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(54) **FABRICATION OF WELDED WHEELS  
WITHOUT FILLER MATERIAL**

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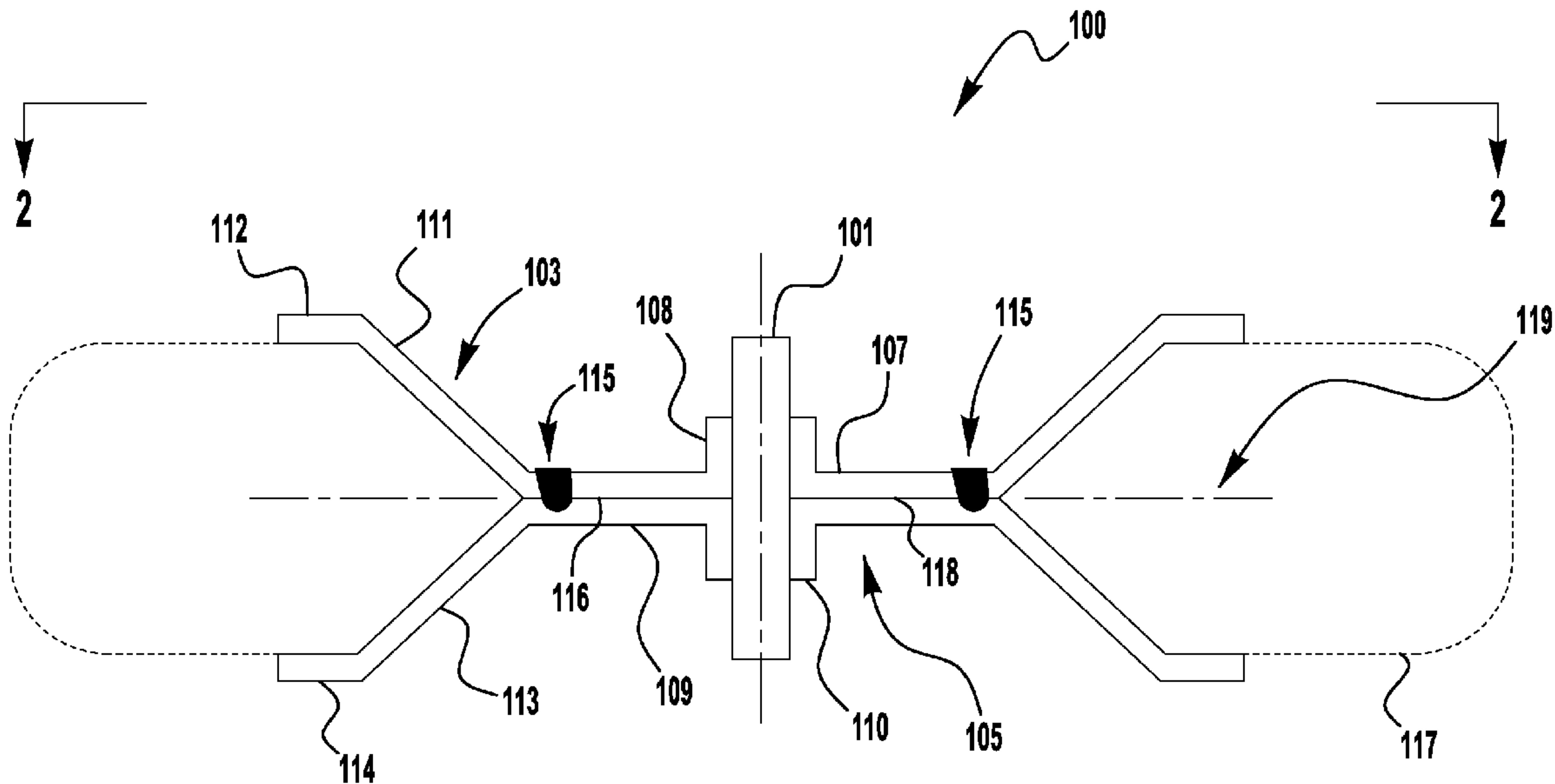
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(57) **ABSTRACT**

A hermetically sealed wheel assembly which has been weld-  
ing autogenously is provided, along with a method and sys-  
tem for welding the wheel assembly. The wheel assembly is  
made up of at least two components which are laser welded to  
each other without the use of filler material to create a her-  
metically sealed wheel assembly.



