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(71) Applicant: HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P. [US/US]; 11445 Compaq Center Drive W., Houston, Texas 77070 (US).

(72) Inventors: GIMENEZ, Jordi; Cami de Can Graells, 1-21, 08174 Sant Cugat de Valles (ES). MARTIN, Pau; Cami de Can Graells, 1-21, 08174 Sant Cugat del Valles (ES). GOMEZ, Francisco; Cami de Can Graells, 1-21, 08174 Sant Cugat del Valles (ES).

(74) Agent: LEMMON, Marcus et al.; HP Inc., Intellectual Property, 3390 E. Harmony Road, Fort Collins, Colorado 80528 (US).

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(54) Title: BUILD MATERIAL SPREADING APPARATUSES FOR ADDITIVE MANUFACTURING

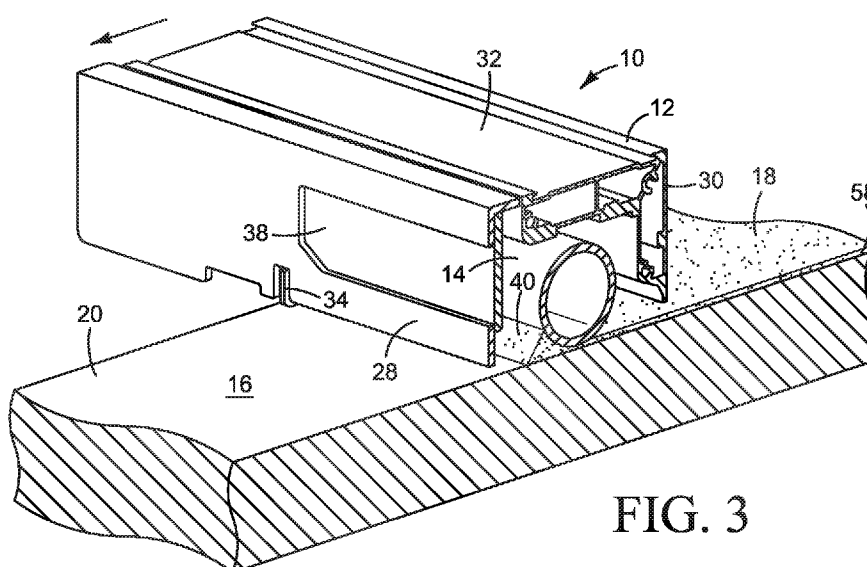


FIG. 3

(57) Abstract: In one example, a build material spreading apparatus for additive manufacturing including a movable spreader to spread build material over a build area, the spreader having a top, a bottom, a front, and a back, and a cover movable with the spreader covering the front, top and back of the spreader.



BUILD MATERIAL SPREADING APPARATUSES FOR ADDITIVE MANUFACTURING

BACKGROUND

[0001] Additive manufacturing machines, sometimes called 3D printers, produce objects by building up layers of material. Digital data may be processed into slices each defining that part of a layer or layers of build material to be formed into the object. In some additive manufacturing machines, the object slices are formed in a powdered build material spread in layers over the build area. Heat may be used to fuse together the particles in each of the successive layers of powder to form a solid object. Heat to fuse build material in each layer may be generated, for example, by applying a liquid fusing agent to the powder in a pattern based on a single slice of the object and then exposing the patterned area to a light or other energy source. The fusing agent absorbs energy to help sinter, melt or otherwise fuse the patterned powder. Manufacturing may proceed layer by layer and slice by slice until the object is complete.

DRAWINGS

[0002] Fig. 1 is an isometric view of a build material spreading apparatus for additive manufacturing implementing one example of a build material containment.

[0003] Fig. 2 is an isometric view with one wall of the example containment from Fig. 1 removed to show parts of the apparatus inside the containment.

[0004] Figs. 3 and 4 are isometric sections taken along the lines 3-3 in Fig. 1 and 4-4 in Fig. 2, respectively.

[0005] Fig. 5 is a side elevation section taken along the line 5-5 in Fig. 1.

[0006] Fig. 6 illustrates one example for the layout of an additive manufacturing machine implementing a spreading apparatus such as the one shown in Figs. 1-5.

[0007] Figs. 7 and 8 are isometric and plan views, respectively, illustrating one example of containment sidewalls as build material blockers flanking a spreader roller.

[0008] Fig. 9 is an isometric partial section taken along the line 9-9 in Fig. 8.

[0009] Fig. 10 is a detail from Fig. 8.

[0010] Fig. 11 is a detail elevation and partial section showing the edge of the build material along one of the example sidewall blockers shown in Figs. 7-10.

DESCRIPTION

[0011] In some additive manufacturing machines, a roller or blade is carried back and forth over the build area to spread powdered build material in layers for fusing. Airborne powder generated during the layering process can contaminate sensitive parts of an additive manufacturing machine. Also, powder can leak away from the build area along the lateral edges of the spreader. Accordingly, a containment is provided for layering powdered build material in an additive manufacturing machine to help control the spread of airborne powder and to help reduce powder leakage along the lateral edges of the spreader.

[0012] In one example, a build material spreading apparatus for additive manufacturing includes a roller, blade or other movable spreader and a containment surrounding the spreader. The containment surrounds the spreader everywhere except along the bottom of the spreader facing the build area where the spreader contacts the build material. For powdered build material, the containment helps control the spread of airborne powder by containing the powder to a region immediately adjacent to the spreader. The containment is movable with the spreader to help contain airborne powder even as the spreader is carried back and forth over the build area.

