(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 June 2005 (16.06.2005)

PCT

(10) International Publication Number
WO 2005/053878 A2

(51) International Patent Classification[7]: B22D

(21) International Application Number:
PCT/US2004/039674

(22) International Filing Date:
24 November 2004 (24.11.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/525,532 26 November 2003 (26.11.2003) US

(71) Applicant *(for all designated States except US)*: **VESUVIUS CRUCIBLE COMPANY** [US/US]; 4604 Campells Run Road, Pittsburgh, PA 15205 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ZHOU, Lei** [CN/US]; 5808 Longview Circle, Bridgeville, PA 15017 (US). **ROBINSON, Quentin** [US/US]; 1 Rosemont Circle, Pittsburgh, PA 15106 (US). **XU, Dong** [CA/CA]; 3016 Hawktail Crescent, Mississauga, Ontario L5M 6W3 (CA). **HEASLIP, Lawrence, J.** [CA/CA]; 4375 Spruce Avenue, Burlington, Ontario L7L-1L7 (CA).

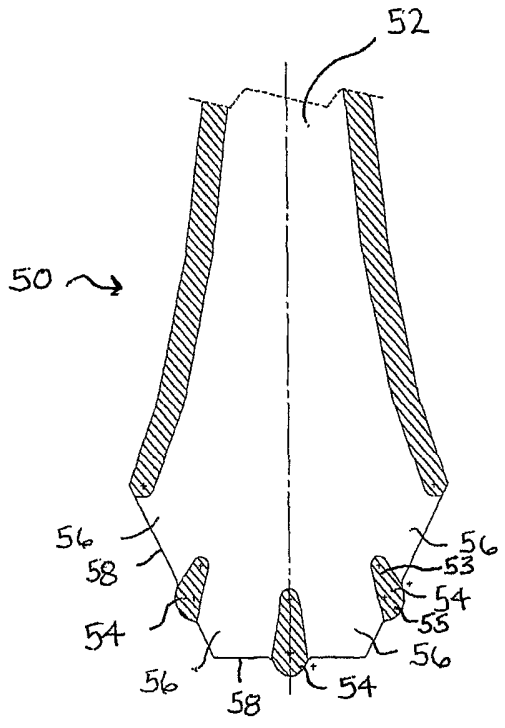
(74) Agents: **SATINA, Donald M.** et al.; Vesuvius USA Corporation, 4604 Campells Run Road, Pittsburgh, PA 15205 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: CASTING NOZZLE WITH EXTERNAL NOSE



(57) Abstract: A nozzle for use in the continuous casting of molten metal which comprises two sidewalls and a bottom face connecting the two sidewalls. There is also a central bore through the nozzle. The nozzle further comprises at least one aperture in the bottom face of the nozzle and at least one baffle located within the aperture connecting the two sidewalls. The baffle divides the aperture into a plurality of outlets. The nozzle is characterized in that at least one of the baffles at least partially extends beyond the bottom face of the nozzle.

WO 2005/053878 A2

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Casting Nozzle With External Nose.

Specification.

Cross-reference to related applications.

[0001] This application claims the benefit under 35 U.S.C. §120 of the filing date of U.S. Provisional Application No. 60/525,532 filed November 26, 2003.

Field of the invention.

[0002] The present invention generally relates to nozzles used for the continuous casting of liquid metal. More specifically, the present invention relates to an improved nozzle having a plurality of outlets.

Description of the related art.

[0003] Thin-slab continuous casting ("TSC") is a recent casting technology for the production of flat steel products. One of the main features of TSC is the relatively small thickness of the casting mold as compared to the width of the casting mold. In the TSC process, liquid metal, and in particular liquid steel, is generally poured into the mold of the casting machine through a casting nozzle. A casting nozzle used for TSC is fashioned from refractory ceramic materials and is shaped to fit within the upper portion of the mold cavity. The shape of the casting nozzle takes the form of a tube with a generally cylindrical upper portion and a generally flat lower portion. The flat lower portion is generally wider and thinner than the upper cylindrical portion. The casting nozzle has a central bore that serves as a flow channel through which the liquid metal flows as it moves through the nozzle. Liquid metal enters the flow channel at the upper end of the casting nozzle, flows through the flow channel, and exits from the outlet end of the flow channel in the lower portion of the casting nozzle. Baffles are often located at the outlet end of the flow channel. Typically, the lower portion of the flow channel contains at least one baffle that divides the flow channel into at least two outlets through which the liquid metal is discharged from the nozzle into the mold.