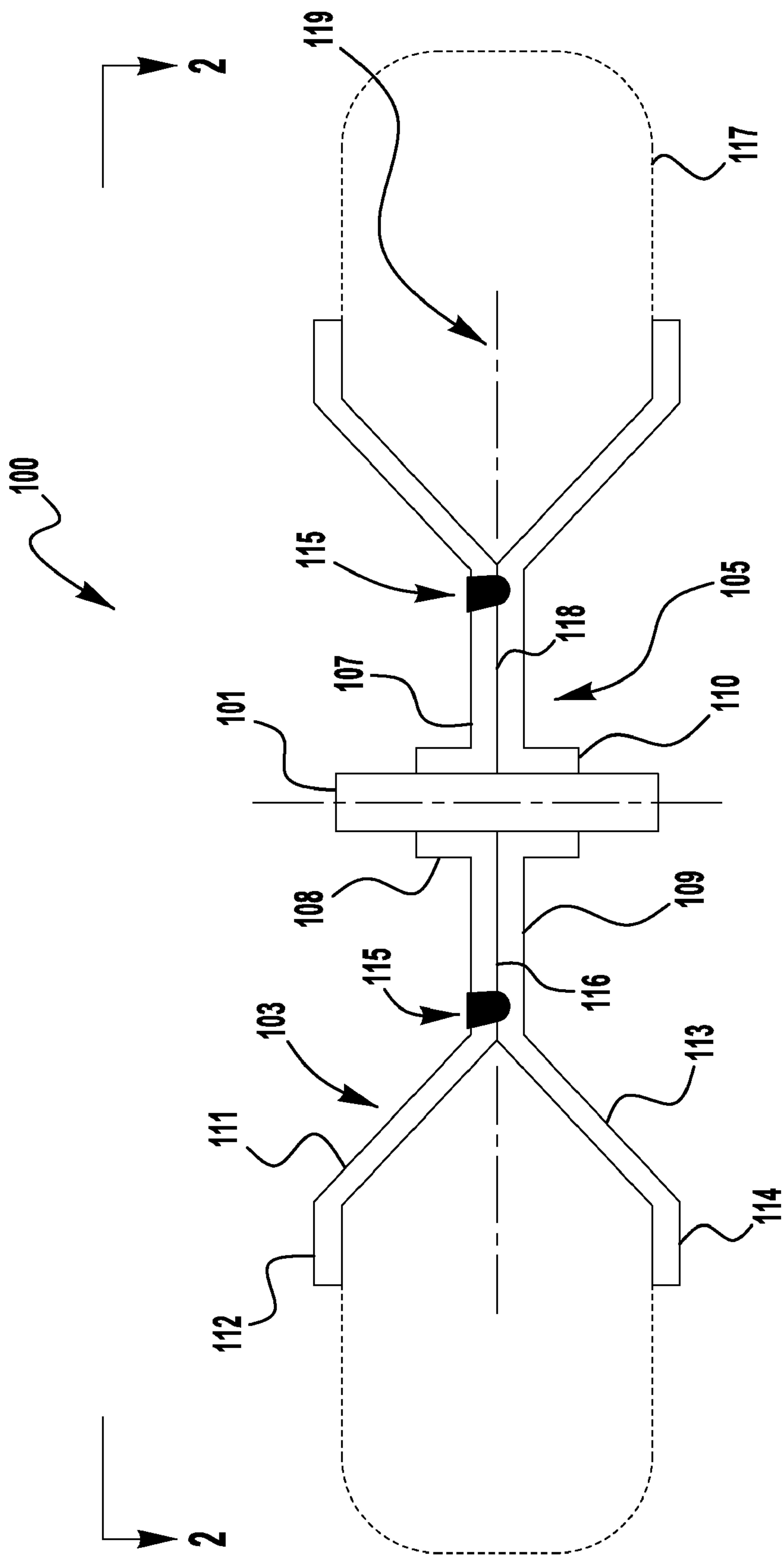
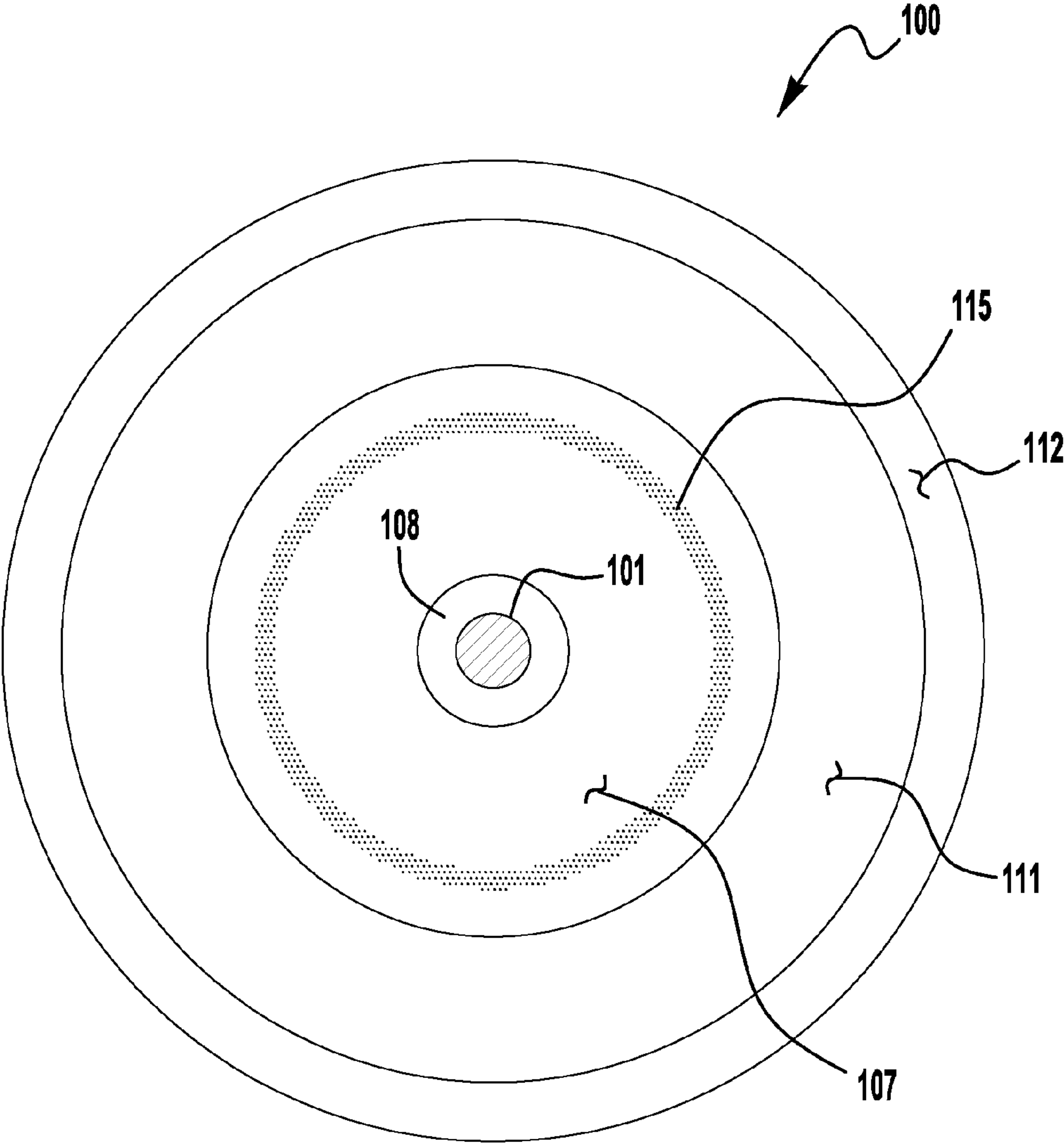
