US008210232B2

(12) **United States Patent**
Xia

(10) **Patent No.: US 8,210,232 B2**
(45) **Date of Patent: Jul. 3, 2012**

(54) **LIGHTWEIGHT BRAKE ROTOR AND COMPONENTS WITH COMPOSITE MATERIALS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1093 days.

(21) Appl. No.: **11/858,596**

(22) Filed: **Sep. 20, 2007**

(65) **Prior Publication Data**

US 2009/0078515 A1 Mar. 26, 2009

(51) **Int. Cl.**
B22D 19/00 (2006.01)
B22D 19/04 (2006.01)
B22D 19/16 (2006.01)

(52) **U.S. Cl.** **164/98**; 164/111; 164/112; 164/137

(58) **Field of Classification Search** 164/98, 164/100, 111, 112, 137

See application file for complete search history.

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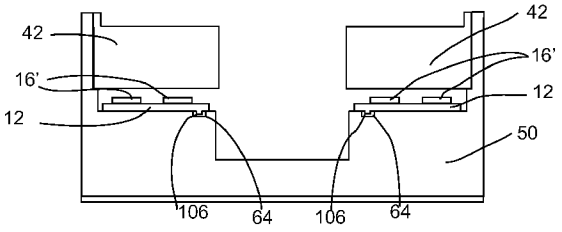
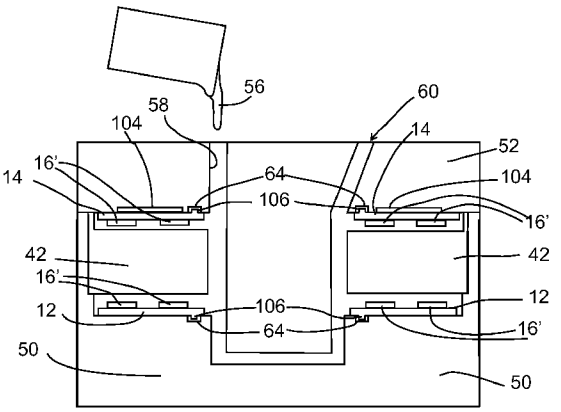
(57) **ABSTRACT**

A method including: placing a first insert and a second insert in a casting mold and wherein the first insert and second insert including a plurality of connecting posts extending in between so that the first insert and second insert are in spaced-apart relationship in the mold, each of the first insert and the second insert including a first material; casting a molten second material into the casting mold so that the second material flows between the first insert the second insert and solidifying the second material.

5 Claims, 10 Drawing Sheets





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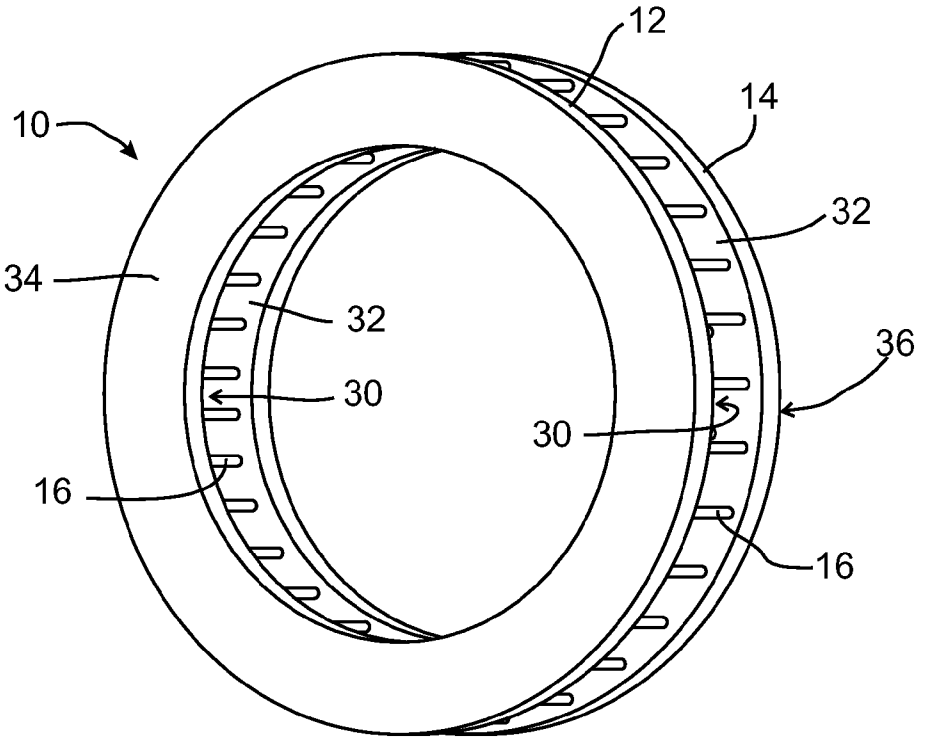
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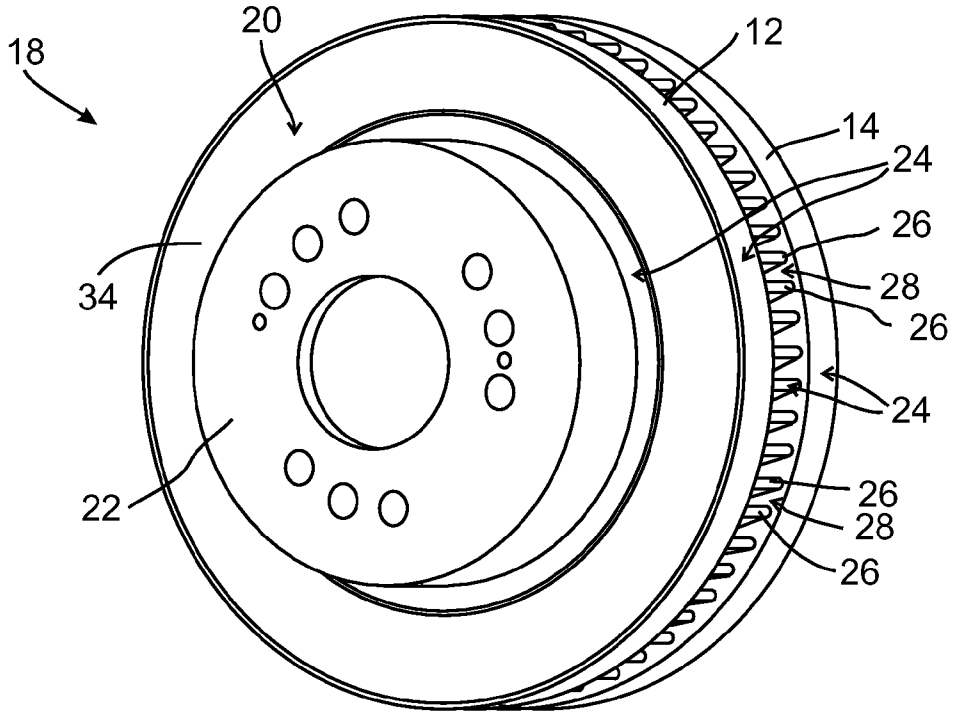
FIG. 1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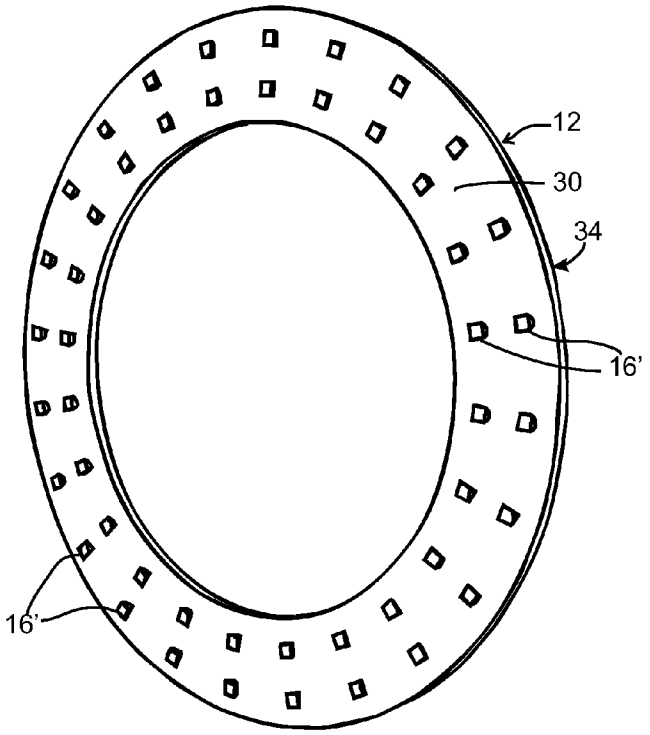
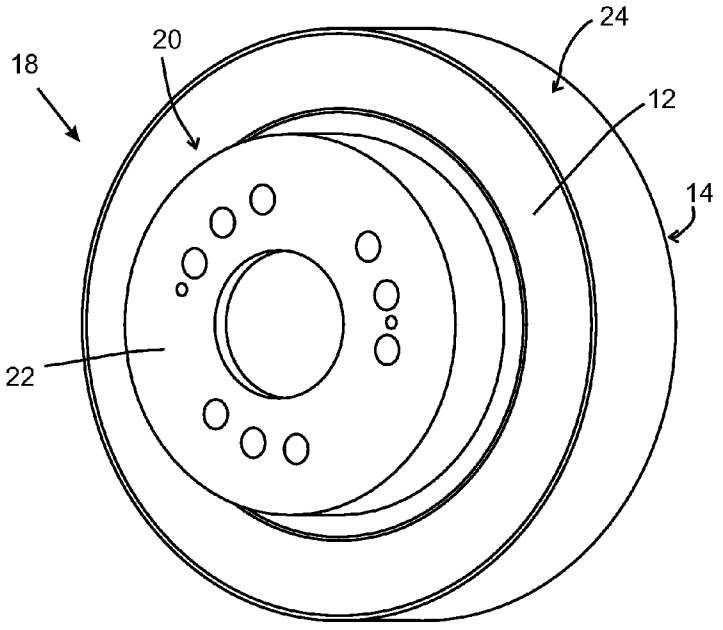


