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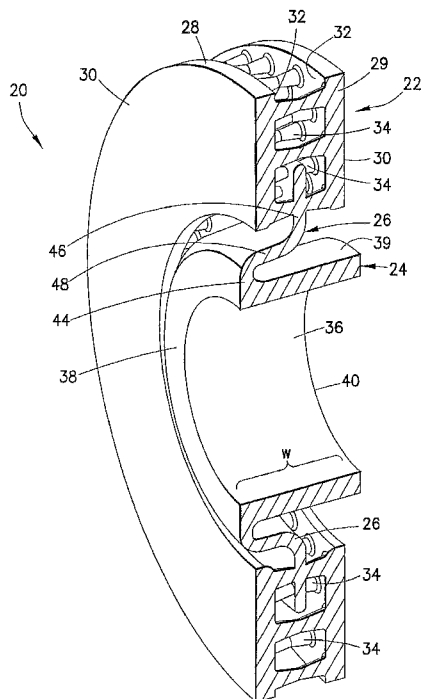


FIG. 5

(57) Abstract: The railway vehicle brake disc includes a cylindrical hub, friction ring, and bell-shaped flange connecting the hub with the friction ring. The cylindrical hub defines a central axis and has an axial width and an outer diameter. The surface at the outer diameter defines an outer hub periphery. The friction ring includes two opposed annular members each having an outer braking surface and an inner surface. The annular members are connected to each other by a plurality of fins extending from the inner surface of one annular member to the inner surface of the other annular member. The bell-shaped flange has an inner portion connected to the hub, an outer portion connected to the fins, and a radial portion connecting the inner portion to the outer portion. The hub, friction ring, and bell-shaped flange are formed integrally from a single material.



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RAILWAY VEHICLE BRAKE DISC

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Application No. 61/265,009, filed November 30, 2009, the entire content of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a railway vehicle brake disc and, further, to a monoblock brake disc having a hub and friction ring connected by a flange.

Description of Related Art

[0003] Brake discs for trains are typically pressed onto the axle or bolted to the wheel. Axle-mounted brake discs can be made from a single casting or may include a separate hub and friction ring that are bolted together, such as found in U.S. Patent No. 6,808,050 to Lehmann et al. One-piece or monoblock brake discs typically incorporate radial spokes connecting the hub to the friction ring, such as found in U.S. Patent No. 4,638,891 to Wirth. Heat generated during braking causes the friction ring to expand radially outward. In the two-piece brake disc design, the friction ring is generally allowed to expand relative to the hub as the disc heats up due to braking. This expansion is accommodated by the disc-hub connection.

[0004] Referring to **Figs. 1 and 2**, a conventional one-piece brake disc **1** includes a friction ring **2** secured to a hub **3** by a plurality of spaced spokes **4**. In this one-piece brake disc design, the spokes **4** that connect the friction ring to the hub **3** are stretched in tension as the friction ring heats up due to braking. The tension of the connecting spokes **4** during braking tends to pull the hub **3** away from the axle, which reduces the press fit of the hub **3** on the axle and can cause the disc to spin on the axle.

[0005] Referring to **Figs. 3 and 4**, a further conventional design utilizes a brake disc **6** having a flange **7** to attach the friction ring **8** to the hub **9**. This brake disc **6** is a two-piece casting with different materials being used for the friction ring **8** than the connecting flange/hub **7, 9**, which presents certain problems during manufacturing of the brake disc **6**.

[0006] United States Patent Application Publication Nos. 2004/0124045 and 2007/0181389 generally disclose brake discs having spokes connecting the hub to the friction ring and are hereby incorporated by reference in their entirety.

SUMMARY OF THE INVENTION

[0007] The railway vehicle brake disc described in detail herein comprises a cylindrical hub, a friction ring, and a bell-shaped flange connecting the hub with the friction ring. The cylindrical hub defines a central axis and has an axial width and an outer diameter. The surface at the outer diameter defines an outer hub periphery. The friction ring includes two opposed annular members each having an outer braking surface and an inner surface. The annular members are connected to each other by a plurality of fins extending from the inner surface of one annular member to the inner surface of the other annular member. The bell-shaped flange has an inner portion connected to the hub, an outer portion connected to the fins, and a radial portion connecting the inner portion to the outer portion. The hub, friction ring, and bell-shaped flange are formed integrally from a single material such that the brake disc is a monoblock brake disc.

[0008] The hub has a first axial end and a second axial end defining the axial width and the inner portion of the bell-shaped flange may be connected to the hub at the first axial end. The inner portion may also extend radially outward from the first axial end in a common plane with the first axial end. Additionally, the inner portion may extend axially past the first axial end. Further, the inner portion may be arcuate-shaped. Moreover, the inner portion may extend radially outward from the outer hub periphery.

[0009] The inner portion, outer portion, and radial portion of the bell-shaped flange may further be of generally uniform or generally non-uniform thickness. The radial portion may define an angle with the outer hub periphery or be generally parallel to the outer hub periphery.

[0010] In a further embodiment, the railway vehicle brake disc comprises a cylindrical hub, a friction ring, and a bell-shaped flange connecting the hub with the friction ring. The cylindrical hub defines a central axis and has an axial width and an outer diameter. The surface at the outer diameter defines an outer hub periphery. The friction ring includes two opposed annular members each having an outer braking surface and an inner surface. The annular members are connected to each other by a plurality of fins extending from the inner surface of one annular member to the inner surface of the other annular member. The bell-shaped flange has an inner portion connected to the hub, an outer portion connected to one of the two opposed annular members, and a radial portion connecting the inner portion to the outer portion.

[0011] In another embodiment, the railway vehicle brake disc comprises a cylindrical hub defining a central axis with the hub having an axial width and an outer diameter. The surface

at the outer diameter defines an outer hub periphery. The disc further includes a friction ring comprising two opposed annular members each having an outer braking surface and an inner surface. The annular members are connected to each other by a plurality of fins extending from the inner surface of one annular member to the inner surface of the other annular member. A flange connects the hub with friction ring. The flange comprises an inner portion connected to the hub, an outer portion connected to the fins, and a radial portion connecting the inner portion to the outer portion. The hub comprises a first axial end and a second axial end defining the axial width, and the inner portion of the flange is connected to the hub at a position intermediate the first axial end and the second axial end. The radial portion may be generally C-shaped. The hub, friction ring, and flange may be formed integrally from a single material such that the brake disc comprises a monoblock brake disc.

[0012] Further details and advantages will become clear upon reading the following detailed description in conjunction with the accompanying drawings, wherein like parts are designated with like reference numerals and characters throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **Fig. 1** is a front view of a conventional monoblock brake disc.

[0014] **Fig. 2** is a cross-sectional view of the brake disc shown in **Fig. 1**.

[0015] **Fig. 3** is a front and partially cut-away view of a further conventional brake disc.

[0016] **Fig. 4** is a cross-sectional view of the brake disc shown in **Fig. 3**.

[0017] **Fig. 5** is a cross-sectional perspective view of a brake disc according to a first embodiment.

[0018] **Fig. 6** is a cross-sectional view of the brake disc shown in **Fig. 5**.

[0019] **Fig. 7** is a schematic view of the brake disc shown in **Fig. 5** showing a finite element analysis computer model of the brake disc.

[0020] **Fig. 8** is a schematic view of the brake disc shown in **Fig. 5** showing a finite element analysis computer model of the brake disc.

[0021] **Fig. 9** is a cross-sectional view of a brake disc according to a second embodiment.

[0022] **Fig. 10** is a schematic view of the brake disc shown in **Fig. 9** showing a finite element analysis computer model of the brake disc.

[0023] **Fig. 11** is a schematic view of the brake disc shown in **Fig. 9** showing a finite element analysis computer model of the brake disc.

[0024] **Fig. 12** is a cross-sectional view of a brake disc according to a third embodiment.

[0025] Fig. 13 is a schematic view of the brake disc shown in Fig. 12 showing a finite element analysis computer model of the brake disc.

[0026] Fig. 14 is a schematic view of the brake disc shown in Fig. 12 showing a finite element analysis computer model of the brake disc.

[0027] Fig. 15 is a cross-sectional view of a brake disc according to a fourth embodiment.

[0028] Fig. 16 is a schematic view of the brake disc shown in Fig. 15 showing a finite element analysis computer model of the brake disc.

[0029] Fig. 17 is a schematic view of the brake disc shown in Fig. 15 showing a finite element analysis computer model of the brake disc.

[0030] Fig. 18 is a cross-sectional view of a brake disc according to a fifth embodiment.

[0031] Fig. 19 is a schematic view of the brake disc shown in Fig. 18 showing a finite element analysis computer model of the brake disc.

[0032] Fig. 20 is a cross-sectional view of a brake disc according to a sixth embodiment.

[0033] Fig. 21 is a schematic view of the brake disc shown in Fig. 20 showing a finite element analysis computer model of the brake disc.

[0034] Fig. 22 is a cross-sectional view of a brake disc according to a seventh embodiment.

[0035] Fig. 23 is a schematic view of the brake disc shown in Fig. 22 showing a finite element analysis computer model of the brake disc.

[0036] Fig. 24 is a cross-sectional view of a brake disc according to an eighth embodiment.

[0037] Fig. 25 is a schematic view of the brake disc shown in Fig. 24 showing a finite element analysis computer model of the brake disc.

[0038] Fig. 26 is a cross-sectional view of a brake disc according to a ninth embodiment.

[0039] Fig. 27 is a schematic view of the brake disc shown in Fig. 26 showing a finite element analysis computer model of the brake disc.

[0040] Fig. 28 is a cross-sectional view of a brake disc according to a tenth embodiment.

[0041] Fig. 29 is a schematic view of the brake disc shown in Fig. 28 showing a finite element analysis computer model of the brake disc.

[0042] Fig. 30 is a cross-sectional view of a brake disc according to an eleventh embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0043] For purposes of the description hereinafter, spatial orientation terms, as used, shall relate to the referenced embodiment as it is oriented in the accompanying drawing figures or

otherwise described in the following detailed description. However, it is to be understood that the embodiments described hereinafter may assume many alternative variations and embodiments. It is also to be understood that the specific devices and components illustrated in the accompanying drawing figures and described herein are simply exemplary and should not be considered as limiting.

[0044] Referring to **Figs. 5-8**, one embodiment of a brake disc **20** includes a friction ring **22**, a hub **24**, and a flange **26**. In the present embodiment, the friction ring **22**, hub **24**, and connecting flange **26** are integrally formed so that the brake disc **20** comprises a monoblock brake disc. The friction ring **22** includes two opposed annular members **28, 29** each having an outer braking surface **30** and an inner surface **32**. The annular members **28, 29** are connected to each other by a plurality of radially-spaced pin fins **34** extending from the inner surface **32** of one annular member **28** to the inner surface **32** of the other annular member **29**, although other suitable fin arrangements, such as radial fins, may be used. The hub **24** includes a cylindrically-shaped body **36** having a first axial end **38** and a second axial end **40**. The cylindrical-shaped body **36** comprises an outer surface forming an outer hub periphery or surface **39**. The cylindrical-shaped body **36** has an axial width **W** defined between the first axial end **38** and the second axial end **40**. The hub body **36** also defines a central opening **42** configured to receive an axle (not shown) and having a central axis **L**. The hub **24** may be press-fit onto the axle as is known in the railway vehicle field.

[0045] The flange **26** is generally bell-shaped and includes an inner portion **44**, an outer portion **46**, and a radial portion **48** and connects the friction ring **22** to the hub body **36**. In the embodiment of **Figs. 5-8**, the inner portion **44** of the flange **26** is connected to the hub body **36** of the hub **24** at the first axial end **38** of the hub body **36** and the flange **26** generally extends to a position approximately midway between the annular members **28, 29** of the friction ring **22**. The outer portion **46** of the flange **26** is connected to a plurality of the pin fins **34** to secure the outer portion **46** of the flange **26** to the inner surfaces **32** of the annular members **28, 29**. As shown more clearly in **Fig. 7**, the outer portion **46** of the flange **26** is connected by two rows of pin fins **34** on each side of the flange **26**, although the number of pin fins **34** connecting the flange **26** to the friction ring **22** may vary.

