instructions to:

route a specified quantity of a first unfused build material to a mixing unit of the 3D printing system;

weigh a delivered quantity of the first material in the mixing unit;

calculate a corresponding quantity of a second unfused build material to be delivered to the mixing chamber based on the delivered quantity of the first material and according to the ratio; and

route the calculated quantity of the second unfused build material to the mixing unit.

14. The non-transitory machine-readable storage medium of claim 13, comprising instructions to route the specified quantity of the first unfused build material from a source of fresh build material to the mixing chamber, and to route the calculated quantity of the second unfused build material from a source of recovered build material to the mixing chamber.

15. The non-transitory machine-readable storage medium of claim 13, comprising instructions to set the predetermined weight ratio in dependence on one or more of the type of the first unfused build material and the type of the second unfused build material.

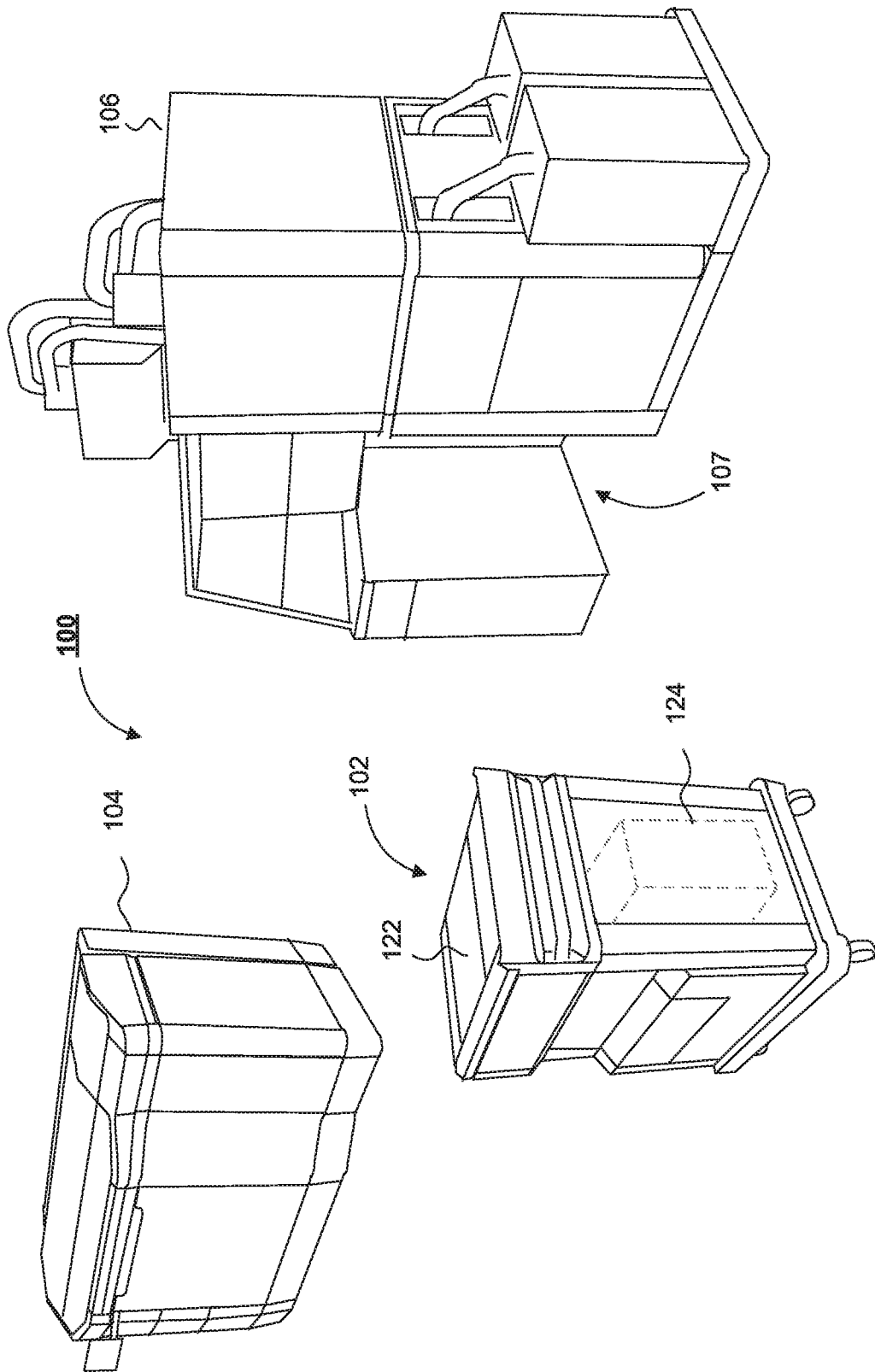
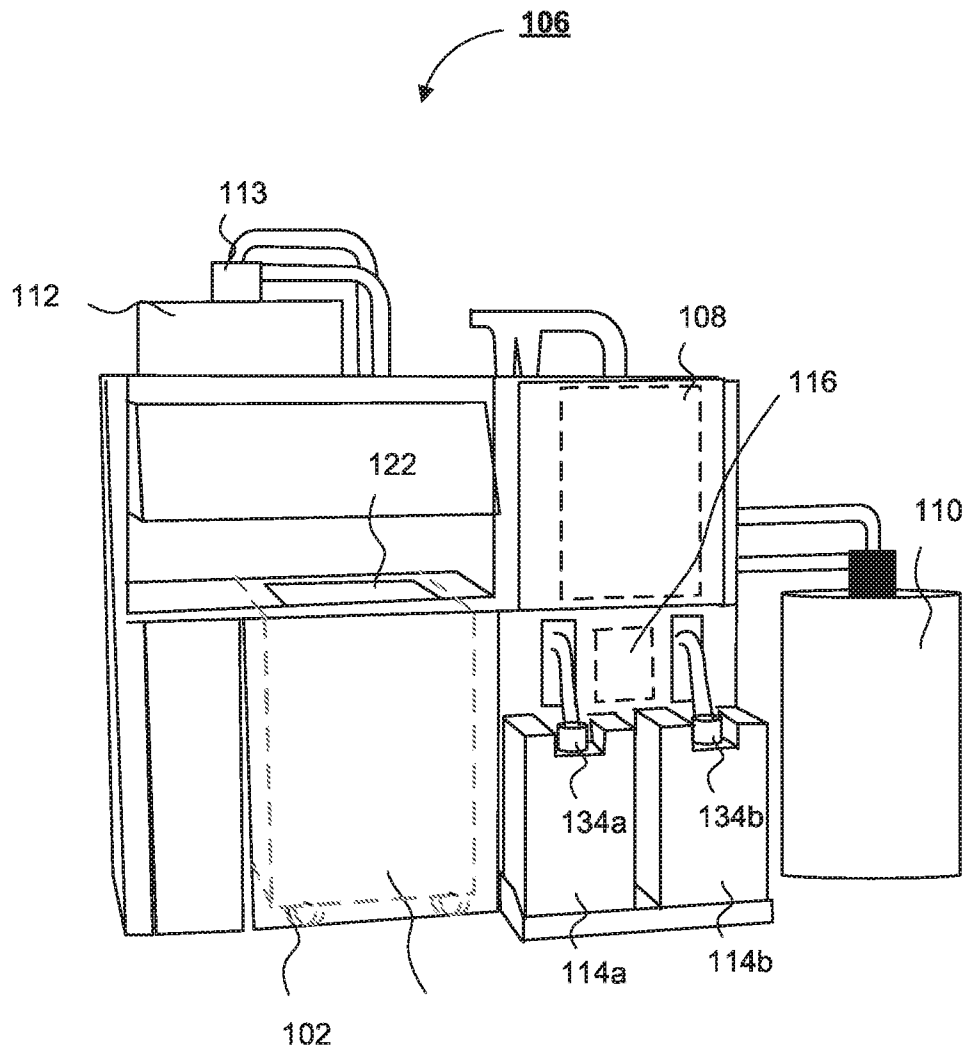


