IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

Vesuvius USA Corporation, an Illinois Corporation Plaintiff, v. ISG Technologies, Inc., a Delaware Corporation; CCPI, Inc., a Delaware Corporation; Foseco, Inc., a Delaware Corporation; and Foseco International Limited, an English Corporation Defendants.	Civil Action No. 03C 5748 JURY TRIAL DEMAND JUDGE GETTLEMAN DOCKETED AUG 18 2003 MAGISTRATE JUDGE KEYS

COMPLAINT

Plaintiff Vesuvius USA Corporation alleges as its complaint against each of the defendants as follows:

THE PARTIES AND JURISDICTION

1. **Plaintiff**. Vesuvius USA Corporation ("Vesuvius") is an Illinois corporation having its principal offices in Champaign, Illinois. Vesuvius maintains a manufacturing facility in Chicago Heights, Illinois, which is within this judicial district. The manufacturing facility in

Chicago Heights produces certain impact pads (which are the type of products that are the subject of this dispute).

2. **Defendants**.

a) ISG Technologies, Inc. ("ISG "), is, on information and belief, a corporation organized and existing under the laws of the State of Delaware, with its principal place of business at Ridgefield, Ohio.

b) CCPI, Inc. ("CCPI"), is, on information and belief, a Delaware corporation, having its principal place of business in Blanchester, Ohio.

c) Foseco International Limited is, on information and belief, an English corporation with its principal place of business in Birmingham, England.

d) Foseco, Inc., is, on information and belief, a Delaware corporation having its principal place of business in Cleveland, Ohio.

e) Defendants are, collectively, parties to a License Agreement dated March 18, 1998 ("License Agreement"), a copy of which is attached as Exhibit A.

3. Upon information and belief, a reasonable opportunity for discovery will show that defendants conduct substantial business in this forum, and are subject to personal jurisdiction in this forum.

JURISDICTION AND VENUE

4. This is a claim for declaratory judgment that U.S. Patent Nos. Re. 35,685 and 5,358,551 ("the Patents") are not infringed by the Plaintiff and that the dispute between the parties are not arbitral. (Copies of the patents are attached as Exhibits B and C). This Court has subject matter jurisdiction under 28 U.S.C. § 1331, 1332, 1338(a) and 2201.

5. Venue is proper in this district under 28 U.S.C. §§ 1391(c).

BACKGROUND

6. Plaintiff reasserts the allegations of paragraphs 1-5 of this complaint as if fully set forth herein.

7. Defendants and American Premier, Inc. ("Premier") entered into the License Agreement. Under the License Agreement, the Defendants granted to Premier the nonexclusive right and license to make, cause to be made, use, sell, have sold, offer for sale and sell impact pads.

8. The License Agreement applied to any Premier product which falls within the scope of the claims of the Patents.

9. Article V of the License Agreement requires Premier and the Defendants to present infringement disputes to three independent, well-qualified patent attorneys for arbitration.

10. Under Section 5.2 of Article V Defendants are required to identify any products they believe infringe within ten days of receiving notice of such products.

11. Article 6.1(b) of the License Agreement provides that Premier may assign the Agreement to the Purchaser or transferee of all or substantially all of its business to which the Agreement relates provided that **no such assignment shall be binding and valid until and unless the assignee or transferee shall have assumed in writing, delivered to the non-assigning Parties, all of the duties and obligations of Premier.**

12. Vesuvius acquired certain assets of Premier after the License Agreement was executed. There has been no written assumption of the duties and obligations of the License Agreement by Vesuvius as required by the License Agreement.

13. On July 18, 2003, Defendants notified Vesuvius that they believed that the standard oval two ripple and Performer impact pads distributed by Vesuvius infringed U.S. Patent Nos. Re. 35, 685 and 5,358,551 and demanded arbitration under Article 5.4 of the License Agreement.

14. On information and belief, Defendants had notice of Vesuvius's alleged infringing pads greater than ten (10) days prior to notification of Vesuvius of the alleged infringement.

15. As a result of the actions above, an actual justiciable controversy exists between Vesuvius and the Defendants as to Vesuvius's alleged infringement of U.S. Patent Nos. Re. 35,685 and 5,358,551. Defendants assert and continue to assert that Vesuvius infringes the claims of the Patents.

16. On information and belief that Defendants had knowledge of the Article 5 of the License Agreement to settle disputes by arbitration and by not notifying Vesuvius within the required 10 day time frame of notice, have acted in a manner inconsistent with Article 5, and Vesuvius has been prejudiced by this failure to notify it of the alleged violation within the stipulated time frame.

COUNT I:

DECLARATORY JUDGMENT OF NO PATENT INFRINGEMENT

17. Plaintiff reasserts the allegations of paragraphs 1-16 of this complaint as if fully set forth herein.

18. Plaintiff Vesuvius has not assumed in writing the duties and obligations of Premier as required by the License Agreement, and Vesuvius is therefore not bound by the arbitration provisions of that Agreement.

19. Since the Agreement is not binding, Vesuvius is entitled to have this Court determine questions of infringement. Pursuant to 28 U.S.C. §§ 1338(a) and 2201, Vesuvius is entitled to a judgment declaring that U.S. Patent Nos. Re. 35, 685 and 5,358,551 are not infringed by plaintiff.

COUNT II:

WAIVER OF ARBITRABILITY

20. Plaintiff reasserts the allegations of paragraphs 1-19 of this complaint as if fully set forth herein.

21. In the event that the Court determines that Vesuvius is bound by the License Agreement, then Defendants have waived their right to arbitrate.

22. Defendants have waived their right to arbitrate by acting in a manner inconsistent with arbitrating the dispute by waiting substantially in excess of the express time frame in Article V of the License Agreement, thereby prejudicing Vesuvius.

JURY DEMAND

23. Vesuvius demands a trial by jury on all issues so triable in this Complaint.

WHEREFORE, plaintiff requests the following relief:

A. A preliminary and permanent injunction precluding Defendants from prosecuting any arbitration proceedings;

B. Judgment declaring that U.S. Patent No. Re. 35,685 is not infringed, either literally or under the doctrine of equivalents, by any product, including impact pads, made, used, sold or offered for sale by plaintiff;

C. Judgment declaring that U.S. Patent No. 5,358,551 is not infringed, either literally or under the doctrine of equivalents, by plaintiff;

D. Judgment that the Defendants have waived arbitrability of the dispute because of acts inconsistent with arbitrating the dispute causing prejudice to Vesuvius ;

E. Judgment awarding Vesuvius its costs and expenses of this action, and reasonable attorney fees, under 35 U.S.C. § 285 and other applicable statutes and laws; and

F. Such other relief as the court may deem just and proper.

Respectfully submitted,

Dated: August 15, 2003

Edward W. Remus
Richard McCaulley
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Chicago, Illinois 60661
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Attorneys for Plaintiff,
VESUVIUS CORPORATION

Of Counsel:

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7/1537-217

LICENSE AGREEMENT

This License Agreement ("Agreement") is made and is effective as of March 18, 1998 by and among Bethlehem Steel Corporation ("Bethlehem"), a corporation of the State of Delaware, having its corporate headquarters at 1170 Eighth Avenue, Bethlehem, Pennsylvania 18016-7699; CCPI Inc., ("CCPI" or "Comat"), a corporation of the State of Delaware, having its principal place of business at 838 Cherry Street, Blanchester, Ohio 45107-1316; Foseco International Limited, a corporation of England having an office and place of business at 285 Long Acre, Nechells, Birmingham, England B7 5JR ("Foseco International"); Foseco, Inc., a Delaware corporation, having its principal place of business at 20200 Sheldon Road, Cleveland Ohio 44142 ("Foseco"); and Premier Refractories Inc., a Delaware corporation, formerly known as Adience, Inc. successor by statutory merger to American Premier, Inc. ("Premier"), having its principal place of business at 901 East 8th Avenue, King of Prussia, Pennsylvania 19406; any or all of which may also hereinafter be referred to respectively as a "Party" or "Parties" to this Agreement.

WHEREAS, Bethlehem is the owner of all right, title, and interest in U.S. Patent No. Re. 35,685 ("the '685 patent") (which is a reissue of U.S. Patent No. 5,169,591);

WHEREAS, Comat is the owner of all right, title and interest in U.S. Patent No. 5,358,551 ("the '551 patent");

WHEREAS, Foseco International is the owner of all right, title and interest in U.S. Patent No. 5,518,153 ("the '153 patent");

WHEREAS, Comat and Foseco are exclusive licensees under Bethlehem's '685 patent; and

WHEREAS, Bethlehem, Comat, Foseco and Foseco International and Premier each represent and warrant that it is fully authorized to deal with and make an agreement respecting the subject matter hereof.

NOW, THEREFORE, in consideration of the above premises and mutual covenants hereinafter contained, and other good and valuable consideration the receipt and adequacy of which is acknowledged, and intending to be bound, Bethlehem, Comat, Foseco, and Foseco International and Premier agree as follows:

ARTICLE I - DEFINITIONS

For the purposes of this Agreement:

1.1 The "Licensed Territory" shall be the United States of America, Canada, and Mexico.

1.2 "Licensed Patents" shall mean Bethlehem's '685 patent (including, without limitation, reissues and reexamination thereof), Foseco's '153 patent (including, without limitation, reissues and reexaminations thereof), and/or Comat's '551 patent (including, without limitation, reissues and reexaminations thereof), and any issued patents in the Licensed Territory claiming priority to those patents, and/or the Canadian and Mexican equivalents thereof, including, without limitation, Comat Canadian

patent application serial No. 2175583 when issued, Comat Mexican patent application serial No. 9408223 when issued, and Bethlehem Canadian patent No. 2,082,459. The Licensed Patents shall also include any other issued patents owned or assigned to one or more of Licensors in the Licensed Territory and any patent applications in the Licensed Territory pending as of the effective date of this agreement owned or assigned to Licensors that otherwise cover, or in the case of a pending patent application will otherwise cover when issued, Licensed Product (as defined below), and any continuing, divisional, reissues or reexaminations thereof once issued.

1.3 "Affiliate" of, or any entity "Affiliated" with, a Party shall mean an entity that directly or indirectly controls, is controlled by, or is under common control with that Party.

1.4 "Selling Value" shall mean the price invoiced by Premier or its Affiliates in U.S. dollars for the sale of Licensed Product to independent third parties less the following amounts: (i) discounts, including cash discounts, or rebates actually allowed or granted, (ii) credits or allowances actually granted upon claims or returns, regardless of the party requesting the return, (iii) freight charges actually paid for delivery; and (iv) taxes or other charges levied or measured by the invoiced amount whether absorbed by the billing or the billed party.

1.5 "Accused Pads" shall mean the accused impact pad devices of a design marketed by Premier in the United States prior to the effective date of this License Agreement sold under the name BOWL SHAPED IMPACT PAD (also known as the SPITOON PAD), CUSHION

PAD, or SUPER CUSHION PAD, all as shown more fully in Exhibit 3 attached to the Settlement Agreement the manufacture, use, or sale of which Licensors contend are covered by a claim of one or more of the Licensed Patents.

1.6 "Licensed Product" shall mean a product sold in a country where one or more Licensed Patents subsist in that country which product falls within the claims of one or more of those Licensed Patents subsisting in that country (e.g., a product sold in Mexico and falling within the claims of an issued Mexican Licensed Patent is a Licensed Product, while the same product sold in the United States of America, but not falling within the claims of an issued U.S. Licensed Patent, is not a Licensed Product). In no event shall a Licensed Product include impact pads of Comat's Design and/or Foseco's Design. The Accused Pads, but not the BOWL SHAPED IMPACT PAD, are Licensed Products and are not products that include Comat's Design and/or Foseco's Design.

1.7 "Licensors" shall mean Bethlehem, Comat, Foseco and Foseco International.

1.8 "Certain Premier Customers" shall mean third parties and their successors to whom Premier actually sold Licensed Product on or before November 5, 1997; for purposes of this Agreement, the date on which Licensed Product is "sold" shall mean the earliest date (i) shipped to a customer, (ii) invoiced to a customer; or (iii) recorded by Premier as a sales transaction to a customer in its books and records kept in the normal course of business.