[0004] As a result of the wide flat geometry of the lower part of the nozzle, the nature of the thermo-mechanical properties of ceramic refractory materials, and the highly varying temperatures to which the nozzle is subjected, the refractory body of the casting nozzle experiences intense transient stresses during use. These stresses concentrate along the narrow sides of the lower portion of the nozzle and in the region of the baffles during use. These stresses become particularly severe during certain steps of the casting process. For example, during nozzle pre-heating, the start of liquid metal flow through the nozzle, and the initial immersion of the nozzle into the liquid metal pool accumulated in the mold. During these process steps, the casting nozzle is subjected to rapid temperature changes and high stress concentrations that can cause cracking of the refractory body of the nozzle. The cracking can lead to the leaking of air into the nozzle, or the leaking of liquid metal out of the nozzle, and even to nozzle breakage during use. Leaking and nozzle breakage can lead to casting process disruptions and degradation of cast metal quality.

[0005] Typically, at least one baffle connects the front refractory wall of the nozzle to the back refractory wall of the nozzle, dividing the flow channel so as to define a plurality of outlets. The baffles do not extend beyond the outer edge of the flow channel. **FIG. 1** shows the lower portion of a traditional casting nozzle **10** with one baffle **12** dividing the flow channel **14** into two outlets **16, 18**. **FIG. 1(c)** illustrates some of the typical locations of cracking **22, 24, 26** found in the nozzle **10**. **FIG. 2** shows the lower portion of another casting nozzle **30** having three baffles **31, 32, 33** dividing the flow channel **34** into four outlets **36, 37, 38, 39**. **FIG. 2(c)** also illustrates the typical locations of cracking **42, 44, 46** in the casting nozzle **30**.

[0006] Nozzles such as those illustrated in **FIGS. 1** and **2** are subject to cracking of the refractory body as the result of the concentration of stress in certain regions. These stresses become particularly severe during certain steps of the casting process, for example, nozzle pre-heating, start of liquid metal flow through the nozzle, and initial immersion of the nozzle into the liquid metal pool accumulated in the mold when the casting nozzle is subjected to rapid temperature changes. During the aforementioned casting process steps, cracking of the baffles and also cracking of the sidewalls frequently occur. The general locations of these cracks are illustrated in **FIGS. 1(c)** and **2(c)**. This cracking may lead to the leaking of air into the nozzle, or the leaking of liquid metal out of the nozzle, and even to nozzle breakage during use. Leaking and nozzle breakage can lead to casting process disruptions and degradation of cast metal quality.

[0007] It has been discovered by the inventors, that cracking of the refractory body of a casting nozzle, as discussed above, typically occurs in stages. The first stage of cracking includes the formation of cracks in the baffles. This first stage may also be accompanied by cracking of the sidewalls at their lower edges. The second stage of cracking involves the propagation and growth of the baffle cracks. If a crack in a baffle grows to completely break the connection of the baffle between the front and back refractory walls of the nozzle, the stress concentrations in the sidewalls are intensified, causing the third stage of cracking. In the third stage of cracking, sidewall cracks either, initiate at the lower sidewall edges and subsequently grow larger, or sidewall cracks already present are caused to grow. In ether case, sidewall cracks may continue to grow until complete failure of the nozzle occurs.

Summary of the invention.

[0008] It is the object of the invention to provide a nozzle for use in the continuous casting of molten metal, the nozzle comprising two sidewalls and a bottom face connecting the two sidewalls, thereby defining a central bore through the nozzle. The nozzle further comprises at least one aperture in the bottom face of the nozzle and at least one baffle located within the aperture connecting the two sidewalls. The baffle thereby divides the aperture into a plurality of outlets. The nozzle is characterized in that at least one of the baffles at least partially extends beyond the bottom face of the nozzle.

Brief description of the several drawings.

[0009] **FIG. 1a** is a cross-sectional view of a traditional casting nozzle.

[0010] **FIG. 1b** is a perspective view of the casting nozzle of **FIG. 1a**.

[0011] **FIG. 1c** is a perspective view of the casting nozzle of **FIG. 1a**, illustrating typical cracking locations.