Figure 1A

**Figure 1B**

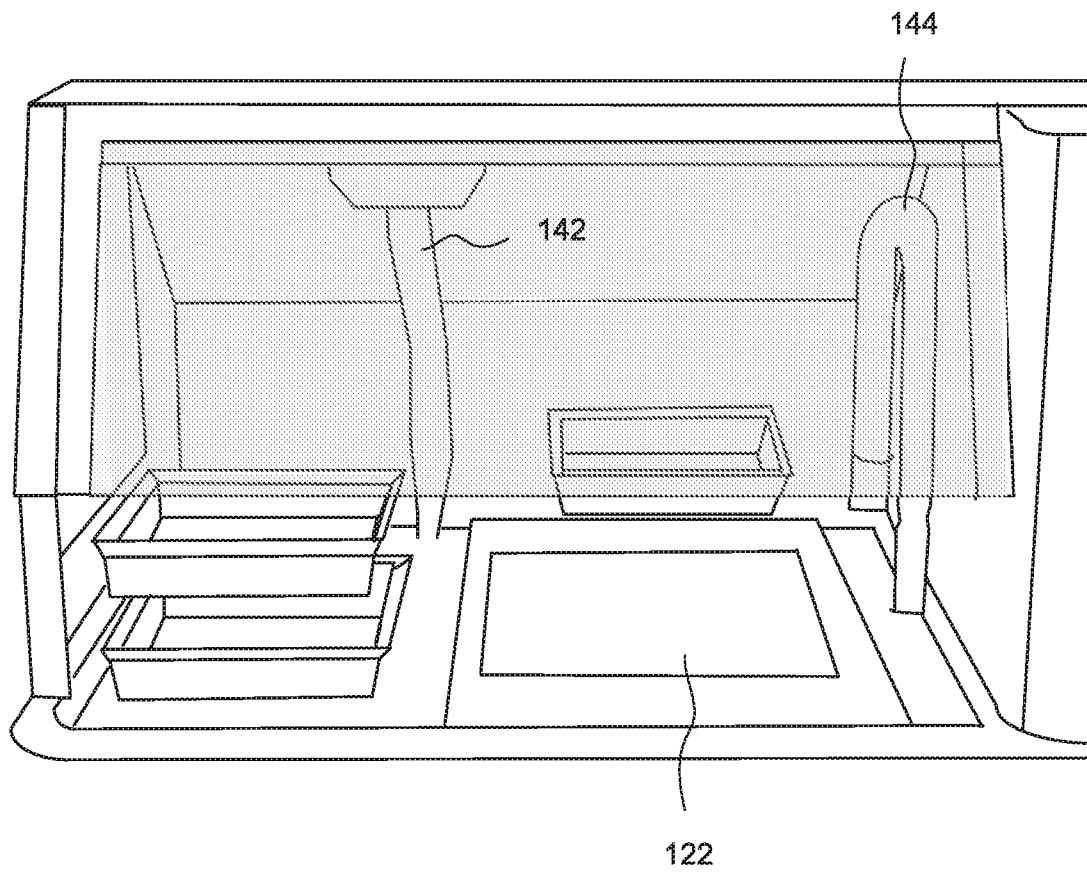


Figure 1C

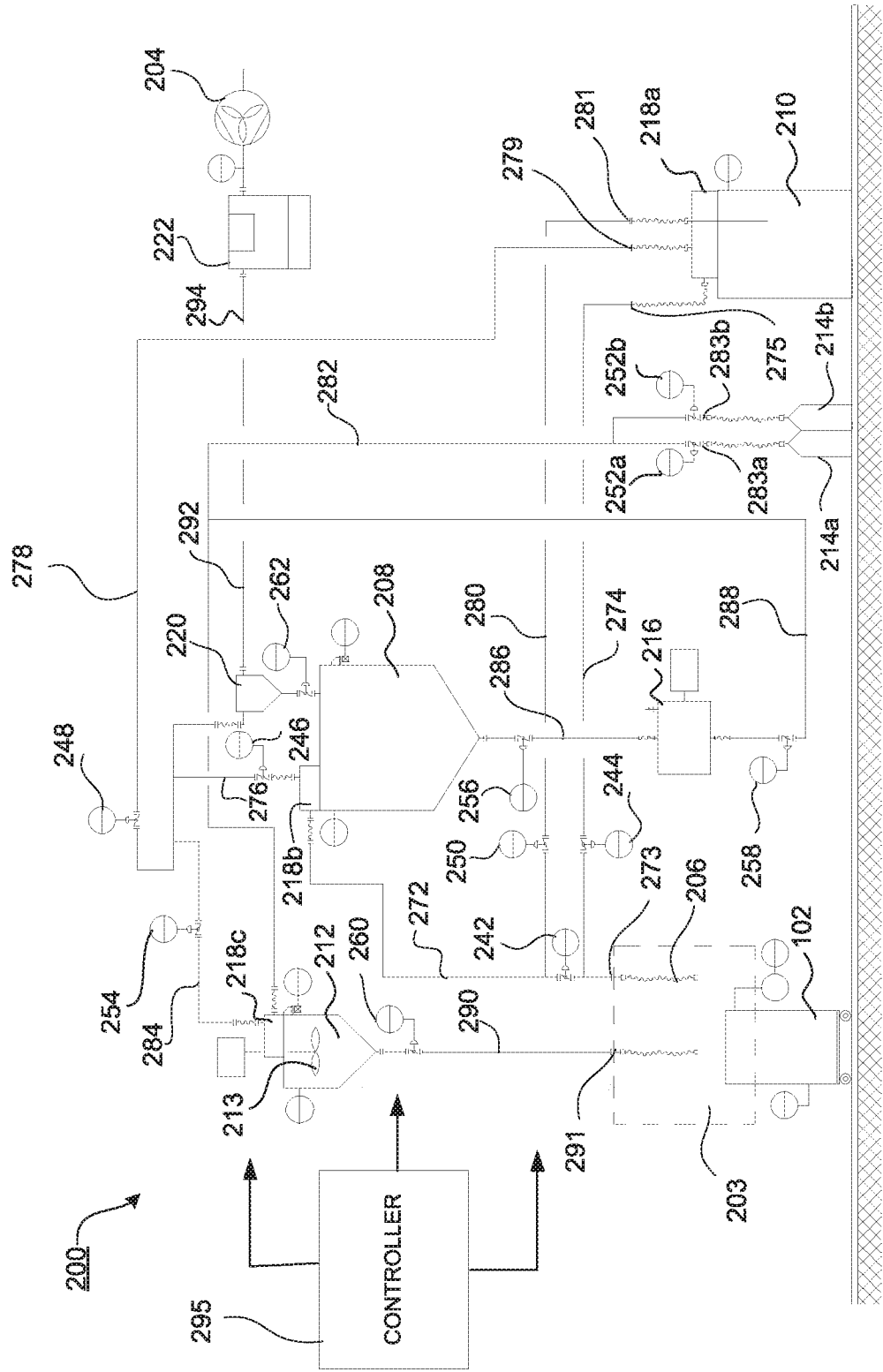


Figure 2A

	Valve											
	250	244	256	276	248	258	242	262	260	254	252a	252b
Recovered build material tank to mixing tank			✓			✓				✓		
Fresh build material supply tank 214a to mixing tank										✓	✓	
Fresh build material supply tank 214b to mixing tank										✓		✓
Unload mixing tank									✓			
Working area to recovered build material tank				✓			✓					
Working area to overflow tank		✓			✓							
Overflow tank to recovered build material tank	✓			✓								
Empty powder trap 220								✓				
Purge process		✓	✓		✓	✓			✓			