[0046] As noted, the flange **26** is generally bell-shaped and the radial portion **48** extends between the inner portion **44** and the outer portion **46** of the flange **26**. In particular, in the present embodiment, the inner portion **44** of the flange **26** connects to the first end **38** of the hub body **36** and the radial portion **48** extends radially outward at a slight taper or angle relative to the outer hub periphery or surface **39** and then transitions to the outer portion **46**.

Thus, the radial portion 48 extends radially from the inner portion 44 and transitions to the outer portion 46 and the outer portion 46 transitions to a position laterally between the annular members 28, 29 of the friction ring 22 in the present embodiment. The outer portion 46 of the flange 26 extends from the radial portion 48 for connection to the pin fins 34. Thus, in the present embodiment, the inner portion 44 and the outer portion 46 of the flange 26 are generally straight or generally parallel with one another (as shown in cross-section) with the radial portion 48 extending between the inner and outer portions 44, 46 at a slight taper or angle. The brake disc 20 may be manufactured from a single material, such as steel, as a one-piece casting, although other suitable materials may be used. As depicted in Figs. 5-8, in the present embodiment, the inner portion 44, outer portion 46, and radial portion 48 generally have a uniform thickness relative to one another, although the inner portion 44, outer portion 46, and radial portion 48 may have a non-uniform thickness as described in certain embodiments discussed below. For instance, the inner portion 44 may have a thinner thickness than the radial portion 48, and the radial portion 48 may have a thinner thickness than the outer portion 46. As shown in Fig. 6, the inner portion 44 of the flange 26 is formed to have an inner or inward facing side thereof in a plane P tangent with or encompassing the first axial end 38 of the hub body 36.

[0047] Due to the shape and configuration of the flange 26 relative to the hub 24 and friction ring 22, when the brake disc 20 is undergoing a braking application, the flange 26 is loaded in bending M rather than in tension as the friction ring 22 expands outward and does not transfer all of the force directly to the hub 24, such that the press-fit between the hub 24 and the axle is maintained. In other words, during thermal loading of the friction ring 22, the press-fit of the hub 24 to the axle is maintained by preventing the radially outward expansion of the hub 24. The displacement and stress of the brake disc 20 under loading are shown in Figs. 7 and 8, respectively, with the different cross-hatching indicating areas of varying displacement or stress. In Fig. 7, as well as the other figures showing displacement discussed below, the brake disc 20 is shown under load in a deformed state and illustrates the flange 26 under the bending moment M. Accordingly, the flange 26 connecting the friction ring 22 to the hub 24 allows the brake disc 20 to handle higher thermal loading while still maintaining the press fit. In a conventional monoblock brake disc, the friction ring pulls directly on the spokes thereby pulling the hub away from the axle and relieving the press fit. During the operation of the brake disc 20, the radial expansion of the friction ring 22 acts to bend or "straighten" the flange 26 such that only a portion of the radial expansion of the friction ring 22 is transferred to the hub 24.

[0048] Referring to **Figs. 9-11**, a further embodiment of a brake disc **20a** is disclosed. The brake disc **20a** of the present embodiment is similar to the brake disc **20** shown in **Figs. 5-8**, but includes a reduced thickness radial portion **48**. As depicted in **Figs. 9-11**, in the present embodiment, the inner portion **44**, outer portion **46**, and radial portion **48** have a non-uniform thickness, with the inner portion **44** having a greater thickness than the radial portion **48**, and the radial portion **48** having a smaller thickness than the outer portion **46**. Moreover, as shown in **Fig. 9**, the inner portion **44** of the flange **26** is formed to have an inner or inward facing side thereof to lie in a common plane **P** tangent with or encompassing the first axial end **38** of the hub body **36**. The displacement and stress of the brake disc **20a** under loading are shown in **Figs. 10** and **11**, respectively, with the different cross-hatching indicating areas of varying displacement or stress.

[0049] Referring to **Figs. 12-14**, another embodiment of a brake disc **20b** is disclosed. The brake disc **20b** of the present embodiment is similar to the brake disc **20** shown in **Figs. 5-8**, except for the connection of the outer portion **46** of the flange **26** to the friction ring **22**. In particular, the outer portion **46** of the flange **26** is connected to the inner surface **32** of one annular member **28** by a single row of pin fins **34** and to the inner surface **32** of the other annular member **29** by two rows of pin fins **34**. Additionally, the flange **26** has a substantially uniform thickness from the outer portion **46** to inner portion **44** and through the radial portion **48**. The radial portion **48** tapers outwardly to the outer portion **46** at a slight angle relative to the outer hub periphery **39** of the hub body **36** of the hub **24**. The displacement and stress of the brake disc **20b** under loading are shown in **Figs. 13** and **14**, respectively, with the different cross-hatching indicating areas of varying displacement or stress.

[0050] Referring to **Figs. 15-17**, yet another embodiment of a brake disc **20c** is disclosed. The brake disc **20c** of the present embodiment is similar to the brake disc **20** shown in **Figs. 5-8**, except for the connection of the outer portion **46** of the flange **26** to the friction ring **22**. In particular, the outer portion **46** of the flange **26** is connected to the inner surfaces **32** of each annular member **28, 29** by three rows of pin fins **34**. Additionally, the flange **26** has a substantially uniform thickness from the outer portion **46** to inner portion **44** and through the radial portion **48**. The radial portion **48** extends radially outward at a slight taper or angle relative to the outer hub periphery **39** of the hub body **36** of the hub **24** as best illustrated in **Fig. 15**, and the inner portion **44** of the flange **26** is formed to have an inner or inward facing side thereof to lie in a common plane **P** tangent with or encompassing the first axial end **38** of the hub body **36**. The displacement and stress of the brake disc **20c** under loading are shown

in **Figs. 16** and **17**, respectively, with the different cross-hatching indicating areas of varying displacement or stress.

[0051] Referring to **Figs. 18-19**, yet a further embodiment of a brake disc **20d** is disclosed. The brake disc **20d** of the present embodiment is similar to the brake disc **20** shown in **Figs. 5-8**, but the flange **26** is reduced in overall thickness and exhibits a generally uniform thickness except where the outer portion **46** connects to the radial portion **48** and where the inner portion **44** connects to the hub **24**. Additionally, the inner portion **44** extends axially past the first axial end **38** of the hub body **36** and exhibits a generally arcuate shape. The radial portion **48** thereafter is formed to be generally parallel to the outer hub periphery **39** of the hub body **36** of the hub **24** as best illustrated in **Fig. 18**. The displacement of the brake disc **20d** under loading is shown in **Fig. 19** with the different cross-hatching indicating areas of varying displacement.

[0052] Referring to **Figs. 20-21**, an alternative embodiment of a brake disc **20e** is disclosed. The brake disc **20e** of the present embodiment is similar to the brake disc **20** shown in **Figs. 5-8**, but the flange **26** has a substantially uniform thickness from the outer portion **46** to the inner portion **44** and through the radial portion **48**. The radial portion **48** extends radially outward at a slight taper or angle relative to the outer hub periphery **39** of the hub body **36** of the hub **24** as best illustrated in **Fig. 20** and the inner portion **44** of the flange **26** is formed to have an inner or inward facing side thereof to lie in a common plane **P** tangent with or encompassing the first axial end **38** of the hub body **36**. The displacement of the brake disc **20e** under loading is shown in **Fig. 21** with the different cross-hatching indicating areas of varying displacement.

[0053] Referring to **Figs. 22-23**, a further alternative embodiment of a brake disc **20f** is disclosed. The brake disc **20f** of the present embodiment is similar to the brake disc **20** shown in **Figs. 5-8**, expect that the flange **26** is connected to the hub **24** at a position axially spaced from the first axial end **38** of the hub body **36** of the hub **24** and extends outward from the outer hub periphery **39** of the hub body **36**. In particular, the radial portion **48** tapers outwardly to the outer portion **46** at a slight angle relative to the outer hub periphery **39** of the hub body **36** of the hub **24**. Additionally, the flange **26** has a substantially uniform thickness from the outer portion **46** to the inner portion **44** and through the radial portion **48**. The displacement of the brake disc **20f** under loading is shown in **Fig. 23** with the different cross-hatching indicating areas of varying displacement.

[0054] Referring to **Figs. 24-25**, a further embodiment of a brake disc **20g** is disclosed. The brake disc **20g** of the present embodiment is similar to the brake disc **20** shown in **Figs. 5-8**,

but the flange 26 includes a thicker radial portion 48 that narrows to the outer portion 46. Further, the radial portion 48 tapers outwardly to the outer portion 46 at a slight angle relative to the outer hub periphery 39 of the hub body 36 of the hub 24, and the inner portion 44 of the flange 26 is formed to have an inner or inward facing side thereof to lie in a common plane P tangent with or encompassing the first axial end 38 of the hub body 36. The displacement of the brake disc 20g under loading is shown in Fig. 25 with the different cross-hatching indicating areas of varying displacement.

[0055] Referring to Figs. 26-27, another embodiment of a brake disc 20h is disclosed. The brake disc 20h of the present embodiment is similar to the brake disc 20 shown in Figs. 5-8 and Figs. 22-23, except the flange 26 is connected to the annular member 28 of the friction ring 22 rather than being connected to the pin fins 34. The flange 26 may also be connected to the other annular member 29. Further, the flange 26 is connected to the hub 24 at a position axially spaced from the first axial end 38 of the hub body 36 of the hub 24 and tapers at an angle toward annular member 28 and extends outward from the outer hub periphery 39 of the hub body 36. In particular, the radial portion 48 tapers outwardly to the outer portion 46 at a slight angle relative to the outer hub periphery 39 of the hub body 36 of the hub 24. The flange 26 has a substantially uniform thickness from the outer portion 46 to the inner portion 44 and through the radial portion 48. The displacement of the brake disc 20h under loading is shown in Fig. 27 with the different cross-hatching indicating areas of varying displacement.

[0056] Referring to Figs. 28-29, yet another embodiment of a brake disc 20i is disclosed. The brake disc 20i of the present embodiment is similar to the brake disc 20 shown in Figs. 5-8, but the flange 26 has a substantially uniform thickness from the outer portion 46 to the inner portion 44 and through the radial portion 48. The radial portion 48 extends generally parallel to the outer hub periphery 39 of the hub body 36 of the hub 24 as best illustrated in Fig. 28 and the inner portion 44 of the flange 26 is formed to have an inner or inward facing side thereof to lie in a common plane P tangent with or encompassing the first axial end 38 of the hub body 36. The displacement of the brake disc 20i under loading is shown in Fig. 29 with the different cross-hatching indicating areas of varying displacement.

[0057] Referring to Fig. 30, a further embodiment of a brake disc 20j is disclosed. The brake disc 20j of the present embodiment is similar to the brake disc 20 shown in Fig. 5-8. The flange 26 of the brake disc 20j, however, generally extends from a middle portion of the hub 24, *i.e.*, between the axial ends of the hub 24. More specifically, the inner portion 44 of the flange 26 generally extends perpendicularly from the midpoint of the hub 24. A generally

C-shaped radial portion **48** transitions from the inner portion **48** and then transitions to the outer portion **46**, which extends to a position laterally between the annular members **28, 29** of the friction ring **22**. Thus, the inner portion **44** and the outer portion **46** are generally aligned with each other (as shown in cross-section) in a direction that extends perpendicularly and radially outward from the hub **24** with the C-shaped radial portion **48** extending between the inner and outer portion **44, 46**.

[0058] While embodiments of a railway vehicle brake disc were provided in the foregoing description, those skilled in the art may make modifications and alterations to these embodiments without departing from the scope and spirit of the invention. Accordingly, the foregoing description is intended to be illustrative rather than restrictive. The invention described hereinabove is defined by the appended claims and all changes to the invention that fall within the meaning and the range of equivalency of the claims are to be embraced within their scope.

