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(72) Inventeur/Inventor:
SIMMONS, ANTHONY GRANT, AU

(73) Propriétaire/Owner:
SIMMONS, ANTHONY GRANT, AU

(74) Agent: ROBIC

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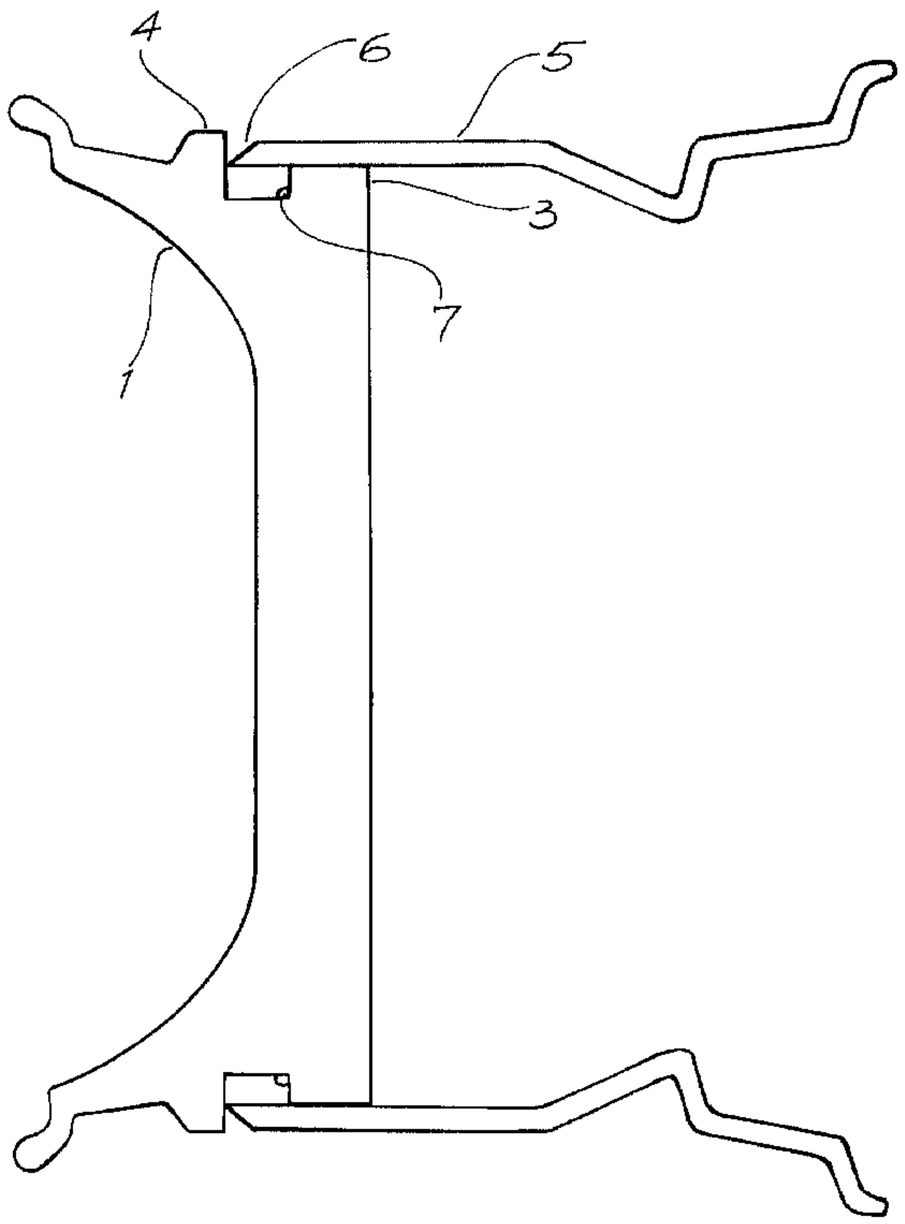
(54) Title: JOINING METAL COMPONENTS



(57) Abrégé/Abstract:
This invention concerns a method of joining forged, machined, formed or cast components with metal tube. In another aspect it concerns a metal object constructed according to the method. The tube heated to expand its diameter, but not sufficiently to anneal it, or otherwise adversely affect its mechanical properties. Then, while the tube is still hot, it is pushed over part of the central component so that part of the tube overlies a circumferential groove in the central component. Then, while still hot, the circumferential part of the tube which overlies the groove, is rolled into the groove, so that when cooled the rolled part of the tube is clamped into the groove. The invention is particularly, but not exclusively, applicable to the construction of vehicle wheels having a forged, machined, formed or cast hub or centre and a metal rim.

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(71)(72) Applicant and Inventor: SIMMONS, Anthony, Grant [NZ/AU]; 3 Ellis Avenue, Alexandria, NSW 2015 (AU).

(74) Agent: F. B. RICE & CO.; 605 Darling Street, Balmain, NSW 2041 (AU).