[0012] **FIG. 2a** is a cross-sectional view of a traditional casting nozzle.

[0013] **FIG. 2b** is a perspective view of the casting nozzle of **FIG. 2a**.

[0014] **FIG. 2c** is a perspective view of the casting nozzle of **FIG. 2a**, illustrating typical cracking locations.

[0015] **FIG. 3** is a cross-sectional view of a casting nozzle in accordance with a first embodiment of the present invention.

[0016] **FIG. 4** is a perspective view of the casting nozzle of **FIG. 3**.

[0017] **FIG. 5** is a cross-sectional view of a casting nozzle in accordance with an alternate embodiment of the present invention.

[0018] **FIG. 6** is a perspective view of the casting nozzle of **FIG. 5**

Detailed description of the preferred embodiments.

[0019] **FIGS. 3** and **4** illustrates the lower portion of a casting nozzle **50** in accordance with an embodiment of the present invention. The nozzle **50** comprises two sidewalls **51** and a bottom face **58** connecting the two sidewalls **51**, thereby defining a central bore **52** through the nozzle **50**. The nozzle **50** further comprises at least one aperture **56** in the bottom face **58** of the nozzle **50** and at least one baffle **54** located within the aperture connecting the two sidewalls **51**. The baffle **54** thereby divides the aperture **56** into a plurality of outlets. The nozzle **50** is characterized in that at least one of the baffles **54** at least partially extends beyond the bottom face **58** of the nozzle **50**.

[0020] In the embodiment illustrated in **FIGS. 3** and **4**, the nozzle **50** preferably comprises three baffles **54** that divide the aperture **56** into four outlets. However, it should be noted that any number of baffles may be used, as long as the desired flow rates and flow patterns are still achieved. The casting nozzle **50** includes baffles **54** that extend beyond the bottom face **58**. As can be seen, the extension of a baffle **54** beyond the bottom face **58** may take the form of a protruding nose or protrusion **55**.

[0021] As best seen in **FIG. 4**, the protruding nose **55** of a baffle **54** has the general shape of a dome, and this dome-like shape is on the exterior of the bottom face **58** of the nozzle **50**. The dome like-shape can be trapezoidal or smoothly curved as shown in **FIG.4**, but the protrusion **55** of the baffle **54** must extend beyond the bottom face **58** of the nozzle **50**. It should be noted that the interior portion **53** of the baffle **54** that is between the sidewalls **51** still serves the traditional purpose of dividing the flow of the molten metal in the central bore **52** into several flow streams that exit the nozzle **50** through the plurality of outlets.

[0022] While the protruding nose **55** of the baffle **54** may extend out any distance from the bottom face **58** of the nozzle **50**, it is preferable that the distance of extension of the protrusion **55** beyond the bottom face **58** of the nozzle be at least equal to one-half of the thickness of the central bore **52** in the region of the baffle **54**. The thickness of the central bore **52** is defined as

the distance of separation between the two sidewalls **51**of the nozzle **50**.

[0023] **FIGS. 5** and **6** illustrate the lower portion of a casting nozzle **70** in accordance with an embodiment of the present invention. The nozzle **70** comprises two sidewalls **71** and a bottom face **78** connecting the two sidewalls **71**, thereby defining a central bore **72** through the nozzle **70**. The nozzle **70** further comprises at least one aperture **76** in the bottom face **78** of the nozzle **70** and at least one baffle **74** located within the aperture connecting the two sidewalls **71**. The baffle **74** thereby divides the aperture **76** into a plurality of outlets. The nozzle **70** is characterized in that at least one of the baffles **74** at least partially extends beyond the bottom face **78** of the nozzle **70**.

[0024] In the embodiment illustrated in **FIGS. 3** and **4**, the nozzle **70** preferably comprises three baffles **74** that divide the aperture **76** into four outlets. However, it should be noted that any number of baffles may be used, as long as the desired flow rates and flow patterns are still achieved. The casting nozzle **70** includes baffles **74** that extend beyond the bottom face **78**. As can be seen, the extension of a baffle **74** beyond the bottom face **78** may take the form of a protruding nose or protrusion **75**.