THE INVENTION CLAIMED IS:

1. A railway vehicle brake disc, comprising:
 - a cylindrical hub defining a central axis, the hub having an axial width and an outer diameter, the surface at the outer diameter defining an outer hub periphery;
 - a friction ring comprising two opposed annular members each having an outer braking surface and an inner surface, the annular members connected to each other by a plurality of fins extending from the inner surface of one annular member to the inner surface of the other annular member;
 - a bell-shaped flange connecting the hub with friction ring, the bell-shaped flange comprising an inner portion connected to the hub, an outer portion connected to the fins, and a radial portion connecting the inner portion to the outer portion; andwherein the hub, friction ring, and bell-shaped flange are formed integrally from a single material such that the brake disc comprises a monoblock brake disc.
2. A railway vehicle brake disc as claimed in Claim 1, wherein the hub comprises a first axial end and a second axial end defining the axial width, and wherein the inner portion of the bell-shaped flange is connected to the hub at the first axial end of the hub.
3. A railway vehicle brake disc as claimed in Claim 2, wherein the inner portion of the bell-shaped flange extends outward from the first axial end in a common plane with the first axial end of the hub.
4. A railway vehicle brake disc as claimed in Claim 2, wherein the inner portion of the bell-shaped flange extends axially past the first axial end of the hub.
5. A railway vehicle brake disc as claimed in Claim 4, wherein the inner portion of the bell-shaped flange is arcuate-shaped.
6. A railway vehicle brake disc as claimed in Claim 1, wherein the inner portion of the bell-shaped flange extends outward from the outer hub periphery.

7. A railway vehicle brake disc as claimed in Claim 1, wherein the inner portion, outer portion, and radial portion of the bell-shaped flange are of uniform thickness.

8. A railway vehicle brake disc as claimed in Claim 1, wherein the inner portion, outer portion, and radial portion of the bell-shaped flange are of non-uniform thickness.

9. A railway vehicle brake disc as claimed in Claim 1, wherein the radial portion of the bell-shaped flange defines an angle with the outer hub periphery.

10. A railway vehicle brake disc as claimed in Claim 1, wherein the radial portion of the bell-shaped flange is generally parallel to the outer hub periphery.

11. A railway vehicle brake disc, comprising:
a cylindrical hub defining a central axis, the hub having an axial width and an outer diameter, the surface at the outer diameter defining an outer hub periphery;
a friction ring comprising two opposed annular members each having an outer braking surface and an inner surface, the annular members connected to each other by a plurality of fins extending from the inner surface of one annular member to the inner surface of the other annular member;
a bell-shaped flange connecting the hub with friction ring, the bell-shaped flange comprising an inner portion connected to the hub, an outer portion connected to one of the two opposed annular members, and a radial portion connecting the inner portion to the outer portion.

12. A railway vehicle brake disc as claimed in Claim 11, wherein the hub, friction ring, and bell-shaped flange are formed integrally from a single material such that the brake disc comprises a monoblock brake disc.

13. A railway vehicle brake disc as claimed in Claim 11, wherein the hub comprises a first axial end and a second axial end defining the axial width, and wherein the inner portion of the bell-shaped flange is connected to the hub at a position intermediate the first axial end and the second axial end.

14. A railway vehicle brake disc as claimed in Claim 11, wherein the inner portion of the bell-shaped flange extends outward from the outer hub periphery.

15. A railway vehicle brake disc as claimed in Claim 11, wherein the inner portion, outer portion, and radial portion of the bell-shaped flange are of uniform thickness.

16. A railway vehicle brake disc as claimed in Claim 11, wherein the inner portion, outer portion, and radial portion of the bell-shaped flange are of non-uniform thickness.

17. A railway vehicle brake disc as claimed in Claim 11, wherein the radial portion of the bell-shaped flange defines an angle with the outer hub periphery.

18. A railway vehicle brake disc, comprising:
a cylindrical hub defining a central axis, the hub having an axial width and an outer diameter, the surface at the outer diameter defining an outer hub periphery;
a friction ring comprising two opposed annular members each having an outer braking surface and an inner surface, the annular members connected to each other by a plurality of fins extending from the inner surface of one annular member to the inner surface of the other annular member; and
a flange connecting the hub with friction ring, the flange comprising an inner portion connected to the hub, an outer portion connected to the fins, and a radial portion connecting the inner portion to the outer portion;
wherein the hub comprises a first axial end and a second axial end defining the axial width, and wherein the inner portion of the flange is connected to the hub at a position intermediate the first axial end and the second axial end.

19. A railway vehicle brake disc as claimed in Claim 18, wherein the radial portion is generally C-shaped.

20. A railway vehicle brake disc as claimed in Claim 18, wherein the hub, friction ring, and flange are formed integrally from a single material such that the brake disc comprises a monoblock brake disc.