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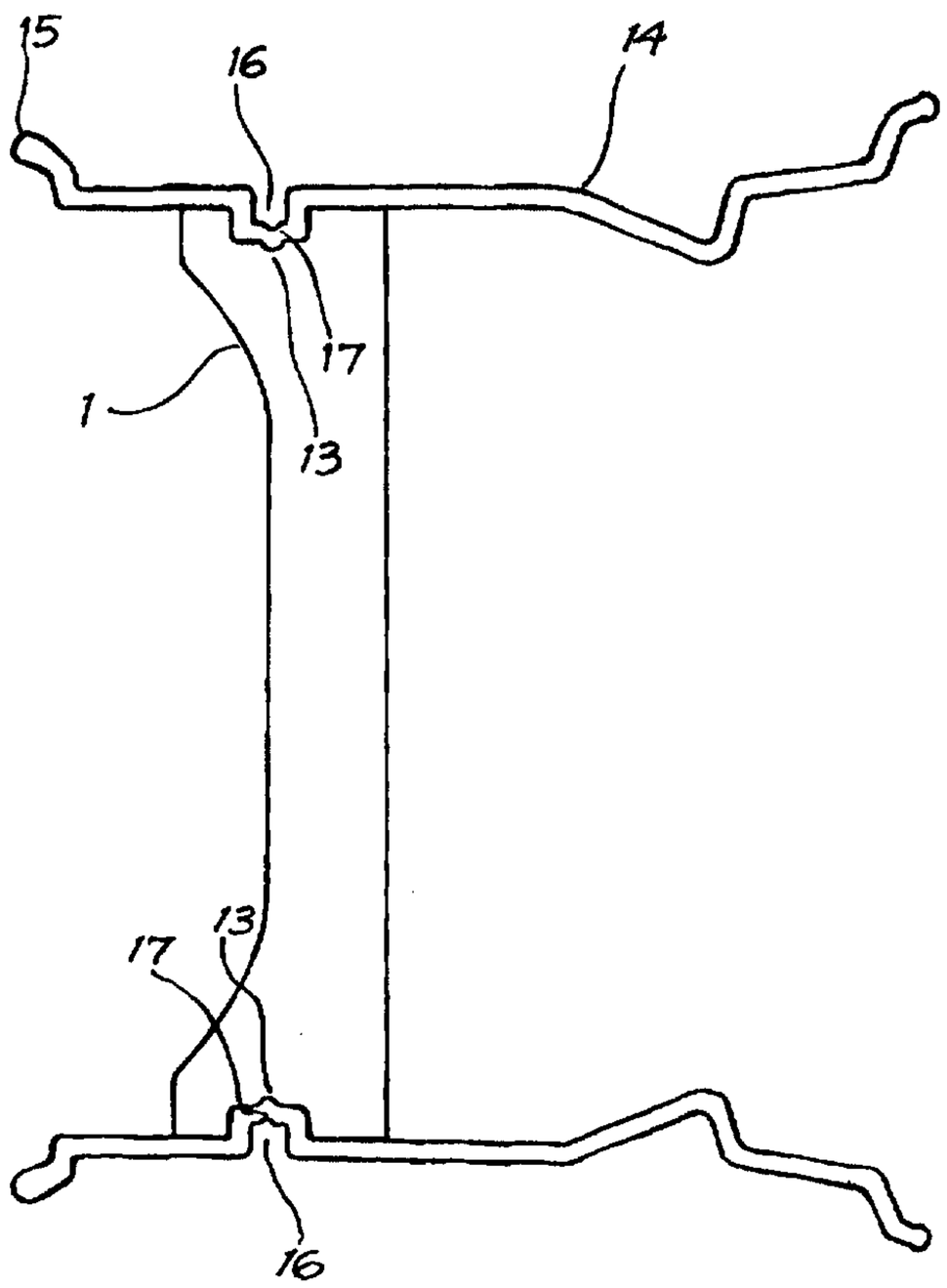
(54) Title: JOINING METAL COMPONENTS

(57) Abstract

This invention concerns a method of joining forged, machined, formed or cast components with metal tube. In another aspect it concerns a metal object constructed according to the method. The tube heated to expand its diameter, but not sufficiently to anneal it, or otherwise adversely affect its mechanical properties. Then, while the tube is still hot, it is pushed over part of the central component so that part of the tube overlies a circumferential groove in the central component. Then, while still hot, the circumferential part of the tube which overlies the groove, is rolled into the groove, so that when cooled the rolled part of the tube is clamped into the groove. The invention is particularly, but not exclusively, applicable to the construction of vehicle wheels having a forged, machined, formed or cast hub or centre and a metal rim.



JOINING METAL COMPONENTS

Technical Field

This invention concerns a method of joining forged, machined, formed or cast components with metal tube. In another aspect it concerns a metal object constructed according to the method. The invention is particularly, but not exclusively, applicable to the construction of vehicle wheels having a forged, machined, formed or cast hub or centre and a metal rim.

Background Art

A large number of techniques are available for the construction of objects such as fabricated car wheels, which require the joining of a circular rim component with a centre, or hub component. Welding is the most common form of joining these parts, but riveting, bolting, and bonding with adhesives are methods also used. Electric welding generate fumes, can distort the parts, can degrade the metallurgy of the parts, and requires high energy inputs and similarity of the metals to be jointed. Friction welding also requires similarity of the metals, expensive technology and machinery which imposes heavy loads on the parts during the joining process. Riveting and bolting methods require the provision of mating flanges which impose styling limitations and add weight to the wheel. The rivet and bolt holes are also points from which cracks can propagate and, particularly with bolted wheels, there is always the risk that the bolts are not tightened such that their performance is totally reliable in extended use. Bonding as the primary means of joining wheel components has not, to date, proved to have market acceptance, following a history of failures in the past.

Summary of the Invention

The invention provides a method of joining forged, machined, formed or cast central components with metal tube. The method comprises the steps of:

heating the tube to expand its diameter, but not sufficiently to anneal it, or otherwise adversely affect its mechanical properties.

Then, while the tube is still hot, pushing the tube over part of the central component so that part of the tube overlies a circumferential groove in the central component.

Then, while still hot, rolling the circumferential part of the tube which overlies the groove, into the groove, so that when cooled the rolled part of the tube is clamped into the groove, and another part is shrunk on to the exterior of the central component.

In accordance with another aspect, the invention provides a method of joining forged, machined, formed or cast central components with metal tube, comprising the steps of:

pushing a tube over part of the central component so that part of the tube overlies a circumferential groove in the central component;

then, heating the tube but not sufficiently to anneal it, or otherwise adversely affect its mechanical properties, and while still hot, rolling the circumferential part of the tube which overlies the groove, into the groove, so that when cooled the rolled part of the tube is clamped into the groove, and another part is shrunk on to the exterior of the central component.

This process may be cheap, and robust, giving reliable results which don't degrade the metallurgy of the joint. It has marketing credibility and offers freedom of styling.

As a preliminary step, the circumferential groove may be machined into the hub or centre component.