1.9 "Collection Agent" shall be Bethlehem acting to collect and receive on the other Licensors behalf and to distribute

among them according to their interest any payments made or to be made to them by Premier under this License Agreement. The Collection Agent can be changed, subject to Premier's approval which shall not be unreasonably withheld, if the existing Collection Agent gives Premier written notice, including an effective date upon which the Collection Agent will change, and Premier does not object in writing within thirty (30) days of receiving such notice. For purposes of this Settlement and License Agreement, payment is considered made once Premier remits payment to the Collection Agent.

1.10

REDACTED

1.11

REDACTED

1.12

REDACTED

1.13

REDACTED

1.14 "Request for Quotation" is a written request submitted by Premier to Comat or Foseco in accordance with paragraph 2.5 hereof.

1.15 "Settlement Agreement" means the Settlement Agreement between Premier Refractories Inc., Bethlehem Steel Corporation, CCPI Inc., Foseco International Limited, and Foseco, Inc. signed on May 1, 1998 (Foseco International Limited may sign no later than May 5, 1998) to which this License Agreement is an attachment.

ARTICLE II - GRANT

2.1 The Licensors hereby grant to Premier the nonexclusive right and license, without the right to sublicense, to

make, cause to be made, use, sell, have sold, offer for sale and otherwise dispose of Licensed Product to Certain Premier Customers in the Licensed Territory. Except as provided for herein, the grant of this license does not permit Premier to sell Licensed Products to any other customers, and Premier shall not sell Licensed Product to any customers other than Certain Premier Customers except as provided for in paragraph 2.5.

2.2 No license is granted by any of the Licensors, either directly or indirectly or by implication, estoppel, or otherwise, under any patent application, know-how, or invention other than the Licensed Patents.

2.3 Premier hereby accepts the rights and licenses granted herein.

2.4 The rights and licenses granted herein shall continue in effect, unless sooner terminated as elsewhere provided in this Agreement, until the expiration of the last to expire of the Licensed Patents. For purposes of this agreement, a patent will also be deemed to have expired if it is held invalid and/or unenforceable by a court of last resort.

2.5

REDACTED

REDACTED

2.6 Premier, at its sole discretion and expense, may nominate an independent accountant to inspect Comat or Foseco's sales records for the previous two years during reasonable business hours at the appropriate offices of Comat or Foseco to determine Comat or Foseco's compliance with paragraph 2.5 hereof. Premier shall nominate such independent accountant to Comat or Foseco (the "Quoting Licensor") in writing. If the Quoting Licensor does not object to such nominated independent accountant within 10 days of notice, such independent accountant shall be deemed approved. If the Quoting Licensor does object to such independent accountant, Premier and the Quoting Licensor shall enter into good faith negotiations to appoint a mutually agreeable independent accountant. The approved independent accountant shall disclose to the Premier only information relating solely to the Quoting Licensor's compliance with paragraph 2.5 hereof. Such independent accountant shall enter into the confidentiality agreement attached to the Settlement Agreement as Exhibit 4 before inspecting such books and records. The independent accountant may make changes to the confidentiality agreement that are reasonable and do not materially adversely affect the Quoting Licensor's interests. Premier shall be responsible for paying the costs of the independent accountant unless the independent accountant determines that the Quoting Licensor has not complied with the provisions of section 2.5 hereof in which case the Quoting Licensor shall pay the costs of the independent accountant.

ARTICLE III - PAYMENTS

3.1 Initial Royalty-free Period - No payment shall be due from Premier for sales of Licensed Product as consideration for the rights and licenses granted herein during the period beginning March 18, 1998 (the effective date of the License Agreement) and ending on July 31, 1998.

3.2

REDACTED

3.3

REDACTED

3.4 Accrual - Royalties shall accrue whenever Licensed Product is shipped or otherwise transferred by or for Premier to a customer. Royalties paid on any Licensed Product which is not finally accepted by a customer or for which Premier does not receive payment, shall be credited to Premier.

3.5 **Comat Product and Foseco Product** - Nothing in this Article III shall be construed as requiring Premier to pay any royalty to Licensors or the Collection Agent in respect of any Comat Product or Foseco Product.

ARTICLE IV - RECORD KEEPING AND PAYMENT

4.1 Premier shall keep reasonable and accurate records of the sales of Licensed Product and impact pads and, within ten (10) days following the end of each calendar quarter during the pendency of this Agreement, Premier shall render to the Collection Agent a written report, certified by the Chief Financial Officer of Premier, setting forth the number of Licensed Product sold (even if none is sold) by product name or number, customers by customer number, the amount of the royalty due and payable on such Licensed Product during such calendar quarter; and Premier shall, upon rendering such report, remit to the Collection Agent the amount of any royalty shown thereby to be due. The Collection Agent shall periodically provide a written list to Premier of pad names or numbers which are to be reported as relating to Comat and which pad names or numbers are to be reported as relating to Foseco. The royalty report shall include information in a manner which reasonably enables the Collection Agent to determine the total royalties which relate to Comat and which relate to Foseco. Such information shall be provided as cumulative information (e.g., a total dollar amount of royalties relating to Comat and total dollar amount of royalties relating to Foseco). Premier shall cooperate reasonably with the Collection Agent in determining the allocation

of royalties that CCPI and Foseco will pay to Bethlehem. In the event that no amount of royalty is payable, Premier shall so report. Such reports shall commence with the report due October 10, 1998 reflecting the sales of Licensed Product from July 31, 1998 through September 30, 1998.

4.2 The remittance of royalties payable on sales covered by the Licensed Patents outside the United States will be payable to the Collection Agent in United States Dollar equivalents at the official rate of exchange of the currency of the country from which the royalties are payable as quoted by The Wall Street Journal, New York Edition, for the last day of the calendar quarter for which the transfer of funds for the royalty payment is made. If the transfer or the conversion into United States Dollar equivalents in any such instance is not lawful or possible, the payment of such part of the royalties as is necessary shall be made by the deposit thereof, in the currency of the country where the sales were made on which the royalty was based, to the credit and account of the Collection Agent or its nominee in any commercial bank or trust company of its choice located in that country, prompt notice of which shall be given by Premier to the Collection Agent.

4.3 Records required for the computation and verification of the royalties to be paid will be kept by Premier. Premier will segregate documents, if practicable, reflecting the customers to whom Licensed Product has been sold and/or the sales of Licensed Product in accordance with the reasonable request of the Collection Agent for review by an independent accountant. The Collection Agent shall have the right, at its sole discretion and

expense, to nominate an independent accountant to inspect such records during reasonable business hours at the appropriate offices of Premier to determine the correctness of any Royalty Report for the two preceding years, but this right may not be exercised more than once in any year. Collection Agent shall nominate such independent accountant to Premier in writing. If Premier does not object to such nominated independent accountant within 10 days of notice, such independent accountant shall be deemed approved. If Premier does object to such independent accountant, Premier and the other parties shall enter into good faith negotiations to appoint a mutually agreeable independent accountant. The approved independent accountant shall disclose to the Collection Agent only information relating solely to the accuracy of the royalty report and the royalty payments made according to this Agreement. Such independent accountant shall enter into the confidentiality agreement attached to the Settlement Agreement as Exhibit 4 before inspecting such books and records. The independent accountant may make changes to the confidentiality agreement that are reasonable and do not materially adversely affect Premier's interests. Collection Agent shall be responsible for paying the costs of the independent accountant. Should the accountant determine that additional royalties are due, then they shall be paid within ten (10) days of such determination; and if the additional royalties are in excess of one percent (1%) of the royalties to be paid, Premier also shall pay the reasonable cost to the Collection Agent of the accountant.

4.4 Any tax required to be withheld on royalties payable to the Collection Agent under the laws of any country shall be deducted from the royalty paid to the Collection Agent by Premier and shall be promptly paid by Premier for and on behalf of the Collection Agent to the appropriate governmental authority, and Premier shall furnish the Collection Agent with proof of payment of such tax together with official or other appropriate evidence issued by the appropriate governmental authority sufficient to enable the Collection Agent to support a claim for income tax credit in respect of any sum so withheld. Any such tax required to be withheld shall be an expense of and borne solely by the Collection Agent.

4.5 In order to permit Bethlehem to determine whether any new pads sold by Premier relate to Comat or Foseco, Premier shall permit Bethlehem's counsel to review certain drawings of Premier in accordance with the provisions of this paragraph 4.5. During January of each calendar year, Bethlehem may provide Premier with a written request to review drawings of pads listed on Premier's quarterly reports (issued pursuant to paragraph 4.1 hereof) for the immediately preceding calendar year, on the condition that such pads were not listed on any quarterly report for any prior calendar year. Bethlehem shall identify such new pads by product name or number. Premier shall permit counsel for Bethlehem to review such drawings at the premises of Premier at a mutually agreeable time and date. Bethlehem's counsel shall keep all information obtained as a result of such inspection in

confidence and shall use such information solely for the purpose of determining whether the new pads relate to Comat or Foseco.

ARTICLE V - DISPUTES

5.1 Subject to Paragraph 13 of the Settlement Agreement, in the event that Premier manufactures or sells or wishes to manufacture or sell an impact pad as to which there is a dispute about whether or not such impact pad is a Licensed Product (and, therefore, whether or not a royalty is due in accordance with Paragraph 3.2 herein), the Parties agree to present the dispute to three (3) independent, well-qualified patent attorneys practicing in the country of the Licensed Territory for which Premier manufactures or sells or wishes to manufacture or sell an impact pad ("IWQPAs"), each of whom will provide a detailed written opinion as to whether or not the pad infringes issued Licensed Patents in the country.

5.2 For purposes of this section, a dispute can arise if a) within ten (10) days after Premier gives at least one of the Licensors written notice of its commercial sale, or intent to commercially sell, a pad for which Premier believes may give rise to a dispute, and at least one of the Licensors notifies Premier in writing of each of the Licensed Patents that it believes the pad infringes; or b) if within ten (10) days of one of the Licensors having notice from Premier or otherwise of a pad sold or used by Premier in the marketplace, the Licensors notify Premier in writing of each of the Licensed Patents that it believes the pad infringes.

5.3 Premier and Licensors shall then jointly select three (3) IWQPAs, each at different firms ("independent" meaning for purposes hereof that neither such attorney nor their firm has theretofore represented or performed legal services for any of the Parties or their Affiliates in any matter, formally or informally, and neither such attorney nor their firm shall have had, prior to such selection, any relationship, professional or personal with Licensors or Premier or any of their attorneys or employees thereof) ("well qualified" meaning for purposes hereof an attorney regularly retained for the purpose of rendering written patent infringement opinions and who has theretofore rendered at least ten (10) such opinions and has been a practicing attorney in this field for a minimum of seven (7) years). None of the parties to this Agreement shall offer or suggest the possibility of future employment or retainer of such selected IWQPA until after all opinions requested of such IWQPA under this Article V have been rendered.

5.4 Within ten (10) days of the notice of paragraph 5.2 herein, Licensors and Premier shall submit to one another a list of five (5) proposed IWQPAs. Licensors and Premier and each IWQPA shall certify that it is independent as defined in Paragraph 5.3 above. Within ten (10) days of receipt of such lists, Licensors shall select one IWQPA from Premier's list and Premier shall select one IWQPA from Licensors' list. Once Licensors and Premier jointly agree on two such IWQPAs, the two IWQPAs shall promptly jointly select a third IWQPA, subject to Licensors' and Premier's approval. The parties will act in good faith to jointly appoint and agree on

the three IWQPAs within fifteen (15) days of the notice of paragraph 5.2. If Premier or Licensors do not submit a list of proposed IWQPAs within the ten (10) day time period, then the submitting party will have the right to select all three IWQPAs from its list.