Figure 2B

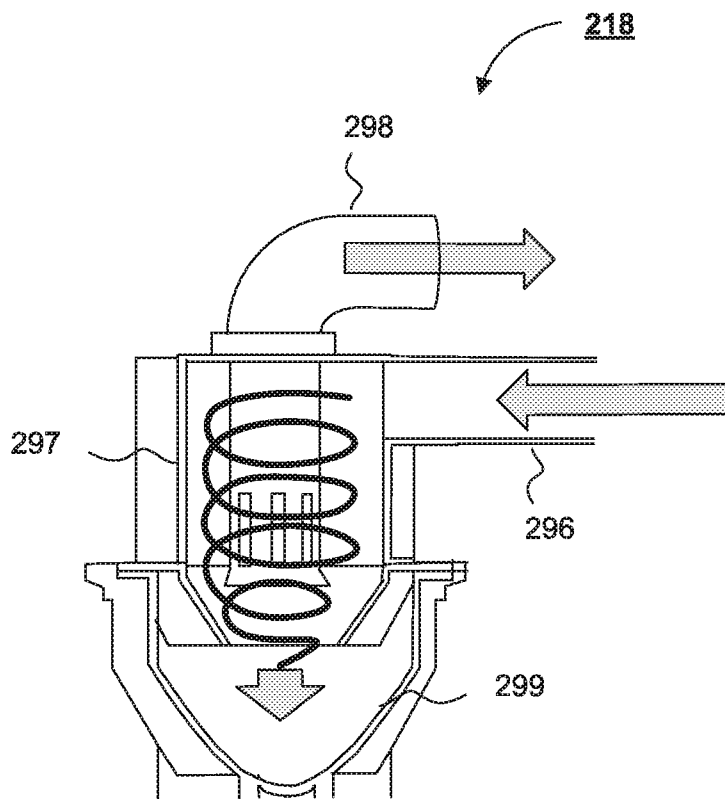


Figure 2C

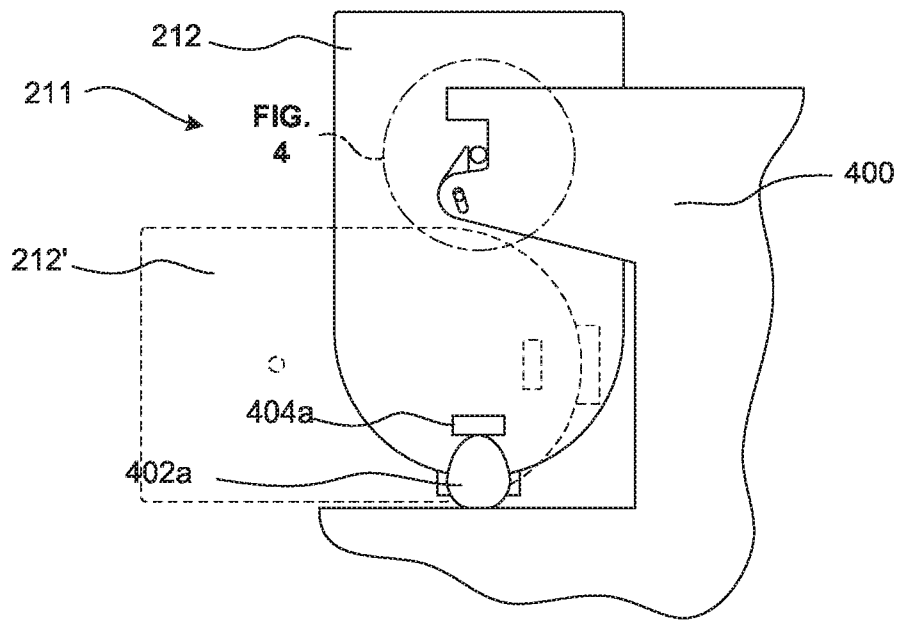


Figure 3