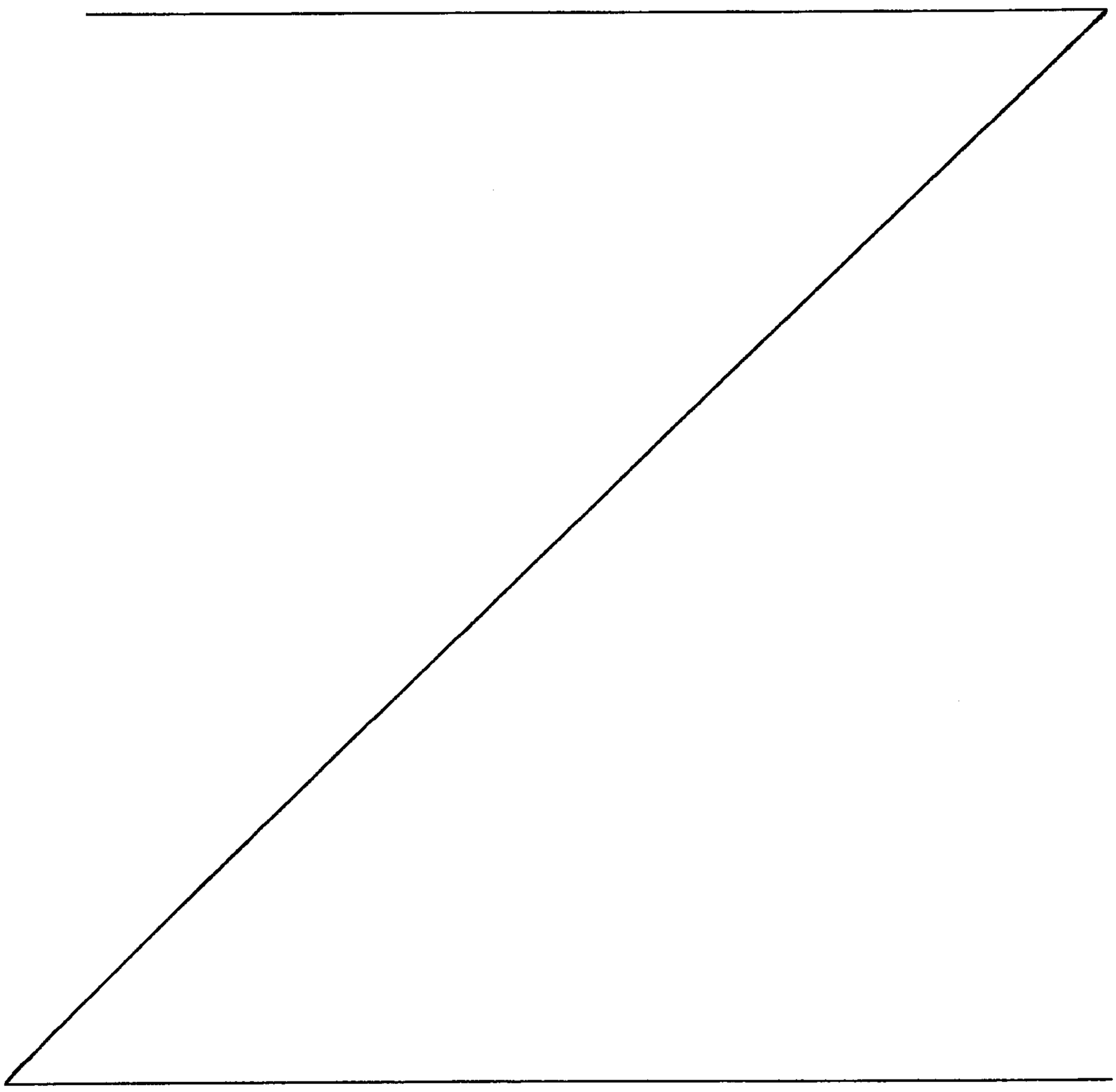
Where an end of the metal tube is to be rolled into the circumferential groove in the central component, then a stop may be provided along one side of the groove. The heated tube may be pushed over the component from the other side until the end of the tube abuts the stop.

The end of the tube abutting the stop may be bevelled, knurled, or similar. After the end of the tube has been rolled into the groove, the stop may be spin forged, while the tube is still hot, into the space remaining in the groove as a result of the bevelling of the end of the tube. This gives a neat appearance and a smooth finish. The spin forged centre material interlocks with the knurled tube end, providing reliable torque transmission capability for the joint. It also locks the joint against any axial movement and any

tendency of the joint and of the rim to open up under load. It also provides a practical way of removing the stop and improving the appearance of the joint without recourse to a secondary operation.

The joint system relies for its integrity on the fact that the rolling and spin forging operations are done hot, that when the whole joint cools, the shrinkage of the formed metal in the joint, relatively to the centre component provides a tight uniform clamping force with a high degree of pre-load.

It is important that the metal tube is heated only sufficiently to increase its ductility, or formability, but not enough to anneal the material or otherwise adversely affect its mechanical properties. For some materials, such as mild steel, which possesses very good formability in the as-supplied condition, heating is not required for any purpose other than to introduce the shrinkage factor into the joint.



Adhesive may be applied to the mating surfaces of the joint prior to assembly to provide a reliable torque transmission capability, and also to seal the joint.

As an alternative, or in addition to bevelling or knurling the end of the tube, dimples may be provided in the floor of the groove into which the tube is rolled in order to provide a mechanical interlock. This may be particularly useful where no stop is employed and the alloy tube is pushed entirely over the central component to extend from either side.

The operation may be applied to the fabrication of a vehicle wheel. In this case, the central component may be a cast, machined, formed or forged hub, and the metal rim of the wheel may comprise a formed tubular structure which is pushed on to the hub. The rim may be pushed on to the hub for a predetermined distance, or pushed right over the hub to extend either side by the desired amounts before the joining process is completed.

In another aspect, the invention provides a vehicle wheel comprising a central cast, machined, formed or forged hub or centre, and a metal rim connected to the hub by being shrunk fit on to it and having at least one part roll formed down into a circumferential groove around the hub or centre.

In addition a stop formed in part of the hub may be spin forged down over the top of the roll formed part of the rim. If the rim is bevelled or knurled before roll forming, then a space will be left afterwards into which the stop may be spin forged. Also in addition, a sealing material may be provided between the rim and the hub in order to improve the bonding, or seal the joint, or both. Dimples may also be introduced into the bed of the groove to provide a mechanical interlock when the rim is rolled into the groove.