5.5 Within twenty (20) days of jointly agreeing to the IWQPAs, two (2) separate submissions will be made to the IWQPAs. One submission will be jointly made by Licensors, the other by Premier. Licensors and Premier shall jointly submit a documentary exhibit including file histories of the Licensed Patents, including references cited therein. Each separate submission shall include no more than the following materials: (1) drawings of the disputed pad, (2) a brief of up to ten (10) double-spaced pages, not including supporting exhibits, describing the operation of the disputed pad, and any arguments which the submitting party believes are relevant to infringement or noninfringement, (3) if available, a video showing the results of any relevant water modeling test, (4) a technical expert's report describing the operation of the pad and/or the ordinary meaning of a claim term to one of ordinary skill in the art, of no more than five (5) double-spaced pages, which shall be accompanied by the expert's curriculum vitae, and/or (5) relevant prior art (for claim interpretation only). Within ten (10) days of reviewing the above submissions each party may submit a no more than five (5) double-space paged rebuttal brief. Each IWQPA shall render his or her respective opinion (without contacting or discussing the issues with other IWQPAs) within thirty (30) days of receiving all the above submissions with

respect to each of the Licensed Patents Licensors contend the disputed pad infringes or will infringe. Each respective opinion shall set forth in detail the reasons the IWQPA concluded there was or was not infringement for each asserted Licensed Patent. If a majority of such opinions conclude that the disputed pad infringes one or more of the asserted Licensed Patents, such disputed pad shall be considered a Licensed Product as defined in Article I, paragraph 1.6 herein. If Premier desires to redesign the subject pad, and a dispute still arises in accordance with paragraphs 5.1 and 5.2 herein, the subject pad shall be submitted to the same three (3) IWQPAs in accordance with the procedures set forth in this Article V. The cost of the IWQPAs shall be borne equally among Premier, CCPI, Bethlehem, Foseco and Foseco International.

5.6 After the selection of the IWQPAs has been made, there shall be no ex parte communications between the Parties or their counsel and the IWQPAs until after such attorneys have submitted their written opinions and all Parties have agreed that ex parte communications with the IWQPAs may occur.

5.7 If after the submissions, any of the IWQPAs have any questions concerning the pad, or its operation, or the asserted Licensed Patent(s), the Parties shall set up a meeting (by telephone or in person), on no less than ten (10) days notice, jointly attended by duly authorized representatives of the parties to answer such questions. Within ten (10) days of the meeting, the parties can submit to the IWQPA, a maximum five (5) page memorandum addressing the issues raised in the meeting.

5.8 The IWQPAs, all counsel and parties, and any persons attending the IWQPAs' sessions, shall treat all written and oral communications made pursuant to this Article V. secret and confidential. All such written and oral communications shall not be used by the Parties, their counsel and the IWQPAs for any reason other than for the purposes of this Article V.

5.9 The procedures set forth in this Article V shall be deemed by the Parties to be an arbitration, the results of which shall be final, conclusive, binding and non-appealable, although if any one of the Parties believes any of the written opinions to be based on a material error of fact or law, the contending party can ask the IWQPA who authored such opinion to reconsider such opinion in writing within ten (10) days of receipt of the opinion. The noncontending party can submit a responsive memorandum to the IWQPA within ten (10) days of receiving the contending parties written request for reconsideration. The IWQPA will then have twenty (20) days to render his decision based on the new submissions.

ARTICLE VI - FURTHER PROVISIONS

6.1 a. This Agreement or any interest herein may be assigned by any of the Licensors upon written notice to the other Parties hereto.

b. This Agreement or any interest herein shall not be assigned or transferred other than by operation of law, in whole or in part, by Premier without the prior written consent of the other Parties hereto, which consent may not be unreasonably withheld. However, without securing such prior written consent,

Premier may assign this Agreement to the purchaser or transferee of all or substantially all of its business to which this Agreement relates provided that no such assignment shall be binding and valid until and unless the assignee or transferee shall have assumed in a writing, delivered to the non-assigning Parties, all of the duties and obligations of Premier.

6.2 The waiver by any Party, whether express or implied, of any provisions of this Agreement, or of any breach or default of any other party, shall not be construed to be a continuing waiver of such provision, or any such succeeding breach or default or of a waiver of any other provisions of this Agreement.

6.3 All matters affecting the interpretation, validity, and performance of this Agreement shall be governed by the internal laws of the State of Delaware without regard to its conflict of law principles, except as otherwise expressly provided herein.

6.4 Any provision hereof which is prohibited or unenforceable in any jurisdiction shall, as to such jurisdiction, be ineffective only to the extend of such prohibition or unenforceability without invalidating the remaining provisions hereof or affecting the validity of enforceability of such provision in any other jurisdiction.

6.5 Any delays in or failures of performance by any Party under this Agreement shall not be considered a breach of this Agreement if and to the extent caused by occurrences beyond the reasonable control of the Party affected, including but not limited to: acts of God; acts, regulations or laws of any government; strikes or other concerted acts of workers; fires; floods;

explosions; riots; wars; rebellions; and sabotage; and any time for performance hereunder shall be extended by the actual time of delay caused by such occurrence.

6.6 It is the mutual desire and intent of the Parties to provide certainty as to their future rights and remedies against each other by defining the extent of their mutual undertakings as provided herein. The Parties have, in this Agreement, incorporated all representations, warranties, covenants, commitments and understandings on which they have relied in entering into such Agreement, and, except as provided for herein, the Parties make no covenant or other commitment to the other concerning its future action. Accordingly, this Agreement: (i) constitutes the entire agreement and understanding between the Parties and there are not promises, representations, conditions, provisions or terms related hereto other than those set forth in such Agreement and (ii) supersedes all previous understandings, agreements and representations between the parties, written or oral.

6.7 All communications, reports, payments and notices required by this Agreement by one Party to the other shall be addressed to the Parties at their respective addresses set forth below or to such other address as requested by either Party by notice in writing to the other.

<u>If a report, communication or notice to Bethlehem:</u>

Bethlehem Steel Corporation
1170 Eighth Avenue
Bethlehem, Pennsylvania 18016-7699

Attention: Patent Counsel

If a payment to Bethlehem:

Bethlehem Steel Corporation
P. O. Box 21102
Lehigh Valley, Pennsylvania 18002-1102

If to Comat:

CCPI Inc.
838 Cherry Street
Blanchester, Ohio 45107-1316

Attention: R. Bruce Mickey

If to Foseco or Foseco International:

Foseco International Inc.
c/o Anthony Money
Foseco Inc.
20200 Sheldon Road
Cleveland, Ohio 44142

If to Premier:

Premier Refractories Inc.
901 E. 8th Avenue
King of Prussia, PA 19406

Attention: Stephen A. Becker

With a copy to:

Premier Refractories International Inc.
1790 Broadway
New York, New York 10019-1412

Attention: Stephen M. Johnson

All such notices, reports, payments and communications shall be made by Certified or Registered First class mail, postage prepaid, or by facsimile transmission where appropriate, and shall be considered made as of the date of receipt, or if such date is not a business day, the first business day thereafter.

6.8 Premier agrees to mark every Licensed Product manufactured and/or sold by its or its Affiliates under this

Agreement with all of the applicable Licensed Patents in accordance with the laws of the jurisdictions in which Licensed Product is sold. Licensors shall inform Premier in writing within ten (10) days of the effective date of the Settlement Agreement of their respective marking practices for marking their own products covered by the Licensed Patents. Without limitation, if Premier follows those practices for the respective Licensed Patents, Premier will be considered to have complied with the provisions of this paragraph.

6.9 Licensors agree to enforce and protect the Licensed Patents from infringement by third parties and to diligently prosecute all such infringers after becoming aware of such infringement, including such infringers that Premier may notify Licensors thereof, except that Licensors shall not be obligated to prosecute acts of infringement against a third party that are de minimis or temporary. Premier shall notify Licensors of third party infringers of which it is actually aware, and shall provide Licensors with information which it believes is reasonably necessary for Licensors to evaluate such acts of infringement.

6.10 Licensors agree during the term of this Agreement to defend and hold harmless Premier from any claim of infringement of any United States and Canadian patent(s) of third parties covering the use, sale, offer for sale, or manufacture of impact pads, if the use, offer for sale or manufacture of the Accused Pads would also infringe such patents, so long as said patent(s) was or were issued prior to the effective date of this agreement. This

obligation of Licensors is, however, subject to the following conditions:

(a) Premier must have given notice to Licensors, of the claim of infringement within sixty (60) days of its receipt from said third party, and

(b) Premier shall render all reasonable assistance to Licensors.

(c) Premier represents and warrants that as of the effective date of the Settlement Agreement, it has no knowledge or reasonable belief that it is infringing any U.S. or Canadian patent of a third party covering Accused Pads or their manufacture.

6.11 This Agreement may be executed in one or more counterparts, each of which shall constitute a binding agreement.

6.12 Premier agrees to indemnify and hold harmless the Licensors, and their representatives, agents, heirs, successors, and assigns from and against any and all claims, damages, and liabilities, asserted by any third parties (private and governmental) for personal injury or death or for loss or damage to property and arising from Premier's and/or its Affiliates negligence or wilful misconduct hereunder.

6.13 Premier has sold a small quantity of SUPER BRAKE PADS to one particular customer, which sales are listed in Exhibit 3 of the Settlement Agreement, and without admitting that such pads infringe any of the Licensed Patents, Premier agrees to pay a royalty to Licensors for the past sale of the pads. For purposes of the Settlement Agreement and License Agreement, however, the

SUPER BRAKE PAD is not one of the Accused Pads nor as the effective date of the Settlement Agreement, a Licensed Product. If at any time in the future Premier decides to manufacture, use, sell or offer for sale the SUPER BRAKE PAD without paying a royalty for such sale, Premier shall notify Licensors of such decision, and the provisions of Article V, herein, would then determine whether such product shall be considered a Licensed Product.

ARTICLE VII - WARRANTY

Subject to Licensors' obligations under Paragraphs 6.9 and 6.10 herein which shall be paramount, nothing in this Agreement shall be construed as:

a) a warranty or representation by the Licensors as to the validity or scope of the Licensed Patents; or

b) a requirement that the Licensors shall file any patent application, secure any patent, or maintain any patent in force, but Licensors shall give Premier notice of any Licensed Patents that are not to be maintained;

c) an obligation to furnish any manufacturing or technical information; or

d) conferring a right without prior written consent, which consent may be unreasonably withheld, to use in advertising, publicly or otherwise, any trademark or trade name of any of the Licensors.

ARTICLE VIII - TERM OF LICENSE: TERMINATION

8.1 The term of this Agreement shall be from the date first written above until the expiration of the last to expire of the Licensed Patents which cover Licensed Product as defined in Paragraph 2.4 herein.

8.2 If any party shall, at any time, default in any material obligation of this Agreement, and such default shall not be cured within sixty (60) days after written notice from the complaining party reasonably specifying the nature of the default, then the complaining party shall have the right to terminate this Agreement by giving written notice to the other parties and such termination shall become effective on the thirtieth (30th) day after giving such notice, provided such default has not been cured prior to the thirtieth (30th) day.

8.3 Any termination pursuant hereto shall not relieve any party of any obligation or liability accrued hereunder prior to such termination, nor rescind or give rise to any right to rescind anything done or any payments made, accrued or other consideration given hereunder prior to the time of such termination and shall not affect in any manner any rights of any Party arising out of this Agreement prior to such termination.

ARTICLE IX - MOST FAVORED LICENSEE

9.1 Except for the currently existing license agreements between Licensors, listed hereto in Exhibit B, Licensors hereby warrant that there are no other existing licenses pursuant to the Licensed Patents. If, during the term of this Agreement,

Licensors grant to any other person or entity any right or license under the Licensed Patents to manufacture, use, sell or offer for sale impact pad devices on terms more favorable than those granted to Premier in this Agreement, then, starting with the earliest date of such grant to any other person or entity, the more favorable terms shall be substituted for those set forth in the present Agreement.

9.2 Licensors hereby agree to inform Premier in accordance with the notice provisions of ARTICLE VI hereof, and submit to them, within thirty (30) days after execution, a copy of any document granting any right or license to any other person or entity under the Licensed Patents. Upon Licensors' request, each such non-public document will be received by Premier's attorneys in confidence and those attorneys can only provide Premier with their opinion as to whether and which new, more favorable terms, Premier is entitled to. Notwithstanding the foregoing, Premier's attorneys may also inform Premier of other terms of the agreement if such a disclosure is reasonably necessary to enable Premier to understand the basis of any opinion provided by Premier's attorneys, or otherwise to enforce its rights under the Settlement Agreement.

IN WITNESS WHEREOF, the parties hereto have duly executed this Agreement through their duly authorized below-noted agents the day and year last written below.

PREMIER REFRACTORIES INC.

By: _____
Name: Stewart Wahrsager
Title: Vice President, Assistant Secretary
Date: May 1, 1998

BETHLEHEM STEEL CORPORATION

By: _____
Name: _____
Title: _____
Date: _____

CCPI, INC.

