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(54) **Feature guided profile restoration grinder apparatus**

(57) A surface machining mechanism 30 modifies a repair segment 24 of a body 10 having a contoured surface 12. The surface machining mechanism 30 includes a frame assembly 32 and one or more guide members 45 for supporting the frame assembly 32 on the contoured surface 12. The guide members 45 mate with the contoured surface 12 and are movable along the contoured surface 12 to guide the frame assembly 32. A machining

apparatus 50 is supported by the frame assembly 32. The machining apparatus 50 engages the repair segment 24 of the body (10) as the machining apparatus 50 is moved along the contoured surface 12. A method of modifying a repair segment 24 of a body 10 having a contoured surface 12 with the surface machining mechanism 30 is also provided.

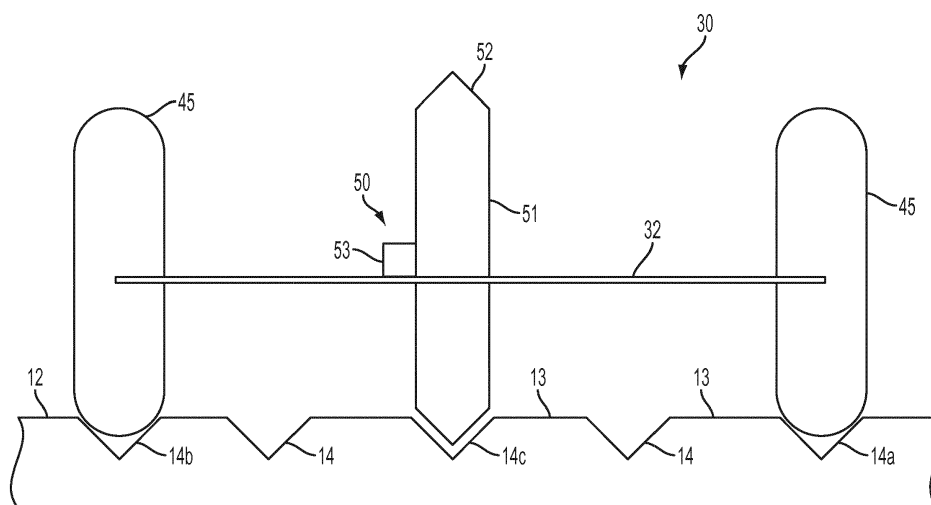


FIG. 3

Description

[0001] The present invention relates generally to surface grinders, and more particularly, to a feature guided profile restoration grinder apparatus.

[0002] Surface grinders are known and used in many different applications. Surface grinders are used, for example, to grind or machine a surface of an object so as to modify a repair segment (e.g., weld repairs, abrasions, etc.). Surface grinders can be used on both planar and non-planar surfaces. Non-planar surfaces can include three-dimensional patterns or profiles. Restoring these non-planar surfaces is time consuming and costly, as existing surface grinders must be manually moved and operated along the three-dimensional surface. Further, the repair segment of the non-planar surface should be modified to substantially match the contour (e.g., size and shape) of the surrounding non-repaired surface. Accordingly, it would be beneficial to provide a grinder apparatus that uses a non-repaired contoured segment as a guide for restoring a repair segment.

[0003] The following presents a simplified summary of the invention in order to provide a basic understanding of some example aspects of the invention. This summary is not an extensive overview of the invention. Moreover, this summary is not intended to identify critical elements of the invention nor delineate the scope of the invention. The sole purpose of the summary is to present some concepts of the invention in simplified form as a prelude to the more detailed description that is presented later.

[0004] In accordance with one aspect, the present invention provides a surface machining mechanism for modifying a repair segment of a body having a contoured surface. The surface machining mechanism includes a frame assembly and one or more guide members for supporting the frame assembly on the contoured surface. The guide members mate with the contoured surface and are movable along the contoured surface to guide the frame assembly. A machining apparatus is supported by the frame assembly. The machining apparatus engages the repair segment of the body as the machining apparatus is moved along the contoured surface.

[0005] In accordance with another aspect, the present invention provides a surface machining mechanism for modifying a repair segment of a body having a contoured surface. The surface machining mechanism includes one or more guide members mating with the contoured surface and being movable along the contoured surface. The guide members include a shape that matches a shape of the contoured surface. The surface machining mechanism further includes a machining apparatus supported by the one or more guide members, the machining apparatus engaging the repair segment of the body as the guide members are moved along the contoured surface.

[0006] In accordance with another aspect, the present invention provides a method of modifying a repair segment of a body having a contoured surface. The method

includes the steps of providing a surface machining mechanism including one or more guide members for mating with the contoured surface and a machining apparatus being supported by the guide members. The method further includes the step of moving the guide members along the contoured surface to guide the machining apparatus and engaging the repair segment of the body with the machining apparatus as the guide members move along the contoured surface.

[0007] The foregoing and other aspects of the present invention will become apparent to those skilled in the art to which the present invention relates upon reading the following description with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of an example body having a contoured surface and a repair segment in accordance with an aspect of the present invention;

FIG. 2 is a perspective view of an example surface machining mechanism provided on the body for restoring the repair segment to match the contoured surface;

FIG. 3 is an end view of the example surface machining mechanism in engagement with the contoured surface;

FIG. 4 is an end view of a second example surface machining mechanism in engagement with a second example contoured surface;

FIG. 5 is a perspective view of the example surface machining mechanism in engagement with the contoured surface after the surface machining mechanism has made a first pass over the repair segment; and

FIG. 6 is a perspective view similar to FIG. 5, but with the surface machining mechanism having fully restored the repair segment to match the contoured surface.

[0008] Example embodiments that incorporate one or more aspects of the present invention are described and illustrated in the drawings. These illustrated examples are not intended to be a limitation on the present invention. For example, one or more aspects of the present invention can be utilized in other embodiments and even other types of devices. Moreover, certain terminology is used herein for convenience only and is not to be taken as a limitation on the present invention. Still further, in the drawings, the same reference numerals are employed for designating the same elements.

[0009] FIG. 1 illustrates a perspective view of an example body 10 having a contoured surface 12, according to one aspect of the invention. In short summary, the body 10 can have a repair segment 24 that represents a

weld repair, surface irregularity, or the like. A surface machining mechanism 30 (shown in FIG. 2) is provided to modify and restore the repair segment 24 to substantially match the surrounding contoured surface 12. In short summary, the surface machining mechanism 30 engages and moves along the contoured surface 12 in a direction towards the repair segment 24. The surface machining mechanism 30 includes a machining apparatus 50 that can engage (e.g., grind, cut, etc.) the repair segment 24. As such, the surface machining mechanism 30 is guided by the contoured surface 12 as the machining apparatus 50 modifies and restores the shape of the repair segment 24 to match the contoured surface 12.

[0010] The body 10 is shown to include a generally cylindrical shape extending between opposing ends. It is to be appreciated that the body 10 is generically/schematically depicted in FIG. 1 for ease of illustration. In one example, the body 10 can include a number of structures that are common in gas turbines. For example, the body 10 can include combustion liners, combustion turbines, or the like. As such, the body 10 shown in FIG. 1 includes only possible structure, as the body 10 includes a number of sizes, shapes, and configurations. Further, the body 10 is not limited to the generally cylindrical shape as shown. Rather, the body 10 could include a flat or substantially flat surface, a tubular shape, conical shape, or the like. In addition, the body 10 is not limited to being used in the above mentioned gas turbine environment, but, instead, could be used in nearly any environment. As such, the body 10 includes any number of structures that have a surface on which repairs (e.g., a welding repair, etc.) may be made.