The method is particularly suitable for the construction of the vehicle wheels due to the homogenous 360 degree clamping and locking affect which is able to be produced. In addition, the method provides for the isolation of the critical locking portion of the joint, that is the roll into the groove, by the shrink fit of the rim on to the central component.

Brief Description of the Drawings

Examples of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 illustrates a first step in a process embodying the invention.

Figure 2 illustrates a second step in the process.

Figure 3 illustrates a third step.

Figure 4 illustrates a fourth step.

Figure 5 illustrates a vehicle wheel constructed to a variation of the process.

The same reference numerals have been used throughout the drawings to refer to corresponding features.

Best Modes for Carrying Out the Invention

The central component of the wheel, a cast, forged, machined or formed hub or centre 1 features a circumferential groove 2 which is machined into it. The outer shoulder 3 of groove 2 has a smaller diameter than the interior shoulder or stop 4.

The preformed alloy tube 5 which is to become the wheel rim has its inner edge 6 bevelled, knurled or similar. An adhesive or sealant 7 may be applied to the mating faces of the central component 1 and the rim 5.

The rim 5 is heated to expand it and increase its ductility or formability. It is not heated enough to anneal the material or to have any adverse affect on its mechanical properties. Once heated, the rim is pushed on to the central component 1 until the bevelled end 6 meets stop 4, as shown in Figure 2.

While still hot, the end of the rim 6 is rolled into groove 2, as shown in Figure 3. The bevelled end of the rim results in a valley 10 being formed within groove 2.

When hot, the stop 4 is spin forged into the valley 7 to leave a smooth finish 11 around the outer diameter of the wheel rim; as shown in Figure 4.

The entire process may be performed on one relatively simple and inexpensive machine. Energy consumption is low, noise emission is low, and there is very little fume output. The time to complete join on the machine may be less than twenty seconds, and even as little as five seconds.

Referring now to Figure 5, the central component 1 in this case includes a central groove 2 having outer shoulder 3 and an inner shoulder 12. In the floor of groove 2 there are concave dimples 13 around the circumference.

The rim 5 comprises both exterior rim parts 14 and interior rim parts 15, and also has a circumferential groove 16 which is rolled out of the flat

rim into groove 2, while the rim is heated. The rim material is impressed into the dimples 13 in the floor of the groove to central component 1 in order to form dimples 17 in the exterior of the rim. The interlocking dimples 13 and 17 provide a mechanical anti-rotation lock. This shows a lightweight two piece car wheel, with the entire rim section formed separate from the centre component.

Although the invention has been described with reference to forming a vehicle wheel it should be appreciated that it may be applied to the construction of many other items, including the construction of alloy space frame such are used in the construction of passenger vehicles. It should also be appreciated that the simple rolling of the rim into the groove and the shrinkage should be perfectly reliable in many applications, but that the spin forging of the stop, of the use of adhesive or interlocking formations improves the joint.

The invention makes possible reliable joints between dissimilar materials. The rim, or tube, component would always be metal, either steel, aluminium or possibly titanium, magnesium or other structural metal. But the hub, or male component, could be either metal or possibly plastic or composite material, such as carbon fibre or metal matrix composite.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

CLAIMS

1. A method of joining forged, machined, formed or cast central components with metal tube, comprising the steps of:

heating the tube to expand its diameter, but not sufficiently to anneal it, or otherwise adversely affect its mechanical properties;

then, while the tube is still hot, pushing the tube over part of the central component so that part of the tube overlies a circumferential groove in the central component;

then, while still hot, rolling the circumferential part of the tube which overlies the groove, into the groove, so that when cooled the rolled part of the tube is clamped into the groove, and another part is shrunk on to the exterior of the central component.

2. A method according to claim 1 further comprising the preliminary step of machining the circumferential groove into the centre component.

3. A method according to claim 1 or 2, where an end of the metal tube is to be rolled into the circumferential groove in the central component, then a stop is provided along one side of the groove.

4. A method according to claim 3, where the heated tube is pushed over the component from the other side until the end of the tube abuts the stop.

5. A method according to claim 4, where the end of the tube abutting the stop is bevelled.

6. A method according to claim 5, where after the end of the tube has been rolled into the groove, the stop is spin forged, while the tube is still hot, into the space remaining in the groove as a result of the bevelling of the end of the tube.

7. A method according to any one of claims 1 to 6, where adhesive is applied to the mating surfaces of the joint prior to assembly.

8. A method according to any one of claims 1 to 7, where dimples are provided in a floor of the groove into which the tube is rolled.

9. A method according to any one of claims 1 to 8, applied to the fabrication of a vehicle wheel, where the central component is a cast, machined, formed or forged hub, and the metal rim of the wheel comprises a formed tubular structure which is pushed on to the hub.

10. A vehicle wheel, comprising a central cast, machined, formed or forged hub or centre, and a metal rim shrunk fit on to the hub and having at least one part roll formed down into a circumferential groove around the hub or centre.

11. A vehicle wheel according to claim 10, where in addition a stop formed in part of the hub is spin forged down over the top of the roll formed part of the rim.

12. A vehicle wheel according to claim 11, where the rim is bevelled before roll forming, and a space is left into which the stop is spin forged.

13. A vehicle wheel according to claim 12, where a sealing material is provided between the rim and the hub.

14. A vehicle wheel according to any one of claims 10 to 13, where dimples are introduced into a floor of the groove to provide a mechanical interlock when the rim is rolled into the groove.

15. A method of joining forged, machined, formed or cast central components with metal tube, comprising the steps of:

pushing a tube over part of the central component so that part of the tube overlies a circumferential groove in the central component;

then, heating the tube but not sufficiently to anneal it, or otherwise adversely affect its mechanical properties, and while still hot, rolling the circumferential part of the tube which overlies the groove, into the groove, so that when cooled the rolled part of the tube is clamped into the groove, and another part is shrunk on to the exterior of the central component.

16. A method according to claim 15 further comprising the preliminary step of machining the circumferential groove into the centre component.

17. A method according to claim 15 or 16, where an end of the metal tube is to be rolled into the circumferential groove in the central component, then a stop is provided along one side of the groove.

18. A method according to claim 17, where the heated tube is pushed over the component from the other side until the end of the tube abuts the stop.