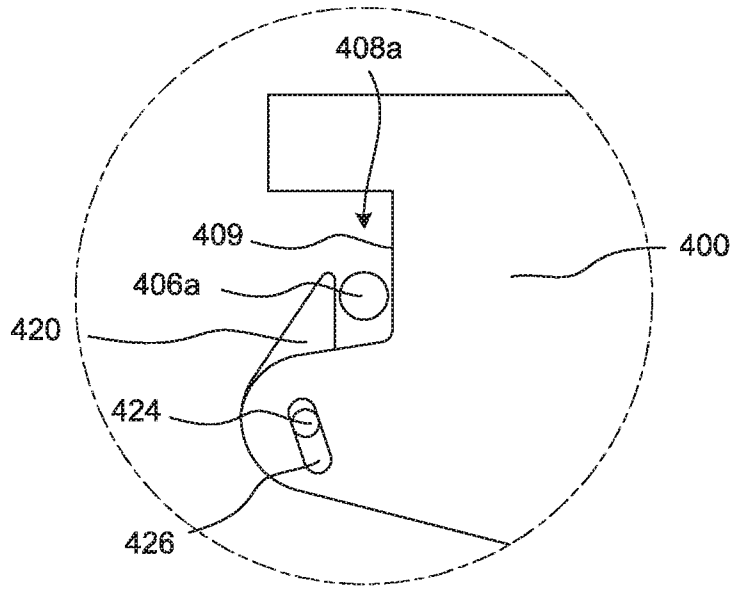
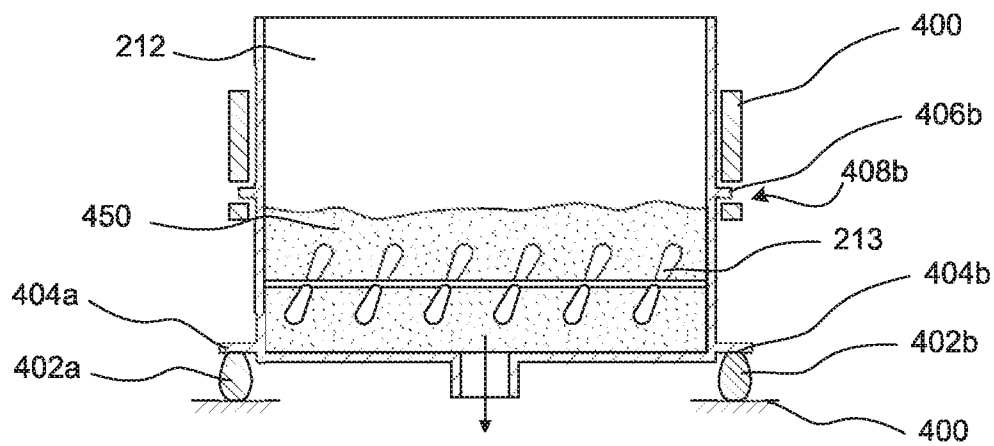
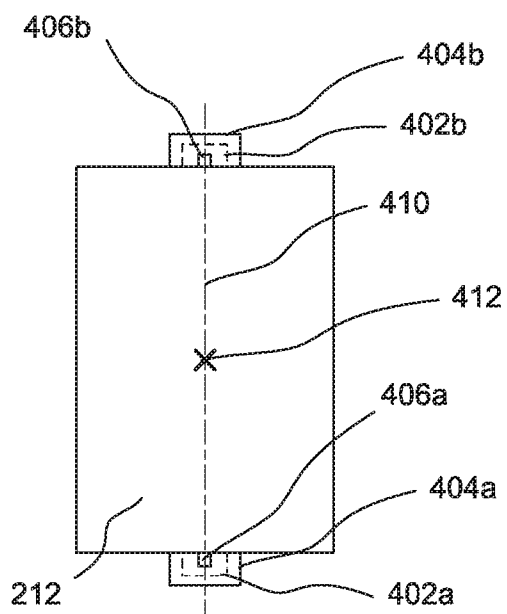