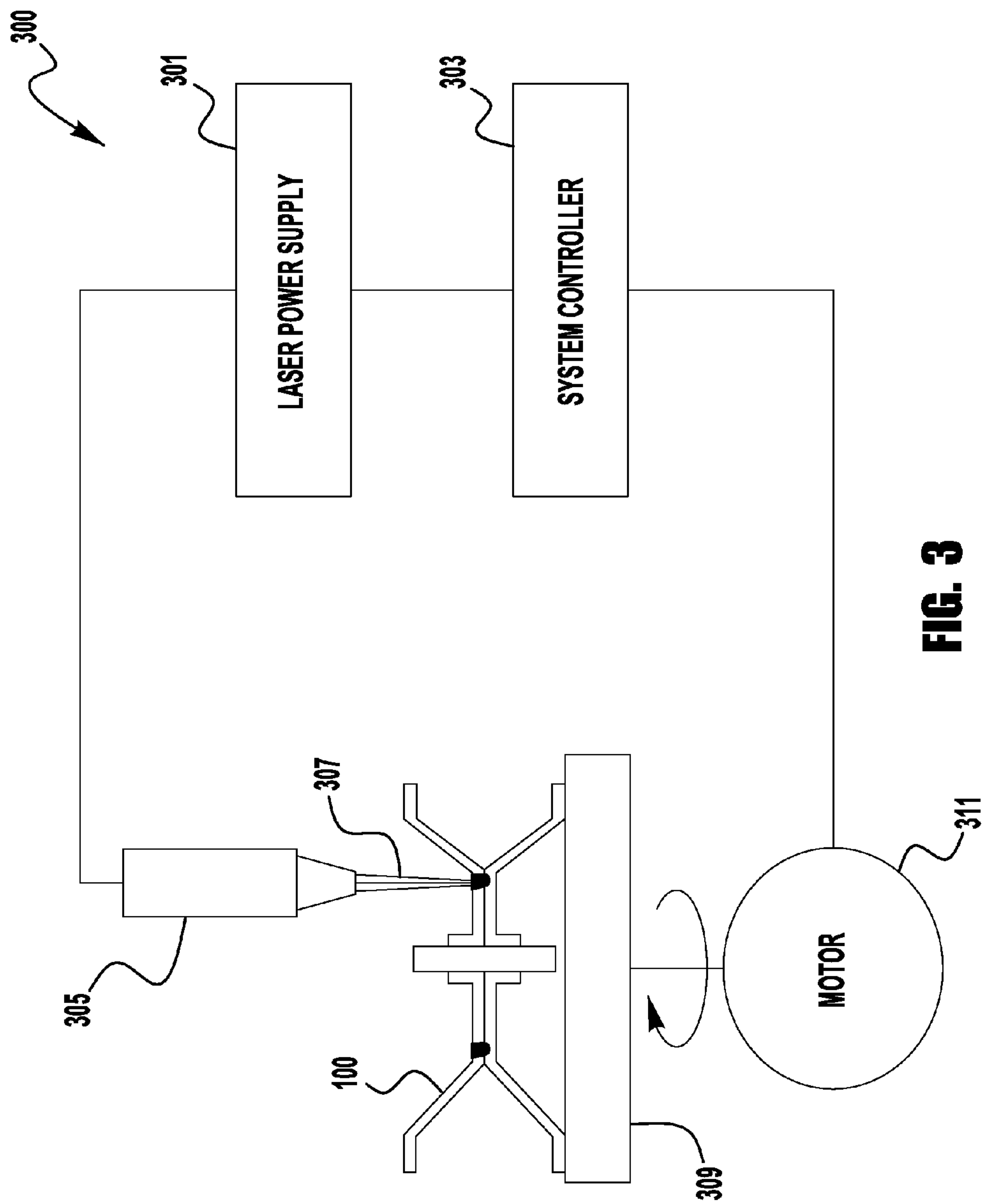
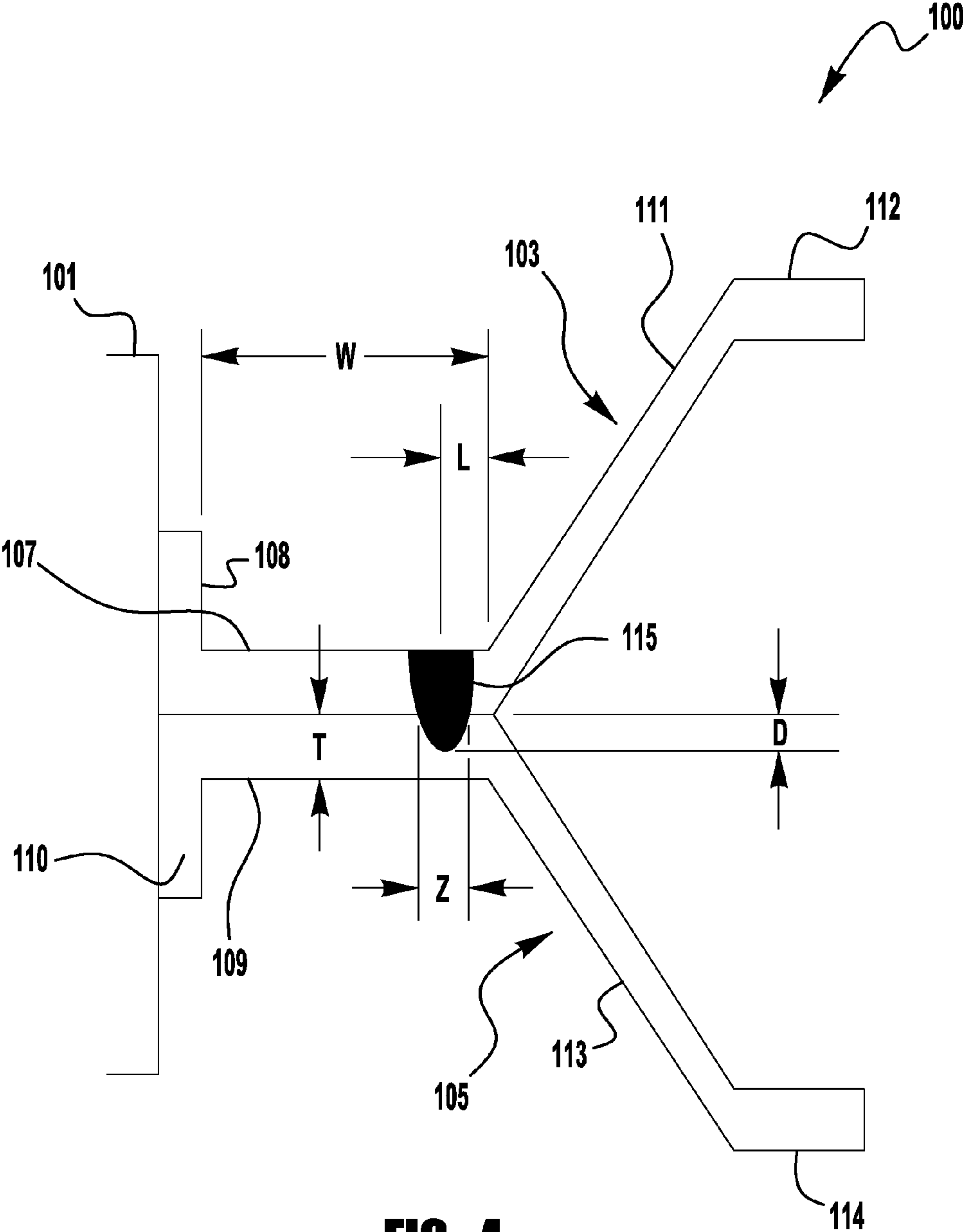