[0011] The body 10 includes the contoured surface 12. The contoured surface 12 defines an outer surface of the body 10 and extends partially or completely along a length the body 10. In one example, the contoured surface 12 includes a non-planar surface, such that the contoured surface 12 includes undulations, grooves, ribs, or the like. As is generally known, by providing the contoured surface 12 with undulations, grooves, ribs, or the like, the contoured surface 12 assists in transferring heat to/from the body 10.

[0012] Referring now to FIG. 2, a portion of the body 10 is shown. In this example, the contoured surface 12 of the body 10 includes a diamond cross-hatch pattern. The diamond cross-hatch pattern has a plurality of diamond shaped projections 13 that are separated by one or more grooves 14 extending therebetween. The contoured surface 12 includes the one or more grooves 14 extending along the body 10. The grooves 14 define an indentation, depression, or the like projecting into the surface of the body 10. The grooves 14 can extend generally parallel to each other in a crisscross pattern around the body 10. In one particular example, the grooves 14 include a V-shaped cross-section projecting into the body 10. Of course, it is to be understood that the grooves 14 are not limited to such a shape, and include any number of different sizes and shapes, such as a square cross-

section, rounded cross-section, combinations of the aforementioned cross-sections, etc. In further examples, it is to be appreciated that the contoured surface 12 is not limited to having the diamond cross-hatch pattern shown in FIGS. 1 and 2, and could include nearly any type of cross-hatch pattern, such as a square cross-hatch pattern, circular cross-hatch pattern, or the like.

[0013] The body 10 further includes the repair segment 24. It is to be appreciated that the repair segment 24 is somewhat generically/schematically depicted, as the repair segment 24 includes a number of different configurations. In some examples, the repair segment 24 includes a weld repair, surface deformity, surface irregularity, etc. Indeed, the repair segment 24 includes nearly any type of surface irregularity in which the repair segment 24 does not match the shape of the contoured surface 12 (i.e., does not have the diamond cross-hatch pattern with grooves 14). In one possible example, a portion of the body 10 is welded to repair a crack, defect, or the like. After the welding process occurs, the location of the weld (corresponding to the repair segment 24) may no longer match the shape of the contoured surface 12. This repair segment 24 reduces the heat transfer efficiency of the body 10. As such, restoring the repair segment 24 to match the shape of the contoured surface 12 can improve heat transfer efficiency of the body 10. The repair segment 24 includes any number of sizes and shapes that may not match the contoured surface 12 including, but not limited to, a substantially planar surface, a surface having one or more raised undulations or projections, depressions, etc. Similarly, the repair segment 24 could be formed at any number of locations along the outer surface of the body 10, and is not limited to the specific location shown in FIG. 2. Indeed, the repair segment 24 includes one repair segment or, in the alternative, a plurality of repair segments.

[0014] Referring still to FIG. 2, an example of the surface machining mechanism 30 is shown in engagement with a portion of the body 10. The surface machining mechanism 30 can be positioned at nearly any location along the body 10. As such, the portion of the body 10 shown in FIG. 2 is representative of nearly any portion of the body 10 shown in FIG. 1. The surface machining mechanism 30 is somewhat generically/schematically depicted in FIG. 2 for illustrative purposes. In further examples, the surface machining mechanism 30 is not limited to the shown structure, as the surface machining mechanism 30 could take on a variety of constructions (e.g., larger, smaller, etc.) in accordance with one or more aspects of the present invention. Indeed, while only one surface machining mechanism is shown and discussed herein, it is to be understood that the discussion may be equally applicable to a plurality of surface machining mechanisms.

[0015] The surface machining mechanism 30 includes a frame assembly 32. The frame assembly 32 is a generally elongate structure that extends between a first end 34 and an opposing second end 36. In the shown exam-

ple, the frame assembly 32 includes a T-shaped body portion 38. It is understood that the frame assembly 32 and T-shaped body portion 38 are generically/schematically depicted in FIG. 1 for illustrative purposes, as the frame assembly 32 includes a number of shapes and constructions. For instance, the frame assembly 32 need not be limited to the size and shape shown in FIG. 1 and, in other examples, the frame assembly 32 could be larger or smaller than in the shown example. In a further example, the frame assembly 32 could also include a variety of structures that improve the gripping/handling of the surface machining mechanism 30. For instance, the frame assembly 32 could include one or more handles, gripping structures, or the like, that allow a user to grip and more easily manipulate/move the surface machining mechanism 30. The frame assembly 32 is also not limited to including the T-shaped body portion 38, and includes any number of shapes, such as polygonal shapes, circular shapes, etc.

[0016] The surface machining mechanism 30 further includes one or more guide members 45 attached to the frame assembly 32. In one example, three guide members are provided, with one guide member being positioned at the first end 34 of the frame assembly 32 and two of the guide members disposed at the opposing second end 36. Of course, it is to be understood that more or fewer guide members can be provided. Further, the guide members 45 could be provided in a number of locations and need not be limited to the shown examples. The guide members 45 could be arranged such that one or more guide members are provided at the first end 34 while one or more guide members are provided at the second end 36. Accordingly, it is to be appreciated that the guide members 45 could be positioned at a variety of locations, and the examples shown herein comprise merely one possible configuration.

[0017] The guide members 45 are movably attached to the frame assembly 32. In one example, the guide members 45 rotate with respect to the frame assembly 32. The guide members 45 could be provided with any number of structures that allow for rotation with respect to the frame assembly 32, such as axles, drive shafts, ball bearings, etc. As the frame assembly 32 is moved along the contoured surface 12, the guide members 45 rotate while mating with (e.g., received within) the grooves 14. As such, the guide members 45 support the frame assembly 32 on the contoured surface 12, and guide the frame assembly 32 along the contoured surface 12. In particular, the guide members 45 can support the frame assembly 32 a distance above the contoured surface 12, such that the frame assembly 32 moves along the contoured surface 12.

[0018] Turning now to FIG. 3, an end view of the surface machining mechanism 30 is shown from the second end 38 of the frame assembly 32. For ease of illustration, only three grooves are shown to be positioned between opposing guide members. However, in further examples, the guide members 45 could be spaced closer together

(i.e., with fewer grooves in between) or farther apart (i.e., with more grooves in between). The guide members 45 are generally circular in shape and have rounded ends. In one example, the guide members 45 include wheels, or other circular components. The guide members 45 have a width that is slightly smaller than a width of the grooves 14. In such an example, the guide members 45 mate with the contoured surface 12 by engaging the grooves 14 and are received within the grooves 14. In particular, the guide members 45 are received within a first groove 14a and a second groove 14b. The guide members 45 will engage and contact walls of the grooves 14, such that the guide members 45 are guided by the grooves 14 as the surface machining mechanism 30 moves along the contoured surface 12. It is to be understood that the guide members 45 are not specifically limited to the size and shape that is shown in FIG. 3, and could include a larger or smaller width than as shown.