By: _____
Name: _____
Title: _____
Date: _____

FOSECO INTERNATIONAL LIMITED

By: _____
Name: _____
Title: _____
Date: _____

FOSECO, INC.

By: _____
Name: _____
Title: _____
Date: _____

IN WITNESS WHEREOF, the parties hereto have duly executed this Agreement through their duly authorized below-noted agents the day and year last written below.

PREMIER REFRACTORIES INC.

By:_____
Name: Stewart Wahrsager
Title: Vice President,
Assistant Secretary
Date: May 1, 1998

BETHLEHEM STEEL CORPORATION

By: M. J. Roberts
Name: M. J. Roberts
Title: Vice President, Technology & Chief
Date: May 4, 1998 Technology Offic

CCPI, INC.

By:_____
Name:_____
Title:_____
Date:_____

FOSECO INTERNATIONAL LIMITED

By:_____
Name:_____
Title:_____
Date:_____

FOSECO, INC.

By:_____
Name:_____
Title:_____
Date:_____

IN WITNESS WHEREOF, the parties hereto have duly executed this Agreement through their duly authorized below-noted agents the day and year last written below.

PREMIER REFRACTORIES INC.

By:_____
Name: Stewart Wahrsager
Title: Vice President,
Assistant Secretary
Date: May 1, 1998

BETHLEHEM STEEL CORPORATION

By:_____
Name:_____
Title:_____
Date:_____

CCPI, INC.

By: R. Bruce Mickey
Name: R. Bruce Mickey
Title: President/CEO
Date: May 1, 1998

FOSECO INTERNATIONAL LIMITED

By:_____
Name:_____
Title:_____
Date:_____

FOSECO, INC.

By:_____
Name:_____
Title:_____
Date:_____

IN WITNESS WHEREOF, the parties hereto have duly executed this Agreement through their duly authorized below-noted agents the day and year last written below.

PREMIER REFRACTORIES INC.

By:_____
Name: Stewart Wahrsager
Title: Vice President,
Assistant Secretary
Date: May 1, 1998

BETHLEHEM STEEL CORPORATION

By:_____
Name:_____
Title:_____
Date:_____

CCPI, INC.

By:_____
Name:_____
Title:_____
Date:_____

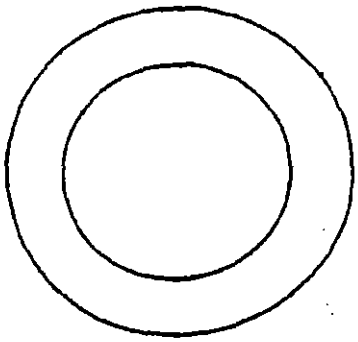
FOSECO INTERNATIONAL LIMITED

By:_____
Name: Geoff Smith
Title: President of Foseco International-Stee
Date: May 6, 1998

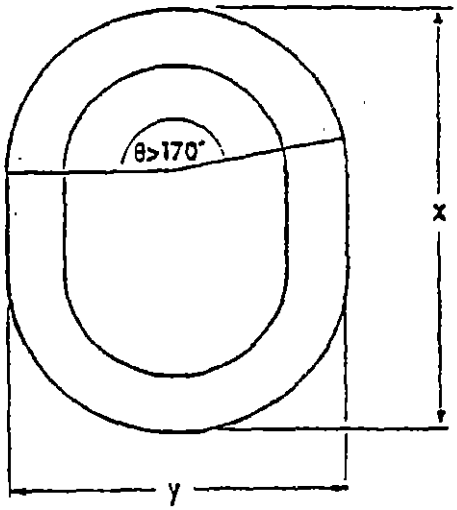
FOSECO, INC.

By:_____
Name: Roger Stanbridge
Title: President
Date: May 1, 1998

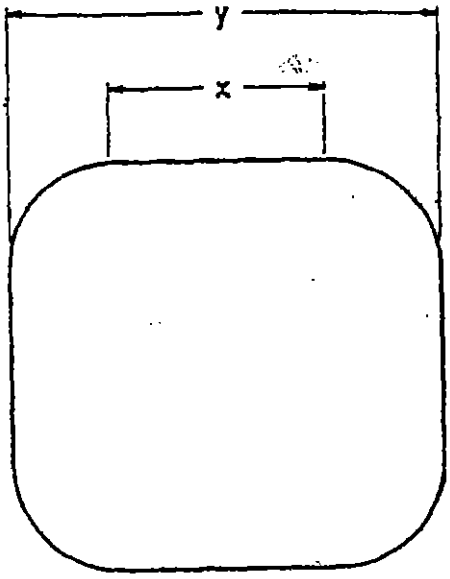
EXHIBIT A



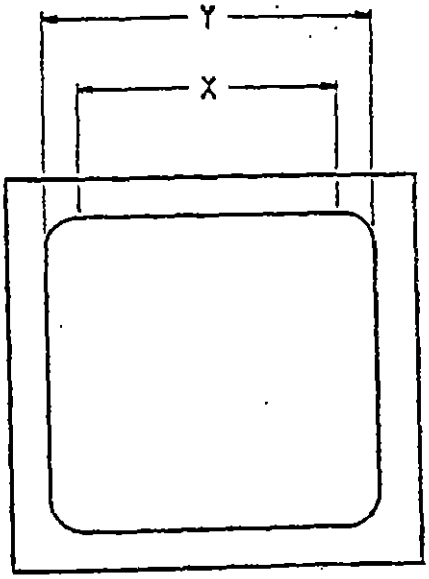
TOP VIEW
FIG. I



x/y ≤ 1.5
TOP VIEW
FIG. II



x/y > 0.6
INTERNAL CAVITY
FIG. III



X/Y > 0.8
TOP VIEW
FIG. IV

CCP10014

LIT\248410

EXHIBIT B

1. PATENT AND TECHNICAL INFORMATION LICENSE AGREEMENT entered into as of May 7, 1993 between Bethlehem Steel Corporation and Foseco International Limited.

2. LICENSE AGREEMENT effective March 2, 1995 between Bethlehem Steel Corporation, CCPI Inc., and Foseco International Limited.

3. AGREEMENT entered into and made effective January 12, 1996 between Foseco International Limited and CCPI Inc., and acknowledged by Bethlehem Steel Corporation February 20, 1996.

4. LICENSE AGREEMENT made effective January 1, 1997 between CCPI Inc. and Foseco International Limited.

EXHIBIT B

1. PATENT AND TECHNICAL INFORMATION LICENSE AGREEMENT entered into as of May 7, 1993 between Bethlehem Steel Corporation and Foseco International Limited.

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4. LICENSE AGREEMENT made effective January 1, 1997 between CCPI Inc. and Foseco International Limited.

B

US00RE35685E

United States Patent [19]

Schmidt et al.

[11] E Patent Number: Re. 35,685

[45] Reissued Date of Patent: Dec. 9, 1997

[54] **IMPACT PAD FOR A CONTINUOUS CASTER TUNDISH**

[75] Inventors: **Manfred Schmidt**; **Scott B. Newman**, both of Bethlehem, Pa.

[73] Assignee: **Bethlehem Steel Corporation**

[21] Appl. No.: **347,975**

[22] Filed: **Dec. 1, 1994**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **5,169,591**
Issued: **Dec. 8, 1992**
Appl. No.: **832,520**
Filed: **Feb. 7, 1992**

[51] **Int. Cl.**[6] **B22D 41/02**

[52] **U.S. Cl.** **266/275**; 266/227

[58] **Field of Search** 266/275, 280, 266/286, 287, 227, 229, 44; 164/437, 337, 335; 222/591, 594

[56] **References Cited**

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33 Metal Producing, Sep. 1994, pp. 21–23, and 47, "Taming the Thunder" by Jo Isenberg–O.Loughlin.

Paper given at an AIME Conference, (04)–Spring 1994, pp. 198–199. "Development of a Turbulence Inhibiting Pouring Pad/Flow Control Device for a Tundish" by D. Bolger.

Primary Examiner—Scott Kastler

Attorney, Agent, or Firm—Harold I. Masteller, Jr.; Joseph W. Berento, III

[57] **ABSTRACT**

An impact pad for eliminating surface turbulence in a continuous caster tundish, the impact pad having a base for receiving an incoming ladle stream, and one or more sidewalls extending in an upward direction along the periphery of the base. Each upward extending sidewall includes an inner surface having an undercut portion facing the incoming ladle stream. And, each undercut portion extends along the length of the inner surface, and comprises a shaped surface for receiving and reversing the direction of a fluid flow generated by the incoming ladle stream.