FIG. 1



**FIG. 2**





**FIG. 4**



## FABRICATION OF WELDED WHEELS WITHOUT FILLER MATERIAL

### PRIORITY

[0001] The present application is a continuation of U.S. patent application Ser. No. 13/269,319 which is incorporated herein by reference in its entirety.

### FIELD OF THE INVENTION

[0002] The present invention relates to the art of welding and more particularly to the fabrication of welded wheels without filler materials.

### BACKGROUND OF INVENTION

[0003] As the art of arc welding has grown, it has found its application in many different structures and uses. It is known that although arc welding can provide a strong bond between metallic components, depending on the process used, it can also result in a weld joint that has porosity. Although in some welding applications an amount of porosity is acceptable, there are other applications where porosity can be problematic. For example, when welding wheel structures that are used for pressurized tires the presence of porosity can result in a welded wheel structure which fails to maintain pressure. To prevent this loss of pressure from occurring it is common to over-weld wheel structures to ensure that the welded wheel structure is capable of maintaining pressure. However, this over-welding increases overall cost of the welded wheel structure by increasing the amount of time needed to weld the wheel and increases the material cost of the wheel, by requiring increases amounts of filler metals used in the welding process. Therefore, it is desirable to provide a welding process which improves the efficiency and quality of welding wheel structures.