[0019] Referring still to FIG. 3, the surface machining mechanism 30 further includes a machining apparatus 50 attached to the frame assembly 32. The machining apparatus 50 is attached to the frame assembly 32 at a location between the first end 34 and the opposing second end 36. In further examples, the machining apparatus 50 is not limited to such a position, and could be positioned closer to the first end 34 or closer to the second end 36. The machining apparatus 50 is thus supported with respect to the contoured surface 12 by the frame assembly 32 and the guide members 45. The machining apparatus 50 can be attached to the frame assembly 32 in any number of ways. In one example, the machining apparatus 50 is attached to a spindle, shaft, or the like that is movably attached with respect to the frame assembly 32. In other examples, the machining apparatus is attached by means of mechanical fasteners, or the like. As will be described in more detail below, the machining apparatus 50 can move, rotate, spin, etc., with respect to the frame assembly 32. It is to be appreciated that the machining apparatus 50 is not limited to including the spindle, shaft, or the like, and that the machining apparatus 50 can include nearly any structure that allows the machining apparatus 50 to move, rotate, etc. with respect to the frame assembly 32.

[0020] The machining apparatus 50 includes a cutting tool 51. The cutting tool 51 is formed of an abrasive and/or resilient material, including steel, aluminum, or the like. In further examples, the cutting tool 51 may include particles, abrasive compounds, or the like that can assist in cutting, grinding, etc. It is to be appreciated that the cutting tool 51 is not limited to the examples described herein, as the cutting tool 51 can include nearly any material that can be used to cut, grind, machine, etc. any number of types of materials. Further, it is to be understood that the cutting tool 51 is a broad term such that the function is not limited to only cutting. Rather, the cutting tool 51 performs a number of surface modifying/restoring operations, including, but not limited to, cutting, grinding, sanding, material removing, etc. The cutting tool 51 in-

cludes, for example, grinding tools, angle grinders, end mills, cutters, etc.

[0021] The cutting tool 51 is positioned within one of the grooves 14 of the contoured surface 12. In one example, the cutting tool 51 is positioned within a third groove 14c that is positioned between the first groove 14a and second groove 14b. The cutting tool 51 has a shape that generally matches a shape of the grooves 14. In the shown example, the cutting tool 51 includes a cutting surface 52 that is generally V-shaped. The V-shape of the cutting surface 52 substantially matches the size and shape of the groove 14 (e.g., V-shaped groove). In this example, the cutting surface 52 can be slightly smaller in size than the grooves 14, such that the cutting tool 51 is received within the grooves 14. As such, the cutting surface 52 need not form-fit or press-fit against the grooves 14. Such looseness allows for the cutting tool 51 to move (e.g., spin, rotate, etc.) within the groove 14 while reducing the contact of the cutting tool 51 with walls of the groove 14. It is to be appreciated that the cutting tool 51 need not be limited to the V-shape as shown in FIG. 2. Rather, in further examples, the cutting tool 51 may have a size and shape that matches other sizes and shapes of the groove 14, such as by having the cutting tool 51 include a generally rounded shape, square shape, or the like.

[0022] The machining apparatus 50 further includes a drive unit 53. The drive unit 53 is somewhat generically/schematically depicted in FIG. 3, as it is understood that the drive unit 53 includes a number of different structures. The drive unit 53 is supported by the frame assembly 32, such as by being attached to the frame assembly 32. The drive unit 53 causes the cutting tool 51 to move. In one example, the drive unit 53 includes a drive shaft that provides rotational movement. The drive shaft extends from the drive unit 53 and attaches to the cutting tool 51, such that the cutting tool 51 can move (e.g., spin, rotate, etc.) with respect to the drive unit 53. The drive unit 53 moves the cutting tool 51, so as to cause rotation, spinning, or the like of the cutting tool 51. The drive unit 53 can be powered by any number of power sources including, but not limited to, an electric motor, compressed air, an engine, or the like.

[0023] In operation, the machining apparatus 50 is brought into contact with the repair segment 24. The cutting tool 51 is driven and rotated by the drive unit 53. The cutting tool 51 will contact the repair segment 24 and modify/restore the repair segment 24 by cutting, grinding, sanding, etc. the repair segment 24. The cutting tool 51 will therefore modify the repair segment 24 by removing any extraneous material from the repair segment 24. The cutting tool 51 can therefore modify the repair segment 24 to substantially match the shape of the contoured surface 12.

[0024] Referring now to FIG. 4, a second example of a surface machining mechanism 130 is shown. In particular, an end view of the surface machining mechanism 130 is shown from the second end 38 of the frame as-

sembly 32. In this example, the contoured surface 12 is not limited to including the diamond cross-hatch pattern having grooves 14. Instead, the contoured surface 12 can also include a plurality of ribs 16. The ribs 16 extend circumferentially around the outer surface of the body 10. The ribs 16 project radially outwardly from the body 10, such that the ribs 16 define an outward projection, protrusion, or the like. The ribs 16 can be separated from each other such that a gap, space, or the like is positioned between adjacent ribs 16. The ribs 16 extend generally parallel to each other around the body 10. In further examples, the ribs 16 can have a longer or shorter radial length (e.g., extending farther or shorter from the outer surface), or could be wider or narrower in width.

[0025] The surface machining mechanism 130 can be positioned at nearly any location along the body 10. As with the example shown in FIG. 3, the surface machining mechanism 130 is again somewhat generically/schematically sized and shaped for illustrative purposes. In further examples, however, the surface machining mechanism 130 is not limited to the shown structure, and could take on a variety of constructions (e.g., larger, smaller, etc.) in accordance with one or more aspects of the invention.

[0026] The surface machining mechanism 130 includes the frame assembly 32. The frame assembly 32 is identical to the frame assembly 32 described above with respect to the surface machining mechanism 30 in FIGS. 1 to 3. As such, the frame assembly 32 need not be fully described again. In short summary, the frame assembly 32 of the surface machining mechanism 130 can include the T-shaped body portion 38 extending between the first end 34 and second end 36.

[0027] The surface machining mechanism 130 further includes one or more guide members 145. As with the example described above with respect to the surface machining mechanism 30, three guide members 145 can be provided, with one guide member being disposed at the first end 34 of the frame assembly 32 while two of the guide members are disposed at the opposing second end 36. In further examples, however, more or fewer guide members can be provided.

[0028] The guide members 145 can be movably attached to the frame assembly 32. In one example, the guide members 145 rotate with respect to the frame assembly 32. The guide members 145 can include any number of structures that allow for rotation with respect to the frame assembly 32, such as axles, drive shafts, ball bearings, etc. As the frame assembly 32 is moved along the contoured surface 12, the guide members 145 rotate while engaging the contoured surface 12. The guide members 145 are generally circular in shape such that the guide members 145 can rotate and traverse along the contoured surface 12. As such, the guide members 145 support the frame assembly 32 on the contoured surface 12, and can guide the frame assembly 32 along the contoured surface 12.

[0029] The guide members 145 each include an engagement portion 146. The engagement portion 146 ex-

tends circumferentially around an outer surface of the guide members 145. The engagement portion 146 of each of the guide members 145 is sized and shaped to receive one of the ribs 16. In one example, the engagement portion 146 defines an indentation or groove that projects inwardly from the outer circumferential surface of the guide members 145 towards a center of the guide members 145. The engagement portion 146 has a size (e.g., width and/or depth) that substantially matches a size of the ribs 16, such that the engagement portion 146 of the guide members 145 can mate with the contoured surface 12. In particular, one of the ribs is received within the engagement portion 146. It is to be understood, however, that the engagement portion 146 could be larger or smaller than as shown and is not specifically limited to the size and shape of FIG. 4. In one particular example, the engagement portion 146 is slightly larger in size than the ribs 16, such that engagement portion 146 need not form-fit or press-fit against the ribs 16. Such looseness minimizes friction between the engagement portion 146 and the ribs 16. As such, the engagement portion 146 moves (e.g., rotates) along the contoured surface 12 while being guided by the ribs 16.