[0013] In one implementation, a lateral part of the containment is configured to control the lateral extent of the layer of build material as it is spread over the build area. This part of the containment may include, for example, a blocker flanking each side of the spreader to block build material spreading laterally away from the build area. Where a full containment is not desired, the blockers may be implemented independently to control build material leaking away from the build area.

[0014] While examples are described below with reference to a powdered build material, examples of the containment are not limited to use with powdered build material. The examples described herein and shown in the figures illustrate but do not limit the scope of the patent, which is defined in the Claims following this Description.

[0015] As used in this document: “build area” means any suitable structural area to support build material for fusing, including underlying layers of both fused and unfused build material and in-process slice and other object structures.

[0016] Fig. 1 is an isometric view of a build material spreading apparatus 10 implementing one example of a containment 12. Fig. 2 is an isometric view from the view angle of Fig. 1 with one panel of the containment removed to show parts of apparatus 10 inside containment 12. Figs. 3 and 4 are isometric sections taken along the lines 3-3 in Fig. 1 and 4-4 in Fig. 2, respectively. Fig. 5 is a side elevation section taken along the line 5-5 in Fig. 1.

[0017] Referring to Figs. 1-5, build material spreading apparatus 10 includes containment 12 surrounding a spreader 14. In this example, the spreader is implemented as a roller 14. Containment 12 and spreader roller 14 are movable together over a build area 16 to spread a build material 18. Any suitable carriage and drive mechanism (not shown) may be used to move spreader roller 14 and containment 12. In the example shown in the figures, build material 18 is depicted as a powdered build material. Also, as noted above, build area 16 in the figures represents any suitable structural area to support build material for fusing, including underlying layers of both fused and unfused build material and in-process slice and other object structures. In this example, build area 16 is formed over a platform 20 that moves up and down inside a container 22 to adjust for the thickness of each layer of build material 18. Thus, a build area 16 for a first layer of build material 18 may be the surface of platform 20. For succeeding layers, the build area 16 may be formed on the underlying layer (or layers) of build material, which may include fused and unfused build material. Container 22 is truncated in Figs. 1-2 along two sides of platform 20. Container 22 is omitted from Figs. 3 and 4.

[0018] Fig. 6 illustrates one example for the layout of an additive manufacturing machine implementing a spreading apparatus 10 such as that shown in Figs. 1-5. As shown in Fig. 6, an object 24 is manufactured on platform 20 in container 22. In this example, spreader roller 14 is bi-directional, moving back and forth over platform 20 to spread build material 18 from supplies 26 on to a build area 16. Platform 20 moves down inside container 22 as each succeeding layer of build material 18 is spread on build area 16 and fused into the corresponding object slice. Manufacturing proceeds layer by layer and slice by slice until object 24 is complete.

[0019] Referring again to Figs. 1-5, containment 12 surrounds roller 14 on five of six sides – the front, back, top, and sides – to contain build material 18 to a region near the spreader. “Front” and “back” as used herein are not intended to suggest any particular direction of motion for roller 14. For a roller 14 that spreads powder moving in both directions over build area 16, roller 14 may be said to move forward and backward over the build area or forward in both directions with the front in one direction becoming the back in the other direction. In any case, the bottom of roller 14 is open for spreading build material 18 over build area 16, as best seen in Figs 3-5.

[0020] Containment 12 includes a front wall 28 covering the front of roller 14, a back wall 30 covering the back of roller 14, a ceiling 32 covering the top of roller 14, and side walls 34, 36 covering the sides of roller 14. Containment front wall 30 and back wall 32 act as curtains, extending down close to build area 16, to contain much of any powder that may become airborne in front of roller 14 and in back of roller 14 as the roller spreads build material 18 over build area 16.

[0021] In this, back wall 30 and ceiling 32 are integral to one another, and with an expanded section for added strength to span of roller 14. Also in this example, front wall 28 includes a window 38 to view roller 14 and the interior of containment 12. Front wall 28 may be removable separate from the other parts of containment 12 to facilitate access to roller 14. As best seen in Fig. 5, the upper parts of each side wall 34, 36 conforms generally to the interior of back wall 30 and ceiling 32. While the size and shape of containment 12 may vary

for different additive manufacturing environments and operations, testing suggests that a powdered build material containment 12 that contains airborne powder to a region within about 25mm of spreader roller 14 will provide effective powder control and within a containment structure (e.g. walls 28-36) sufficiently compact and lightweight to move with roller 14 without adversely affecting the performance of the spreader.

[0022] Figs. 7 and 8 are isometric and plan views, respectively, illustrating sidewalls 34, 36 as build material blockers flanking spreader roller 14. Fig. 9 is an isometric partial section taken along the line 9-9 in Fig. 8. Fig. 10 is a detail from Fig. 8. Referring to Figs. 7-10, each blocker 34, 36 includes a leading part 35 that extends forward from roller 14 at least far enough to block a pile 40 of build material 18 pushed up in front the roller. For a roller 14 that spreads build material 18 back and forth over a build area, each blocker 34, 36 will also include a trailing part 37 that extends backward from roller 14. Of course, which part 35, 37 is the leading part and which is the trailing part depends on the direction of motion of roller 14, which is from right to left in the figures.

[0023] Each blocker 34, 36 is located laterally inside the perimeter of container 22 and over platform 20. In this configuration, blockers 34, 36 may be a static device. Thus, blockers 34, 36 in Figs. 7-10 are stationary with respect to roller 14 and stationary laterally with respect to platform 20 and container 22. In the example shown, each blocker 34, 36 is oriented vertically inside the edge of platform 20. Other orientations are possible, for example to control or vary the edge profile of build material 18.