[0025] As best seen in **FIG. 6**, the protruding nose **75** of a baffle **74** has the general shape of a section of a cylinder, and this cylindrical-section shape is on the exterior of the nozzle body. Alternatively, the protruding nose could have the shape of a section of a pyramid, trapezoid, or rectangular box, although a curved convex surface as shown in **FIG. 6** is preferable. As discussed above with regard to the embodiment shown in **FIGS. 3** and **4**, the protrusion **75** of the baffle **74** must extend beyond the bottom face **78** of the nozzle **70**. It should be noted that the interior portion **73** of the baffle **74** that is between the sidewalls **71** still serves the traditional purpose of dividing the flow of the molten metal in the central bore **72** into several flow streams that exit the nozzle **70** through the plurality of outlets.

[0026] While the protruding nose **75** of the baffle **74** may extend out any distance from the bottom face **78** of the nozzle **70**, it is preferable that the distance of extension of the protrusion **75** beyond the bottom face **78** of the nozzle be at least equal to one-half of the thickness of the central bore **72** in the region of the baffle **74**. The thickness of the central bore **72** is defined as the distance of separation between the two sidewalls **71**of the nozzle **70**.

[0027] A characteristic feature of a casting nozzle of the present invention is the incorporation into the nozzle body of an external protrusion on a baffle. The presence of an external baffle protrusion significantly diminishes stress concentrations in all of the critical regions in the lower nozzle body and significantly reduces the sensitivity of the nozzle body to cracking during nozzle preheating, start of liquid metal flow through the nozzle, and initial immersion of the nozzle into the liquid metal accumulated in the mold, or any other occasion when the casting nozzle is subjected to rapid temperature changes. The presence of an external protruding nose significantly inhibits cracking of the baffle equipped with the nose and thus interrupts the first and second stages of nozzle cracking so as to render nozzle leakage and ultimately nozzle failure by sidewall cracking to be considerably less likely. The inventors have found that it is preferable to

fashion a casting nozzle such that all baffles have an external protruding nose, however even the inclusion of a single nose in a casting nozzle with multiple baffles provides a significant reduction in stress concentration and thus a great reduction in the potential of failure by cracking.

[0028] Obviously, numerous modifications and variations of the present invention are possible. It is, therefore, to be understood that within the scope of the following claims, the invention may be practiced otherwise than as specifically described.

Claims.

We claim:

1. A nozzle for use in the continuous casting of molten metal, the nozzle comprising:

   a) two sidewalls and a bottom face at an outlet end of the nozzle connecting the two sidewalls, thereby defining a central bore through the nozzle;

   b) at least one aperture in the bottom face of the nozzle; and

   c) at least one baffle located within the aperture, and connecting the two sidewalls, thereby dividing the at least one aperture into a plurality of outlets;

   characterized in that at least one of the baffles at least partially extends beyond the bottom face of the nozzle.

2. The nozzle of claim 1, characterized in that the nozzle comprises three baffles.

3. The nozzle of claims 1 or 2, characterized in that the baffles extend beyond the bottom face of the nozzle a distance equal to approximately one half of the distance between the two sidewalls at the baffles.

4. The nozzle of claims 1 to 3, characterized in that all of the baffles at least partially extend beyond the bottom face of the nozzle.

5. The nozzle of claims 1 to 4, characterized in that the portion of the baffle extended beyond the bottom face of the nozzle is cylindrical in shape.

6. The nozzle of claims 1 to 4, characterized in that the portion of the baffle extended beyond the bottom face of the nozzle is trapezoidal in shape.

7. The nozzle of claims 1 to 4, characterized in that the portion of the baffle extended beyond the bottom face of the nozzle is curved and convex in shape.

8. A nozzle for use in the continuous casting of molten metal, the nozzle comprising:

   a) two sidewalls and a bottom face at an outlet end of the nozzle; and

   b) more than one outlet in the bottom face of the nozzle; and

   c) a protrusion from the bottom face of the nozzle in between at least one pair of outlets.