[0030] The engagement portion 146 includes a generally V-shaped cross-section. However, it is to be appreciated that the engagement portion 146 need not be limited to such a shape. Rather, in further examples, the engagement portion 146 can have a size and shape that matches other sizes and shapes of the ribs 16, such as by having a rounded-shaped cross-section, a square-shaped cross-section, or the like.

[0031] Referring still to FIG. 4, the surface machining mechanism 130 further includes a machining apparatus 150. The machining apparatus 150 can be attached to the frame assembly 32 in an identical manner as described above with respect to the surface machining mechanism 30. For example, the machining apparatus 150 is attached along the frame assembly 32 at a location between the first end 34 and the opposing second end 36. As such, the machining apparatus 150 is supported with respect to the contoured surface 12 by the frame assembly 32 and the guide members 145. The machining apparatus 150 can be attached to the frame assembly 32 in any number of ways. In one example, the machining apparatus 150 is attached to a spindle, shaft, or the like that is attached to the frame assembly 32. In other examples, the machining apparatus is attached by means of mechanical fasteners, or the like. As will be described in more detail below, the machining apparatus 150 moves, rotates, spins, etc., with respect to the frame assembly 32. It is to be appreciated that the machining apparatus 150 is not limited to including the spindle, shaft, or the like as the machining apparatus 150 can include nearly any structure that allows the machining apparatus 150 to move, rotate, etc. with respect to the frame assembly 32.

[0032] The machining apparatus 150 further includes a cutting tool 151. The cutting tool 151 is positioned ad-

jacent one of the ribs 16. The cutting tool 151 can be positioned in relatively close proximity to the contoured surface 12 adjacent the ribs 16. It is to be appreciated that the distance between the cutting tool 151 and ribs 16 shown in FIG. 4 is not to scale for illustrative purposes and to more clearly depict the relative position of the cutting tool 151 with respect to the rib 16. However, in operation, the cutting tool 151 can be closer to both the contoured surface 12 and ribs 16. The cutting tool 151 can include a generally circular shape that can move (e.g., spin, rotate, etc.) with respect to the ribs 16. The cutting tool 151 is not limited to being positioned on a side of the rib 16, and in further examples, could be adjusted in position with respect to the ribs 16.

[0033] The machining apparatus 150 further includes the drive unit 53. The drive unit 53 is identical in structure and function to the drive unit 53 described above with respect to the machining apparatus 50. For example, the drive unit 53 is supported by the frame assembly 32, such as by being attached to the frame assembly 32. The drive unit 53 includes a drive shaft that provides rotational movement. The drive shaft could extend from the drive unit 53 and attach to the cutting tool 151, such that the cutting tool 151 moves (e.g., spin, rotate, etc.) with respect to the drive unit 53. The drive unit 53 can be powered by any number of power sources including, but not limited to, an electric motor, compressed air, an engine, or the like.

[0034] The cutting tool 151 can be formed of an abrasive and/or resilient material, including steel, aluminum, or the like. In further examples, the cutting tool 151 may include particles, abrasive compounds, etc. bonded or adhered to the machining apparatus 150 to assist in grinding. The cutting tool 151 is not limited to the examples described herein, as the cutting tool 51 can include nearly any material, such that the surface machining mechanism 130 can be used to cut, grind, machine, etc. any number of types of materials. Further, it is to be understood that the cutting tool 151 is a broad term such that the function is not limited to only cutting. Rather, the cutting tool 151 can perform any number of surface modifying/restoring operations, including, but not limited to, cutting, grinding, sanding, material removing, etc.

[0035] In operation, the machining apparatus 150 is brought into contact with the repair segment 24. In particular, the cutting tool 51 contacts the repair segment 24 and modifies the repair segment 24 by cutting, grinding, sanding, etc. the repair segment 24. The cutting tool 51 therefore restores the repair segment 24 and removes extraneous material from the repair segment 24. The cutting tool 51 will modify and restore the repair segment 24 to substantially match the shape of the contoured surface 12.

[0036] Turning now to FIGS. 5 and 6, the operation of the surface machining mechanism 30, 130 can now be described in more detail. It is to be appreciated that FIG. 5 depicts the surface machining mechanism 30 described above with respect to FIGS. 2 and 3. However,

the surface machining mechanism 130 described with respect to FIG. 4 can operate in a substantially identical manner. Accordingly, the description of the operation with regard to FIGS. 5 and 6 is applicable to each of the surface machining mechanisms 30, 130 described herein.

[0037] Referring first to FIG. 5, the surface machining mechanism 30 is moved along the contoured surface 12 of the body 10. In particular, the surface machining mechanism 30 is moved from the position shown in FIG. 2, and over the repair segment 24. By moving the surface machining mechanism 30 over the repair segment 24, the machining apparatus 50 engages the repair segment 24 of the body 10. The cutting tool 51 moves (e.g., spins, rotates, etc.) as the surface machining mechanism 30 is moved. As such, the cutting tool 51 engages the repair segment 24 and modifies the repair segment 24. In particular, since the cutting tool 51 matches a size and shape of one of the grooves 14, the cutting tool 51 can remove material from the repair segment 24 and modify the shape of the repair segment 24 to match the remaining grooves 14.

[0038] The surface machining mechanism 30 can be moved one or more times over the repair segment 24. In some examples, the surface machining mechanism 30 can make a single pass over the repair segment 24, which modifies the repair segment 24 to match the remaining grooves 14. In other examples, it may be necessary for the surface machining mechanism 30 to make multiple passes back and forth over the repair segment 24. This may be due, at least in part, to larger and/or denser repair segments. At the position shown in FIG. 5, the surface machining mechanism 30 has made at least one pass over the repair segment 24. Indeed, after this at least one pass, the repair segment 24 may be slightly modified, but may not completely match the remaining grooves 14 (i.e., see the partially modified contour of the repair segment 24 in FIG. 5). In such an example, it may be necessary to make another pass of the surface machining mechanism 30 over the repair segment 24. Indeed, the surface machining mechanism 30 can be moved along a first direction 80 towards the repair segment 24. To make a subsequent pass, the surface machining mechanism 30 could be moved along a direction that is opposite from the first direction 80 (e.g., a second direction 81 shown in FIG. 2).

[0039] Referring now to FIG. 6, the surface machining mechanism 30 is shown after the requisite number of passes have been made over the repair segment 24. In this example, the repair segment 24 is not shown, as the repair segment 24 has been fully modified so as to match the contoured surface 12. It is to be appreciated that while the repair segment 24 is not shown in FIG. 6, in other examples, traces or remnants of the repair segment 24 may be left over even after the modification has been completed. In such examples, the repair segment 24 may still be slightly visible even while substantially matching the shape of the contoured surface 12. Accordingly, even

after the surface machining mechanism 30 has finished modifying the repair segment 24, an exact match of the repair segment 24 and the contoured surface 12 need be provided.

[0040] The examples shown in FIGS. 5 and 6 depict the surface machining mechanism 30 remaining within one set of grooves 14. However, in further examples, the repair segment 24 may be wider than as shown, such that the repair segment 24 extends over a plurality of adjacent grooves 14. In such an example, the surface machining mechanism 30 can make the requisite number of passes over the repair segment 24 within one of the grooves 14. After the modification of the repair segment 24 within this groove has been completed, the surface machining mechanism 30 may be moved (e.g., lifted and removed from the groove 14) and replaced in one of the adjacent grooves 14. The surface machining mechanism 30 can then move along this adjacent groove for the requisite number of passes over the repair segment 24. This process of moving the surface machining mechanism 30 to adjacent grooves 14 can be continued until all or substantially all of the repair segment 24 has been modified to substantially match the contoured surface 12.