[0024] In the example shown, roller 14 extends outboard through an opening 42 in each blocker 34, 36. Thus, in this example, an upper extent 44 of each blocker 34, 36 at least partially surrounds roller 14 and a lower extent 46 protrudes below roller 14. While any suitable technique may be used to mount blockers 34, 36 to the spreader carriage, in this example each blocker 34, 36 is part of a mounting assembly 48 that includes a U-shaped bracket 50 and a spring 52. The outboard part 54 of bracket 50 is mounted to the carriage, allowing a cantilevered blocker 34, 36 at the inboard part of bracket 50 to be suspended over platform 20, and in this example encircling roller 14 without

bearing on roller 14. The top 32 of containment 12 presses a tab 53 on spring 52, as best seen in Figs. 4 and 5, to bias bracket 50 and thus blockers 34, 36 into the desired position against a datum 55 (Fig. 5) at the inside of the back 30 of containment 12.

[0025] Referring now also to the detail of Fig. 11, the lower extent 46 of each blockers 34, 36 may protrude slightly below roller 14 if desired to help control the edge profile of build material 18 as it is spread over build area 16. As shown in Fig. 11, the edge 56 of a layer 58 of a powdered build material 18 tends to collapse into the free space below the blocker outboard toward the wall of container 22. The thickness of layer 58 corresponds to a gap 60 between the bottom of roller 14 and build area 16. While the extent of this collapse may vary depending on the characteristics of the powder and the thickness of layer 58, the lower extent 46 and position of blockers 34, 36 inside the perimeter of container 22 helps control the slope of the collapsing powder along edge 56 to inhibit leakage but without impeding the spreading operation.

[0026] The examples shown in the figures and described above illustrate but do not limit the patent, which is defined in the following Claims.

[0027] "A", "an", and "the" as used in the Description and Claims means at least one.

CLAIMS

1. A powdered build material spreading apparatus for additive manufacturing, comprising:
 - a movable spreader to spread powdered build material in a layer over a build area; and
 - a regional containment surrounding the spreader everywhere except in a region below the spreader facing the build area, to contain powdered build material to a region near the spreader.
2. The apparatus of Claim 1, where the containment is movable with the spreader.
3. The apparatus of Claim 2, where:
 - the spreader extends laterally across the build area from a first end to a second end opposite the first end; and
 - the containment is located inboard from the ends of the spreader.
4. The apparatus of Claim 3, where a lateral part of the containment is to control a lateral extent of powder spread in a layer over the build area.
5. The apparatus of Claim 4, where a cover part of the containment is to contain the spread of powder to a region surrounding the spreader.
6. The apparatus of Claim 5, where the spreader is to contain powdered build material to a region within 25mm of the spreader.
7. A build material spreading apparatus for additive manufacturing, comprising:
 - a movable spreader to spread build material over a build area, the spreader having a top, a bottom, a front, and a back; and

a cover movable with the spreader covering the front, top and back of the spreader.

8. The apparatus of Claim 7, comprising sides adjoining the cover and flanking each side of the spreader inside a perimeter of the build area.

9. The apparatus of Claim 8, where the sides block build material spreading laterally away from the build area when the spreader is spreading build material over the build area.

10. The apparatus of Claim 9, comprising an access panel in the cover to allow access to the spreader under the cover.

11. A process for spreading powdered build material in an additive manufacturing machine, comprising:
spreading powdered build material over a work area; and
simultaneously with the spreading, containing the powdered build material to a region surrounding the spreader.

12. The process of Claim 11, where the containing includes containing the powdered build material to a region near the spreader.