### SUMMARY OF THE INVENTION

[0004] An exemplary embodiment of the present invention is a wheel structure and a method of welding a wheel structure, where the method of welding the wheel structure includes positioning a first wheel section having a first web portion adjacent to a second wheel section having a second web portion, such that each of the first and second web portions are contacting each other. The method includes directing a laser beam to the first web portion, and autogenously welding the first web portion to the second web portion with a laser beam such that the laser beam passes through an entire thickness of the first web section and the laser beam penetrates at least a portion of a thickness of the second web portion. The autogenously welding creates a hermetically sealed weld joint around a center the welded first and second wheel sections.

### BRIEF DESCRIPTION OF DRAWINGS

[0005] The above and/or other aspects of the invention will be more apparent by describing in detail exemplary embodiments of the invention with reference to the accompanying drawings, in which:

[0006] FIG. 1 is a diagrammatical representation of a welded wheel in accordance with an exemplary embodiment of the present invention;

[0007] FIG. 2 is a diagrammatical representation of another view of the exemplary wheel of FIG. 1;

[0008] FIG. 3 is a diagrammatical representation of an exemplary embodiment of a welding system of the present invention; and

[0009] FIG. 4 is a diagrammatical representation of another view of the exemplary wheel of FIG. 1.

### DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0010] Referring now to the drawings wherein the showings are for the purpose of illustrating exemplary embodiments of the invention only and not for the purpose of limiting the same, an apparatus and system used in practicing the invention is shown in detail in FIGS. 1-4.

[0011] FIGS. 1 and 2 depict a wheel assembly 100 in accordance with an exemplary embodiment of the present invention. The wheel assembly 100 contains a hub 101 and two wheel sections 103 and 105 which are to be welded to each other. The hub 101 may or may not be a part of the completed wheel assembly 100 depending on the applications. As shown in FIG. 1, the wheel assembly 100 can have a tire 117 mounted to it. The tire 117 and the sections 103/105 create a void or cavity 119 which can be filled with air or gas under pressure and it is desirable for the sections 103 and 105 to be able to form an air tight and secure assembly for use. The shape and construction of the sections 103 and 105 shown in FIGS. 1 to 4 are intended to be exemplary and other embodiments of the present invention can utilize wheel sections having different shapes as different applications require.

[0012] As shown in the Figures, each of the sections 103 and 105 contain a hub portion 108/110 which make contact with the hub 101 or other otherwise adjacent to the centerline of the wheel assembly 100. The hub portions 108/110 can have a flange extension, as shown, which extends along a length of the hub 101 or wheel centerline, or can have other shapes as needed. Extending radially outward from the hub portions 108/110 are web portions 107/109 which are oriented perpendicular to the radial centerline of the assembly 100. In the embodiment shown, the web portions 107/109 are of the same length, but in other embodiments this may not be the case. Also, in the embodiment shown the web portions are shown as solid. However, in other exemplary embodiments it is contemplated that holes can be made web portions 107/109 to reduce the overall weight of the wheel assembly 100. The holes can be of any shape but are usually made as circles, ovals or ellipses so as to avoid creating locations of stress concentrations. The sizing and number of holes should be determined to ensure that the structural integrity of the webs 107/109 are sufficient for their expected loading. The holes should also be positioned radially inward from the weld bead 115—which will be discussed in more detail below.

[0013] Extending from the radially outward edges of the web portions 107/109 are angled portions 111/113. The angled portions 111/113 diverge from each other respectively to define at least a portion of the pressure void 119. As shown in FIG. 1 the angled portions are angled between 0 and 90 degrees from the cross-sectional centerline of the assembly 100. The angle to be chosen is based on the design and application of the wheel assembly 100. In some exemplary embodiments the angle can be 90 degrees from the cross-sectional centerline. Extending from the radially outward edge of the angled portions 111/113 are flange portions 112/114. The flange portions 112/114 can be utilized to hold a tire 117 or other similar component as needed. In the embodiment shown the flange portions 112/114 are oriented parallel to the



cross-sectional centerline of the assembly **100** as shown. However, in other embodiments this is not required as other angles can be utilized based on the application and design needs. In some exemplary embodiments, the flange portions **112/114** are not needed as the angled portions **111/113** can themselves be utilized to hold any structure or tire **117**.

[0014] In the embodiments shown the wheel sections **103/105** are shown as an integral component such that the hub, web, angled and flange portions are all made of a single piece of material (usually metal). This can be formed in many different ways including pressing a flat material into the desired shape. However, other exemplary embodiments are not limited to the use of integral sections **103/105** as the sections **103/105** can be made up of welded components.

[0015] The two wheel sections **103/105** are secured to each other by welding their respective web portions **107/109**, which make contact with each other when the assembly **100** is assembled. As such, each of the web portions **107/109** have surfaces **116/118** which are parallel to each other and made such that the surfaces **116/118** are flush with each other when the portions **103/105** are positioned adjacent to each other for assembly. It is not required that the surfaces **116/118** be flush with each other for the entire length of the web portions **107/108**. However, these surfaces **116/118** should be flush with each other at least at the weld joint **115**.