[0041] The invention has been described with reference to the example embodiments described above. Modifications and alterations will occur to others upon a reading and understanding of this specification. Example embodiments incorporating one or more aspects of the invention are intended to include all such modifications and alterations insofar as they come within the scope of the appended claims.

[0042] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A surface machining mechanism for modifying a repair segment of a body having a contoured surface, the surface machining mechanism including:

a frame assembly;

one or more guide members for supporting the frame assembly on the contoured surface, the guide members being configured to mate with the contoured surface and being movable along the contoured surface to guide the frame assembly; and

a machining apparatus supported by the frame assembly, the machining apparatus engaging the repair segment of the body as the machining apparatus is moved along the contoured surface.

2. The surface machining mechanism of clause 1, wherein the contoured surface includes a plurality of grooves extending along the body, wherein the guide members are configured to be received within the

grooves.

3. The surface machining mechanism of any preceding clause, wherein the machining apparatus is configured to be received within one of the plurality of grooves. 5

4. The surface machining mechanism of any preceding clause, wherein the guide members are movable within the grooves to guide the frame assembly. 10

5. The surface machining mechanism of any preceding clause, wherein the contoured surface includes a plurality of ribs extending along the body, wherein the ribs are configured to be received within openings in the guide members. 15

6. The surface machining mechanism of any preceding clause, wherein the machining apparatus is positioned adjacent and in contact with one of the plurality of ribs. 20

7. The surface machining mechanism of any preceding clause, wherein the machining apparatus is configured to machine the repair segment of the body such that the repair segment matches the contoured surface. 25

8. The surface machining mechanism of any preceding clause, wherein the one or more guide members includes three guide members with one of the guide members disposed at a first end of the frame assembly and the remaining two guide members being disposed at an opposing second end of the frame assembly. 30 35

9. The surface machining mechanism of any preceding clause, wherein the machining apparatus is attached to the frame assembly at a location between the first end and the second end of the frame assembly. 40

10. The surface machining mechanism of any preceding clause, wherein the machining apparatus includes a grinding tool. 45

11. A surface machining mechanism for modifying a repair segment of a body having a contoured surface, the surface machining mechanism including: 50

one or more guide members being configured to mate with the contoured surface and being movable along the contoured surface, wherein the guide members include a shape that is configured to match a shape of the contoured surface; and 55

a machining apparatus supported by the one or

more guide members, the machining apparatus engaging the repair segment of the body as the guide members are moved along the contoured surface.

12. The surface machining mechanism of any preceding clause, wherein the contoured surface includes a plurality of grooves extending along the body, wherein the guide members are configured to be received within the grooves.

13. The surface machining mechanism of any preceding clause, wherein the machining apparatus is configured to be received within one of the plurality of grooves.

14. The surface machining mechanism of any preceding clause, wherein the contoured surface includes a plurality of ribs extending along the body, wherein the ribs are configured to be received within the openings in the guide members.

15. The surface machining mechanism of any preceding clause, wherein the one or more guide members includes three guide members with one of the guide members disposed at a first end of the frame assembly and the remaining two guide members being disposed at an opposing second end of the frame assembly.

16. The surface machining mechanism of any preceding clause, wherein the machining apparatus is attached to the frame assembly at a location between the first end and the second end of the frame assembly.

17. The surface machining mechanism of any preceding clause, wherein the machining apparatus includes a grinding tool.

18. A method of modifying a repair segment of a body having a contoured surface, the method including the steps of:

providing a surface machining mechanism including one or more guide members for mating with the contoured surface and a machining apparatus being supported by the guide members;

moving the guide members along the contoured surface to guide the machining apparatus; and

engaging the repair segment of the body with the machining apparatus as the guide members move along the contoured surface.

19. The method of any preceding clause, further including the step of modifying the repair segment of

the body to match the contoured surface after engaging the repair segment with the machining apparatus.

20. The method of any preceding clause, wherein the surface machining mechanism further includes a frame assembly supported by the guide members.

Claims

1. A surface machining mechanism (30) for modifying a repair segment (24) of a body (10) having a contoured surface (12), the surface machining mechanism (30) including:

a frame assembly (32);
one or more guide members (45) for supporting the frame assembly (32) on the contoured surface (12), the guide members (45) being configured to mate with the contoured surface (12) and being movable along the contoured surface (12) to guide the frame assembly; and
a machining apparatus (50) supported by the frame assembly (32), the machining apparatus (50) engaging the repair segment (24) of the body (10) as the machining apparatus (50) is moved along the contoured surface (12).

2. The surface machining mechanism of claim 1, wherein the contoured surface (12) includes a plurality of grooves (14) extending along the body (10), wherein the guide members (45) are configured to be received within the grooves (14).

3. The surface machining mechanism of claim 2, wherein the machining apparatus (50) is configured to be received within one of the plurality of grooves (14), wherein, preferably, the guide members (45) are movable within the grooves (14) to guide the frame assembly (32).

4. The surface machining mechanism of claim 1, 2 or 3, wherein the contoured surface (12) includes a plurality of ribs (16) extending along the body (10), wherein the ribs (16) are configured to be received within openings in the guide members (45), wherein, preferably, the machining apparatus (50) is positioned adjacent and in contact with one of the plurality of ribs (16).

5. The surface machining mechanism of any preceding claim, wherein the machining apparatus (50) is configured to machine the repair segment (24) of the body (10) such that the repair segment (24) matches the contoured surface (12).

6. The surface machining mechanism of any preceding

claim, wherein the one or more guide members (45) includes three guide members with one of the guide members disposed at a first end (34) of the frame assembly (32) and the remaining two guide members being disposed at an opposing second end (36) of the frame assembly (32), wherein, preferably, the machining apparatus (50) is attached to the frame assembly (32) at a location between the first end and the second end of the frame assembly.

7. The surface machining mechanism of any preceding claim, wherein the machining apparatus (50) includes a grinding tool.

8. A surface machining mechanism (30) for modifying a repair segment (24) of a body (10) having a contoured surface (12), the surface machining mechanism (30) including:

one or more guide members (45) being configured to mate with the contoured surface (12) and being movable along the contoured surface (12), wherein the guide members (45) include a shape that is configured to match a shape of the contoured surface (12); and
a machining apparatus (50) supported by the one or more guide members (45), the machining apparatus (50) engaging the repair segment (24) of the body (10) as the guide members (45) are moved along the contoured surface (12).

9. The surface machining mechanism of claim 8, wherein the contoured surface (12) includes a plurality of grooves (14) extending along the body (10), wherein the guide members (45) are configured to be received within the grooves (14), wherein, preferably, the machining apparatus (50) is configured to be received within one of the plurality of grooves (14).

10. The surface machining mechanism of claim 8 or claim 9, wherein the contoured surface (12) includes a plurality of ribs (16) extending along the body (10), wherein the ribs (16) are configured to be received within the openings in the guide members (45).

11. The surface machining mechanism of claim 8, 9 or 10, wherein the one or more guide members (45) includes three guide members with one of the guide members disposed at a first end (34) of the frame assembly (32) and the remaining two guide members being disposed at an opposing second end (36) of the frame assembly (32), wherein, preferably, the machining apparatus (50) is attached to the frame assembly (32) at a location between the first end (34) and the second end (36) of the frame assembly (32).

12. The surface machining mechanism of any one of

claims 8 to 11, wherein the machining apparatus (50) includes a grinding tool.