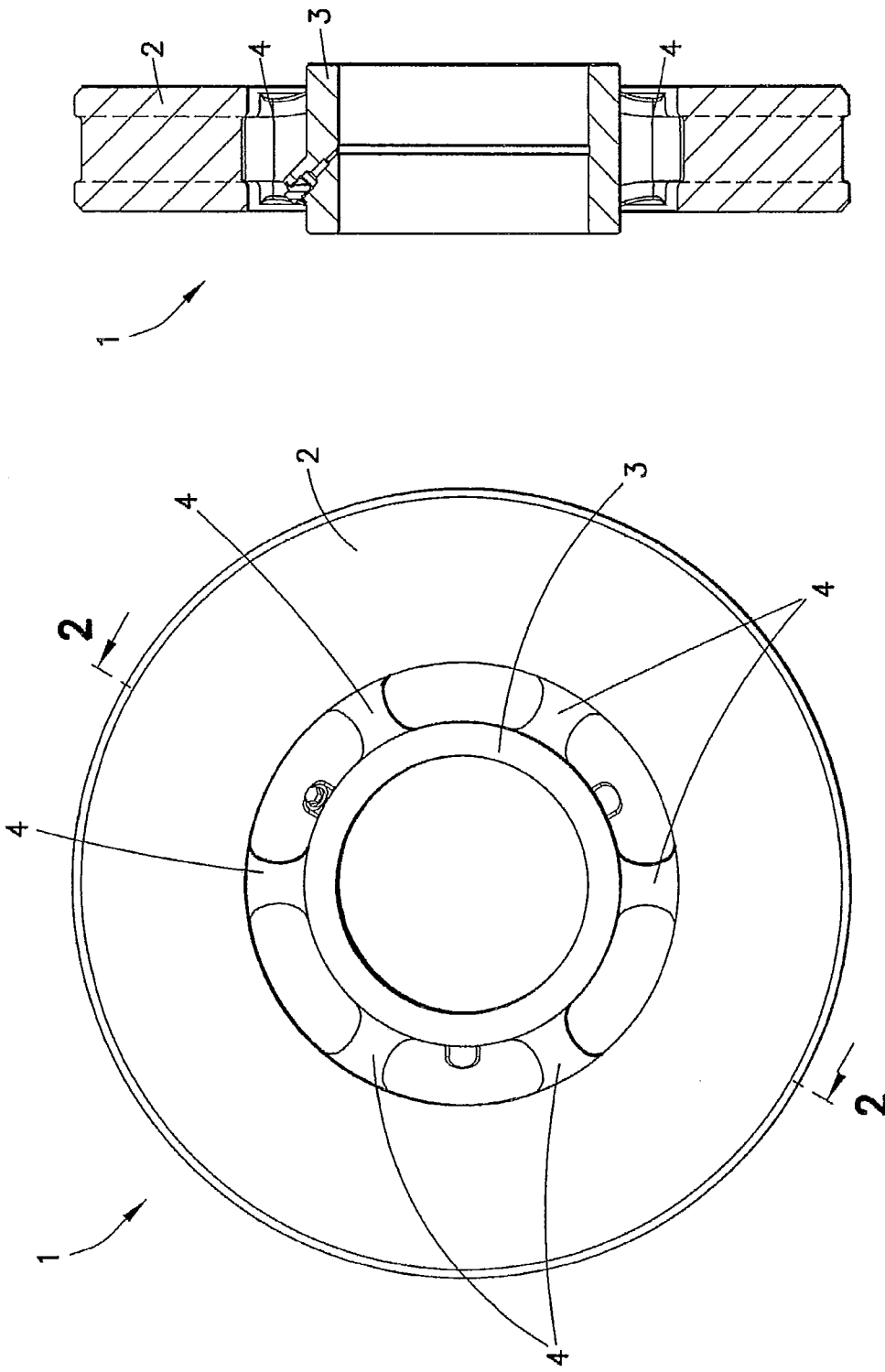


FIG. 2
PRIOR ART

FIG. 1
PRIOR ART

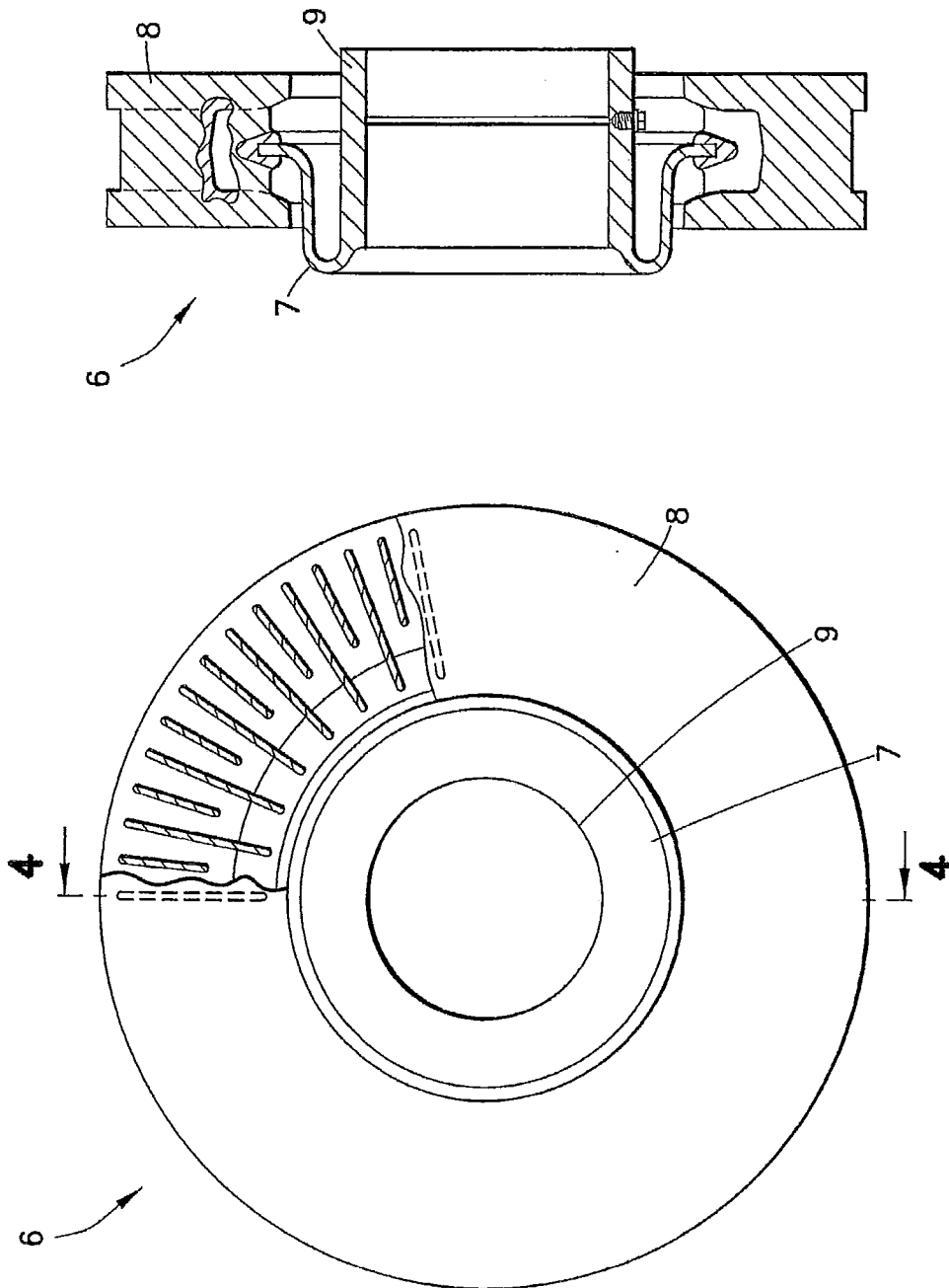


FIG. 4
PRIOR ART

FIG. 3
PRIOR ART

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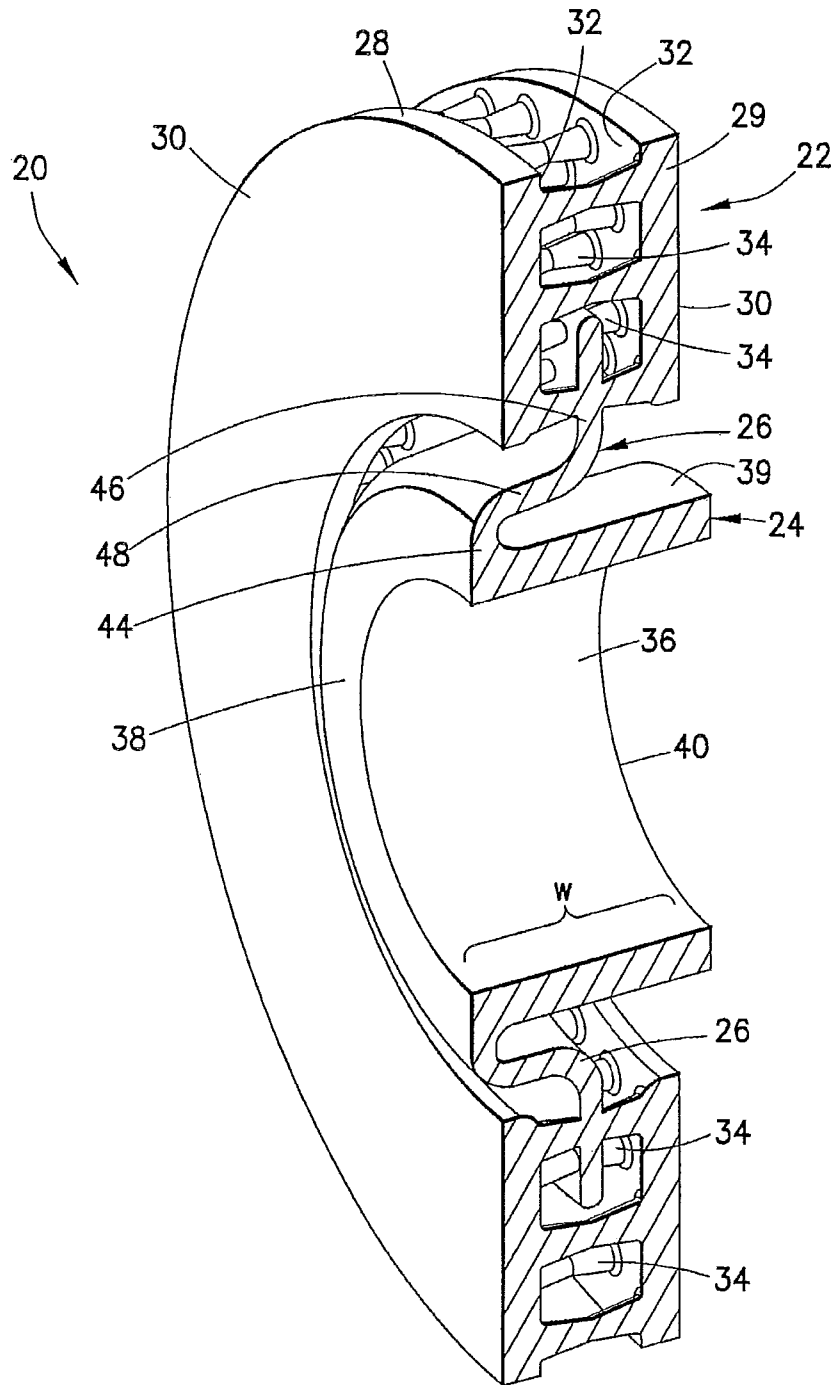