19. A method according to claim 18, where the end of the tube abutting the stop is bevelled.

20. A method according to claim 19, where after the end of the tube has been rolled into the groove, the stop is spin forged, while the tube is still hot, into the space remaining in the groove as a result of the bevelling of the end of the tube.

21. A method according to any one of claims 15 to 20, where adhesive is applied to the mating surfaces of the joint prior to assembly.

22. A method according to any one of claims 15 to 21, where dimples are provided in a floor of the groove into which the tube is rolled.

23. A method according to any one of claims 15 to 22 applied to the fabrication of a vehicle wheel, where the central component is a cast, machined, formed or forged hub, and the metal rim of the wheel comprises a formed tubular structure which is pushed on to the hub.

24. A vehicle wheel, comprising a central cast, machined, formed or forged hub or centre, and a metal rim connected to the hub by being pressed onto it and having at least one part roll formed down into a circumferential groove around the hub or centre.

25. A vehicle wheel according to claim 24, where in addition a stop formed in part of the hub is spin forged down over the top of the roll formed part of the rim.

26. A vehicle wheel according to claim 25, where the rim is bevelled before roll forming, and a space is left into which the stop is spin forged.

27. A vehicle wheel according to claim 26, where a sealing material is provided between the rim and the hub.

28. A vehicle wheel according to any one of claims 24 to 27, where dimples are introduced into a floor of the groove to provide a mechanical interlock when the rim is rolled into the groove.