13. The process of Claim 11, where the containing includes covering the spreader during the spreading.

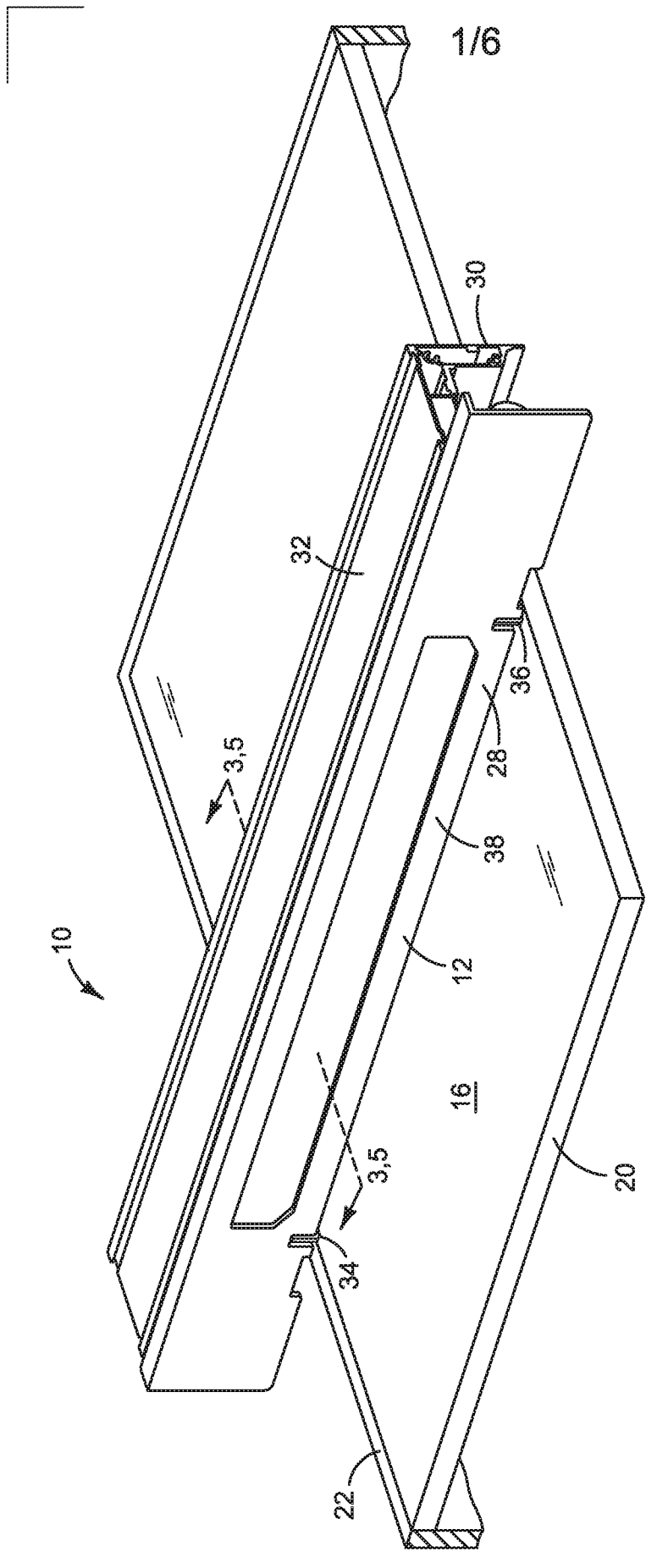