47 Claims, 3 Drawing Sheets

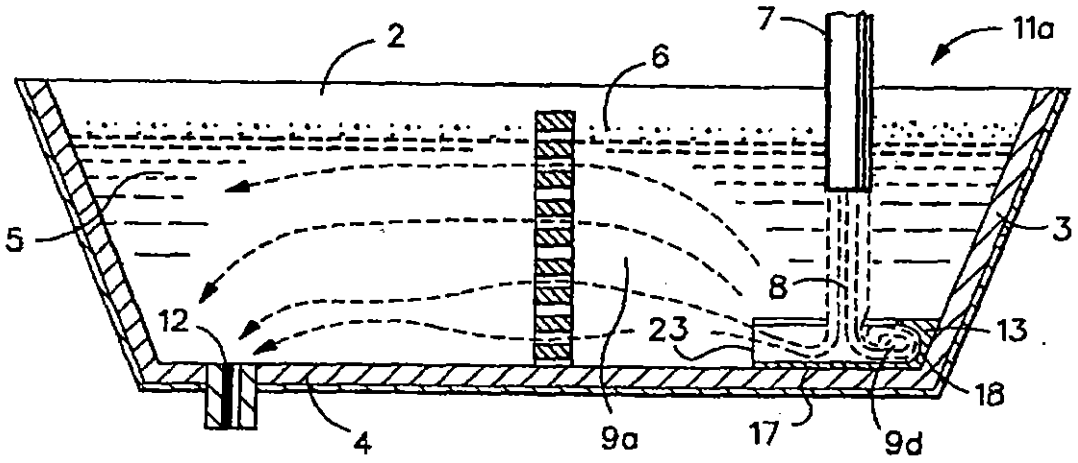


Fig. 1

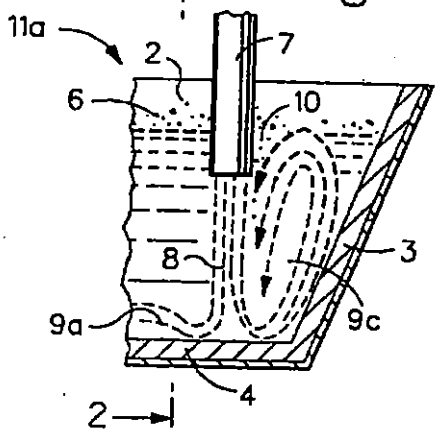


Fig. 2

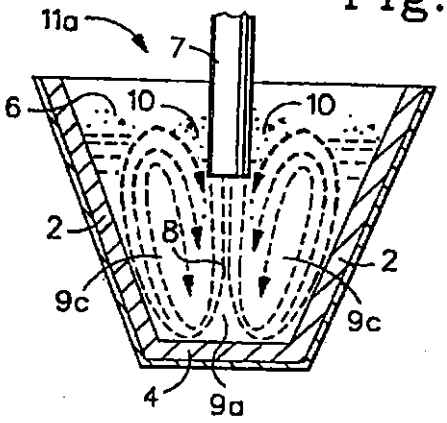


Fig. 3a

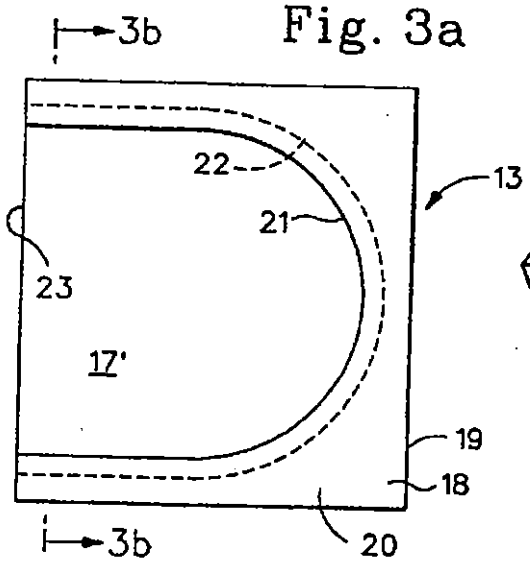


Fig. 3b

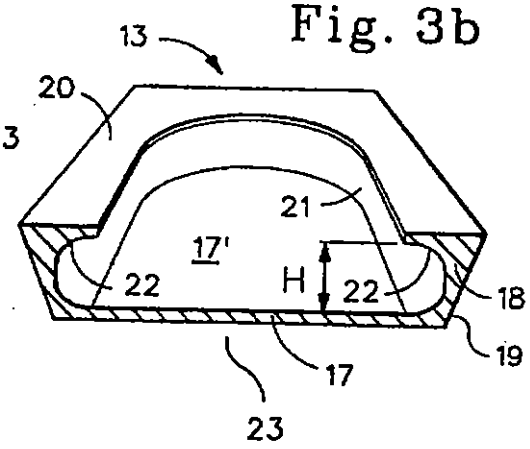
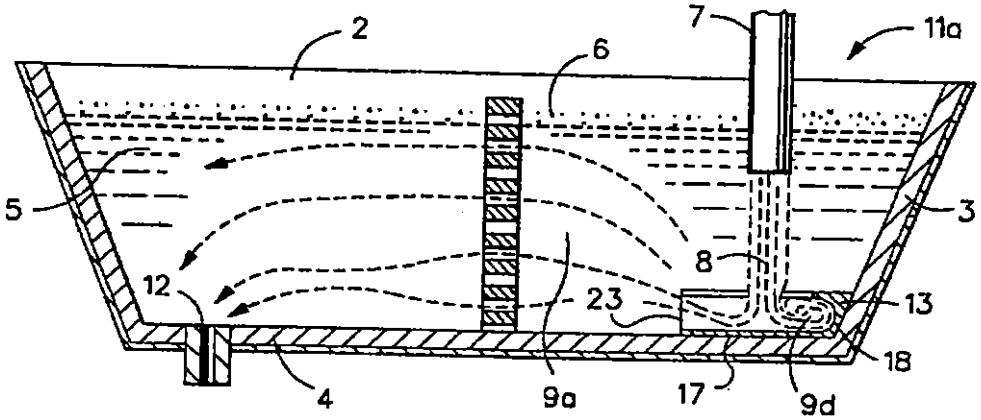


Fig. 4



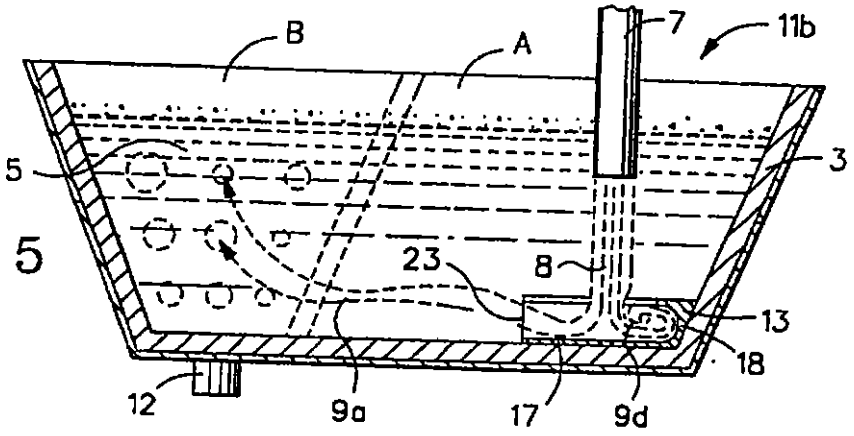


Fig. 5

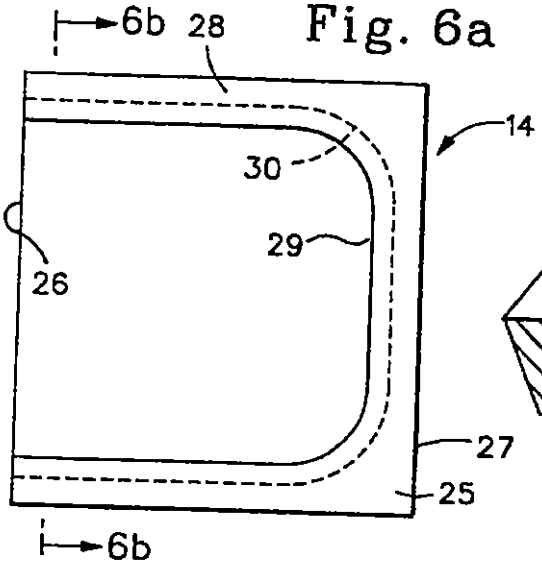


Fig. 6a

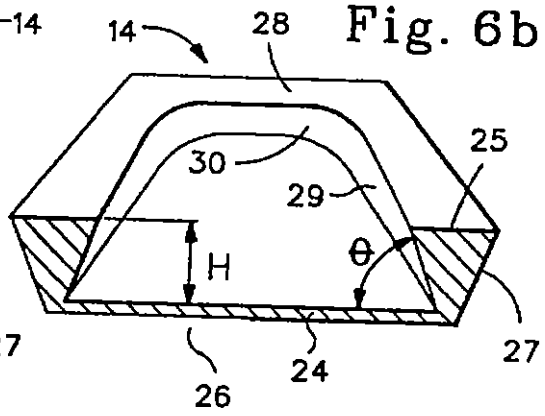


Fig. 6b

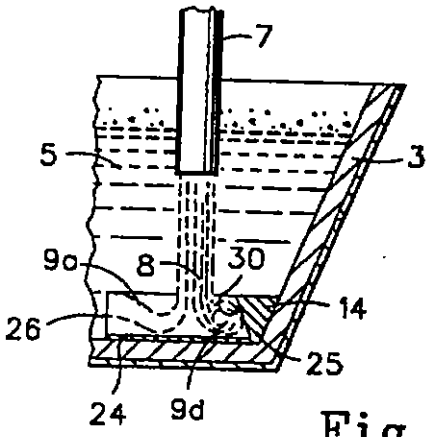


Fig. 7

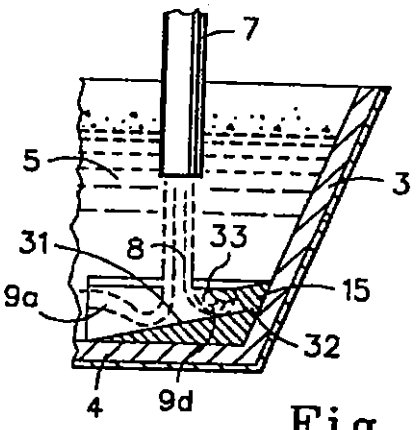


Fig. 8

Fig. 9

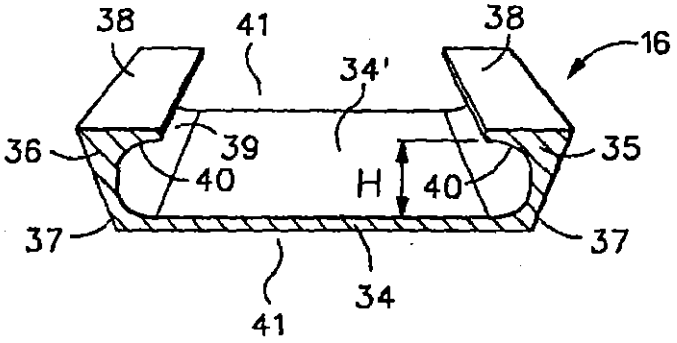


Fig. 10

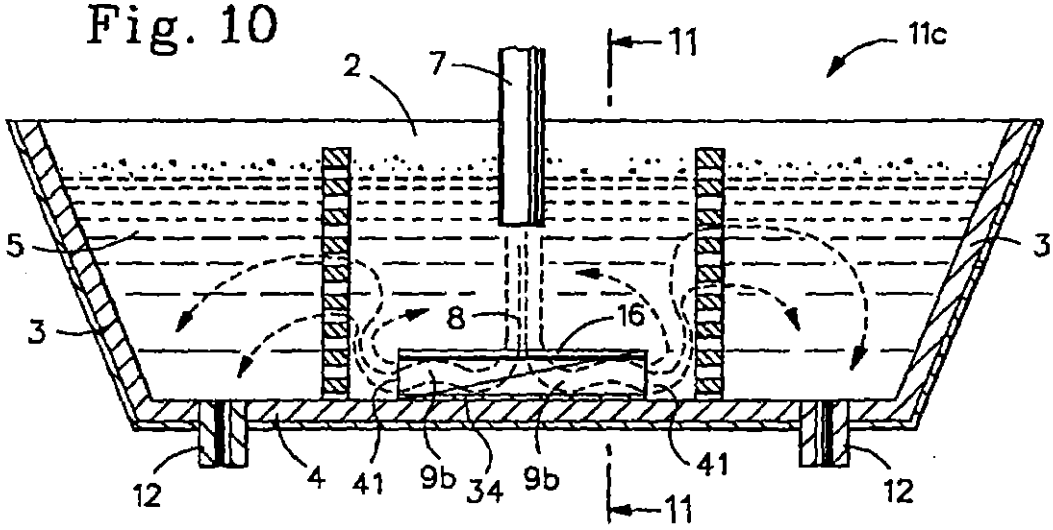
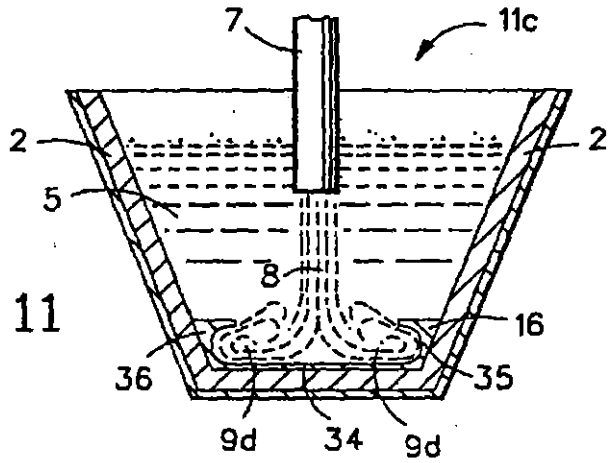


Fig. 11



IMPACT PAD FOR A CONTINUOUS CASTER TUNDISH

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

This invention is directed to apparatus for reducing surface turbulence in a molten metal bath, and more particularly, to impact pads for controlling the fluid flow pattern of an incoming ladle stream for the purpose of reducing surface turbulence within a continuous caster tundish.

Tundishes, located between the ladle delivering liquid steel to the caster floor and the continuous caster mold, are large containers for holding a reservoir of liquid steel. The liquid steel is transferred from the ladle through a ladle shroud extending into the tundish, and the liquid steel is fed at a continuous or semicontinuous flow rate controlled by a stopper rod, or by a slide gate assembly.

Extensive water flow-model studies have been made throughout the steelmaking industry to simulate liquid steel fluid flow patterns within an actual tundish. These water flow-models have been beneficial in determining critical areas of tundish design such as depth of bath, well block locations, and placement of fluid flow control devices within the tundish. As a result of these studies, it is well-known that the fluid flow generated by the incoming ladle stream is reflected from the flat tundish floor toward the surface of the liquid steel. This generated fluid flow, causes a turbulent boiling action and extensive wave motion at the surface of the steel bath. Additionally, where the fluid flow forces are obstructed by structural barriers such as tundish side and end walls, the ladle stream fluid flow surges upward, along such barriers, and causes excessive turbulence at the surface of the liquid steel bath. The excessive turbulence produced by the upward surge breaks up the tundish flux cover, and produces a downward surge around the ladle shroud. The broken flux cover allows the liquid steel to be exposed to the atmosphere which sets up conditions conducive to altering the chemistry of the steel bath. The chemical changes typically involve loss of aluminum from the bath and/or absorption of oxygen and nitrogen into the steel. The downward, shear flow of the liquid steel swirling around the ladle shroud, entraps particles from the broken slag cover within the ladle stream.