FIG. 5

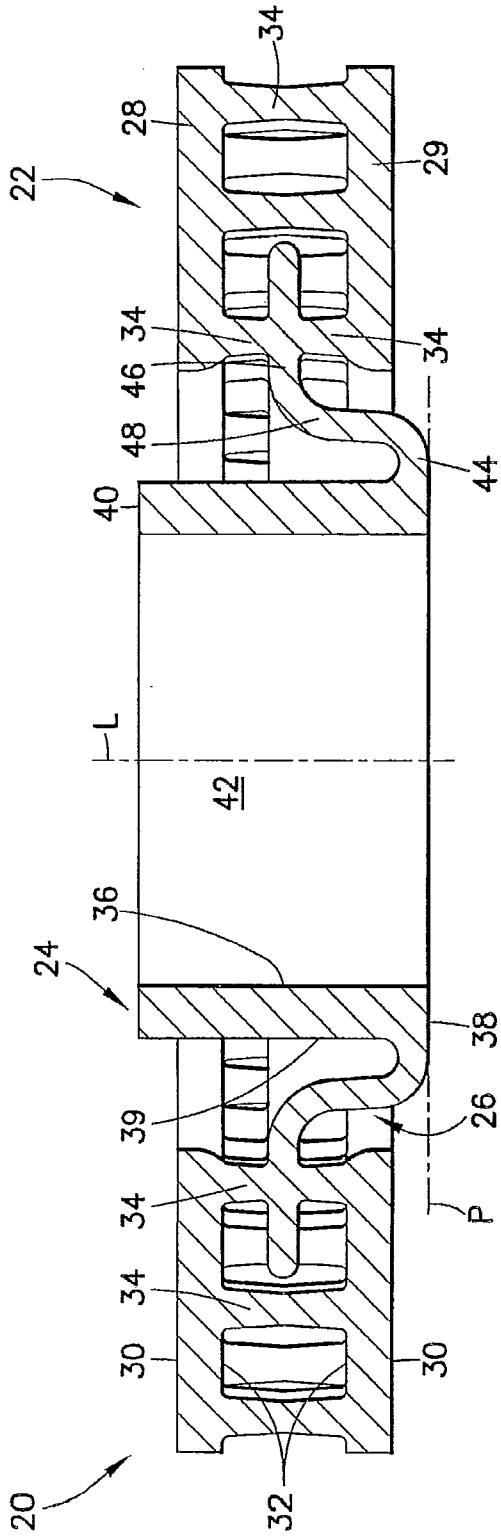


FIG. 6

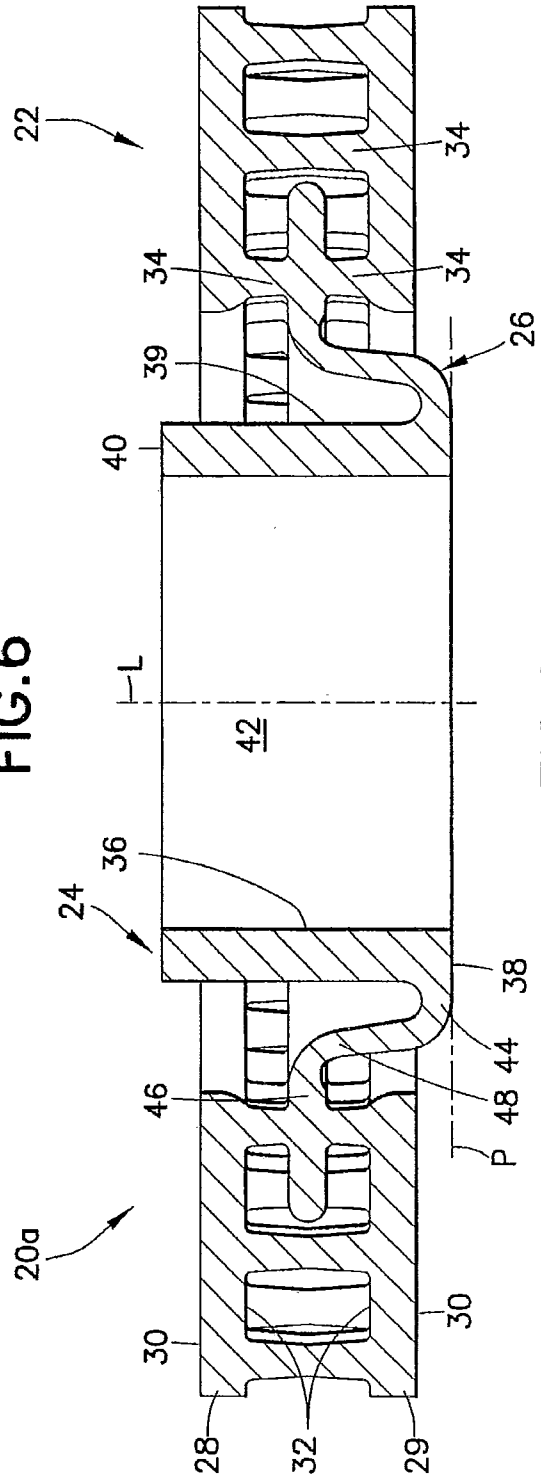


FIG. 9

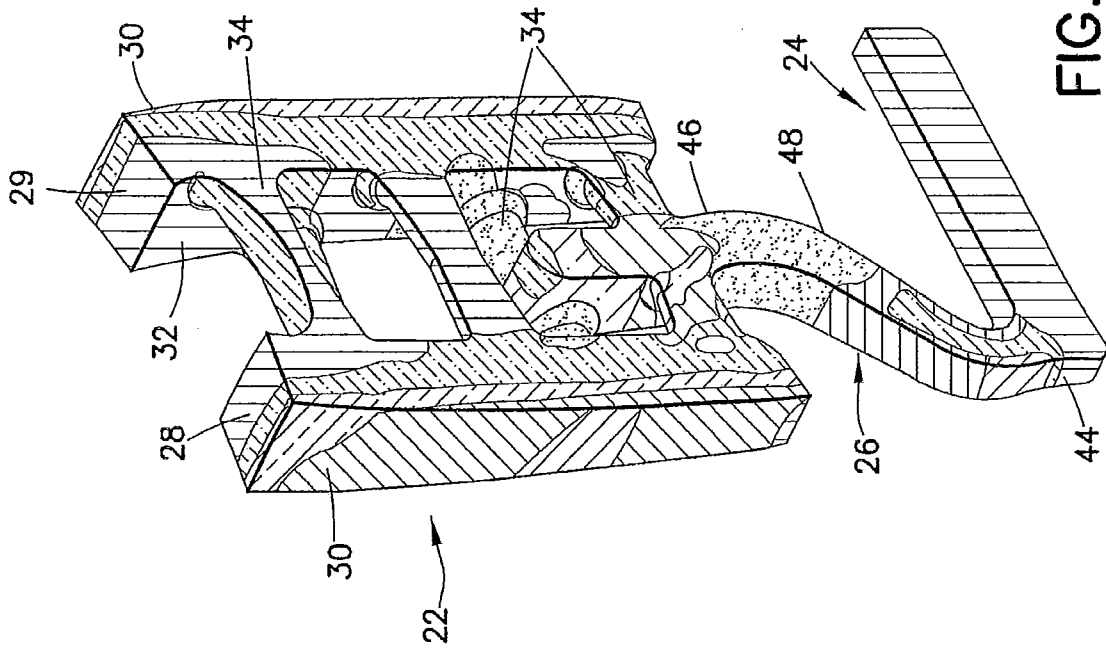


FIG. 8

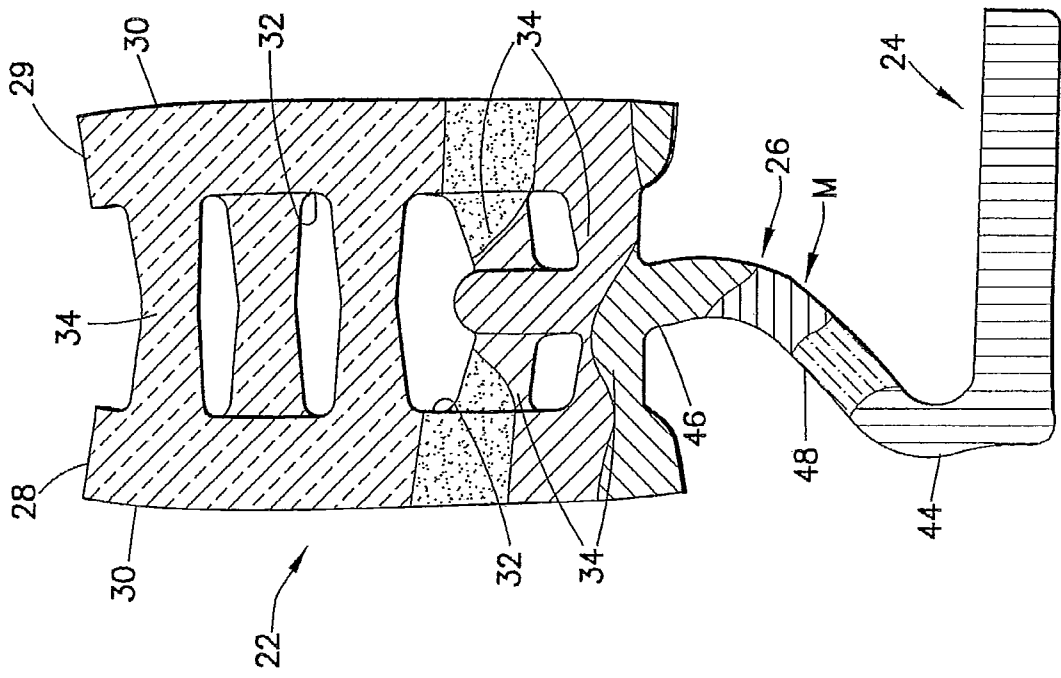


FIG. 7

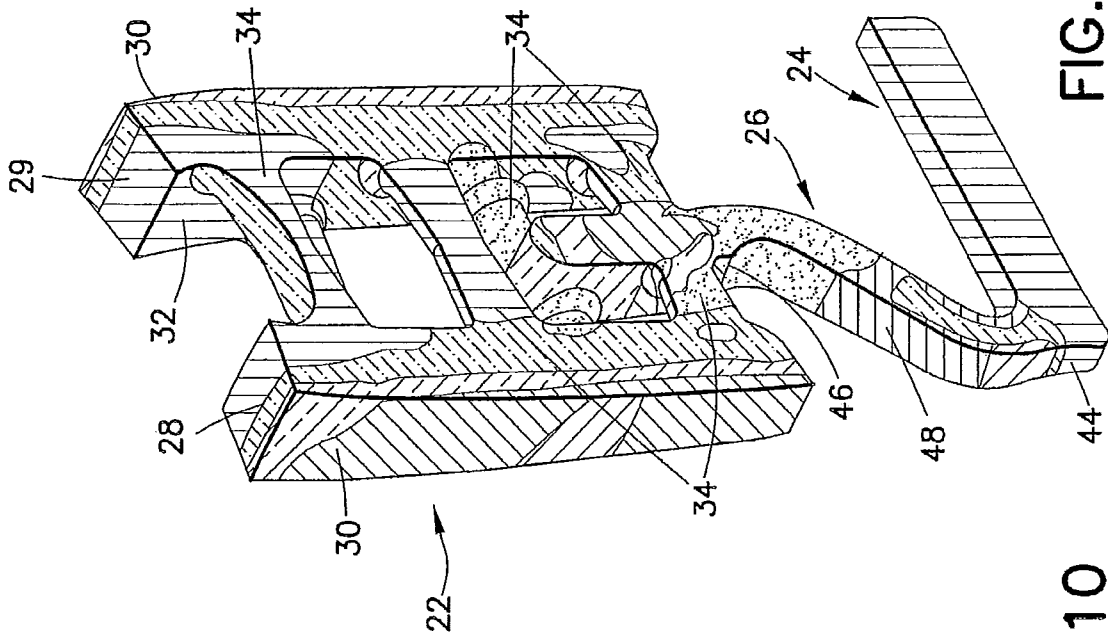


FIG. 11

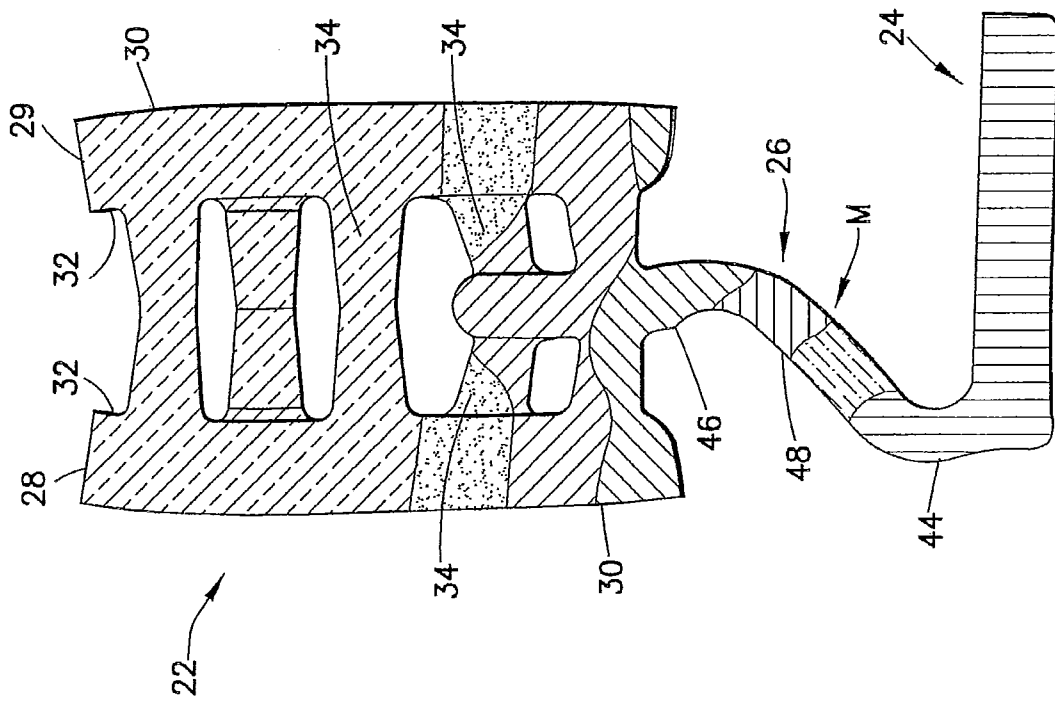


FIG. 10