[0016] In the shown exemplary embodiment, the weld joint **115** is a continuous weld joint **115** which forms a circular pattern around the assembly **100**. The weld joint **115** is made by welding through one of the wheel sections **103/105** and into the other of the wheel sections **103/105**. In the embodiment shown in FIG. 1, the weld joint is welded through the section **103** and into the section **105**. However, as shown the weld joint **115** does not fully penetrate the thickness of the second of the sections (section **105** in FIG. 1). In some embodiments, as discussed further below, the joint **115** can fully penetrate the thickness of both sections **103/105** at the weld.

[0017] Unlike prior welded wheel assemblies this weld joint **115** is not made via the use of arc welding or with the use of filler metals. Rather the weld joint **115** is made using a laser welding system in which no filler metal is used—this is commonly referred to as an autogenous weld. Filler metal is typically used to fill gaps during welding and/or to provide additional material to a joint to form a fillet, or the like. However, because the surfaces **116/118** are flush with each other at the weld joint **115** there is no gap to fill and therefore the weld joint **115** is made entirely of the material of the web portions **107/109** and no filler metal is needed.

[0018] Furthermore, because the weld joint **115** is made to penetrate through the entire thickness of one section **103** and into at least some of the second section **105**, the joint **115** creates a continuous seal around the entire wheel assembly **100**. Because of this seal any pressure in the pressure zone **119** (like air pressure) will be unable to pass between the portions **103/105** and escape at the hub **101**—which is a problem with arc welded wheels. Thus, this weld joint **115** creates a hermetic weld joint. Therefore, embodiments of the present invention can create a welded wheel assembly **100** having a weld made with no filler material which provides the needed structural integrity and the needed air tight seal for pressurized wheel applications. With embodiments of the present invention, a significant amount of filler material and

welding is avoided, as it is often needed to weld the sections **103/105** to the hub **101**—with filler metal—to provide the required air tight seal.

[0019] As shown in FIG. 2, the weld joint **115** has a circular pattern along a radius from the center of the assembly **100**. However, embodiments of the present invention are not limited in this regard. For example, it is contemplated that the weld joint **115** can have a zig-zag or undulating pattern along a radius from the center of the assembly **100**. Such a pattern would increase the overall length of the weld joint **115** to provide added structural integrity. However, the weld joint **115** should be continuous so as to provide the requisite hermetic seal between the sections **103/105**, if the wheel is to be used in a pressurized application. It is noted that to the extent holes are placed in the webs **107/109** to reduce the weight of the assembly (as discussed above) the weld joint **115** should be placed radially outward from the holes to provide the needed air tight seal—in pressurized applications. Of course, many different types of patterns can be used for the welding operation.

[0020] It is further noted that although a single weld joint **115** is shown in the figures, the present invention is not limited in this regard. Specifically, additional weld joints can be used to increase the strength of the wheel assembly **100**. For example, another weld joint can be positioned radially inward or outward from the weld joint **115**. Further, any additional joint does not have to be continuous but can be an intermittent or spot weld joint. As long as one weld joint (**115**) is continuous, any additional weld joint will not have to be continuous to provide the requisite air tight seal. Of course, it can be continuous as well—if needed.

[0021] FIG. 3 depicts an exemplary welding system **300** for welding the assembly **100** described above. As discussed above, the weld joint **115** is created using a laser welding system with no filler metal. The system **300** includes a laser power supply **301** which supplies power to a laser **305**. The laser **305** can be any known type of laser which is capable of laser welding, including but not limited to carbon dioxide, Nd:YAG, Yb-disk, YB-fiber, fiber delivered or direct diode laser systems. Further, white light or quartz laser type systems can be used if they have sufficient energy. Other embodiments of the system may employ electron beam energy. Exemplary lasers should have power capabilities in the range of 1 to 20 kW. Higher power lasers can be utilized, but can become very costly. In the embodiment shown, the laser **305** is emitting a single beam **307** to weld the joint **115**. However, a multiple beam configuration can also be employed if desired. A multiple beam configuration can use multiple lasers **305** and/or beam splitters with a single laser **305** as desired. In such an embodiment the separate beams can be used to make separate portions of the same continuous weld, or can be positioned adjacent to each other to make a wider weld joint.

[0022] The laser **305** emits a beam **307** having a sufficient energy and shape to fully penetrate or keyhole the entire thickness of the web portion **107/109** of one of the wheel sections **103/105** and at least some of the thickness of the web portion **107/109** of the other of the wheel sections **103/105**. This will be discussed further below.

[0023] The system **300** also includes a system controller **303** which monitors and/or controls the power supply **301** and/or the laser **307** to produce a sufficient weld. Additionally, in the embodiment shown the controller **303** also controls a motor **311** which is coupled to a platen **309** which rotates during welding. In the embodiment shown, the platen



**309** is rotated while the laser **305** and beam **307** remain stationary to complete the weld. Of course, in other exemplary embodiments the laser **305** can be moved to create the joint **115**. In further embodiments, both the wheel **100** and the laser **305** can be moved to create the weld, or the laser **305** can remain stationary while the beam **307** is moved using optics of the laser **305**. Embodiments of the present invention are not limited in this regard, as other means of creating the weld can be used. For example, other configurations can use mirrors or optics external to the laser optics which move and translate to create the desired weld pattern.