Surface requirements, and cleanliness standards for modern high quality steel products, dictate that impurities and chemical changes can not be tolerated within the product. Heretofore, there have been various attempts to reduce or eliminate surface turbulence within a continuous caster tundish to improve the quality of the finished steel product. These attempts have included a wide assortment of dams and weirs which redirect the ladle stream fluid flow away from the surface of the bath. One such attempt, comprising wall dams extending along the tundish sidewalls near the surface of the liquid steel bath, is disclosed in Applicant's prior U.S. Pat. No. 4,715,586 granted Dec. 29, 1987. Although many past fluid flow control devices have been somewhat successful in controlling fluid flow and reducing surface turbulence, they tend to cause operational problems. Caster operators have found that wall dams are difficult and expensive to install and maintain. The operators have also discovered, that because of their location within the tundish, and because of their high profiles, the past flow control devices interfere with tundish deskulling apparatus, and are damaged, or destroyed during the deskulling operations.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a fluid flow control device for reducing surface turbulence in the vicinity of the ladle shroud in a continuous caster tundish.

It is a further object of this invention to provide a fluid flow control device to prevent breakup of the tundish flux cover, and reoxidation of the liquid steel bath.

It is a further object of this invention to provide a fluid flow control device to prevent slag entrainment within the liquid steel bath.

It is a further object of this invention to provide a fluid flow control device for receiving and reversing the direction of the radiating fluid flow generated by an incoming ladle stream.

It is a further object of this invention to provide a fluid flow control device which is easily installed in the flat bottom portion of a continuous caster tundish.

It is still a further object of this invention to provide a fluid flow control device which can be easily replaced during refurbishing of the tundish.

We have discovered that the foregoing objects can be attained with an impact pad having a base for receiving an incoming ladle stream, and one or more sidewalls extending in an upward direction along the periphery of the base. Each upward extending sidewall includes an inner surface having an undercut portion facing the incoming ladle stream. Each undercut portion extends along the length of the inner surface, and each undercut portion comprises a shaped surface for receiving and reversing the direction of a fluid flow generated by the incoming ladle stream.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-section view of a water flow-model study tundish having an asymmetrical fluid flow pattern.

FIG. 2 is a transverse cross-section view taken along the lines 2—2 of FIG. 1.

FIG. 3a is a plan view showing the preferred embodiment of the impact pad invention for use in a tundish having an asymmetrical ladle stream fluid flow pattern.

FIG. 3b is a front perspective view taken along the line 3b—3b of FIG. 3a.

FIG. 4 is a longitudinal cross-section view through a single strand caster tundish showing the preferred embodiment of the impact pad invention.

FIG. 5 is a longitudinal cross-section view through a multiple strand "T" shaped tundish showing the preferred embodiment of the impact pad invention.

FIG. 6a is a plan view showing an alternate embodiment of the impact pad invention for use in a tundish having an asymmetrical fluid flow pattern.

FIG. 6b is a perspective view taken along the line 6b—6b of FIG. 6a.

FIG. 7 is a longitudinal cross-section view through the end wall portion of a tundish showing the alternate embodiment of the impact pad invention for use in a tundish having an asymmetrical fluid flow pattern.

FIG. 8 is a longitudinal cross-section view through the end wall portion of a tundish showing a second alternate

embodiment of the impact pad invention for use in a tundish having an asymmetrical fluid flow pattern.

FIG. 9 is a front perspective view showing the preferred embodiment of the impact pad invention for use in a tundish having a symmetrical ladle stream fluid flow pattern.

FIG. 10 is a longitudinal cross-section view through a multiple strand caster tundish showing the preferred impact pad invention for use with a symmetrical fluid flow pattern.

FIG. 11 is a transverse cross-section view taken along the lines 11—11 of FIG. 10.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The overall geometry of a continuous caster tundish is dictated by the location and number of strands within the casting machine. A rectangular, or a "Bathtub" shaped tundish, is customarily used with a single strand caster, and a trough shaped tundish is generally used for a multiple strand caster. Likewise, the location of the well blocks, and the tundish impact pad, is also determined by the casting machine design.

Referring to FIG. 4 of the drawings, a tundish 11a for a single strand caster, is shown having a well block 12 at one end of the tundish, and an impact pad 13 positioned adjacent to the end wall 3 at the end opposite the well block. This tundish arrangement produces an asymmetrical fluid flow 9a within the reservoir of liquid steel 5.

FIGS. 10 and 11 illustrate a tundish 11c for a multiple strand caster. The tundish well blocks 12 are spaced apart along the length of the tundish floor 4, and the tundish impact pad 16 is located between adjacent well blocks 12. This tundish arrangement produces a symmetrical fluid flow shown at 9b.

A variation of the multiple strand tundish comprises a "T" shaped reservoir shown as 11b in FIG. 5. Tundish 11b is comprised of two trough shaped reservoirs arranged perpendicular to each other. One end of the first trough shaped reservoir A, intersects the second reservoir B. The opposite end portion of reservoir A includes an impact pad 13 adjacent end wall 3. In this tundish arrangement, the incoming ladle stream generates an asymmetrical fluid flow 9a, similar to the fluid flow shown in FIG. 4.

Referring to FIGS. 1 and 2, water flow-model studies have shown that the fluid flow, generated by an incoming ladle stream, is reflected from the flat tundish floor 4 in an upward direction toward the surface of the liquid steel. If this fluid flow is restricted by the tundish walls, the restricted fluid flow is forced upward along the surface of such walls, and the resulting upward surge causes a boiling wave motion at the surface of the steel bath.

FIG. 1 illustrates a single strand tundish 11a having an asymmetrical fluid flow 9a. The ladle shroud 7 is shown adjacent end wall 3 opposite the well block 12. End wall 3 obstructs the fluid flow 9a, and the restricted forces cause an upward fluid flow surge along end wall 3. This upward flow follows a circular path 9c, and comprises an upward surge along the face of wall 3, and a downward flow around the ladle shroud 7. The upward surge of circular flow 9c causes excessive turbulence at the surface of the bath, breaks up a protective flux or slag cover 6, and exposes the liquid steel to the outside atmosphere, thereby creating conditions for possible uncontrolled chemical changes within the liquid steel bath. The downward flow around the ladle shroud generates shear and vortices and pulls broken particles 10, from the flux cover 6, down into the liquid steel bath, creating inclusions within the finished steel product.

As shown in FIG. 2, water flow-model studies have also shown that the sidewalls 2 of tundish 11a also restrict the fluid flow generated by the ladle stream. The restrictive sidewalls 2 cause similar circular fluid flows 9e which further intensify surface turbulence and break up of the protective flux cover 6.

Referring to FIGS. 3a through 5 of the drawings, an impact pad 13, for use in a tundish having an asymmetrical fluid flow 9a, is shown located adjacent the end wall 3 of a tundish and positioned below the ladle shroud 7. The impact pad, which is a refractory shape, includes a base 17 having an erosion resistant top surface for receiving the incoming ladle stream 8. Impact pad 13 further includes a sidewall 18 extending in an upward direction along the periphery of base 17. Sidewall 18 partially encircles the incoming ladle stream 8 providing an open side 23 along one edge of the impact pad adjacent well blocks 12.

Sidewall 18 includes an inclined outer surface 19 contiguous with the tundish walls, a top surface 20 having a semi-circular or "C" shaped, serpentine edge partially encircling the ladle stream 8, and an inner surface 21 facing the incoming ladle stream. Sidewall 18 further includes a curvilinear undercut portion 22 having a shaped surface capable of reversing the direction of the fluid flow 9a. Undercut 22 extends along the length of the inner surface 21 below top surface 20, and undercut 22 has one end tangent to top surface 17 of base 17. In order to achieve effective control over the fluid flow generated by the incoming ladle stream, the height "H", of the curvilinear undercut, is ≧ the inside diameter of the shroud delivering the liquid steel into the tundish.

As shown in FIGS. 4 and 5, the incoming ladle stream 8 falls onto the base top surface 17', generates a radial asymmetrical fluid flow 9a, and emanates toward the impact pad sidewall 18. The curvilinear undercut 22, extending along the inside surface 21 of sidewall 18, captures the fluid flow within its shaped surface, and forces the fluid flow into a reversed direction back toward the incoming ladle stream. The reversed fluid flow forms an eddy current 9d, which is gradually disbursed along the open side 23, toward the well blocks 12 at the opposite end of the tundish.

FIGS. 6a, 6b and 7, disclose an alternate impact pad embodiment for use in a tundish having an asymmetrical fluid flow 9a. The alternate impact pad 14 is shown adjacent a tundish end wall 3, and positioned below the ladle shroud 7 to receive the incoming ladle stream 8. The alternate impact pad embodiment comprises a refractory shape having a base 24, and a sidewall 25 extending in an upward direction along the periphery of base 24. Sidewall 25 partially encircles the incoming ladle stream 8 to provide an open side 26 along the edge of the impact pad adjacent well blocks 12.

The impact pad sidewall 25 includes an inclined outer surface 27 contiguous with the tundish walls, a top surface 28 having a "C" shaped, serpentine edge partially encircling the ladle stream 8, and an inner surface 29 facing the incoming ladle stream. The inner surface 29, of sidewall 25, is sloped at an angle θ in a downward direction from the serpentine edge, of top surface 28, toward the inclined outer surface 27 to provide a planar undercut 30. Angle θ is between 45° and 75°, and the planar undercut portion 30 extends along the length of the inner surface 29 below top surface 28. In order to achieve effective control over the fluid flow generated by the incoming ladle stream, the height "H", of the planar undercut, is ≧ the inside diameter of the shroud delivering the liquid steel into the tundish.

As shown in FIG. 7, planar undercut 30, extending along the inside surface 29 of sidewall 25, captures the fluid flow within its shaped surface, and forces the fluid flow into a reversed direction back toward the incoming ladle stream. The reversed fluid flow forms an eddy current 9d, which is gradually disbursed along the open side 26, toward the well blocks 12 at the opposite end of the tundish.

A second alternate embodiment of the impact pad invention for use in a tundish having an asymmetrical fluid flow 9a, is shown as 15 in FIG. 8. Impact pad 15 is positioned adjacent tundish end wall 3 and below ladle shroud 7 to receive the incoming ladle stream 8. Impact pad 15 comprises a base having a top surface 31 sloped in a downward direction from the tundish end wall 3 toward the tundish floor 4. Impact pad 15 further includes a pad sidewall 32 extending in an upward direction along the periphery of the base. Sidewall 32 partially encircles the incoming ladle stream 8, and includes an inner surface having a planar undercut surface 33 similar to undercut 30, sloped in a downward direction at angle θ between 45° and 75°.

FIGS. 9–11 illustrate the preferred embodiment of the impact pad invention for use in a continuous casting tundish having a symmetrical ladle stream fluid flow 9b. Impact pad 16 comprises a base 34 having an erosion resistant top surface 34', sidewalls 35 and 36 extending along opposite edges of base 34, and two open ends 41 located between the opposed pad sidewalls 35 and 36. Pad sidewalls 35 and 36 extend in an upward direction from their respective opposite base edge portions, and each pad sidewall, 35 and 36, includes an inclined outer surface 37 contiguous with a tundish wall, a top surface 38, and an inner surface 39 facing the incoming ladle stream. Each pad sidewall 35 and 36 further includes a curvilinear undercut portion 40 having a shaped surface capable of reversing the direction of the fluid flow 9d generated by the incoming ladle stream 8. Each undercut 40 extends along the length of inner surface 39 below top surface 38, and each undercut 40 has one end tangent to top surface 34' of base 34.

As shown in FIGS. 10 and 11 of the drawings, the inclined outer surface 37 of sidewalls 35 and 36 are positioned adjacent the tundish sidewalls 2. The incoming ladle stream 8 falls onto the base top surface 34', generates a radial symmetrical fluid flow, and emanates toward the impact pad sidewalls 35 and 36. The curvilinear undercut 40, extending along each inside surface 39 of sidewalls 35 and 36, captures the fluid flow within their shaped surface, and forces the fluid flow into a reversed direction back toward the incoming ladle stream. The reversed fluid flow forms eddy currents 9d, which are gradually disbursed along the open ends 41, toward the well blocks 12 spaced apart along the length of the tundish floor.

Although impact pad 16 has been shown to comprise a curvilinear undercut 40, it should be understood that the undercut portion could just as well comprise a sloped planar undercut as disclosed in FIGS. 6a–8.

And, although FIG. 10 shows only two well blocks, it should be understood that a casting machine for casting more than two continuous strands would require more than two well blocks spaced apart along the length of the tundish floor.