- 13.** A method of modifying a repair segment (24) of a body (10) having a contoured surface (12), the method including the steps of: 5

providing a surface machining mechanism (30) including one or more guide members (45) for mating with the contoured surface (12) and a machining apparatus (50) being supported by the guide members (45); 10
moving the guide members (45) along the contoured surface (12) to guide the machining apparatus (50); and 15
engaging the repair segment (24) of the body (10) with the machining apparatus (50) as the guide members (45) move along the contoured surface (12). 20

- 14.** The method of claim 13, further including the step of modifying the repair segment (24) of the body (10) to match the contoured surface (12) after engaging the repair segment (24) with the machining apparatus (50). 25

- 15.** The method of claim 13 or claim 14, wherein the surface machining mechanism (30) further includes a frame assembly (32) supported by the guide members (45). 30

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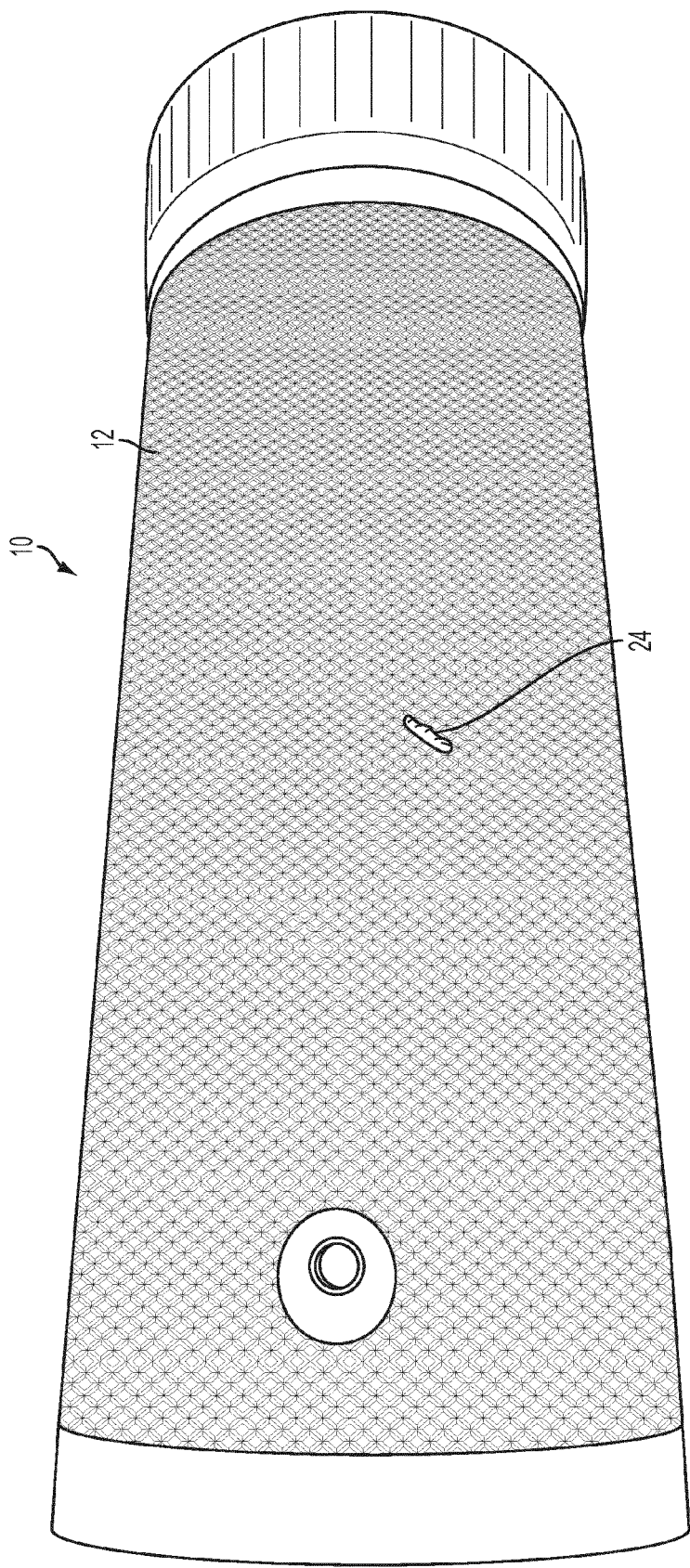