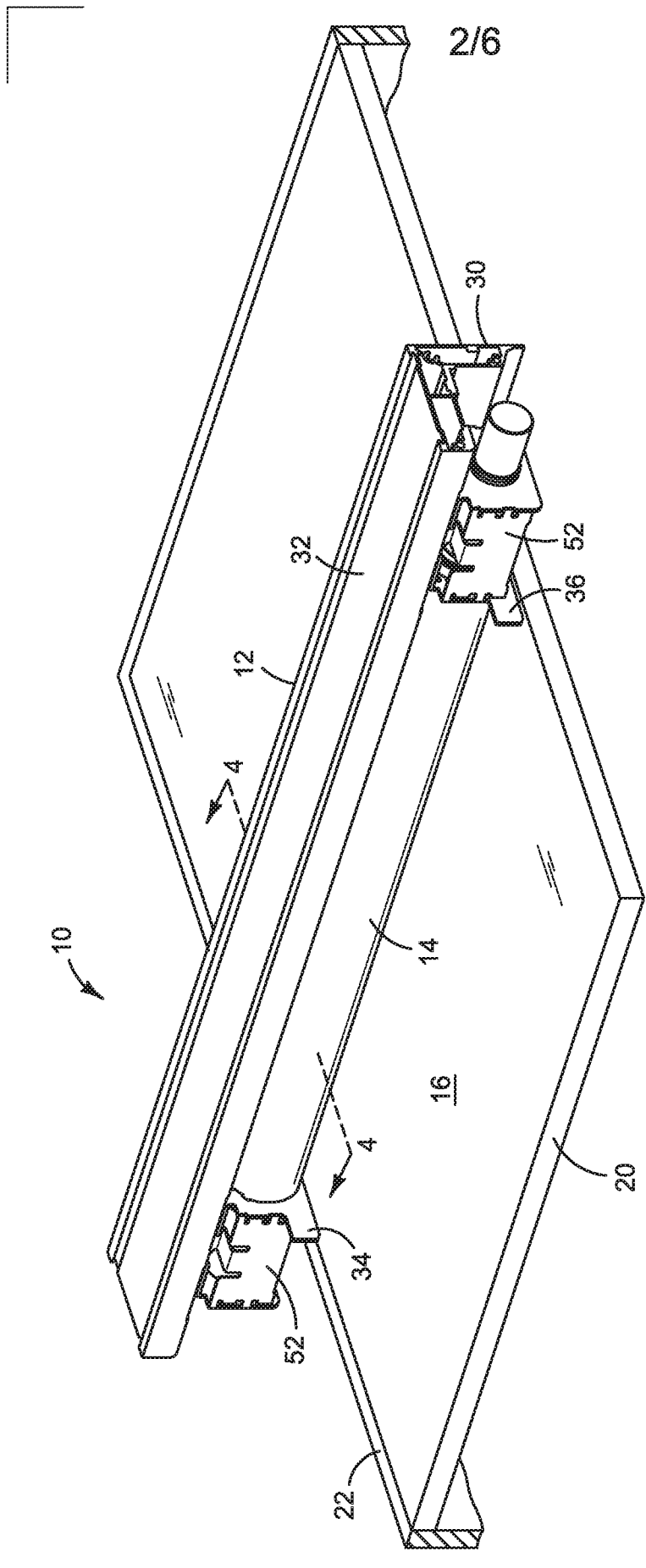
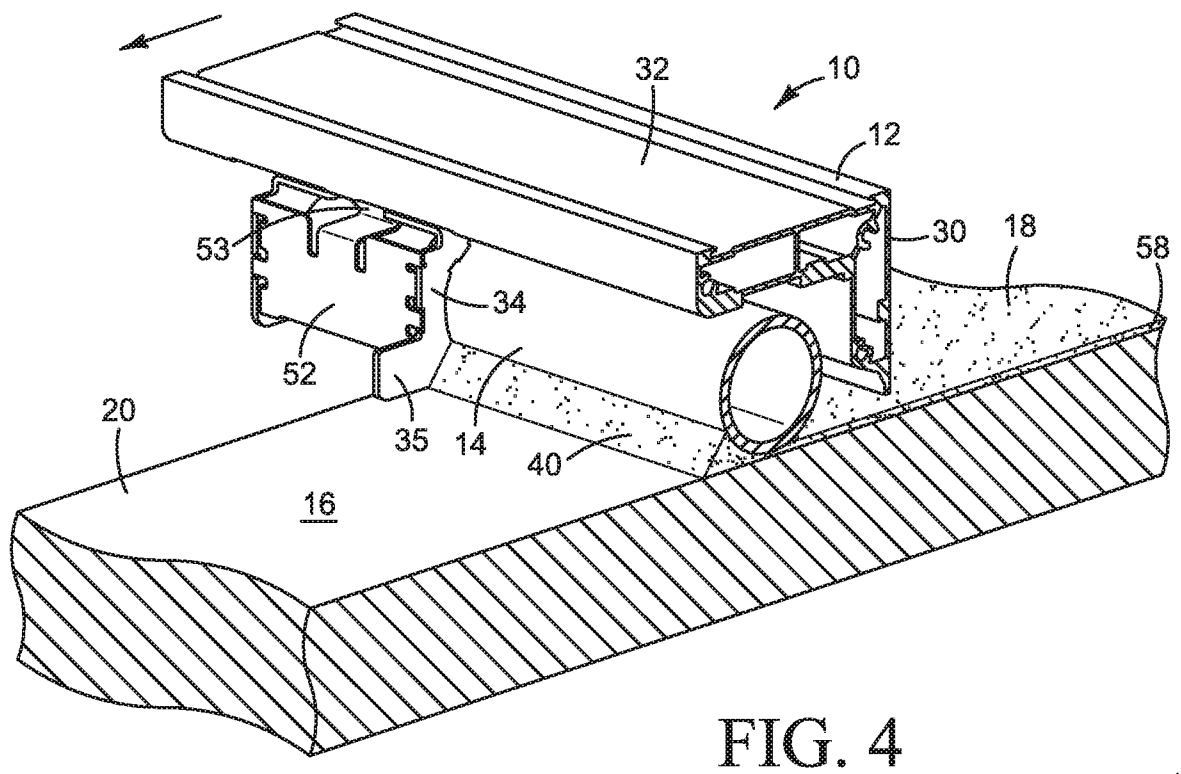
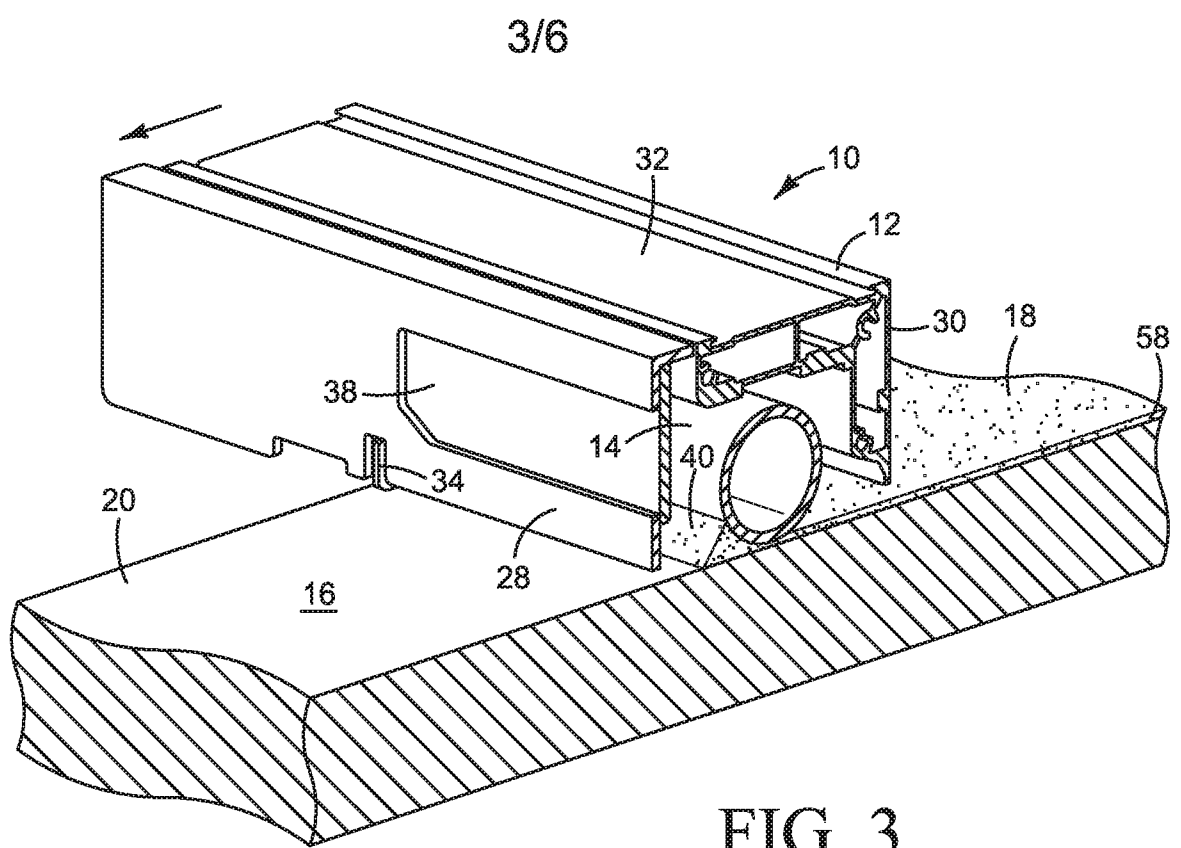