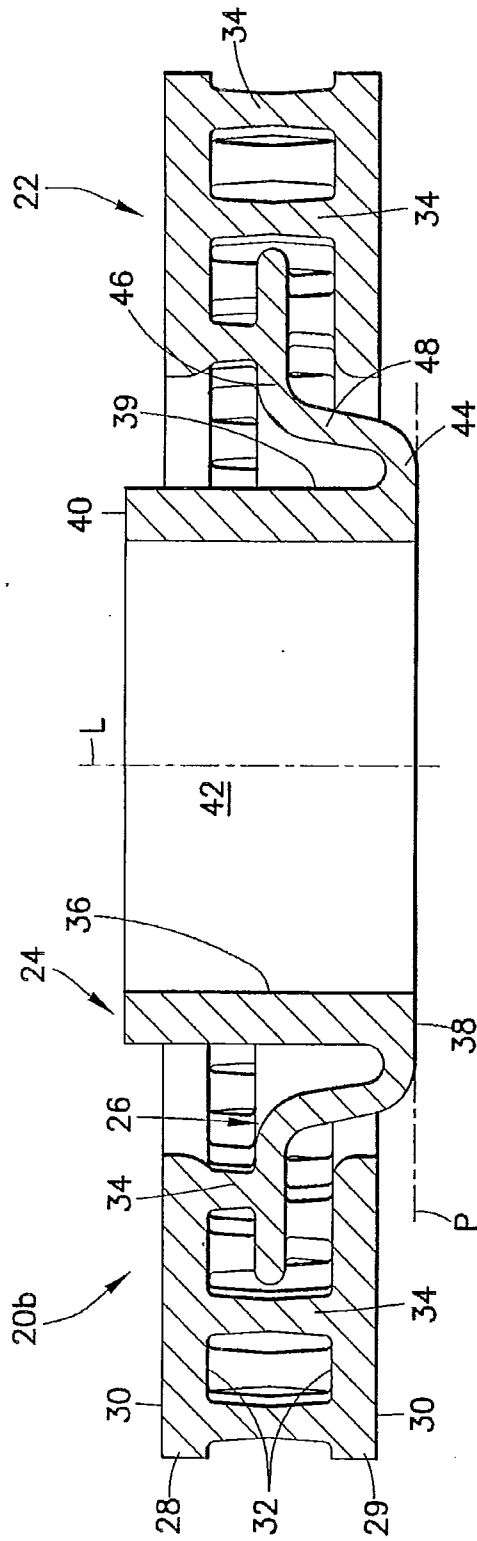


FIG. 12

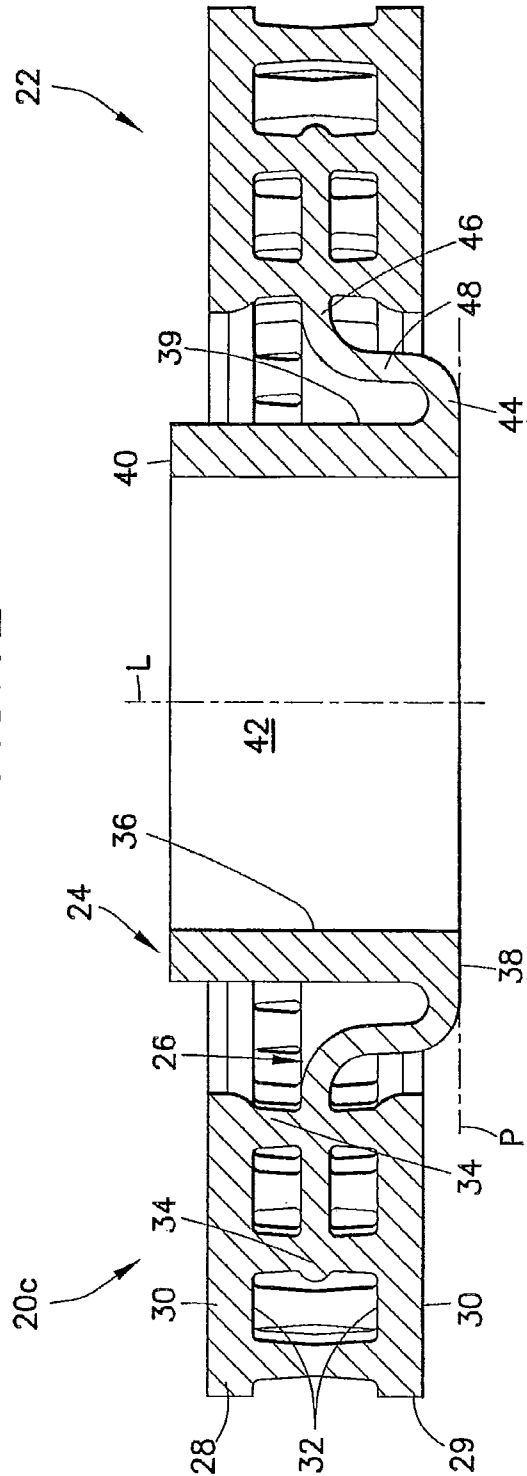


FIG. 15

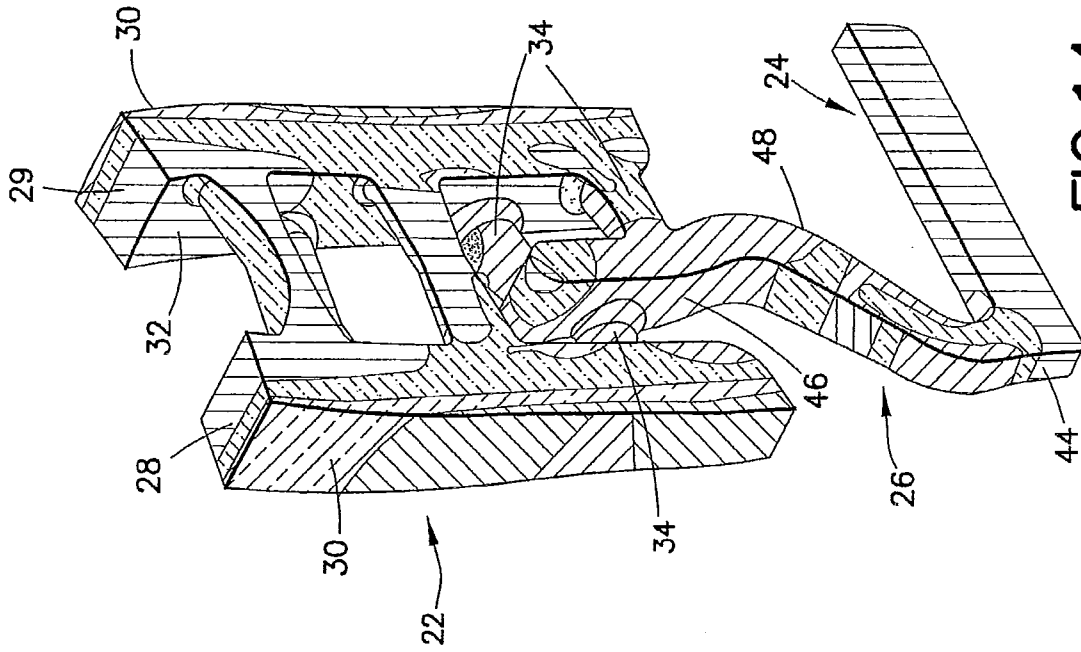


FIG. 13

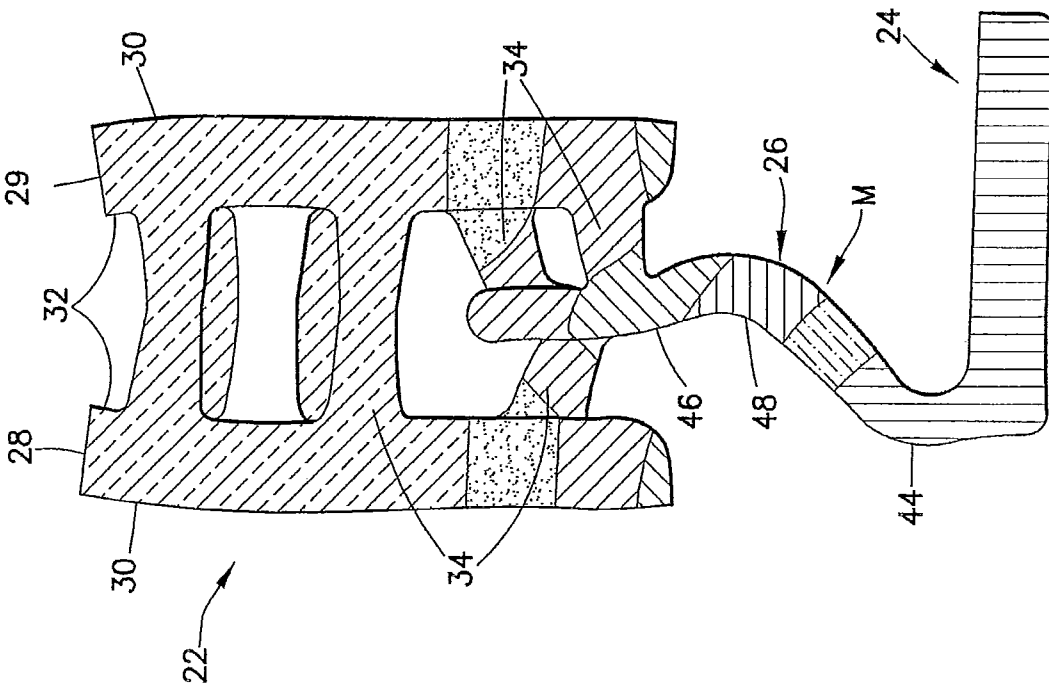


FIG. 14

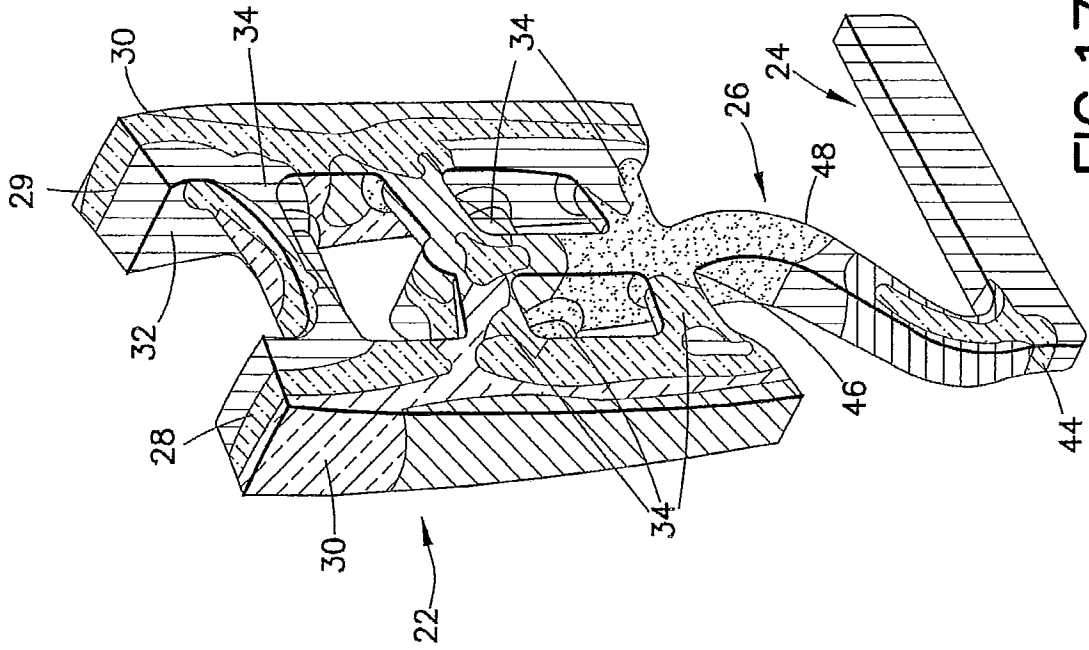


FIG. 17

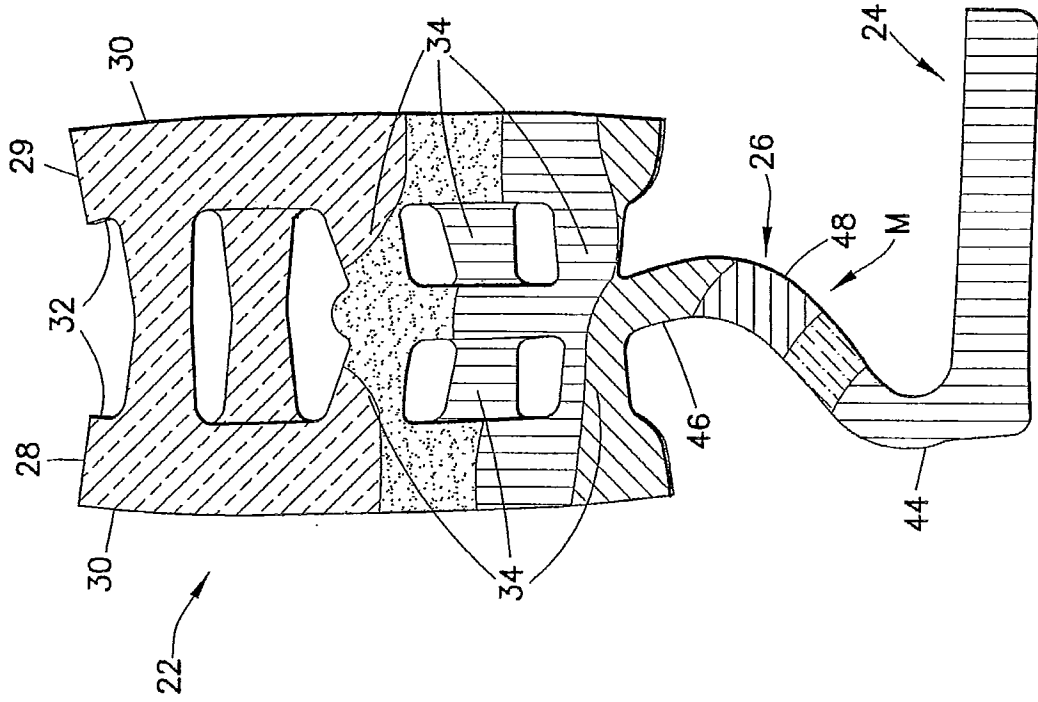


FIG. 16