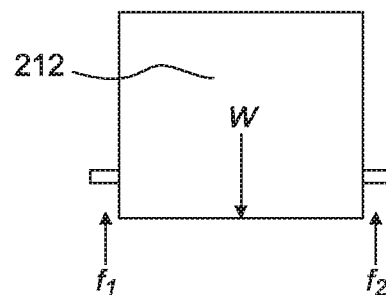
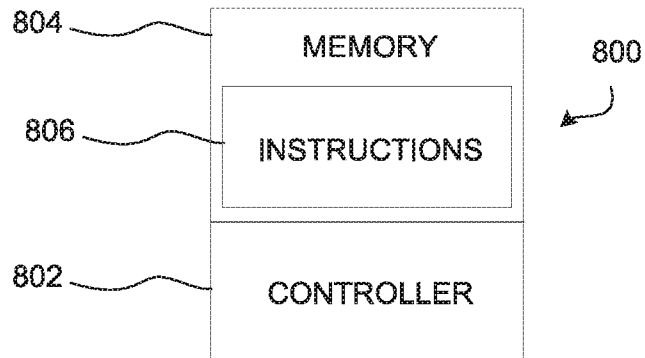
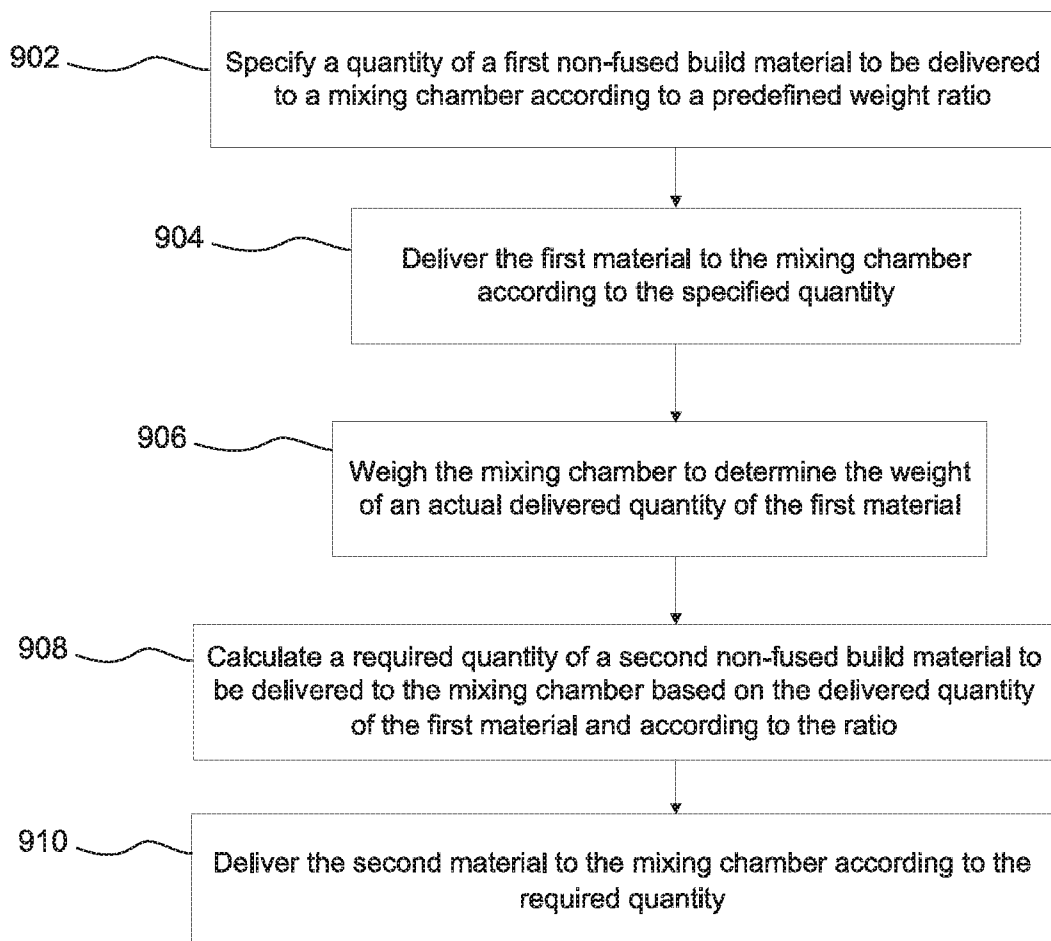