FIG. 1





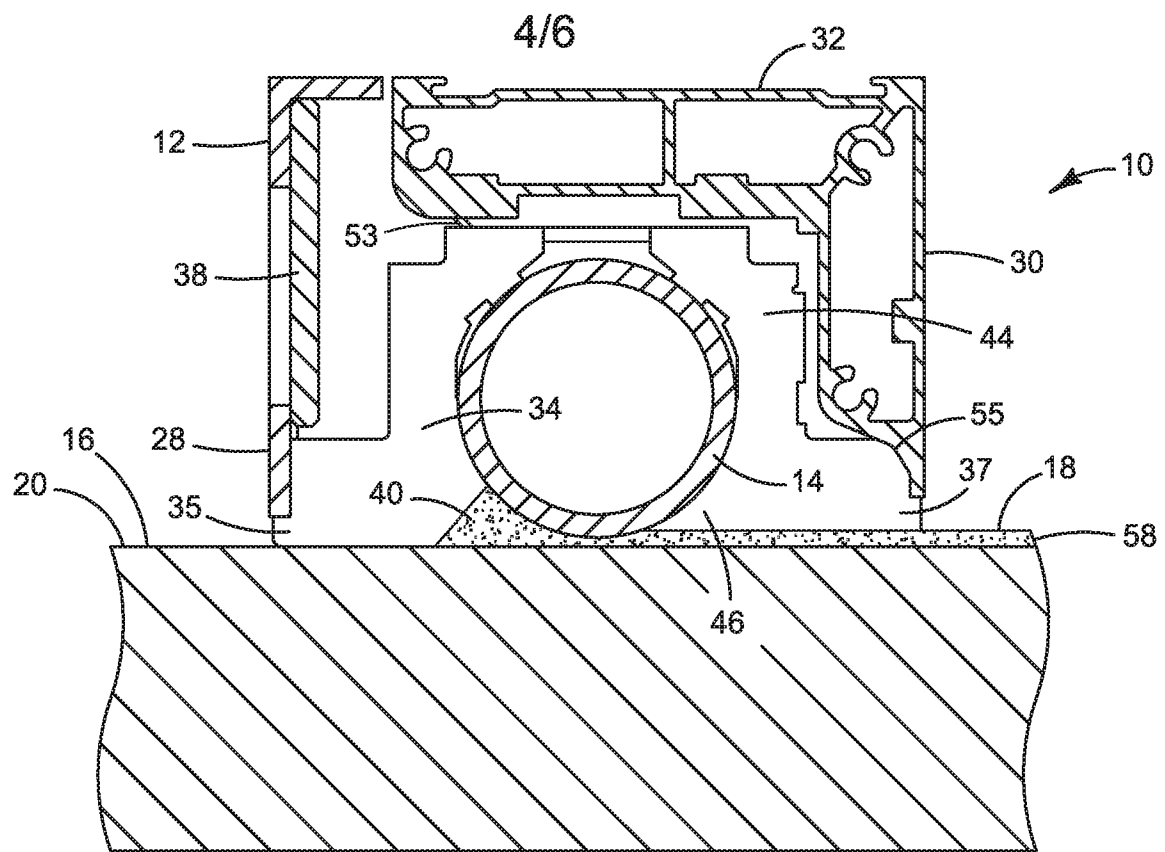


FIG. 5

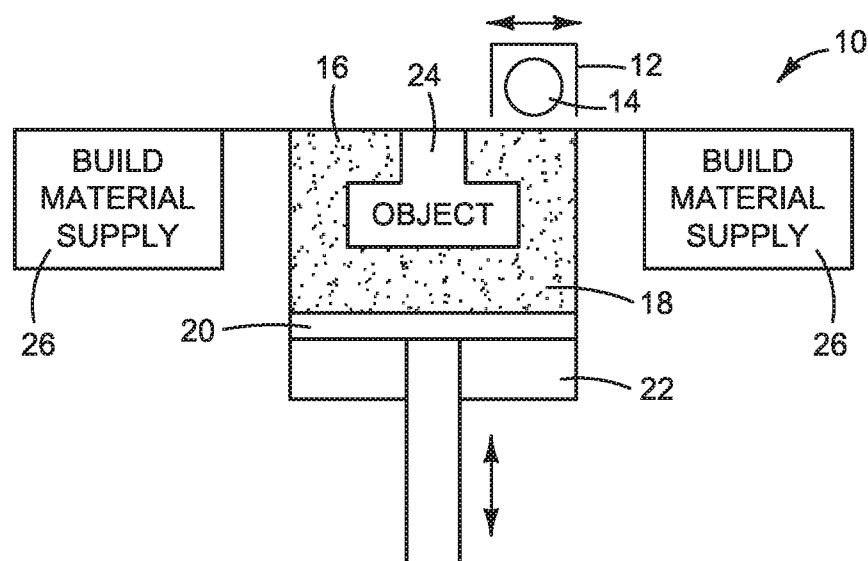