FIG. 3



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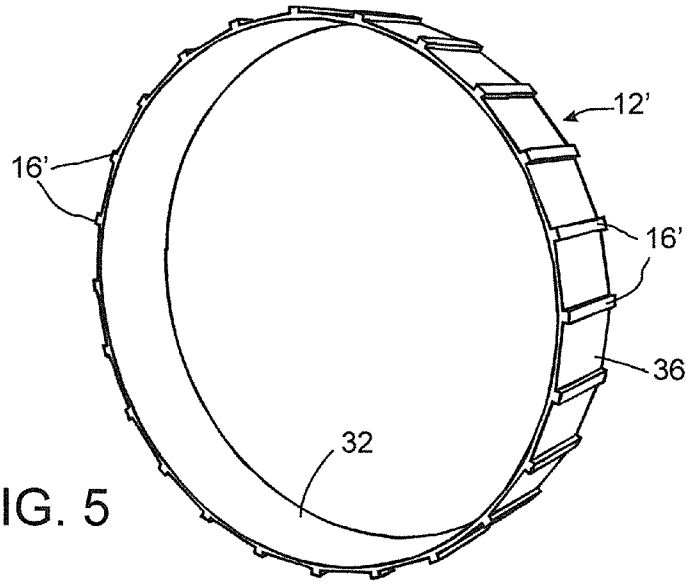

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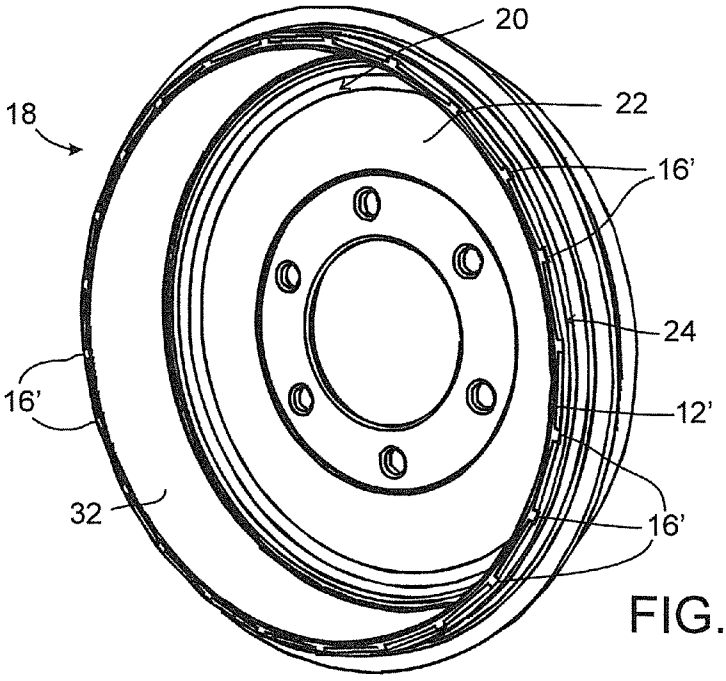

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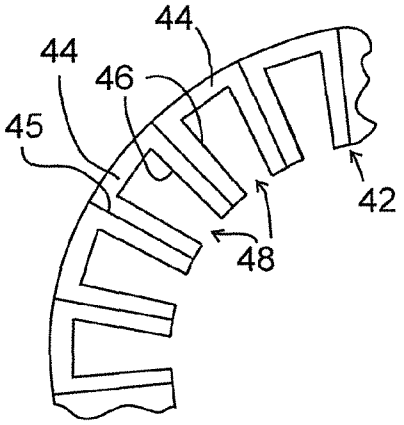