[0024] It is noted that although the controller **303**, power supply **301**, laser **305**, motor **311** and platen **309** are shown as separate components in FIG. 3, this is done for clarity. It is contemplated that at least some or all of these components can be made into an integral unit or assembly to perform the welding operation. It is not required that these components are separate physical structures.

[0025] Turning now to FIG. 4, a more detailed view of the joint **115** is shown. As shown, the web **107** has a length  $W$  and the center of the weld joint **115** is positioned a distance  $L$  from the outer radial edge of the web **107**. In most embodiments this distance should be relatively small so that the joint **115** is close to the angled portions **111/113**. This will aid in minimizing the moment forces on the webs **107/109** when the assembly **100** is in use. In exemplary embodiments of the present invention, the distance  $L$  should be based on the thickness of the web material and the design loads on the wheel in the area of the weld **115**. If the web is of sufficient thickness and stiffness the distance  $L$  can approach 0% of the length  $W$ . However, in other embodiments the distance  $L$  is in the range of 10 to 80% of the web length  $W$ .

[0026] Furthermore, the web **109** has a thickness  $T$  and the weld joint **115** penetrates the web **109** by a distance  $D$ . In exemplary embodiments the distance  $D$  is less than the thickness  $T$ . In some exemplary embodiments, the distance  $D$  is in the range of 5 to 100% of the thickness  $T$ , as long as the distance  $L$  results in a structurally sound weld. In other embodiments the distance is in the range of 20 to 75%. Of course, other depths can be employed as needed. In fact, in some exemplary embodiments the joint **115** will keyhole through both web portions **107/109**. These welds will penetrate 100% of the thickness  $T$  and provide a “witness mark” on the back of the web to allow for inspection of the weld joint—to ensure sufficient penetration. However, to the extent that both web portions **107/109** are fully keyholed the back bead of the joint **115** should be controlled carefully so that no significant amount of weld metal sags below the bottom web portion **109** as this could create a cavity in the upper surface of the weld joint (as no filler metal is employed).

[0027] In some exemplary embodiments the depth of the weld joint **115** in the lower portion **109** can vary along the length of the weld. For example, it may not be structurally necessary for the weld joint to have a constant depth in the lower web portion **109**. Therefore, in some exemplary embodiments portions of the weld joint **115** can be at a first depth and other portions of the joint **115** can have a second depth, which is shallower than the first depth. For example, the first depth  $D$  can be go up to 100% of the thickness  $T$  of the web **109** and the second depth can be in the range of 5 to 50% of the thickness  $T$ , where the second depth is less than the first depth. Any change or depth differential can be made as long as at least one weld results in a hermetic seal and the weld joint(s) meet the desired mechanical strengths. The length of

the different depth sections can vary as well depending on the strength requirements of the weld joint **115**. For example, the first depth can be welded for 2 inches while the shallower depth can then be welded for 5 inches and then return to the first depth for 2 inches, etc. This allows for the optimization of the weld joint **115** in the wheel. This oscillating depth can be created by changing the energy density of the beam **307** during the welding operation. Such an embodiment can speed the welding operation and conserve welding energy. This variation in weld depth can also be achieved by changing the shape of the beam **307**, the energy density of the beam, and/or the speed of the welding process.

[0028] The cross-sectional width of the weld joint **115** at the meeting of the surfaces **116/118** should be sufficient to provide the needed structural integrity for the weld. Embodiments of the present invention are not limited by the overall cross-sectional shape of the weld joint, except that the point **115** should have the required structural integrity. To increase the width of the joint **115** (if needed) a multi-beam laser welding process can be used. In exemplary embodiments, the weld joint **115** at the meeting of the web portions **107/109** has a width  $Z$ . The width  $Z$  should be sufficient to hermetically seal the wheel **100** as well as provide whatever strength is needed. In some exemplary embodiments of the present invention the width  $Z$  is in the range of 10 to 100% of the thickness  $T$ . In some exemplary embodiments, the weld joint **115** may not be needed to provide strength to the wheel. As such, a thinner weld joint **115** can be employed which is used to primarily hermetically seal the wheel. For example, in such embodiments the weld joint can have a width  $Z$  in the range of 5 to 50% of  $T$ . In some exemplary embodiments, the width  $Z$  is not constant for the entire weld. For example, it may not be necessary to have the entire length of the weld joint **115** at a constant thickness because of strength requirements. In such embodiments, some portions of the joint **115** can have a first thickness  $Z$ , while other portions have a second thickness  $Z$  which is less than the first section. In such embodiments the first sections can provide the bulk of the strength of the joint **115** while the thinner sections provide less strength but continue the hermetic seal. Such embodiments allow for the conservation of energy during the welding process. In some exemplary embodiments, multiple beams can be used to vary the width of the weld joint **115** during welding.

[0029] Embodiments of the present invention allow for the creation of hermetically sealed wheel assemblies **100** which have been welded autogenously in less than half of the time as prior art wheels, with significantly less cost and less product scrapping due to porosity from arc welding.