FIG. 6

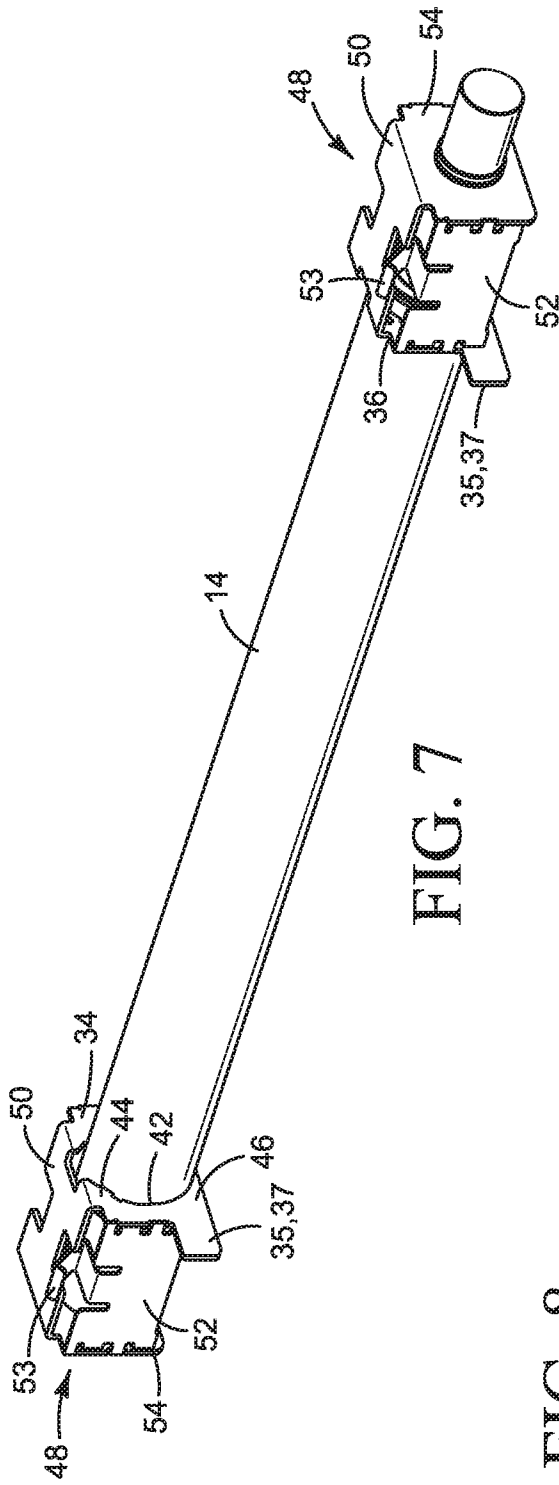
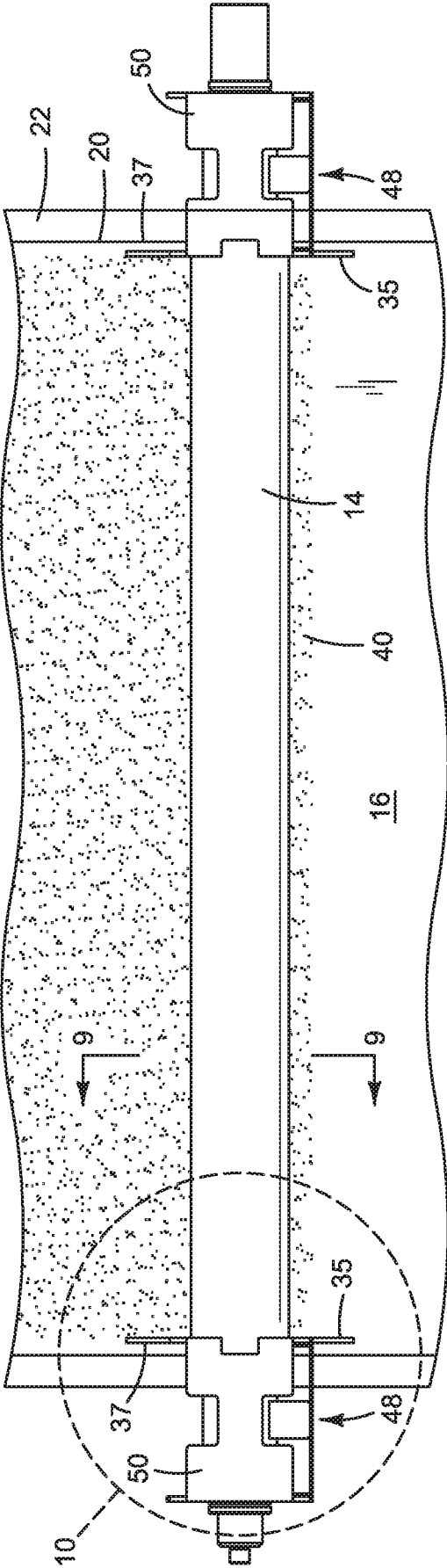