FIG. 1

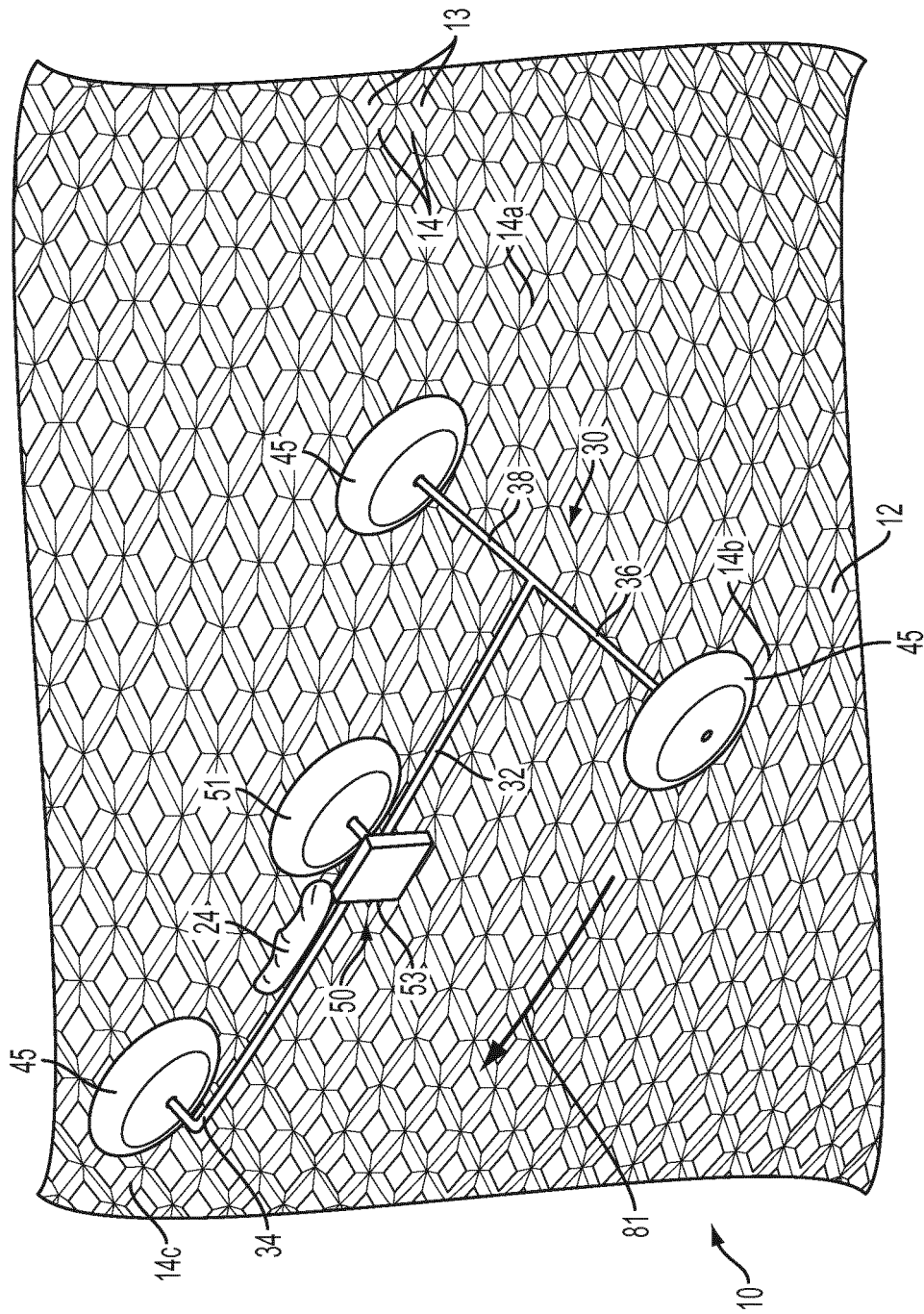


FIG. 2

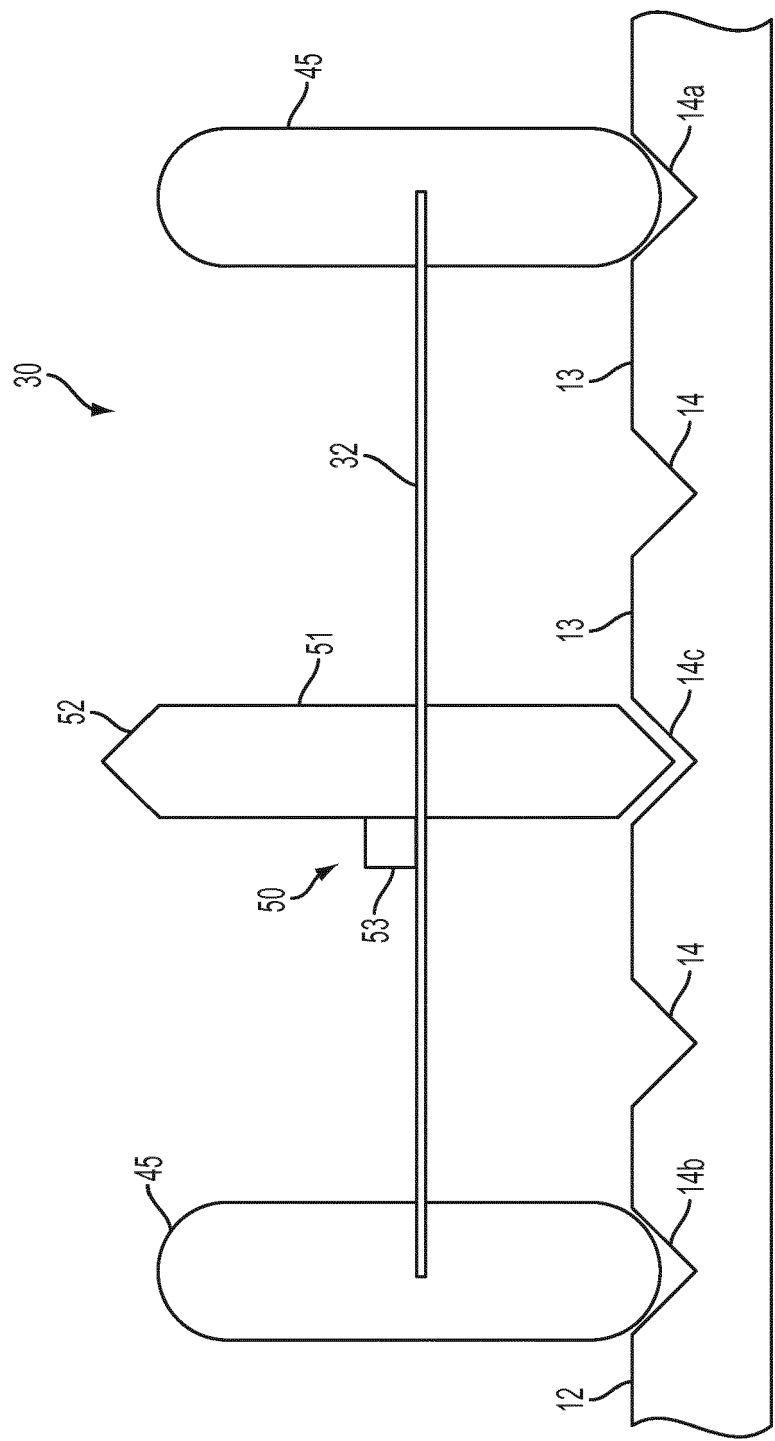


FIG. 3