While this invention has been illustrated and described in accordance with a preferred embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

We claim:

1. An impact pad for reversing the direction of a fluid flow generated by an incoming liquid stream, said impact pad

comprising: a base having a surface against which said liquid stream impacts, a peripheral top surface to expose said base, and a sidewall extending in an upward direction along the periphery of said base, said sidewall extending between said base and said peripheral top surface and including;

a) a first end, a second end remote from said first end, and

b) an inner surface including an undercut extending continuously below said peripheral top surface.

2. The invention described in claim 1 wherein said sidewall extends along three sides of said base periphery.

3. The invention described in claim 1 wherein said peripheral top surface comprises a "C" shaped configuration.

4. The invention described in claim 1 wherein said undercut is a curvilinear surface.

5. The invention described in claim 4 wherein said curvilinear surface comprises a first arcuate surface below said peripheral top surface, a second arcuate surface tangent to said base surface against which said liquid strum impacts, and a transitional surface extending between said first arcuate surface and said second arcuate surface.

6. The invention described in claim 1 wherein said undercut is a planar surface below said peripheral top surface, said planar surface being sloped at an angle θ of between 45° and 75°.

7. An impact pad for reversing the direction of a fluid flow generated by an incoming liquid stream, said impact pad comprising: a base having a surface against which said liquid stream impacts, a first sidewall extending in an upward direction along a first edge of said base, and a second sidewall extending in an upward direction along a second edge of said base, said first sidewall and said second sidewall being opposite hand, and said first and said second sidewall each including;

a) a first end, a second end remote from said first end, and a top surface, and

b) an inner surface including an undercut extending continuously below said top surface, said undercut including a curvilinear surface having a first arcuate surface below said top surface, a second arcuate surface tangent to said base surface against which said liquid stream impacts, and a transitional surface extending between said first and said second arcuate surfaces.

8. An impact pad for reversing the direction of a fluid flow generated by an incoming liquid stream, said impact pad comprising: a base having a surface against which said liquid stream impacts, a first sidewall extending in an upward direction along a first edge of said base, and a second sidewall extending in an upward direction along a second edge of said base, said first sidewall and said second sidewall being opposite hand, and said first and said second sidewall each including;

a) a first end, a second end remote from said first end, and a top surface, and

b) an inner surface including an undercut extending continuously below said top surface, said undercut being a planar surface sloped at an angle θ of between 45° and 75°.

9. In a continuous caster tundish for containing a reservoir of molten metal having an asymmetrical fluid flow generated by an incoming ladle stream, the tundish including first end wall, a second end wall, sidewalls and a floor, said floor having one or more well blocks located near said first end wall, and said floor including a ladle stream impact area positioned proximate said second end wall, wherein the improvement comprises an impact pad for reversing the

direction of said fluid flow generated by said incoming ladle stream comprising: a base having a surface against which said liquid stream impacts, a peripheral top surface to expose said base, and a sidewall extending in an upward direction along the periphery of said base, said sidewall extending between said base and said peripheral top surface and including;

a) a first end, a second end remote from said first end, and

b) an inner surface including an undercut extending continuously below said peripheral top surface.

10. The invention described in claim 9 wherein said sidewall extends along three sides of said base periphery.

11. The invention described in claim 9 wherein said peripheral top surface comprises a "C" shaped configuration.

12. The invention described in claim 9 wherein said first end and said second end remote from said first end provide a fluid flow outlet, said outlet being located along said base portion adjacent the well blocks of the tundish.

13. The invention described in claim 9 wherein said undercut is a curvilinear surface.

14. The invention described in claim 13 wherein said curvilinear surface comprises a first arcuate surface below said peripheral top surface, a second arcuate surface remote from said first arcuate surface and tangent to said base surface against which said liquid stream impacts, and a transitional surface extending between said first arcuate surface and said second arcuate surface.

15. The invention described in claim 14 wherein a height "H" of said curvilinear surface is ≧ the inside diameter of said tubular ladle shroud.

16. The invention described in claim 9 wherein said undercut is a planar surface below said peripheral top surface, said planar surface being sloped at an angle θ of between 45° and 75°.

17. The invention described in claim 16 wherein a height "H" of said planar surface is ≧ the inside diameter of said tubular ladle shroud.

18. The invention described in claim 16 wherein said base surface against which said liquid stream impacts is sloped in a downward direction from said second tundish end wall toward said tundish floor.

19. In a continuous caster tundish for containing a reservoir of molten metal having a symmetrical fluid flow generated by an incoming ladle stream, the tundish including a first sidewall, a second sidewall, end walls and a floor, said floor having two or more well blocks spaced along the length thereof, and said floor including a ladle stream impact area positioned between adjacent well blocks, wherein the improvement comprises an impact pad for reversing the direction of said fluid flow generated by said incoming ladle stream comprising: a base having a surface against which said liquid stream impacts, a first sidewall extending in an upward direction along a first edge of said base, and a second sidewall extending in an upward direction along a second edge of said base, said first sidewall and said second sidewall being opposite hand, and said first and said second sidewall each including;

a) a first end, a second end remote from said first end, and a top surface, and

b) an inner surface including an undercut extending continuously below said top surface, said undercut including a curvilinear surface having a first arcuate surface below said top surface, a second arcuate surface tangent to said base surface against which said liquid stream impacts, and a transitional surface extending between said first and said second arcuate surfaces.

20. The invention described in claim 19 wherein a height "H" of said curvilinear undercut is ≧ the inside diameter of said ladle shroud.

21. In a continuous caster tundish for containing a reservoir of molten metal having a symmetrical fluid flow generated by an incoming ladle stream, the tundish including a first sidewall, a second sidewall, end walls and a floor, said floor having two or more well blocks spaced along the length thereof, and said floor including a ladle stream impact area positioned between adjacent well blocks, wherein the improvement comprises an impact pad for reversing the direction of said fluid flow generated by said incoming ladle stream comprising: a base having a surface against which said liquid stream impacts, a first sidewall extending in an upward direction along a first edge of said base, and a second sidewall extending in an upward direction along a second edge of said base, said first sidewall and said second sidewall being opposite hand, and said first and said second sidewall each including;

a) a first end, a second end remote from said first end, and a top surface, and

b) an inner surface including an undercut extending continuously below said top surface, said undercut being a planar surface sloped at an angle θ of between 45° and 75°.

22. The invention described in claim 20 wherein a height "H" of said curvilinear undercut is ≧ the inside diameter of said ladle shroud.

23. An impact pad, comprising: a base having a surface against which an incoming ladle stream impacts and upon which the fluid thereof flows, a peripheral top surface to expose said base, and a side wall extending in an upward direction along the periphery of said base, said side wall extending between said base and said peripheral top surface and including an inner surface having an undercut extending continuously below said peripheral top surface so that the fluid flow of the ladle stream is forced into a reversed direction back toward the incoming ladle stream.

24. The invention described in claim 23 wherein said undercut is a curvilinear surface.

25. The invention described in claim 24 wherein said curvilinear surface comprises a first arcuate surface below said peripheral top surface, a second arcuate surface remote from said first arcuate surface and tangent to said base surface against which said incoming ladle stream impacts, and a transitional surface extending between said first arcuate surface and said second arcuate surface.

26. The invention described in claim 23 wherein said undercut is a planar surface below said peripheral top surface, said planar surface being sloped at an angle ϕ of between 45° and 75°.

27. In a continuous caster tundish for containing a reservoir of molten metal having fluid flow generated by an incoming ladle stream, the tundish including a first end wall, a second end wall, sidewalls, and a floor, said floor including at least one well block for discharging molten metal from the continuous caster tundish, and the floor including an impact area to receive the incoming ladle stream, the impact area positioned proximate a shroud introducing the incoming ladle stream, wherein the improvement comprises an impact pad located in the impact area for reversing the direction of the fluid flow generated by the incoming ladle stream comprising: a base having a surface against which the incoming ladle stream impacts, a peripheral top surface to expose said base, and a sidewall extending in an upward direction along the periphery of said base, said sidewall extending between said base and said peripheral top surface

and including an inner surface having an undercut extending continuously below said peripheral top surface so that fluid flow of the ladle stream is forced into a reversed direction back toward the incoming ladle stream.

28. The invention described in claim 27 wherein said undercut is a curvilinear surface.

29. The invention described in claim 28 wherein said curvilinear surface comprises a first arcuate surface below said peripheral top surface, a second arcuate surface remote from said fast arcuate surface and tangent to said base surface against which said incoming ladle stream impacts, and a transitional surface extending between said first arcuate surface and said second arcuate surface.

30. The invention described in claim 29 wherein said shroud is tubular and the height "H" of said curvilinear surface is $\geqq$ the inside diameter of said shroud.

31. The invention described in claim 27 wherein said undercut is a planar surface below said peripheral top surface, said planar surface being sloped at an angle ϕ of between 45° and 75°.

32. The invention described in claim 31 wherein said shroud is tubular and the height "H" of said planar surface is $\geqq$ the inside diameter of said shroud.

33. The invention described in claim 31 wherein said base surface against which said incoming ladle stream impacts is sloped in a downward direction from a tundish end wall toward said tundish floor.

34. An impact pad for reversing the direction of fluid flow generated by an incoming ladle stream, said impact pad comprising: a base having a surface against which an incoming ladle stream impacts, a peripheral top surface to expose said base, and a sidewall extending in an upward direction along the periphery of said base, said sidewall extending between said base and said peripheral top surface and including an inner surface having an undercut for receiving and reversing the direction of a fluid flow generated by the incoming ladle stream.

35. The impact pad of claim 34, wherein:

a) said undercut is arcuate.

36. The impact pad of claim 34, wherein:

a) said undercut is planar.

37. The impact pad of claim 34, wherein:

a) said sidewall extends partially about said base.

38. The impact pad of claim 37, wherein:

a) said sidewall has first and second remote ends forming therebetween an opening through which the fluid flow may flow.

39. The impact pad of claims 35 or 36, wherein:

a) said undercut extends along the length of said inner surface.

40. The impact pad of claim 34, wherein:

a) said peripheral top surface is C-shaped in plan.

41. The impact pad of claim 34, wherein:

a) said base is rectangular in plan, and

b) there are two sidewalls, each sidewall extending along an edge of said base and said sidewalls extending in parallel.

42. An impact pad for reversing the direction of a fluid flow generated by an incoming ladle stream, said impact pad comprising: a base having a surface against which an incoming ladle stream impacts, a peripheral top surface to expose said base, and a sidewall extending from said base in an upward direction, said sidewall extending between said base and said peripheral top surface and including an inner surface having an undercut extending below said peripheral top surface for receiving and reversing the direction of a fluid flow generated by the incoming ladle stream.

43. The impact pad of claim 42, wherein:

a) said undercut is arcuate.

44. The impact pad of claim 42, wherein:

a) said undercut is planar.

45. The impact pad of claims 43 or 44, wherein:

a) said undercut extends along the length of said inner surface.

46. The impact pad of claim 45, wherein:

a) said sidewall extends partially about said base.

47. The impact pad of claim 46, wherein:

a) said sidewall is peripherally disposed about said base.