9. The nozzle of claim 8, characterized in that the nozzle comprises three protrusions.

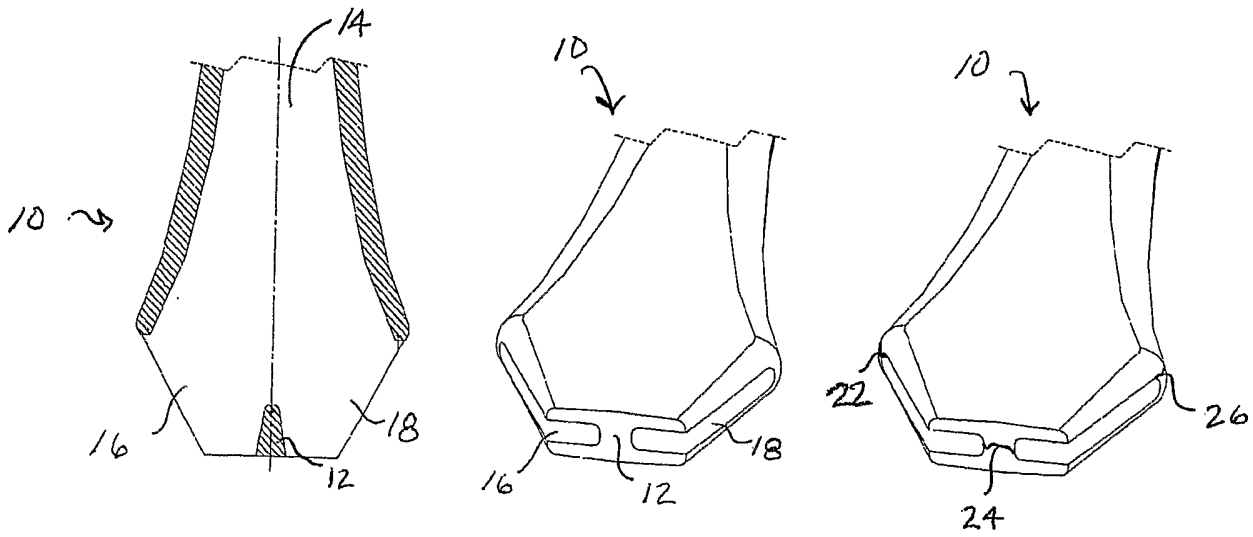
10. The nozzle of claims 8 or 9, characterized in that the protrusion extend beyond the bottom face of the nozzle a distance equal to approximately one half of the distance between the two sidewalls at the outlet.

11. The nozzle of claims 8 to 10, characterized in that a protrusion is present between each pair of outlets.

12. The nozzle of claims 8 to 11, characterized in the protrusions are cylindrical in shape.

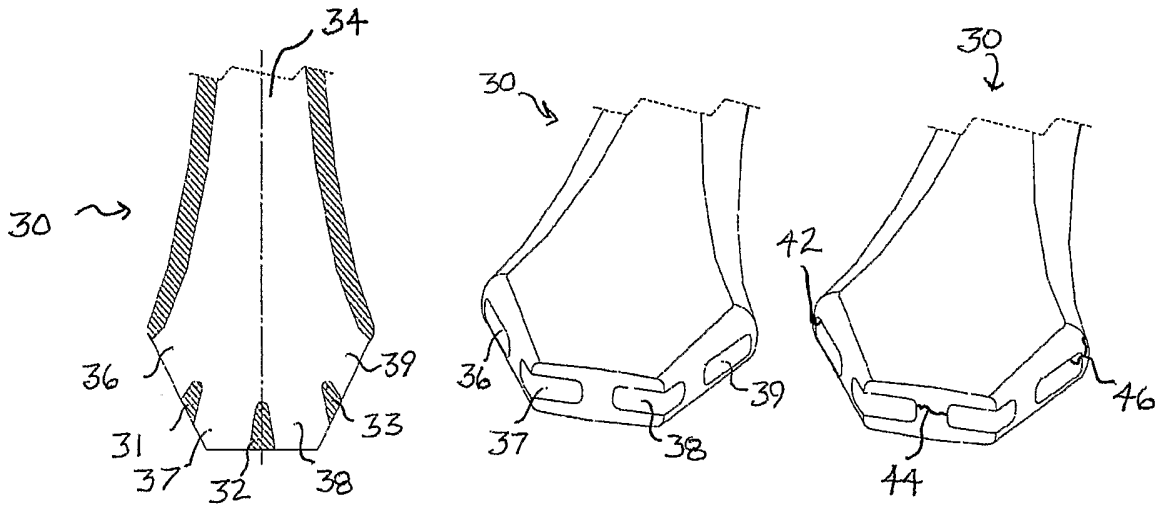
13. The nozzle of claims 8 to 11, characterized in that the protrusions are trapezoidal in shape.