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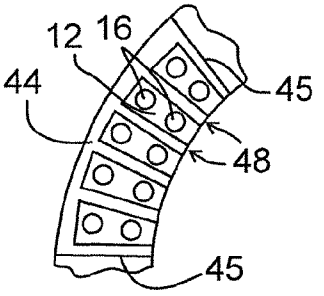

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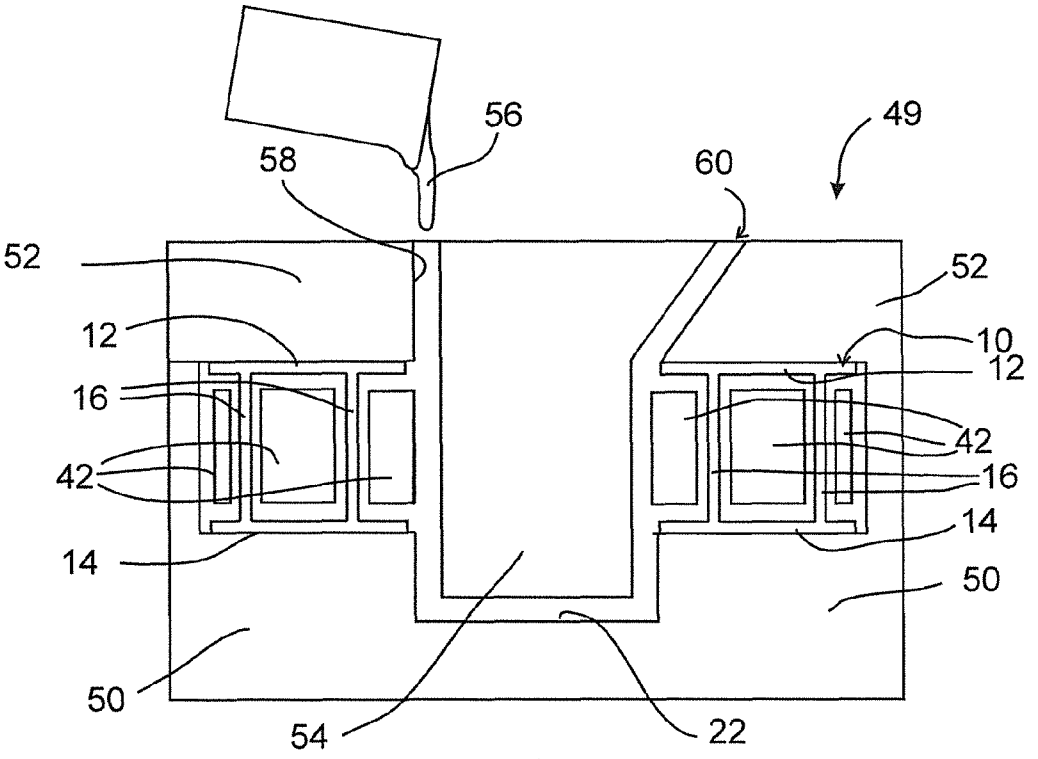

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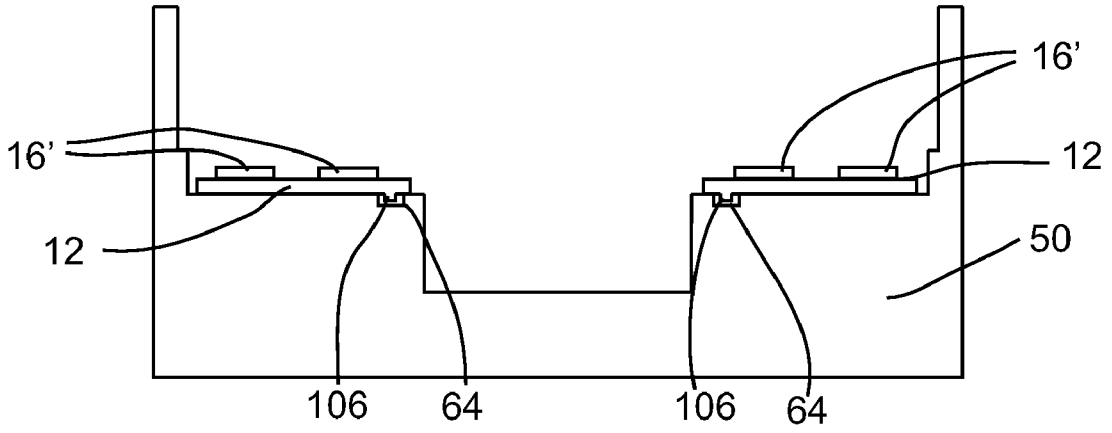

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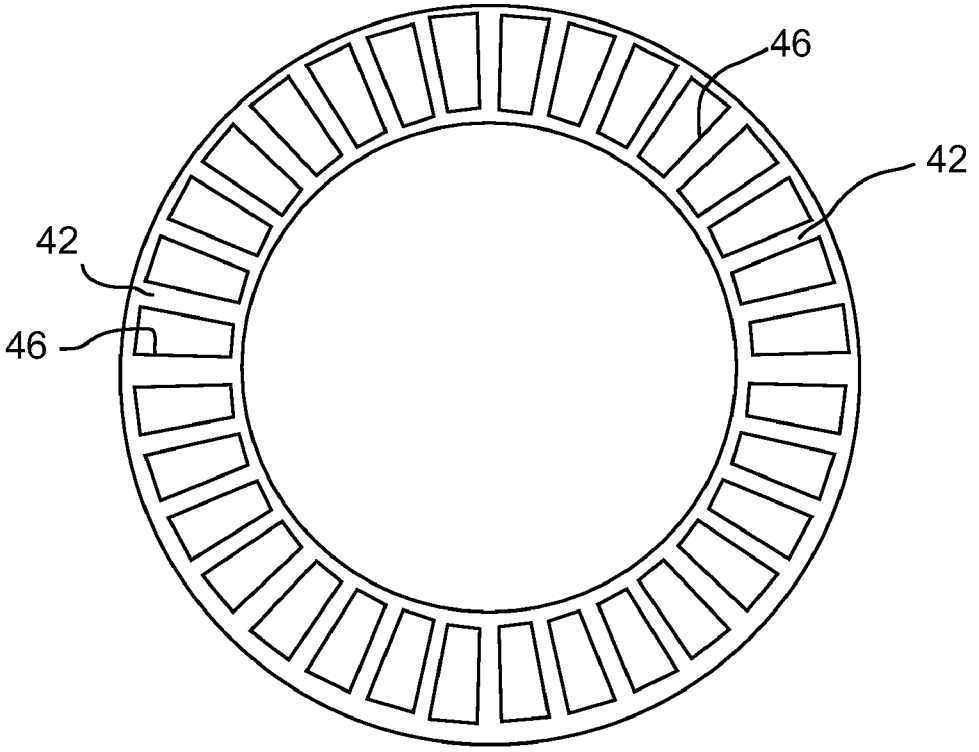