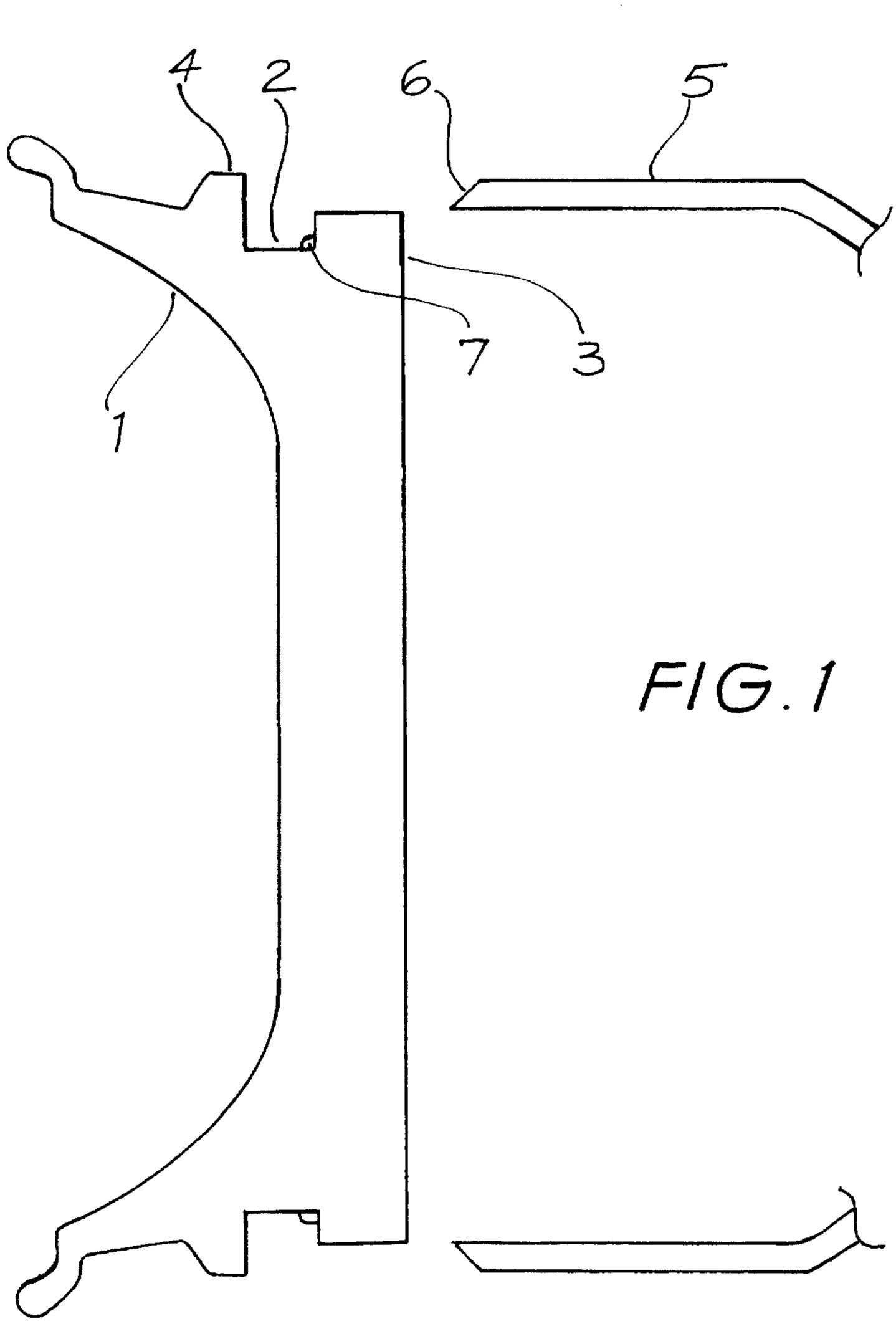


FIG. 1

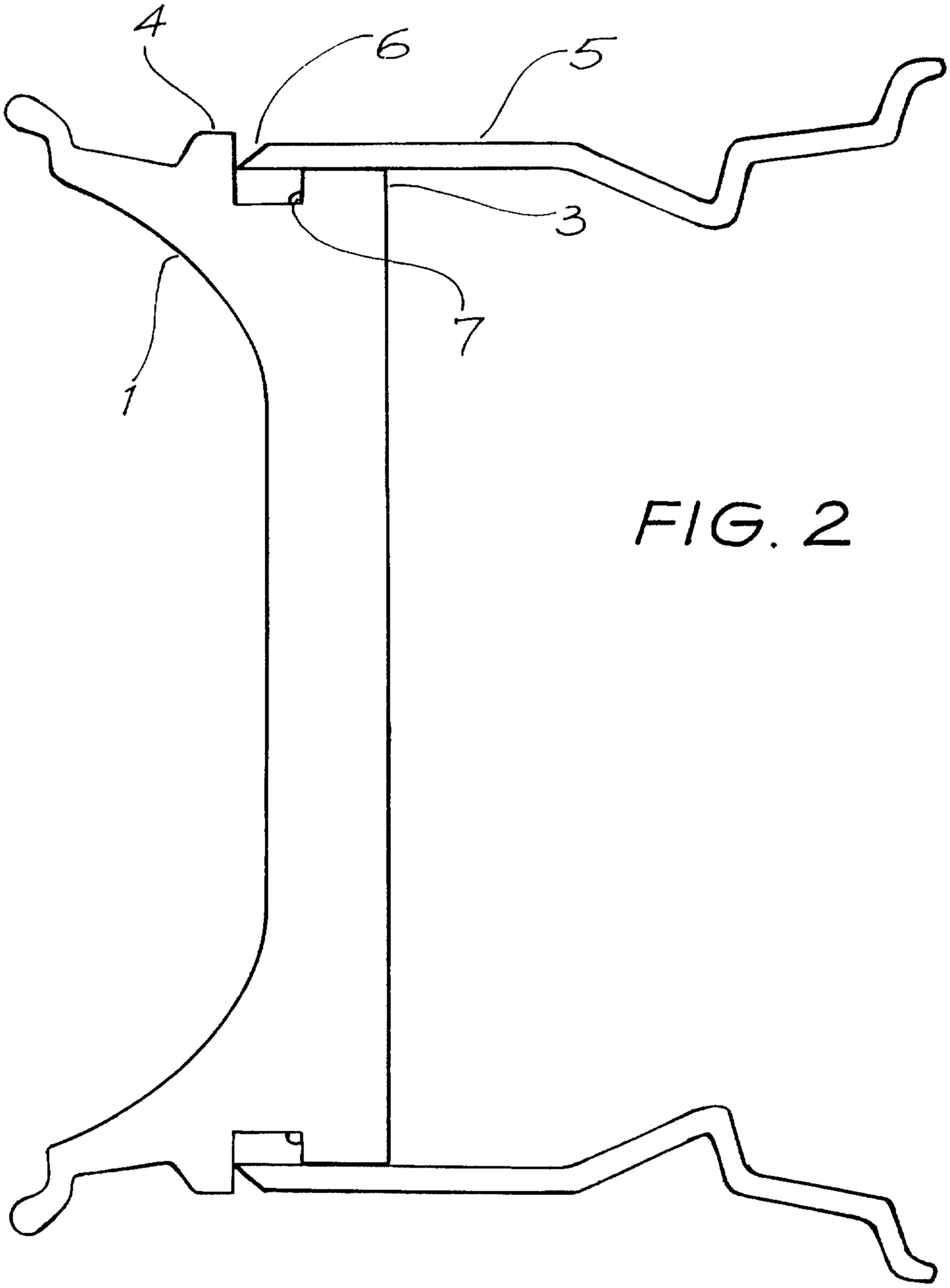


FIG. 2

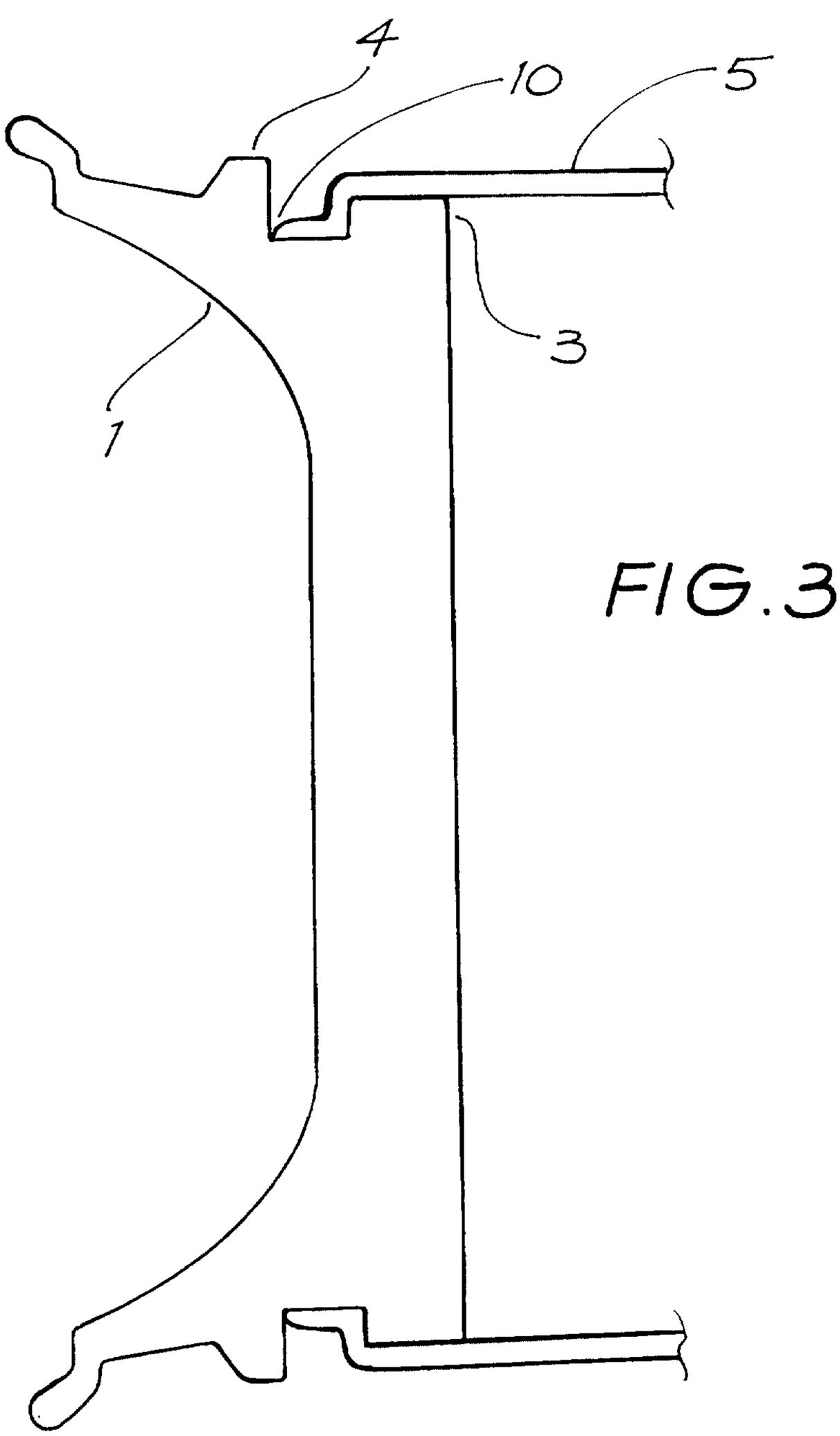