14. The nozzle of claims 8 to 11, characterized in that the protrusions are curved and convex in shape.



(a) (b) (c)

Fig. 1



(a) (b) (c)

Fig. 2

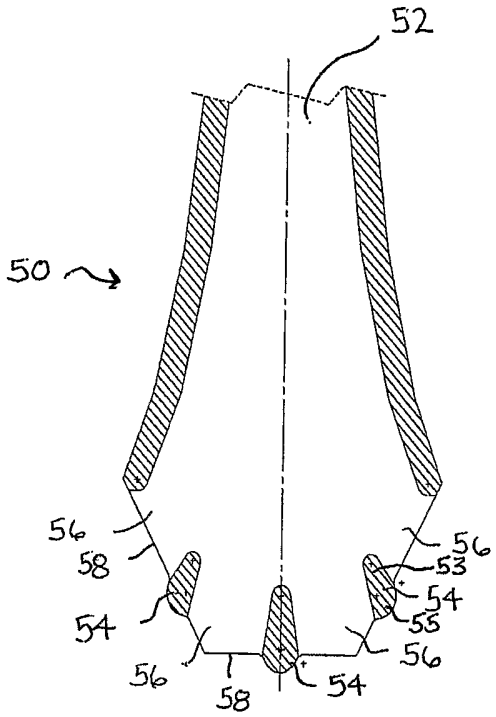


Fig. 3

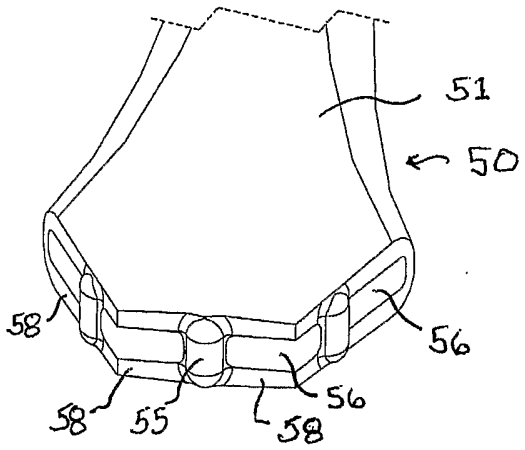


Fig. 4

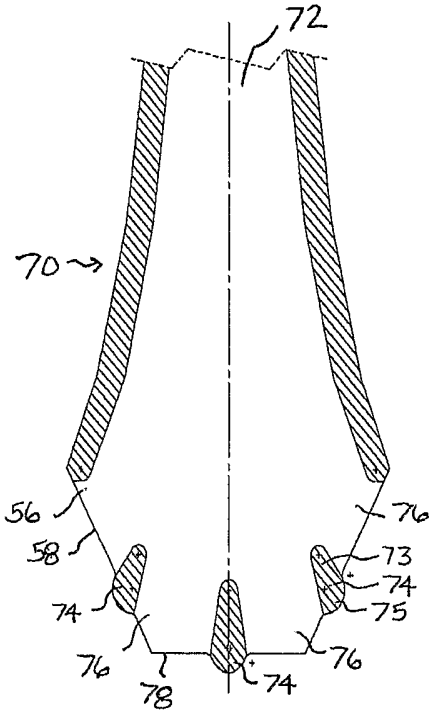


Fig. 5

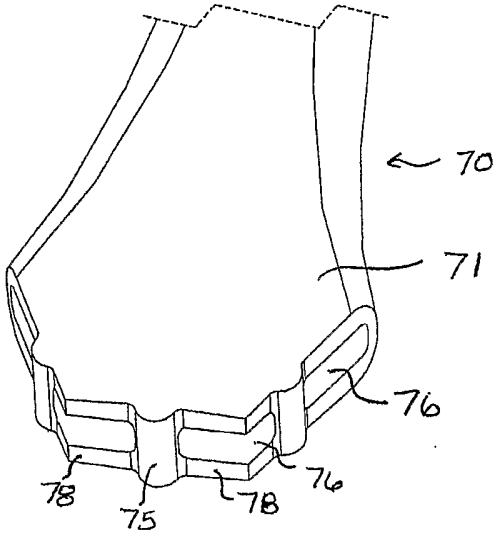


Fig. 6