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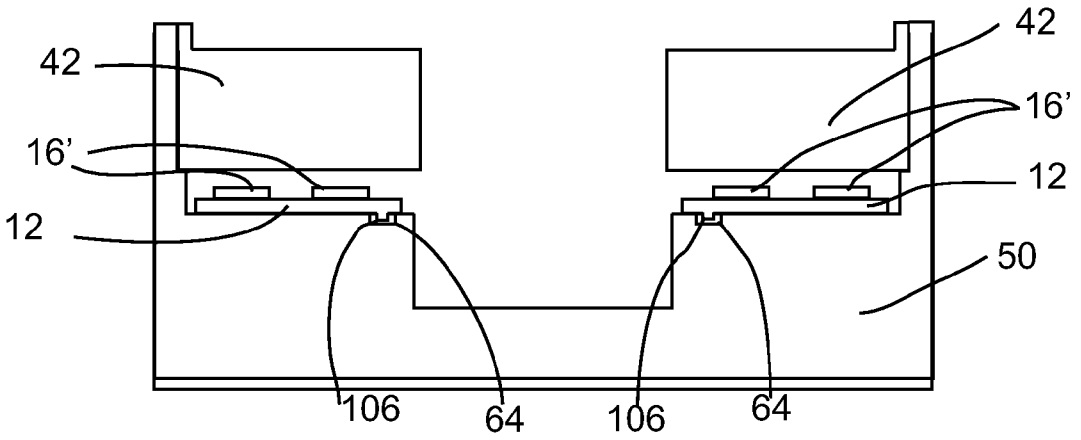

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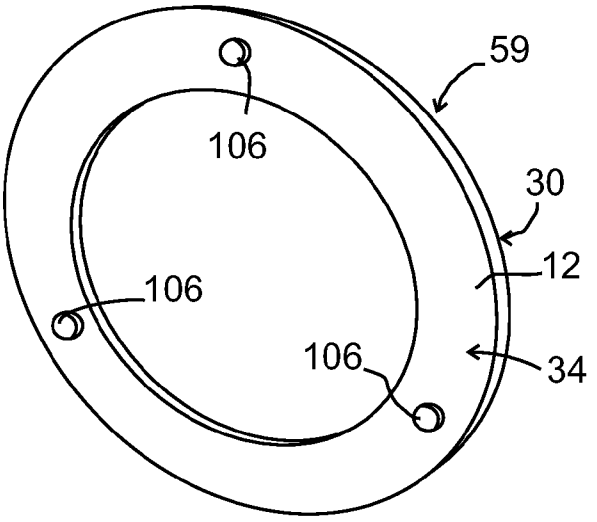
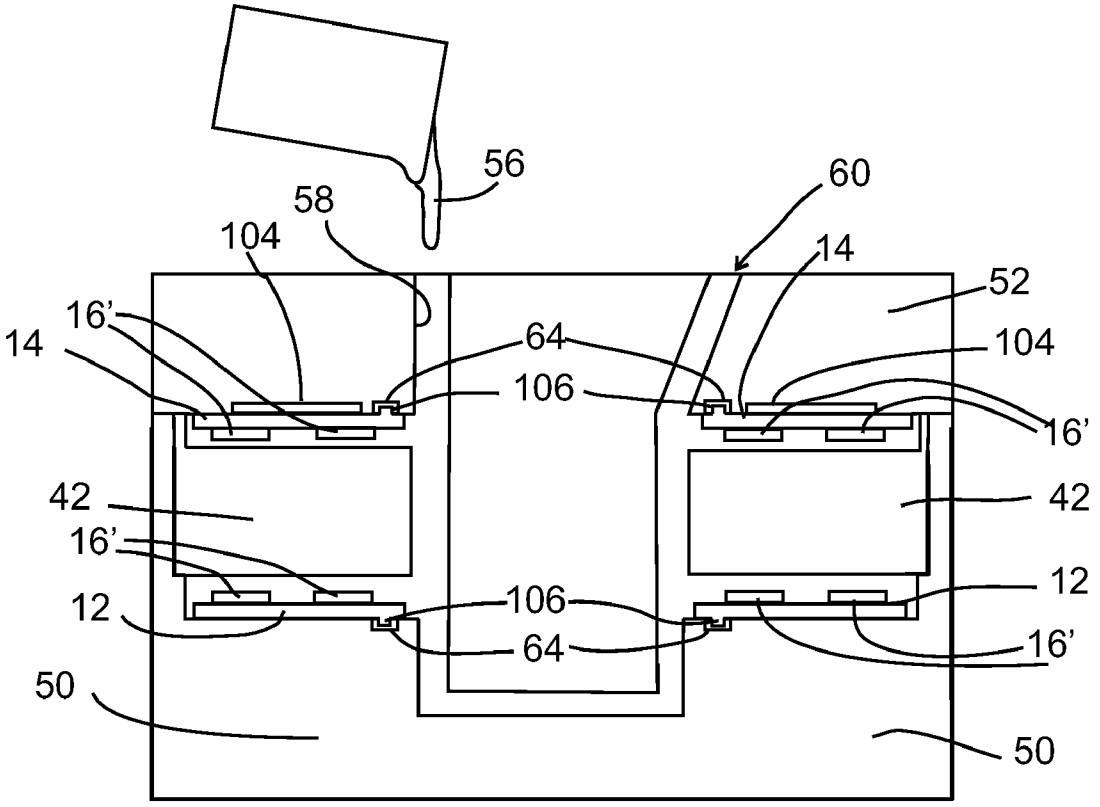