FIG.3

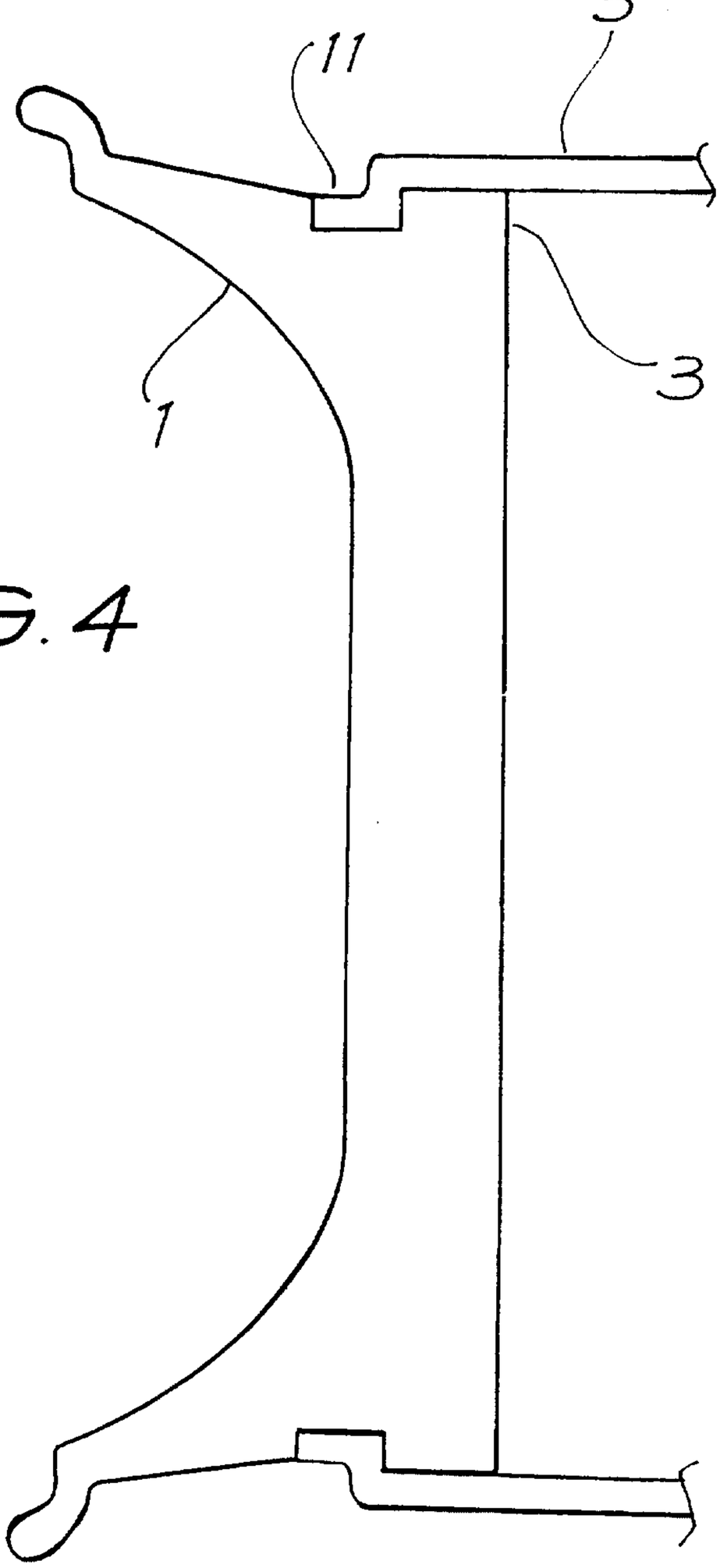


FIG. 4

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