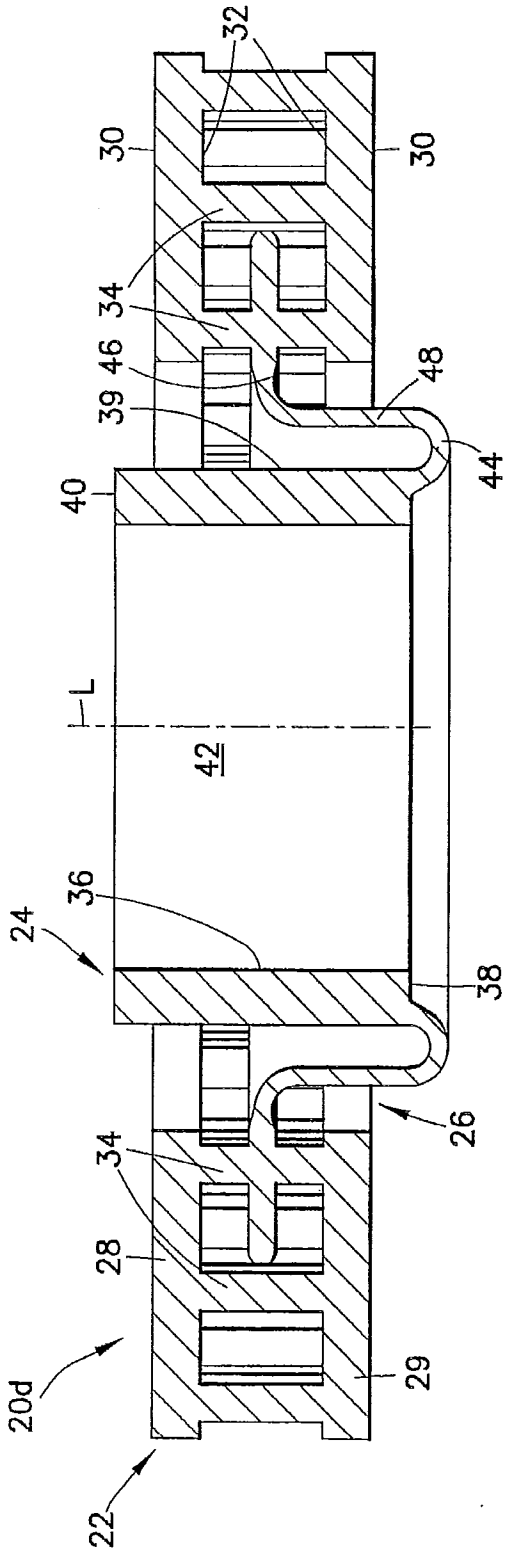


FIG. 18

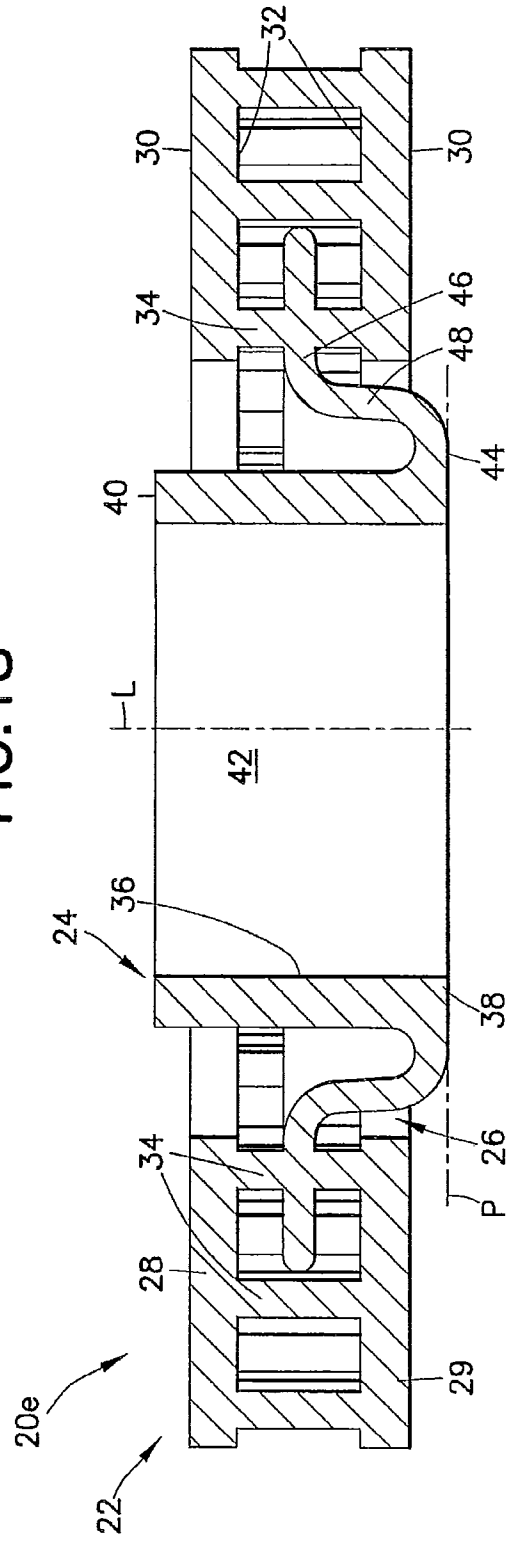


FIG. 20

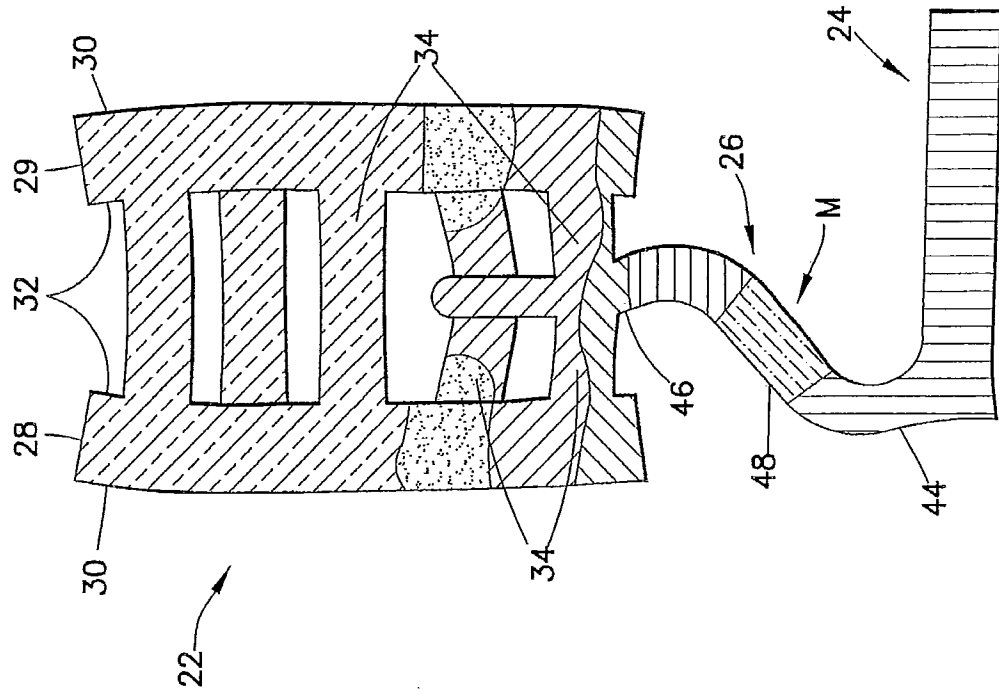


FIG. 21

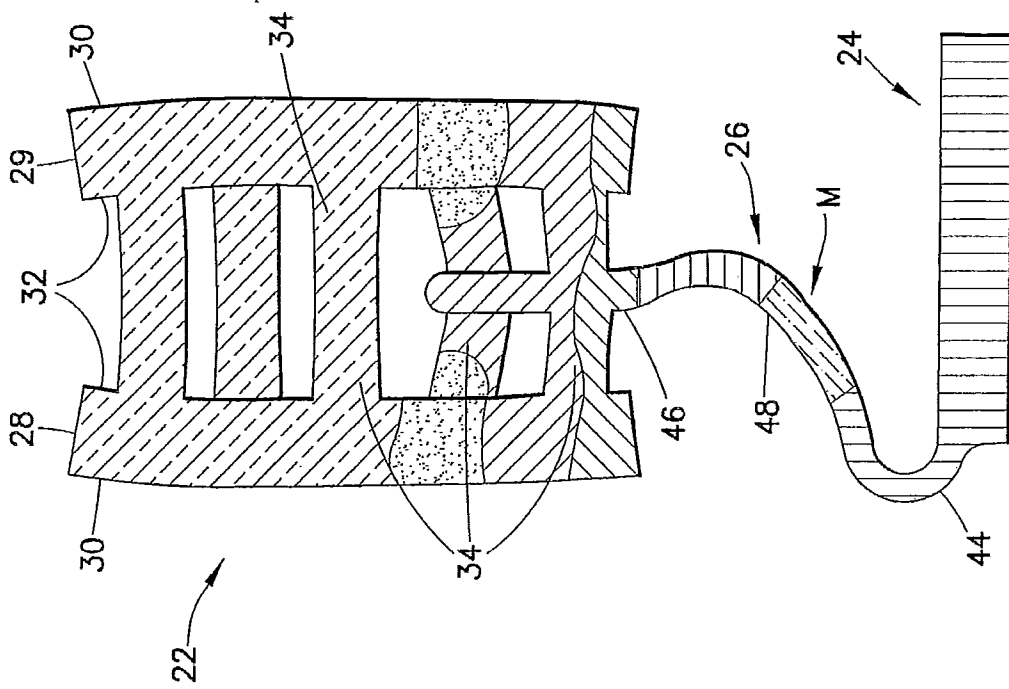


FIG. 19

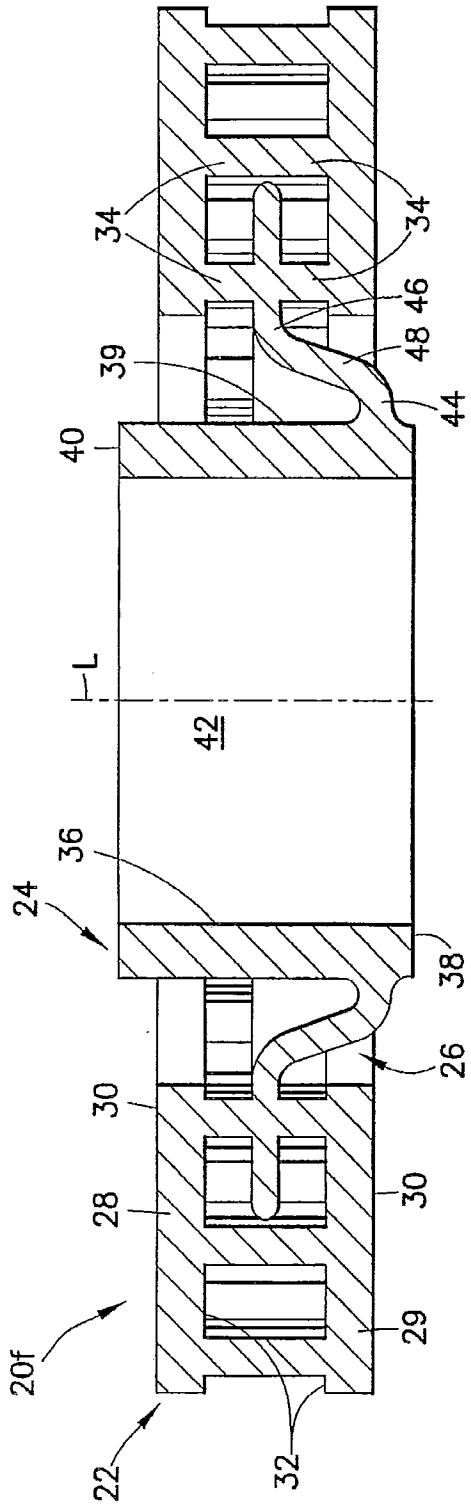


FIG. 22

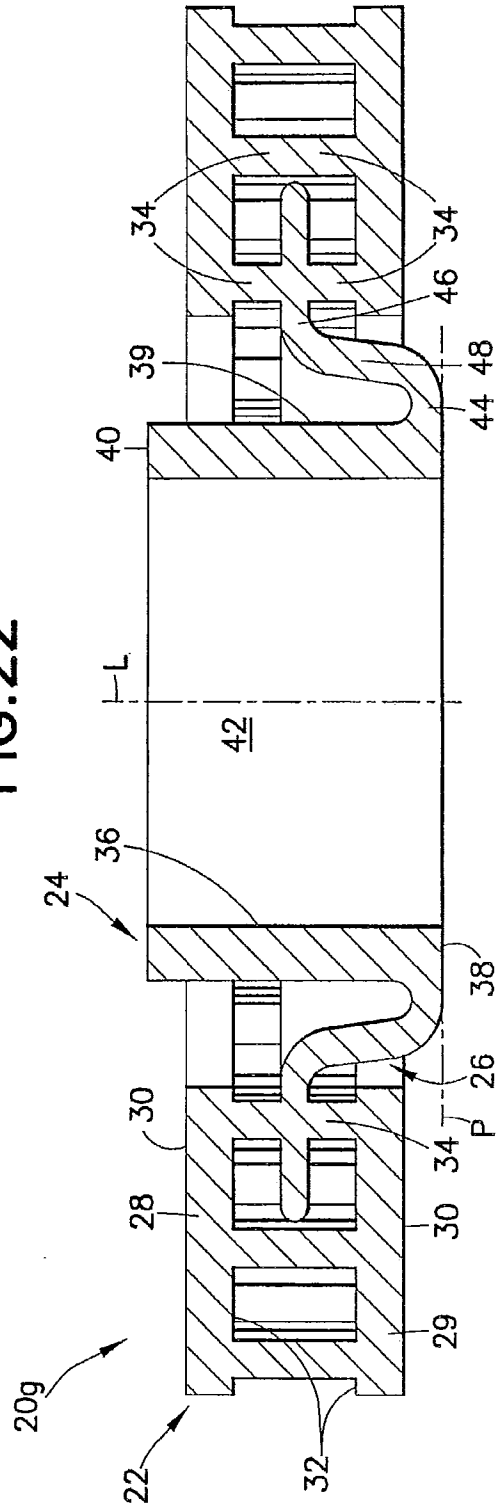


FIG. 24