FIG. 13



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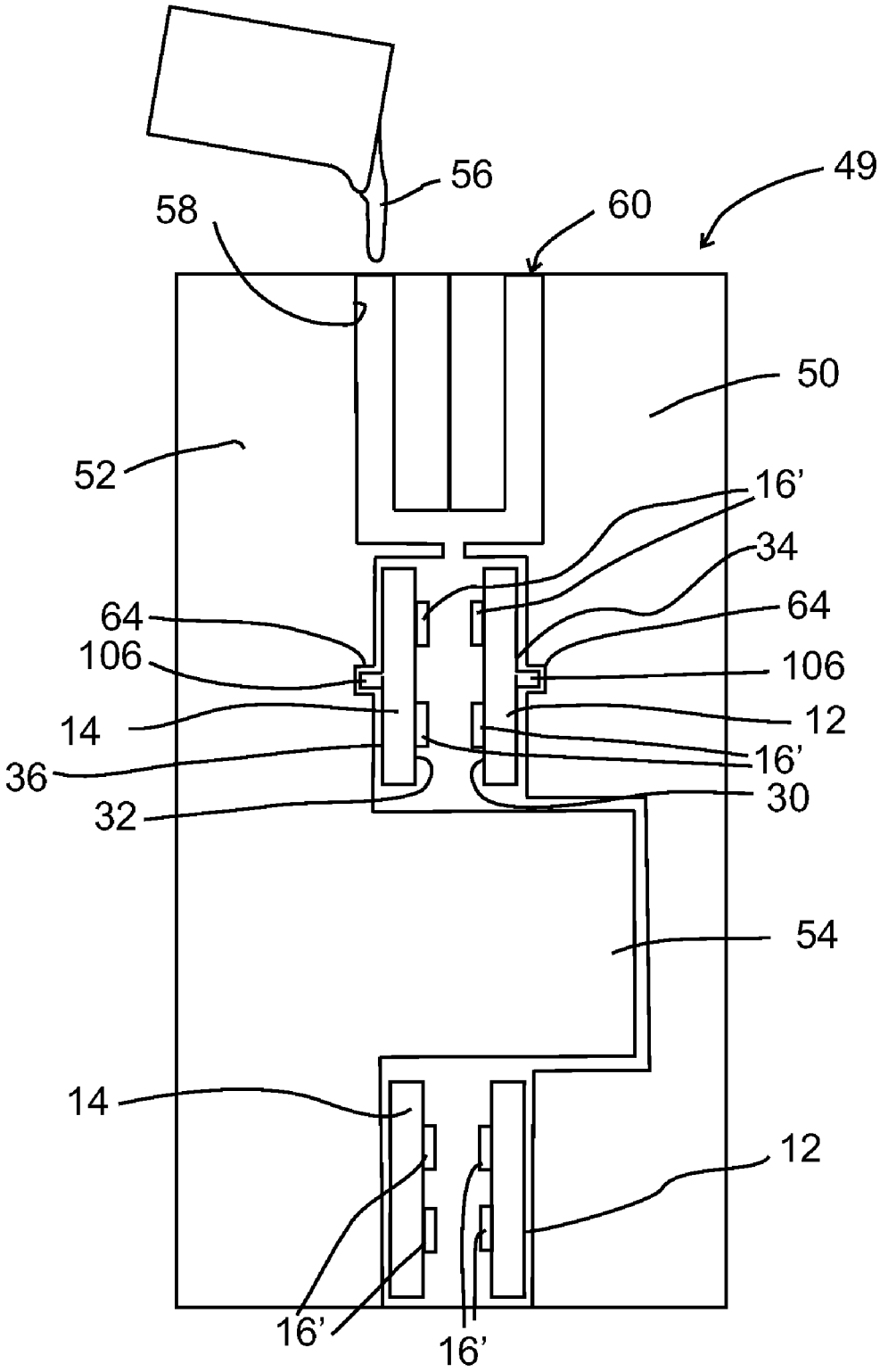
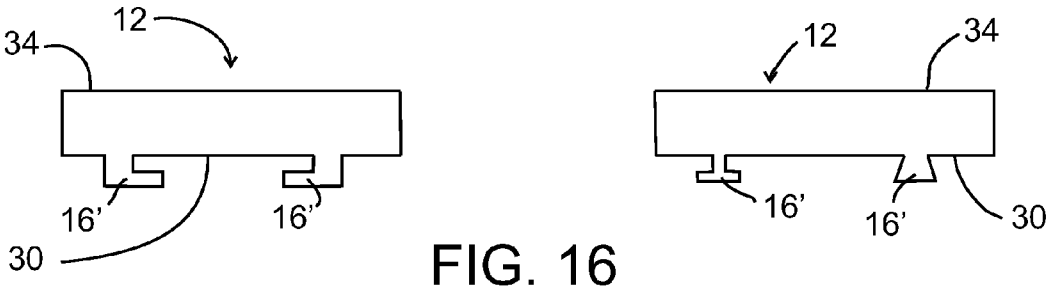


FIG. 15



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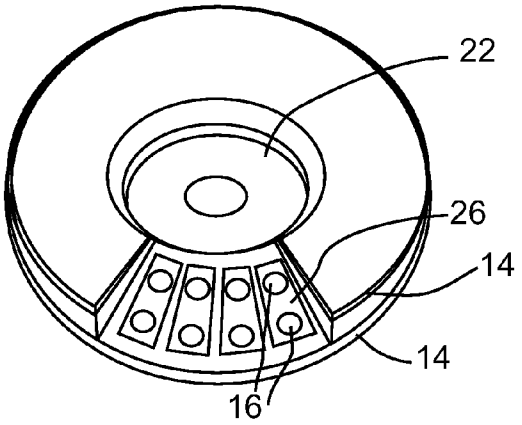