Figure 4

**Figure 5****Figure 6****Figure 7**

**Figure 8****Figure 9**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2017/031996

A. CLASSIFICATION OF SUBJECT MATTER		
B29C 64/30 (2017.01) B29C 64/314 (2017.01) B29C 64/321 (2017.01) B33Y 40/00 (2015.01) B01F 7/02 (2006.01)		
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)		
B29C 64/30, 64/314, 64/227, 64/321, 67/00-67/24, B33Y 40/00, B01F 7/02		
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, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/0140852 A1 (OBJECT GEOMETRIES LTD.) 10.06.2010, par. [0043], [0063], [0100]-[0106], fig. 2b	9, 11, 13, 15
Y		10, 12, 14
A		1-8
Y	RU 2477219 C2 (EOS ELECTRO OPTICAL SYSTEMS) 10.03.2013, claims 10, 11, p. 6, lines 44-46, fig. 1-3	10, 12, 17
A	US 2012/0267813 A1 (EOS GMBH ELECTRO OPTICAL SYSTEMS) 25.10.2012	1-15
A	JP 2012193996 A (YAMATO SCALE CO LTD) 11.10.2012	1-15
☐ 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 document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
06 July 2017 (06.07.2017)		24 August 2017 (24.08.2017)
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. Grigoruk Telephone No. 8-499-240-25-91