[0030] Of course, it should be noted that the sections **103/105** can have other weld joints than those described herein as needed or desired. For example, in some other exemplary embodiments the hub portions **108/110** can be welded to the hub **101** for added strength. Alternatively the hub portions **108/110** can be autogenously welded to the hub in lieu of welding through the web portions **107/109**. Depending on the construction of the wheel **100** the autogenous weld joint can be placed anywhere as needed so that the desired strength and hermetic seal is achieved. Further, the sections **103/105** can be welded to each other at the contact point between the sections (the seam where they contact each other) inside the void **119**. These welds can be laser welds as described herein. Of course, there can be multiple welds on the wheel assembly **100** as desired, where at least one weld is autogenous. Depending on the fit of the sections **103/105**, it may be nec-



essary in some parts of the wheel to use a weld with filler material to fill in gaps. This can be done with any known welding method which uses filler material.

**[0031]** While the invention has been particularly shown and described with reference to exemplary embodiments thereof, the invention is not limited to these embodiments. It will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. A method of welding a wheel structure, comprising:  
positioning a first wheel section having a first web portion adjacent to a second wheel section having a second web portion, such that each of said first and second web portions are contacting each other;  
directing a laser beam to said first web portion; and  
autogenously welding said first web portion to said second web portion with a laser beam such that said laser beam passes through an entire thickness of said first web section and said laser beam penetrates 5 to 100% of a thickness of said second web portion;  
wherein said autogenously welding creates a continuous hermetically sealed weld joint around a center of the welded first and second wheel sections,  
wherein said first web portion has a web length between a hub portion positioned radially inward from said first web portion and an angled portion positioned radially outward from said first web portion, and said weld joint is positioned on the first web portion 10 to 80% of the web length inward from said angled portion, and  
wherein a width of said weld joint at the point at which said first and second web portions contact each other is in the range of 5 to 50% of the thickness of said second web portion.
2. The method of claim 1, wherein said weld joint penetrates 20 to 75% of said thickness of said second web portion.
3. The method of claim 1, wherein said weld joint is welded in a pattern having a nonconstant radial distance from said center.
4. The method of claim 1, wherein a depth of said weld joint in said second web portion varies along a length of said weld joint.
5. The method of claim 4, wherein said weld joint has a first portion with a first depth of up to 100% of the thickness of said second web portion and a second depth of 5 to 50% of the thickness of said second web portion, where said second depth is less than said first depth.
6. The method of claim 4, wherein said weld joint has a first portion with a first depth of 20 to 50% of the thickness of said second web portion and a second depth of 5 to 50% of the thickness of said second web portion, where said second depth is less than said first depth.
7. The method of claim 1, wherein said width of said weld joint at said contact point varies along a length of said weld joint.
8. The method of claim 1, wherein at least one of said first and second web portions has cavities through an entire thickness of said first or second web portion and said weld joint is positioned radially outward from said cavities.

9. A welded wheel structure, comprising:  
a first wheel section having a first web portion;  
a second wheel section having a second web portion, where each of said first and second web portions are contacting each other; and  
a continuous hermetically sealed weld joint which welds said first web portion to said second web portion, such that said weld joint passes through an entire thickness of said first web portion and 5 to 100% of a thickness of said second web portion;  
wherein said weld joint is positioned radially around a center of said welded first and second sections,  
wherein said weld joint is an autogenous weld joint,  
wherein said first web portion has a web length between a hub portion positioned radially inward from said first web portion and an angled portion positioned radially outward from said first web portion, and said weld joint is positioned on the first web portion 10 to 80% of the web length inward from said angled portion, and  
wherein a width of said weld joint at the point at which said first and second web portions contact each is in the range of 5 to 50% of the thickness of said second web portion.
10. The welded wheel structure of claim 9, wherein said weld joint penetrates 20 to 75% of said thickness of said second web portion.
11. The welded wheel structure of claim 9, wherein said weld joint is welded in a pattern having a nonconstant radial distance from said center.
12. The welded wheel structure of claim 9, wherein a depth of said weld joint in said second web portion varies along a length of said weld joint.
13. The welded wheel structure of claim 12, wherein said weld joint has a first portion with a first depth of up to 100% of the thickness of said second web portion and a second depth of 5 to 50% of the thickness of said second web portion, wherein said second depth is less than said first depth.
14. The welded wheel structure of claim 12, wherein said weld joint has a first portion with a first depth of 20 to 50% of the thickness of said second web portion and a second depth of 5 to 50% of the thickness of said second web portion, wherein said second depth is less than said first depth.
15. The welded wheel structure of claim 9, wherein said width of said weld joint at said contact point varies along a length of said weld joint.
16. The welded wheel structure of claim 9, wherein at least one of said first and second web portions has cavities through an entire thickness of said first or second web portion and said weld joint is positioned radially outward from said cavities.
17. A welded wheel structure, comprising:  
a first wheel section having a first web portion;  
a second wheel section having a second web portion, where each of said first and second web portions are contacting each other and have the same length; and  
a continuous hermetically sealed weld joint which welds said first web portion to said second web portion, such that said weld joint passes through an entire thickness of said first web portion and 5 to 100% of a thickness of said second web portion;  
wherein said weld joint is positioned radially around a center of said welded first and second sections,  
wherein said weld joint is an autogenous weld joint, and  
wherein a width of said weld joint at the point at which said first and second web portions contact each is in the range

of 5 to 50% of the thickness of said second web portion,  
and wherein said second width is less than said first  
width.

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