FIG. 17A

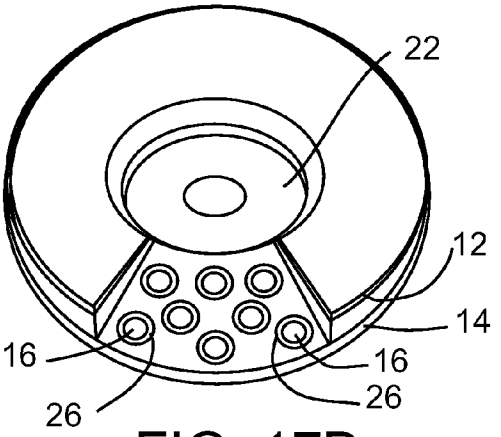

FIG. 17B

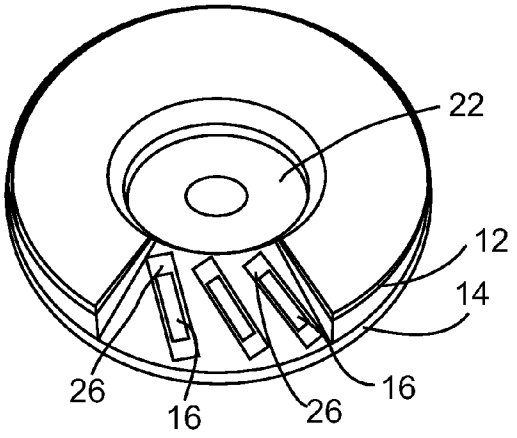

FIG. 17C

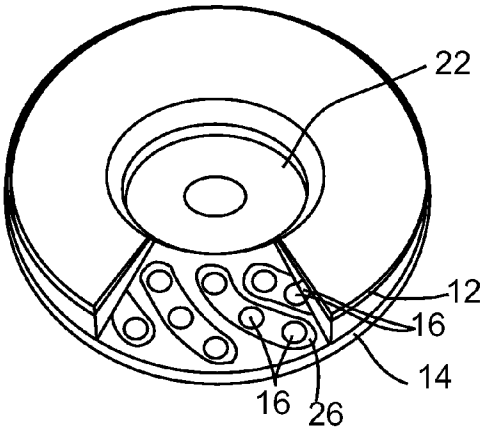

FIG. 17D

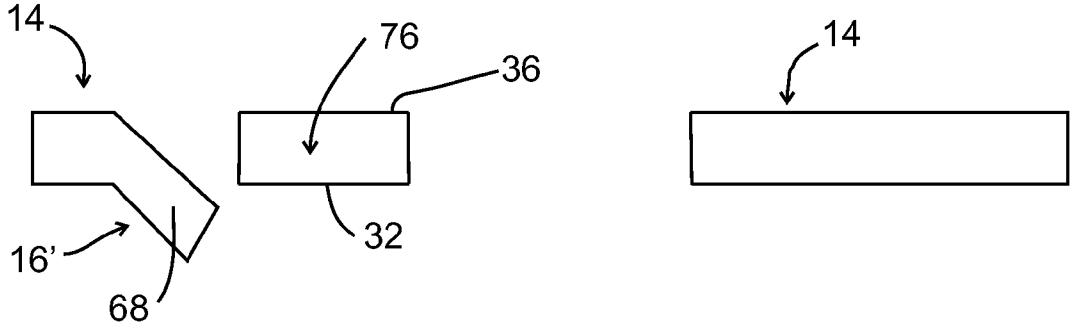

FIG. 18

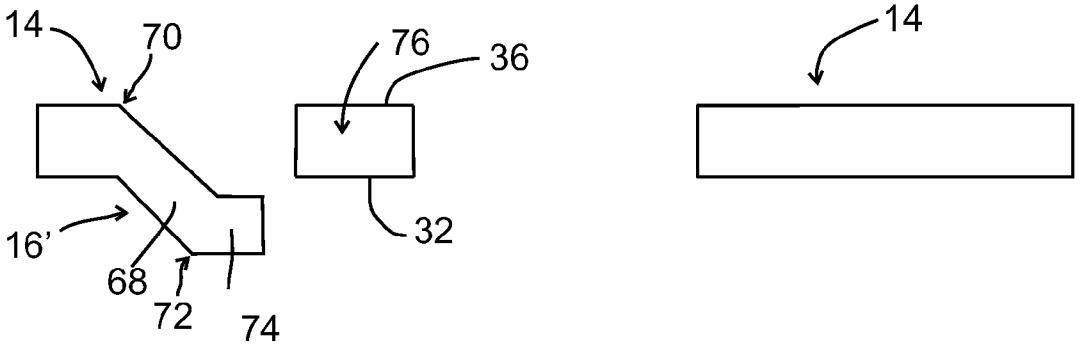

FIG. 19

LIGHTWEIGHT BRAKE ROTOR AND COMPONENTS WITH COMPOSITE MATERIALS

TECHNICAL FIELD

The field to which the disclosure generally relates includes methods of joining different materials and products made therefrom.

BACKGROUND

Vehicles that include wheels such as, but not limited to, automobiles, trucks, buses, airplanes and the like typically include braking systems. Such braking systems commonly include drum or disc brake rotors.

SUMMARY OF EXEMPLARY EMBODIMENTS

One embodiment of the invention includes a method comprising: placing a first insert and a second insert in a casting mold and wherein the first insert and second insert comprising a plurality of connecting posts extending in between so that the first insert and second insert are in spaced-apart relationship in the mold, each of the first insert and the second insert comprising a first material; casting a molten second material into the casting mold so that the second material flows between the first insert and the second insert and solidifying the second material to provide a product comprising a cast over body portion with the first insert and second insert and so that the second material is mechanically locked or metallurgically bonded to the first material and so that one or both of the first insert and the second insert provides working surface for the product.

Other exemplary embodiments of the invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while disclosing exemplary embodiments of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. **1** illustrates a braking wheel useful in a method according to one embodiment of the invention.

FIG. **2** illustrates a vented disc brake rotor including a braking wheel and a cast over body portion including a hub according to one embodiment of the invention.

FIG. **3** illustrates an insert with projections having a trapezoidal shape useful in making an brake rotor according to one embodiment of the invention.

FIG. **4** illustrates a non-vented disc brake rotor including a braking wheel and a cast over body portion including a hub according to one embodiment of the invention.

FIG. **5** illustrates a braking wheel for a drum rotor useful in a method according to one embodiment of the invention.

FIG. **6** illustrates a drum rotor including a braking wheel and cast over body portion including a hub according to one embodiment of the invention.

FIG. **7** illustrates a sectioned core insert useful in making a disc brake rotor according to one embodiment of the invention.

FIG. **8** illustrates a sectional plan view of a sectioned casting core overlying a portion of a braking wheel including an annular disc and post extending therefrom and wherein the post received in slots formed in the casting core according to one embodiment of the invention.

FIG. **9** illustrates a method of making a disc brake rotor according to one embodiment of the invention.

FIG. **10** illustrates placing a first annular disc insert in a casting mold in a method of making a brake rotor according to one embodiment of the invention.

FIG. **11** illustrates a casting core including a plurality of channels formed therein for use in a method according to one embodiment of the invention.

FIG. **12** illustrates a method of placing the casting core of FIG. **10** in a casting mold according to one embodiment of the invention.

FIG. **13** illustrates an annular disc insert including locating features useful in a method according to one embodiment of the invention.

FIG. **14** illustrates a method of closing the casting mold and pouring molten material into the mold according to one embodiment of the invention.

FIG. **15** illustrates a vertical casting method including placing the first and second annular disc insert with locating feature in first and second mold halves respectively, and pouring molten material into the casting mold according to one embodiment of the invention.

FIG. **16** is a sectional, side view of an annular disc insert including a plurality of projections which may have a trapezoid-shape, L-shape or T-shape that is useful according to one embodiment of the invention.

FIG. **17**A is a perspective view with portions broken away of a brake rotor with straight vanes according to one embodiment of the invention.

FIG. **17**B is a perspective view with portions broken away of a brake rotor with pillar-type vanes according to another embodiment of the invention.

FIG. **17**C is a perspective view with portions broken away of a brake rotor with straight, tangential vanes according to another embodiment of the invention.

FIG. **17**D is a perspective view with portions broken away of a brake rotor with curved, tangential vanes according to another embodiment of the invention.

FIG. **18** is a sectional, side view of an annular insert including downwardly extending legs stamped out of the insert and useful in a method according to one embodiment of the invention.