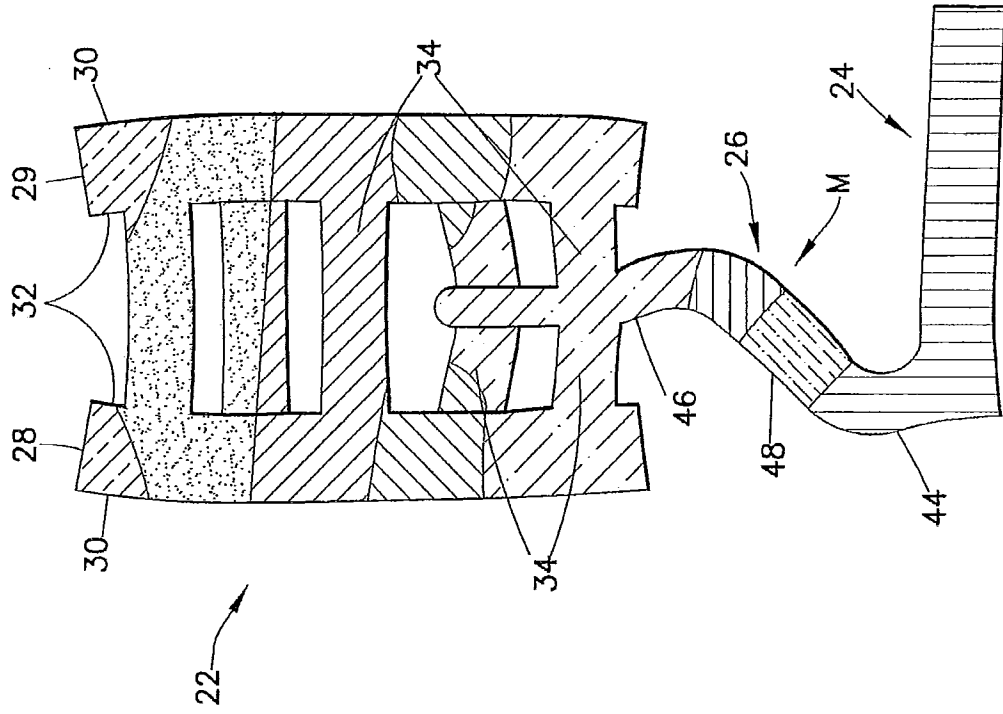


FIG. 23

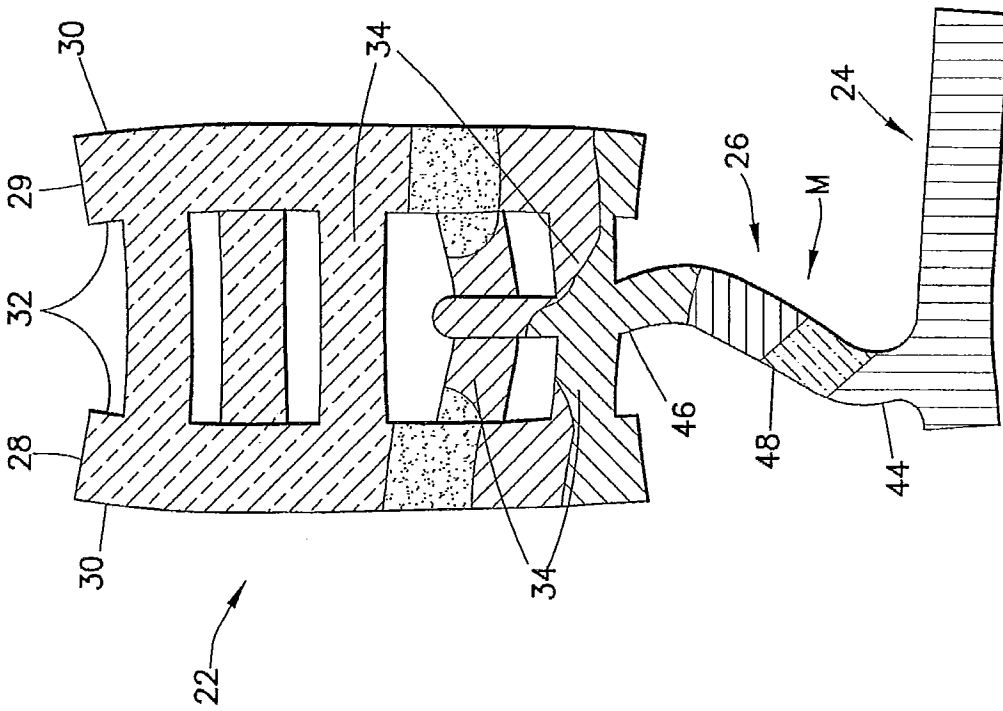


FIG. 25

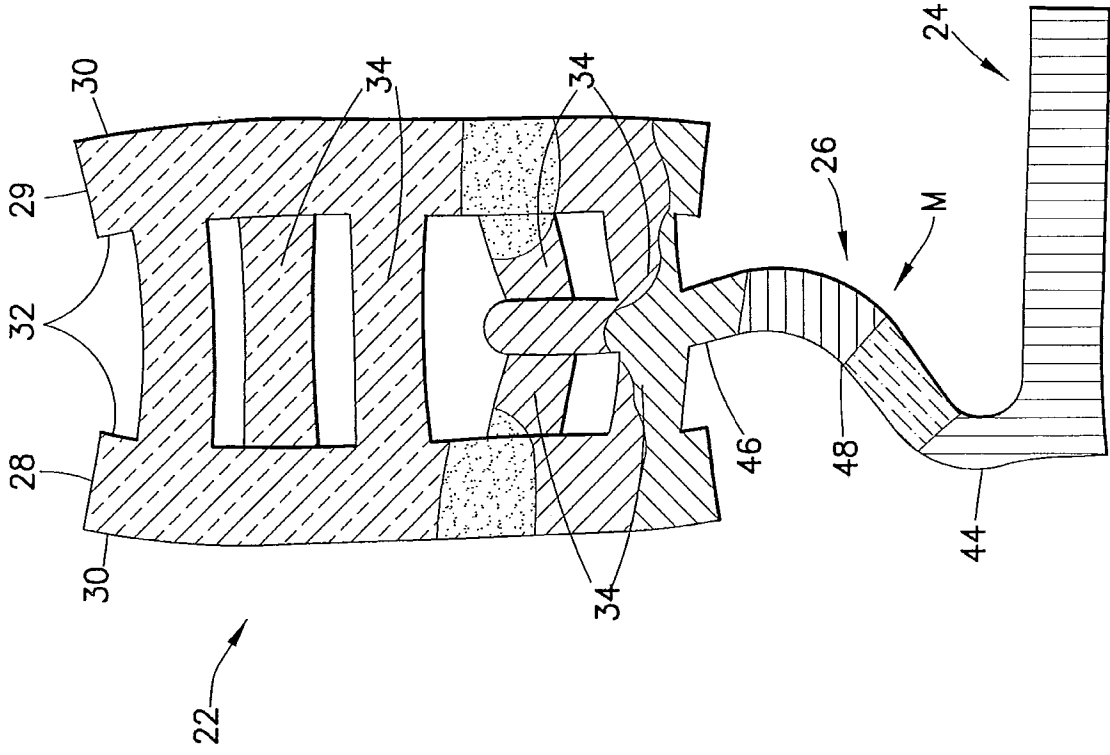


FIG. 29

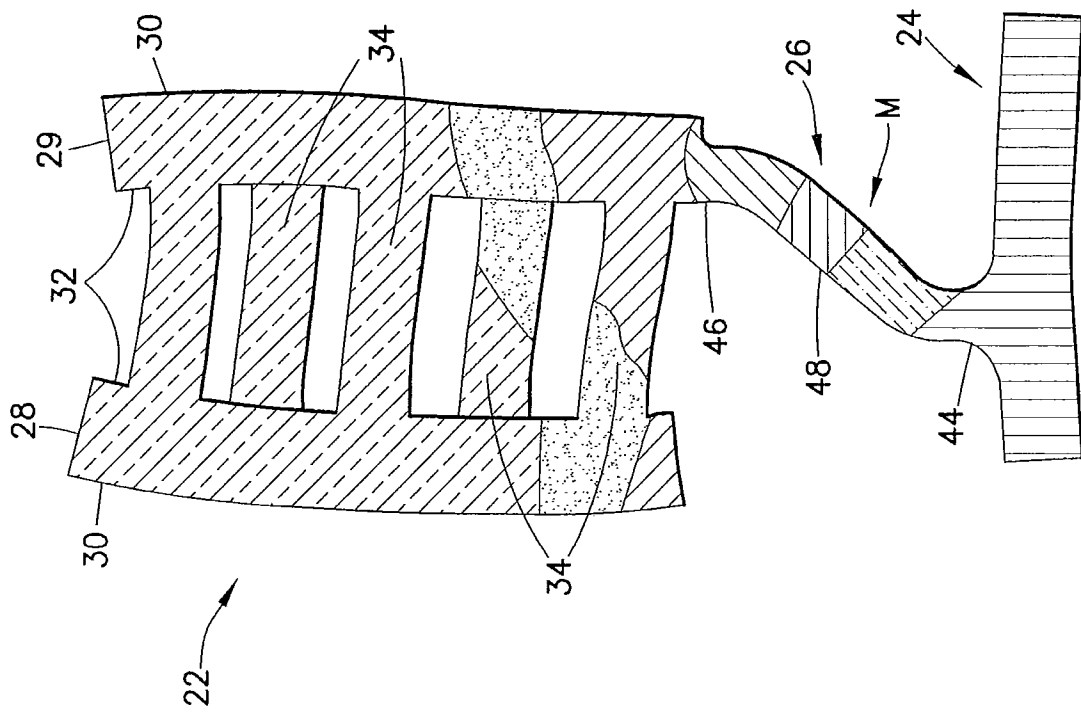


FIG. 27

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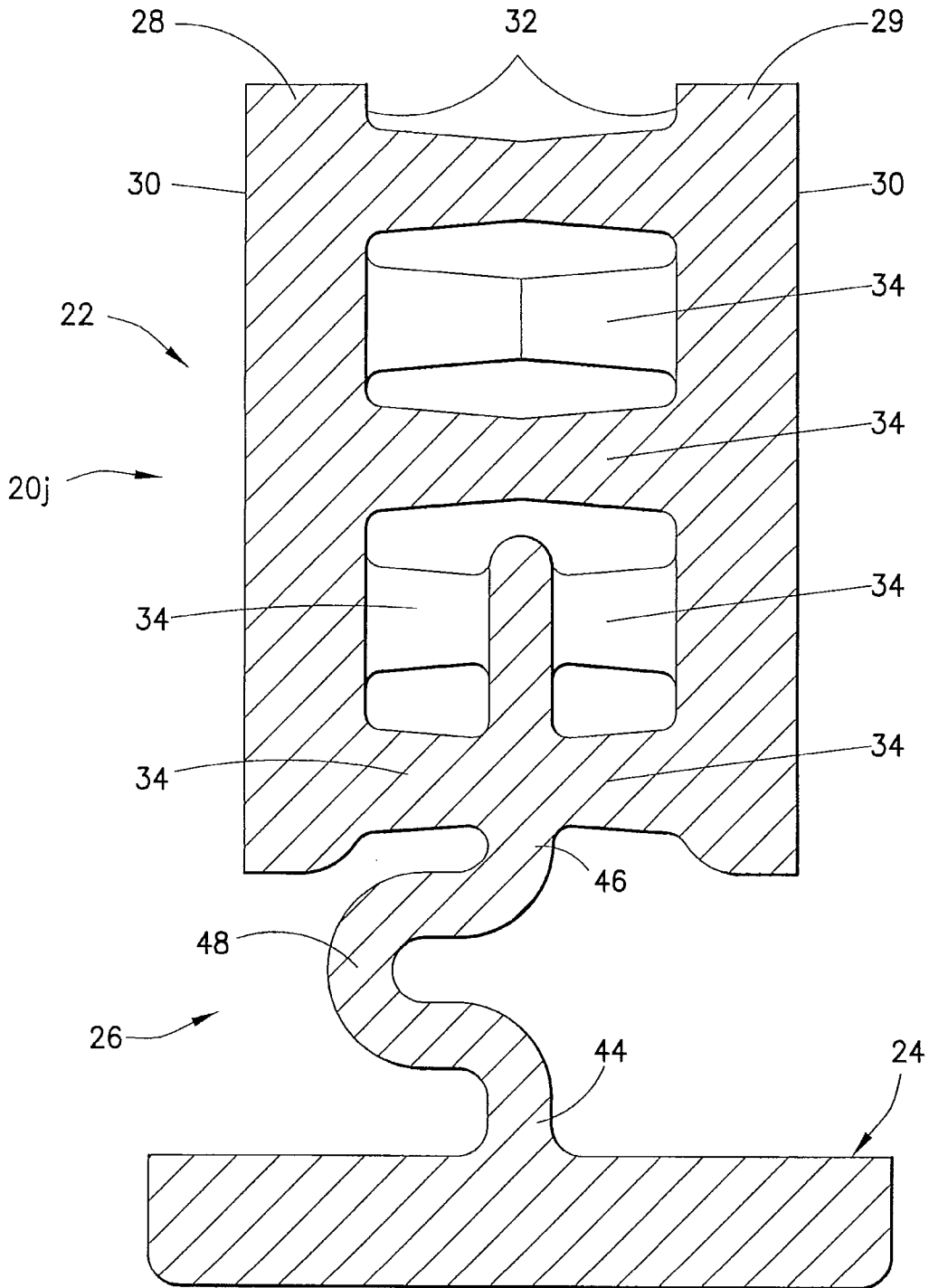


FIG.30