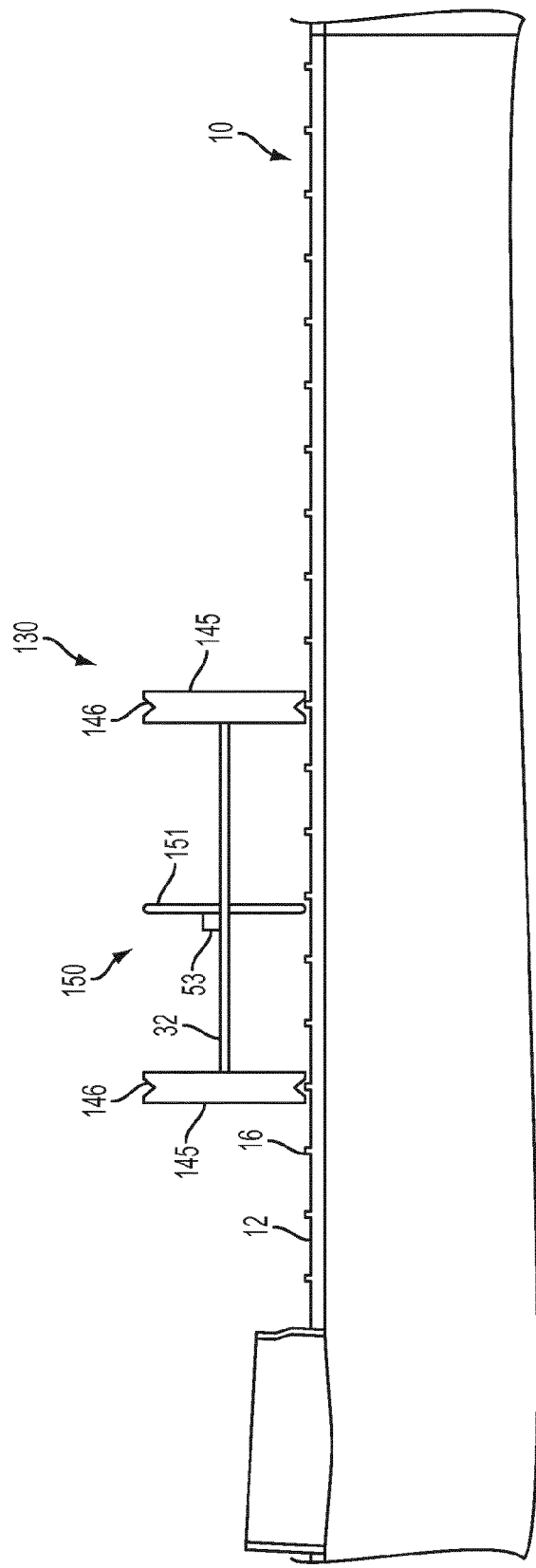
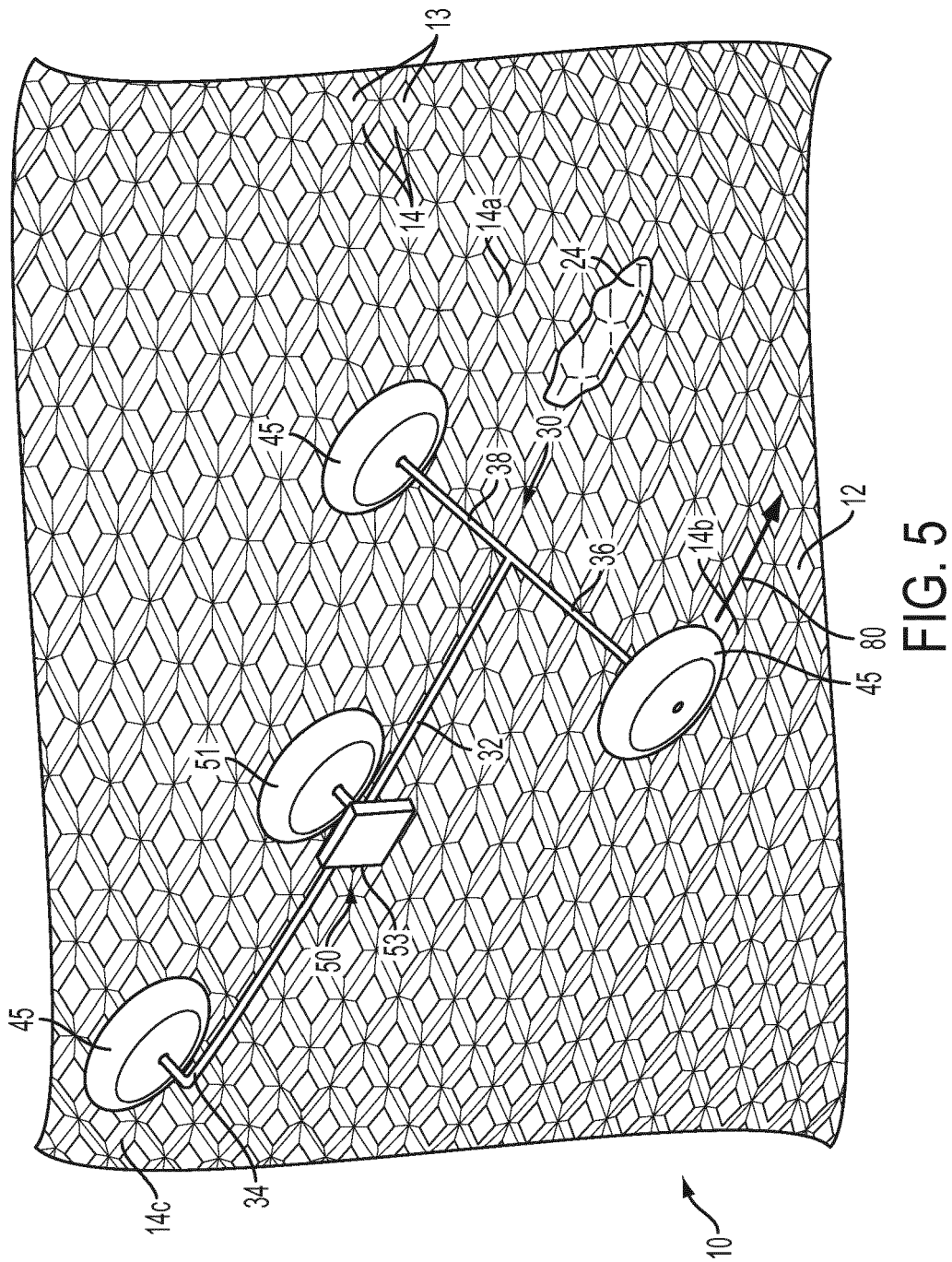


FIG. 4



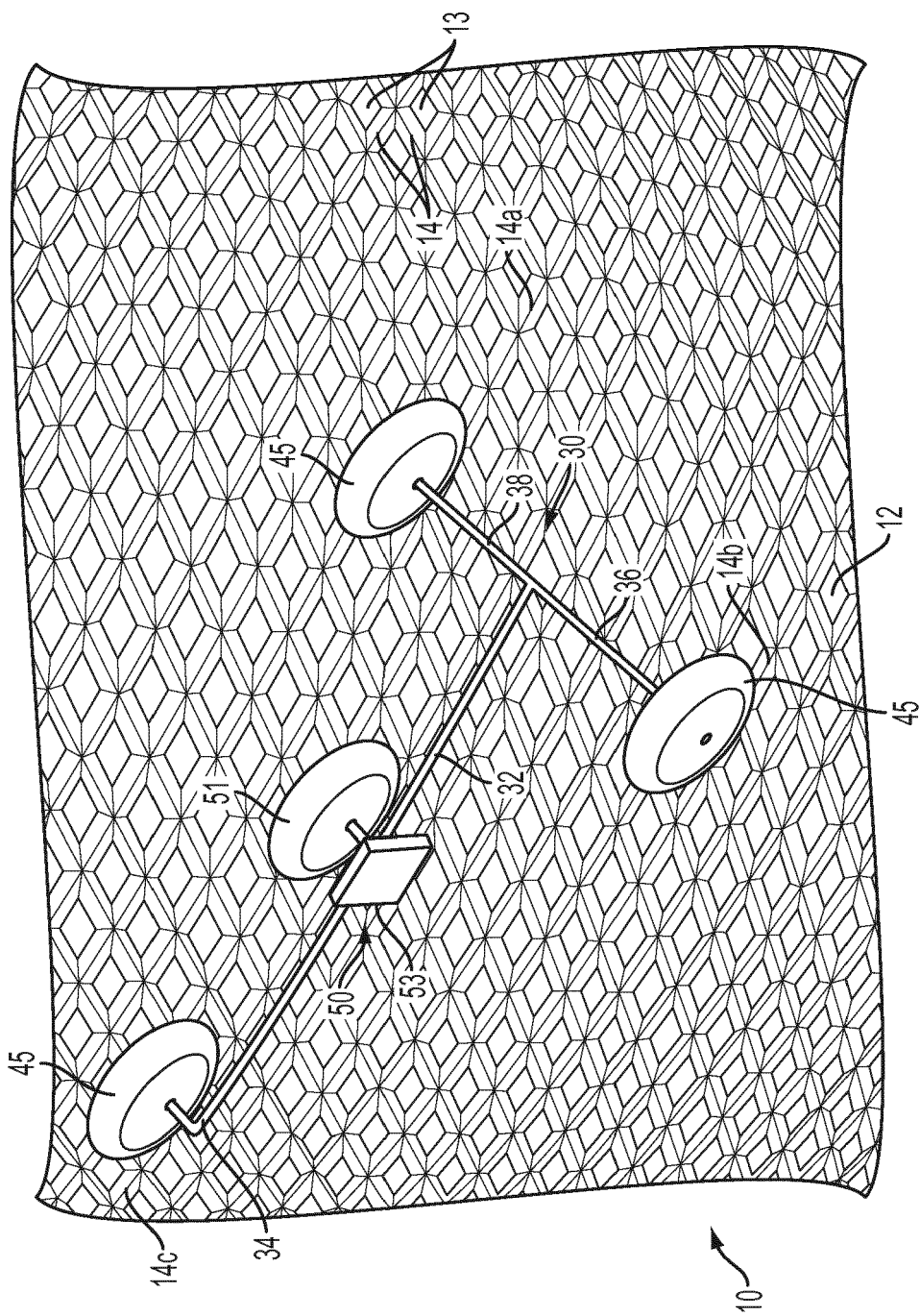


FIG. 6