FIG. **19** illustrates a sectional, side view of an annular insert including a tab stamped out of the insert including a downwardly extending leg portion and a foot useful in one embodiment of the invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

The following description of the embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

Referring now to FIG. **1**, one embodiment of the invention includes providing a braking wheel **10** which may include a first insert **12** and a second insert **14** which are maintained in spaced-apart relationship to each other by a plurality of posts **16** extending between the first insert **12** and the second insert **14**. In one embodiment, the first insert **12**, the second insert **14** and the posts **16** extending therebetween are cast from a

single first material and are a continuous casting. The braking wheel **10** may be manufactured by casting, welding or other similar methods.

The braking wheel **10** may be utilized to make a disc brake rotor **18** shown in FIG. **2**. The disc brake rotor **18** includes a cast over body **20** including a hub portion **22** and a second portion **24** extending between the first insert **12** and the second insert **14**. The second portion **24** of the cast over body **20** may cover the insert annular inner surface and the outer circumferential surfaces of the inserts **12**, **14**. A plurality of vanes **26** or fins extending between the first insert **12** and the second insert **14** may define a plurality of vents **28** or channels therebetween to provide a vented brake rotor as shown in FIG. **2**. The vanes **26** may be straight-shaped vanes, curved vanes, pillar-type vanes or any other type vane known to those skilled in the art. In one embodiment, each of the posts **16** of the brake wheel **10** may be surrounded by an associated vane **26** so that the cast over body **20** is mechanically locked to the brake wheel **10** or metallurgically bonded thereto at the post **16**.

The braking wheel **10** may be made from a first material, such as cast iron to provide a first braking surface **34** on an outer face of the first insert **12** and a second braking surface **36** on an outer surface of the second insert **14**. The cast over body **20** may be made of a second material that has a density and melting point less than that of the first material. In one embodiment of the invention the second material may include aluminum or alloy thereof. In one embodiment, all the exposed surfaces of the rotor comprise the second material except the two annular braking surfaces **34**, **36** which comprise the first material. This arrangement prevents corrosion of the first material except at the exposed braking surfaces **34**, **36**. However, any corrosion at the exposed braking surfaces **34**, **36** may be removed by the brake pads rubbing against the braking surfaces **34**, **36**.

Referring again to FIG. **1**, in one embodiment, the post **16** and/or an inner surface **30** of the first insert **12** and/or an inner surface **32** of the second insert **14** may be treated, for example by applying a coating of graphite so that the inner surfaces **30**, **32** and/or the posts **16** is wet by the molten second material and a metallurgical bond is formed between the cast over body portion and the inserts **12**, **14** or post **16**.

Referring now to FIG. **3**, in one embodiment the first insert **12** (or the second insert **14**) includes a plurality of trapezoid-shaped projections **16'** extending from an inner surface **30** of the first insert **12** (or an inner surface **32** of the second insert **14**) thereof and wherein the second material is mechanically locked to the first material at the projections during a casting process. At least one of the outer surface **34** of the first insert **12** (or the outer surface **36** of the second insert **14**) provides a first braking surface. Still other embodiment of annular disc inserts with projections **16'** are illustrates in FIGS. **16**,**18** and **19**.

Referring now to FIG. **4**, alternatively, the second portion **24** of the cast over body **20** may completely fill the space between the first insert **12** and the second insert **14** to provide a solid non-vented disc brake rotor **18**.

Referring now to FIG. **5**, in another embodiment of the invention, the brake wheel **10** may be constructed and arranged to form a cylindrical inner wall **14** with projections **16'** extending from an outer surface **36**. In one embodiment the projection **16'** may have a trapezoid-shape, T-shape, L-shape, rectangular-shape and the like. Some examples of the designs for the projections **16'** are shown in FIG. **16**. An inner face **32** of the cylindrical wall provides a braking surface.

Referring now to FIG. **6**, the brake wheel **10** of FIG. **5** may be utilized to provide a cast over body **20** defining a hub portion **22** and a second portion **24** to completely cover all the projections **16'** on the braking wheel **10** to provide a drum brake rotor **18**.

Referring now to FIG. **7**, a casting core **42** may be utilized to make a vented disc brake rotor shown in FIG. **2**. The casting core **42** may be a permanent metal core. In one embodiment the core **42** may be sectioned **45** into many pieces each of which may be slid between the first insert **12** and second insert **14** from a position associated with the outer diameter of the brake wheel **10** towards the center thereof. Each portion **44** of the core **42** may include at least one slot **46** formed therein having an open end **48** to receive the posts **16** extending between the first insert **12** and the second insert **14**.

FIG. **8** is a sectional, planer view of a braking wheel **10** including a first insert **12** and a plurality of posts **16** extending upwardly therefrom and portions **44** of a core **42** overlying the first insert **12**. During the casting operations, the slots **46** formed in each portion **44** of the core **42** will be filled with the second material to form vanes **26** extending between the first insert **12** and the second insert **14**. The vane **26** may capture the posts **16** or projections **16'** and be mechanically locked thereto or the posts or projections may be treated so that the second material used to form the vane **26** is metallurgically bonded to the posts **16** or projections **16'**. The core **42** may then be removed to leave vents **28** or channels between vanes **26**.

Referring now to FIG. **9**, one embodiment of the invention includes placing a braking wheel **10** and including a core **42** into at least one of a first portion **50** of a casting mold **49** or second portion **52** of a casting mold wherein the second portion **52** includes a projection **54** constructed and arranged to extend into the first portion **50** of a casting mold **49** to define the hub **22** of the brake rotor. The casting mold **49** may be a permanent metal mold. The material utilized for the braking wheel may be a first material such as cast iron and a second molten material **56** may be poured into the casting mold through a charge line **58**. The second molten material **56** may be of a second material such as aluminum which has a lower melting point and is lighter than the first material. The casting mold **49** may include a vent **60** and other features known to those skilled in the art.

FIGS. **10-14** illustrate another embodiment of making a brake rotor. The first insert **12** may be a separate annular disc **12** with trapezoidal projections **16'** as shown in FIG. **16** and placed in the first portion of a casting mold **50**. Thereafter, a casting core **42** may be placed over the first insert **12** (as shown in FIG. **12**). The core **42** as shown in FIG. **11** may be a single intact piece including a plurality of channels **46** formed therein and constructed and arranged to produce vanes **26** during the casting process. FIG. **13** illustrates one embodiment of the invention in which the first insert **12** or the second insert **14** may include an annular disc portion **59** with locating features **106** on the braking surfaces **34**, **36**. As shown in FIG. **14**, in one embodiment each of the first portion **50** and second portion **52** of the casting mold **49** may include the locating features **64** working together with the locating features **106** on the inserts to hold the inserts in place in the mold for casting. For example a plurality of recesses **64** formed therein to receive the locating features **106** so that each of the first insert **12** and second insert **14** may be held in a designed position. In another embodiment the second portion **52** of the casting mold **49** may include a magnet **104** to hold the second insert **14** and then be placed over the first portion **50** to close the mold **49**, and the molten second material **56** may then be poured in through a charge line **58** to form

a brake rotor having a cast over body **20** including a hub **22** and a second portion **24** (not shown) extending between the first insert **12** and the second insert **14**. The locating features **106** on the first insert **12** and the second insert **14** may be machined off later. The locating features **106** may also be constructed to rest on the shoulder of a specially designed mold and may be clamped onto by the mold halves. To make a non-vented disc brake rotor the core **42** is not used.