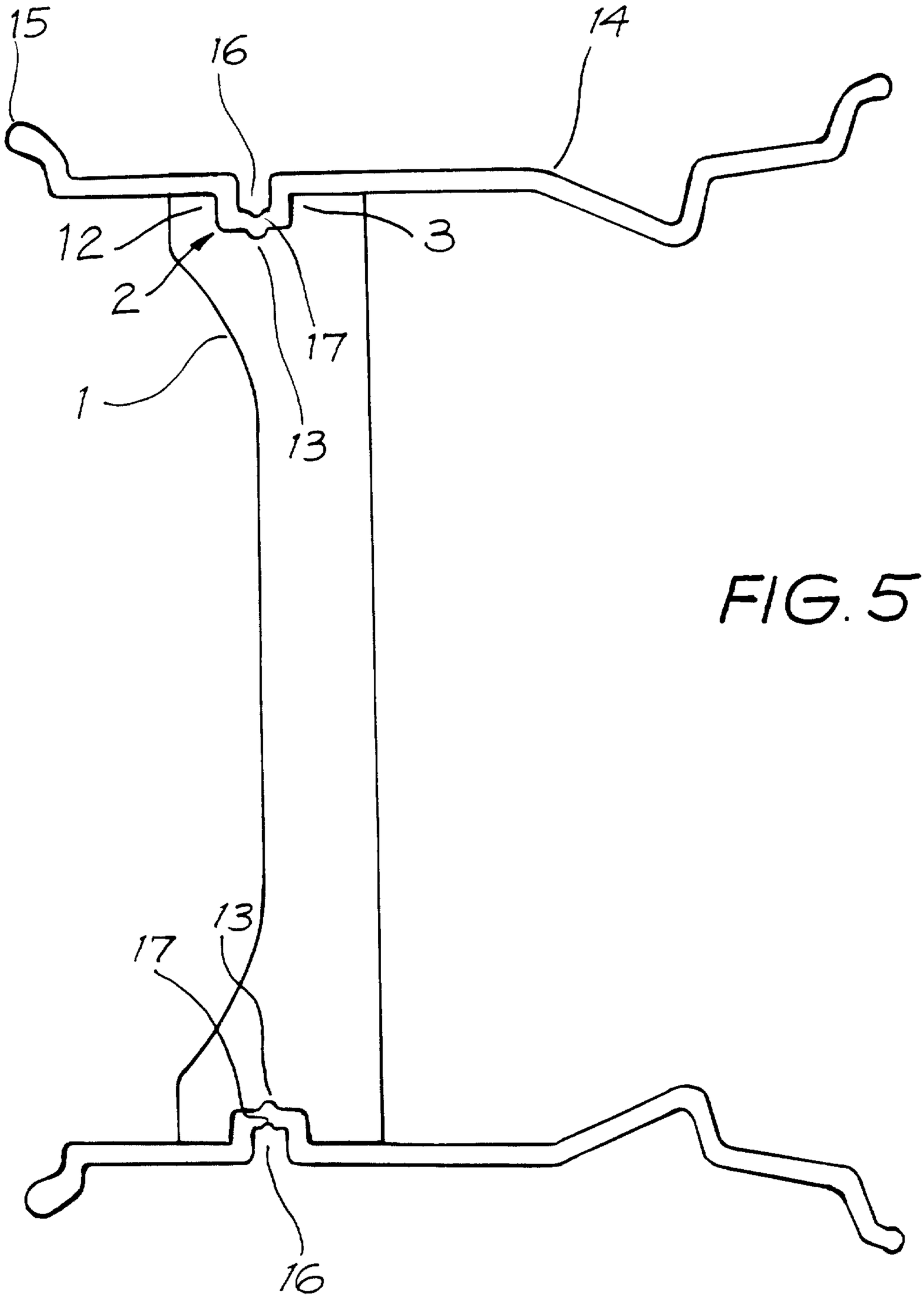
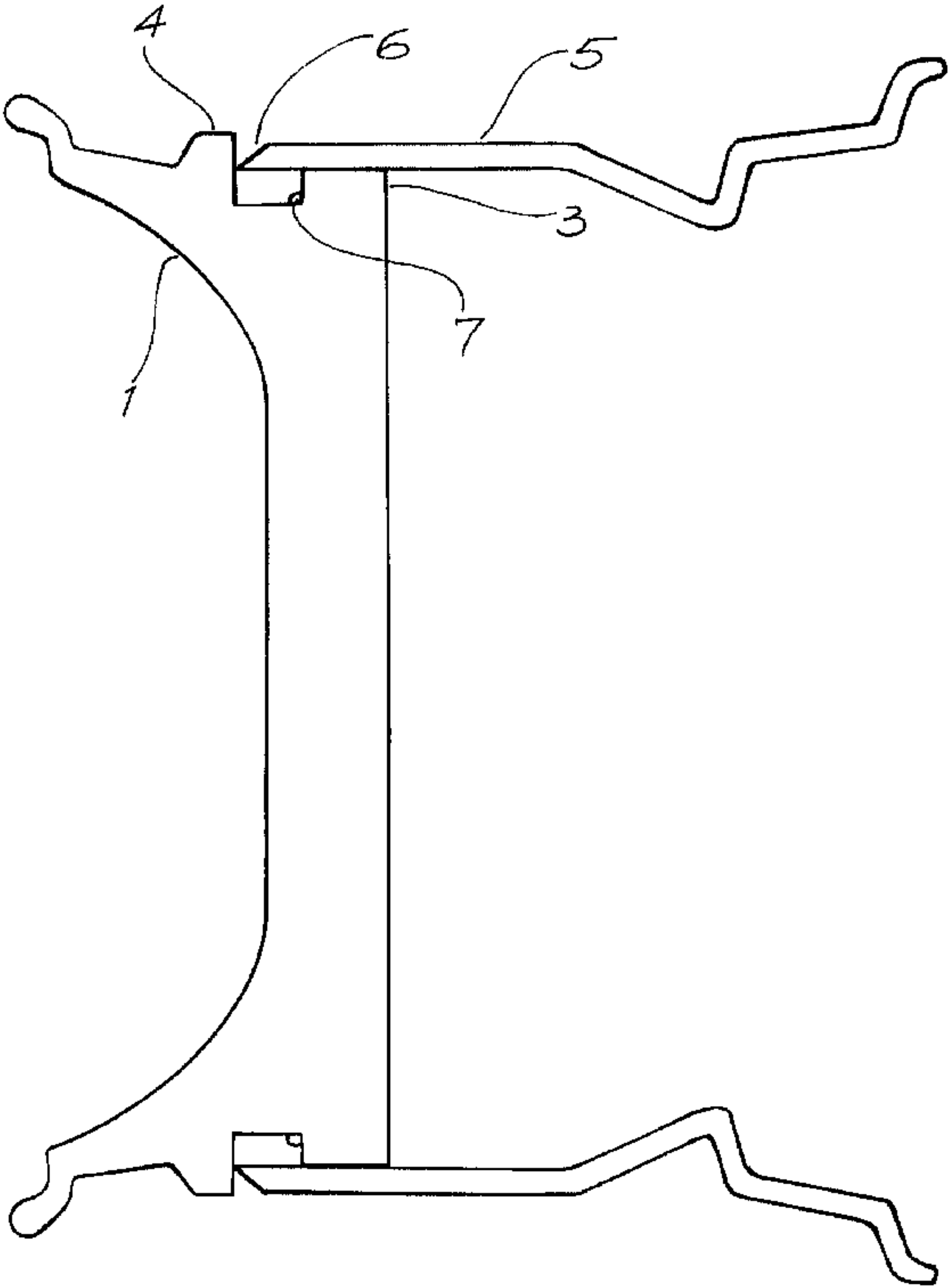


FIG. 5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