FIG. 8



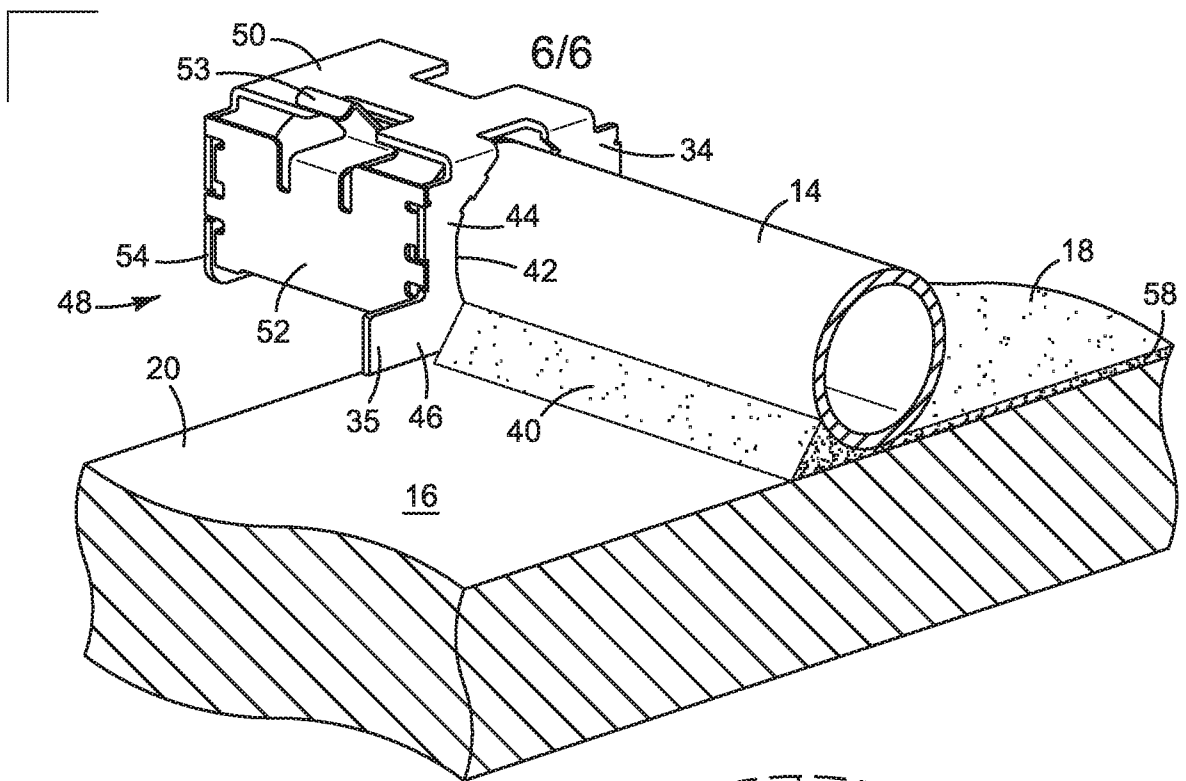


FIG. 9

FIG. 10

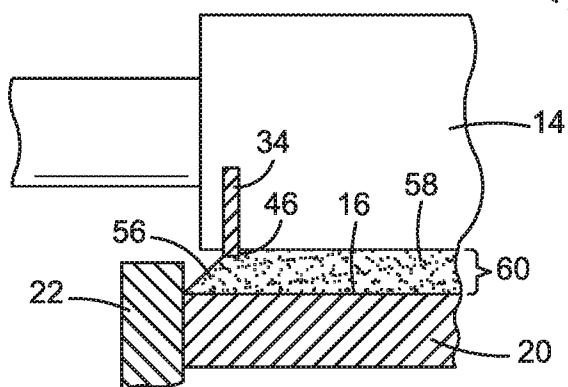
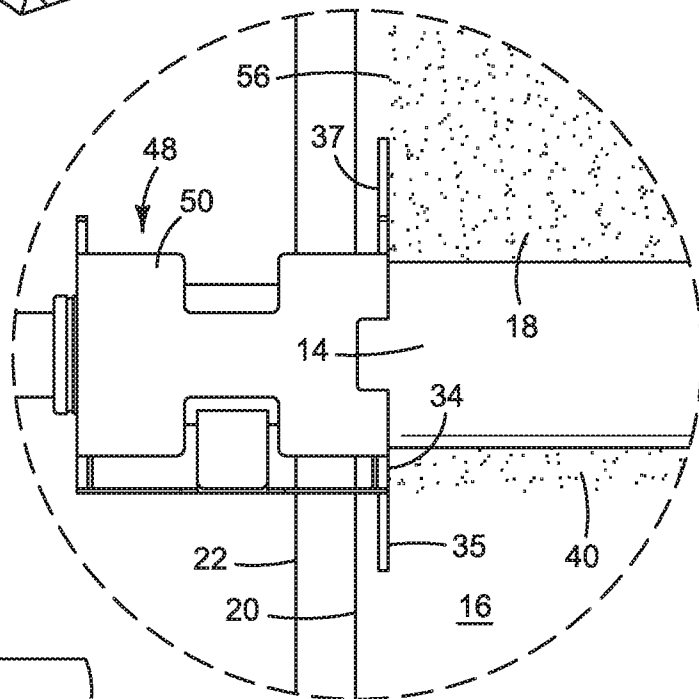


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/032066**A. CLASSIFICATION OF SUBJECT MATTER****B29C 67/00(2006.01)i, B33Y 40/00(2015.01)i, B33Y 30/00(2015.01)i, B33Y 50/02(2015.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
B29C 67/00; B29C 41/02; B65B 1/04; B29C 35/08; B33Y 40/00; B33Y 30/00; B33Y 50/02Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: print, powder, spread, roller, containment, wall, airborne, platform**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 2005-0225007 A1 (LAI, WEI-HSIAN et al.) 13 October 2005 See paragraph [0047] and figure 3.	1-13
A	US 5934343 A (GAYLO, CHRISTOPHER M. et al.) 10 August 1999 See claim 1 and figure 4.	1-13
A	WO 2012-111382 A1 (BROTHER KOGYO KABUSHIKI KAISHA et al.) 23 August 2012 See abstract.	1-13



Further documents are listed in the continuation of Box C.



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International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



Facsimile No. +82-42-481-8578

Authorized officer

CHO, Ki Yun

Telephone No. +82-42-481-5655



INTERNATIONAL SEARCH REPORT

Information on patent family members

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