Referring now to FIG. **15**, in another embodiment each of the first insert **12** and second insert **14** may be held in a vertical position. Molten material **56** may be poured into the casting mold **49** to provide a rotor including a cast over body portion **20** including a hub portion **22** and a second portion **24** extending between the first insert **12** and the second insert **14**, for example as shown in FIG. **4**.

FIG. **16** illustrates one embodiment of a first insert **12** (or second insert **14**) including a plurality of projections **16'** extending outwardly from a inner surface **30** of the first insert **12**. The first insert **12** may include an outer first braking surface **34**. The projections **16'** may be constructed and arranged so that a mechanical lock is provided when the second material is cast into the casting mold. The projections **16'** may have any of a variety of shapes. For example, the projection **16'** may be trapezoid-shaped, L-shaped, T-shaped or may have any shape providing a shoulder or surface against which the second material may be trapped and thereby preventing the first insert **12** (or second insert **14**) from being pulled away from the second portion **24** of the cast over body **20**.

FIG. **17**A is a perspective view with portions broken away of a brake rotor according to one embodiment of the invention which includes straight vanes **26** with individual posts **16** trapped therein. FIG. **17**B is a perspective view with portions broken away of a brake rotor according to another embodiment of the invention of a pillar-type design. FIG. **17**C is a perspective view with portions broken away of a brake rotor according to another embodiment of the invention including tangential, straight aluminum vanes **26** with vane-shaped cast iron posts **16** trapped inside the aluminum vanes **26**. FIG. **17**D is a perspective view with portions broken away of a brake rotor according to another embodiment of the invention including tangential, curved aluminum vanes **26** with individual cast iron post **16** trapped inside the vanes **26**.

FIG. **18** illustrates another embodiment of the invention including an insert **14** which includes a plurality of projections **16'** which may be formed by stamping a downwardly extending leg portion **68** out of the insert such as stainless steel or other material suitable for stamping.

As shown in FIG. **19**, the projection **16'** may include a first bend **70** and second bend **72** therein to define a leg portion **68** and a foot portion **72** which may be substantially parallel to the main body portion **76** of the insert **14**. In one embodiment, the projection **16'** may be stamped out of the main body portion **76** of the insert **14** at a location that is not in use.

Various embodiments of the invention may include any design features as that in traditional brake rotor designs, e.g., cross drilled holes or other machined features on the rotor surface, as well as coatings or heat treatment of rotor surfaces and the like. Various surface treatments may be performed on the first insert **12**, second insert **14** and projections **16'** or posts **16** to improve the brake and/or rotor performance.

According to various illustrative embodiments of the invention, frictional damping may be achieved by the movement of the interfacing surfaces of the first material and the second material against each other.

One embodiment of the invention includes a product which may have a frictional damping means. In embodiments wherein at least a portion of at least one of inner faces **30**, **32** of the inserts **12**, **14** respectively, or the posts **16** may be coated with a material to product frictional damping. The coating may include fibers or particles that resist flowing when exposed to the temperature of a molten material such as in casting.

The above description of embodiments of the invention is merely exemplary in nature and, thus, variations thereof are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. A method comprising:

placing a first insert and a second insert in a casting mold so that the first insert and second insert are in spaced-apart relationship in the mold, each of the first insert and the second insert comprising a first material;

casting a molten second material into the casting mold so that the second material flows between the first insert and the second insert and solidifying the second material to provide a product comprising a cast over body portion with the first insert and second insert, the cast over body portion comprising the second material and so that the second material is mechanically locked or metallurgically bonded to the first material and so that one or both of the first insert and the second insert provides working surface(s), further comprising a plurality of posts extending between and permanently connecting the first insert and the Second insert and wherein the second material surrounds each post and wherein the second material is mechanically locked to the first material at the posts, and wherein the posts extending between and connecting the inserts may be in the shape of round rods, rectangular bars, or curved fins, and wherein the first insert and the second insert and the plurality of posts are a single continuous workpiece, further comprising providing a sectioned annular casting core comprising a plurality of core sections, the core having slots formed therein each with an opened end, placing the core sections between the first insert and the second insert prior to casting, and wherein an associated post is received in the slot through the open end, and after the solidifying, removing the core to provide vanes extending between the first insert and the second insert where the slots in the casting core were and to provide vent channels between the vanes, and wherein a permanent mold and permanent core may be used to cast the second material.

2. A method as set forth in claim **1** wherein each of the first insert and the second insert includes a plurality of projections extending from an inner face thereof, and wherein the second material is mechanically locked to the first material at the projections, and wherein the projection is trapezoid-shaped, T-shaped, L-shaped, or rectangular-shaped, and wherein the first insert or second insert and the projections are a single continuous workpiece.

3. A method as set forth in claim **1** wherein the second material has a lower melting point, and a lower density if so designed, than that of the first material and wherein the examples of the first material are cast iron, steel, and ceramic composite and the examples, of the second material are aluminum alloy and cast steel.

4. A method as set forth in claim **1** wherein the first insert comprises a first annular brake disc and wherein the second insert comprises a second annular brake disc and wherein the second material comprises-a hub and a cast over body portion extending between the first insert and the second insert and wherein the brake rotor is a disc brake rotor and wherein the first braking surface is provided by an outer surface of the first

insert, and further comprising a second braking surface provided by an outer surface of the second insert, and wherein the brake rotor is either solid or vented.

5. A method comprising:

placing at least a first insert in a casting mold so that the first insert comprising a, plurality of projections extending from first surface thereof and the first insert comprising a second surface, the second surface providing a working surface; the first insert comprising a first material;

casting a molten second material into the casting Mold so that the second material provides a cast over body portion comprising the second material and so that the second material is mechanically locked to the plurality of projections and solidifying the second material to provide a drum brake rotor and wherein the first insert comprises a cylindrical wall with projections extending from an outer surface of the cylinder wall and wherein the brake surface is provided by an inner wall of the cylindrical wall, further comprising providing a coating on an inner surface of the first insert to provide frictional damping, and the coating comprising fibers or particles that resist flowing when exposed to the temperature of a molten second material.

* * * * *