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United States Patent [19]

Saylor

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[45] Date of Patent: Oct. 25, 1994

[54] TURBULENCE INHIBITING TUNDISH AND IMPACT PAD AND METHOD OF USING

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[21] Appl. No.: 153,662

[22] Filed: Nov. 16, 1993

[51] Int. Cl.[5] C21B 7/14

[52] U.S. Cl. 75/584; 164/437; 222/594; 266/275

[58] Field of Search 266/275, 227, 287; 164/437; 222/594; 75/584

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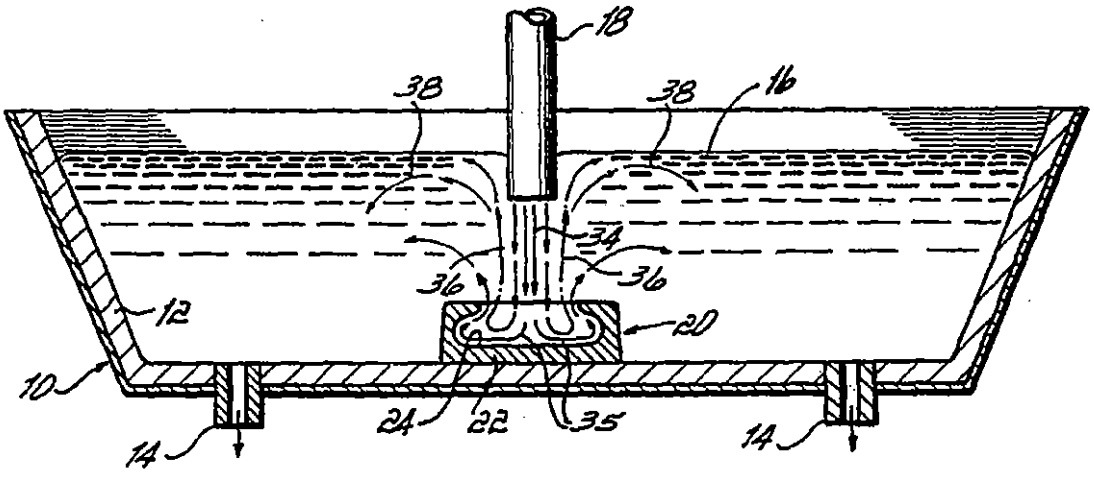
Primary Examiner—Melvyn J. Andrews
Attorney, Agent, or Firm—Wood, Herron & Evans

[57] ABSTRACT

A tundish and, more specifically, an impact pad is formed with a bottom impact surface and includes an outer side wall extending upwardly therefrom which fully encloses an interior space or cavity having an upper opening into which molten metal is directed from a ladle shroud. The outer side wall of the pad includes an inner surface extending from the bottom impact surface to the opening of the pad. The inner side wall surface includes an annular portion which extends inwardly and upwardly toward the opening of the pad. In the preferred embodiment, the inner side wall surface curves continuously from the bottom impact surface to a vertical wall defining the opening of the pad. The pad redirects the pouring stream back into itself causing the counter current flows to slow each other down thereby minimizing turbulence and inhibiting high velocity flow within the tundish. The upward flow is further is advantageously directed away from the incoming pouring stream toward the surface of the bath.

21 Claims, 2 Drawing Sheets



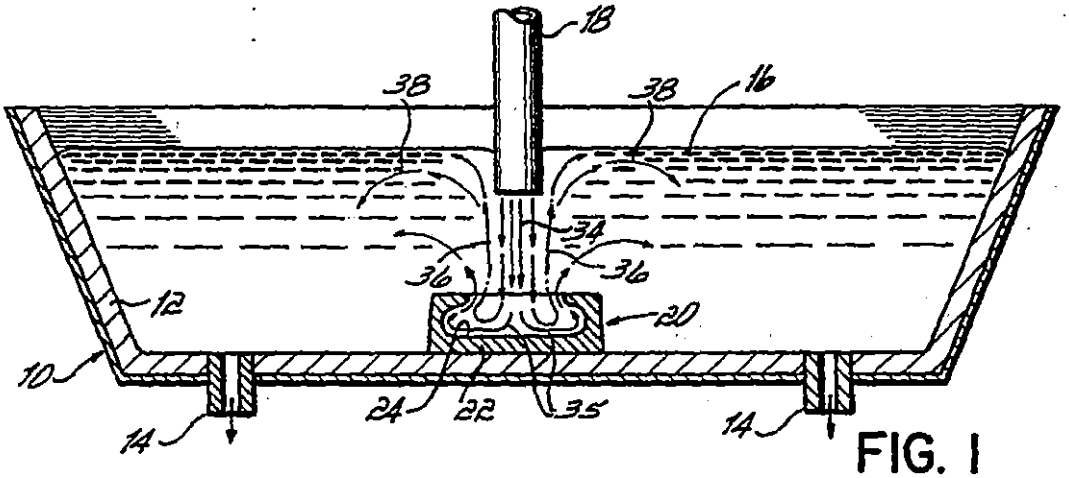


FIG. 1

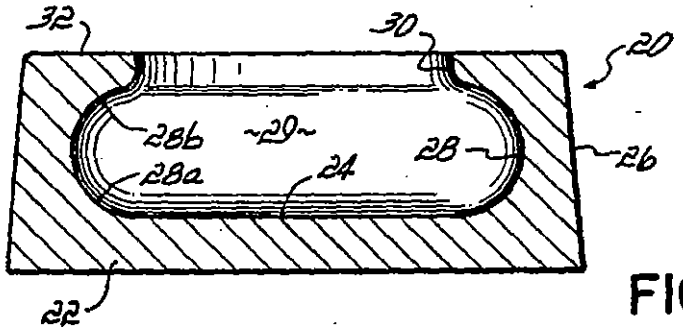


FIG. 2

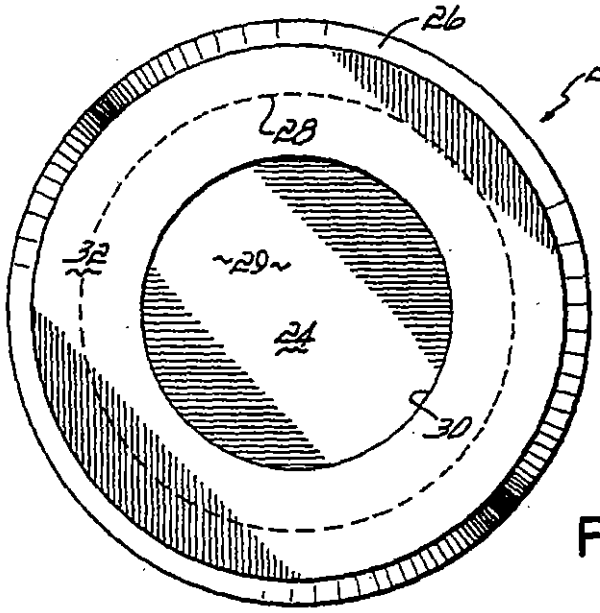


FIG. 3

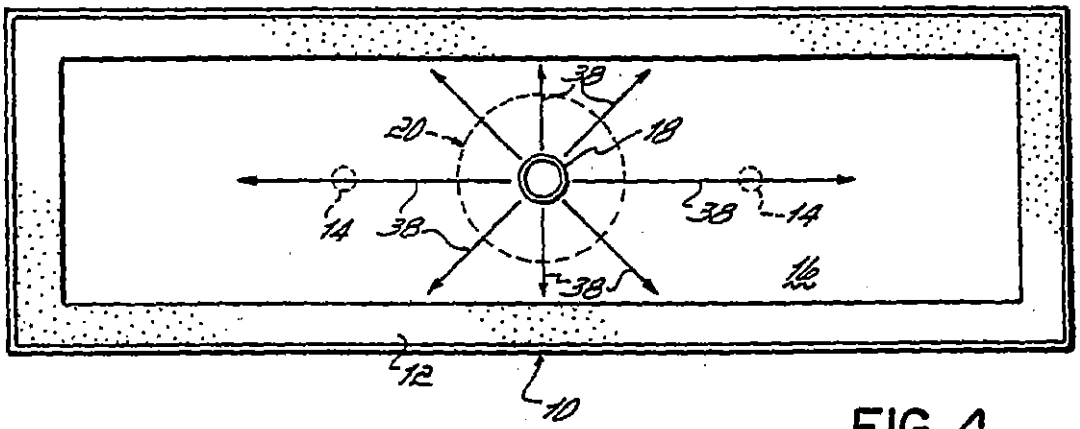


FIG. 4

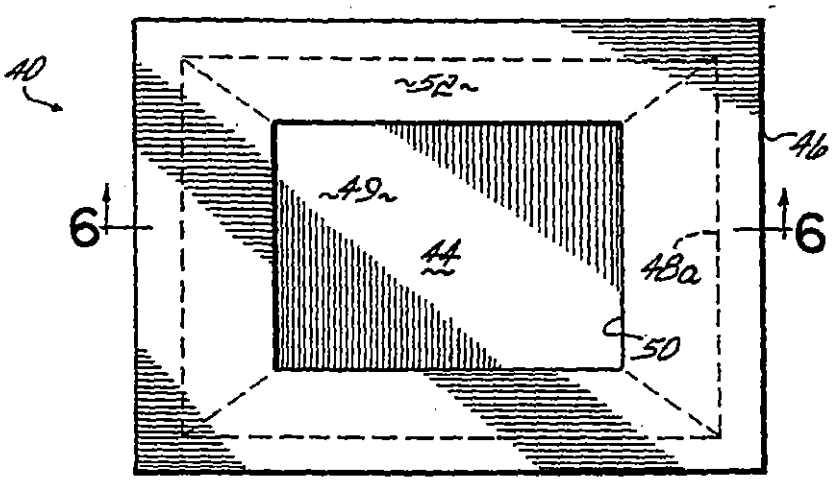


FIG.5

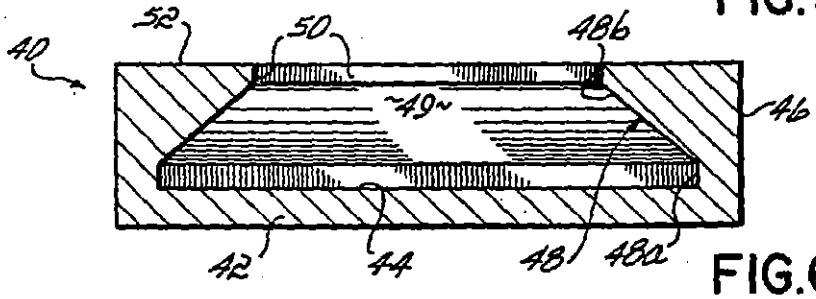


FIG.6

TURBULENCE INHIBITING TUNDISH AND IMPACT PAD AND METHOD OF USING

BACKGROUND OF THE INVENTION

The present invention generally relates to tundish vessels and, more particularly, to tundish impact pads designed to inhibit turbulent flow of molten metal within the tundish.

Tundishes are used to hold a quantity or bath of molten metal, such as molten iron or steel, delivered from a ladle through a ladle shroud. A tundish is disposed between the ladle and the casting apparatus or mold which receives the molten metal and forms various shaped products therefrom. The ladle is positioned several feet above the tundish and a ladle shroud, in the form of a long tube, leads from the ladle into the tundish. The ladle shroud delivers the molten metal to the tundish in a tight, compact stream. This incoming stream of molten metal can, for example, have kinetic energy ranging from 2 to 10 Watts/ton.

Pouring pads placed within tundishes have been widely used to prevent damage to the working and safety linings of a tundish by the force of the incoming stream of molten metal. The kinetic energy of the incoming stream of molten metal also creates turbulence which can spread throughout the tundish if the flow of molten metal is not properly controlled. Many times, this turbulence has a detrimental effect on the quality of cast products formed from metal taken from the tundish. More specifically, turbulent flow and high velocity flow within the tundish can, for example, have the following harmful effects:

1. Excessive turbulence can disturb the steel surface and promote emulsification of the slag at ladle changes or during operation of the tundish with a relatively low level of molten metal.

2. High velocities produced by turbulent flow in the pouring area can cause erosion of the working lining of the tundish which is typically comprised of a refractory material having a much lower density than impact pads.

3. Highly turbulent flow within the tundish can impede the separation of inclusions, especially inclusions less than 50 microns in size, due to the fluctuating nature of such turbulent flows.

4. High speed flows may also increase the possibility of slag being directed into a mold through increased vortexing of the molten metal in the tundish which draws slag downwardly toward the outlet.

5. Turbulent flow within the tundish may result in disturbance of the slag/metal interface near the top of the metal bath and thereby promote slag entrainment as well as the possibility of opening up an "eye" or space within the slag layer which can be a source of reoxidation of the molten metal.

6. High levels of turbulence in the tundish can be carried down into the pouring stream between the tundish and the mold. This can cause "bugging" and "flaring" of the pouring stream which thereby lead to casting difficulties.

7. High velocity flow in the tundish has also been attributed to a condition known as "short circuiting". Short circuiting refers to the short path a stream of molten metal may take from the ladle to the impact pad to the nearest outlet in the tundish. This is undesirable since it reduces the amount of time inclusions have to be dissipated within the bath. Instead, the high velocity flow sweeps relatively large inclusions down into the mold where they reduce the quality of the cast products.

A typical flat impact pad causes an incoming ladle stream to impact the top of the pad and travel quickly to the side or end walls of the tundish. When the stream reaches the side and/or end walls, it rebounds upward to the surface of the tundish where it changes direction toward the center of the tundish or, in other words, toward the incoming ladle stream. This creates undesirable inwardly directed circular flows in the tundish. The opposing flows on either side or end of the tundish travel toward the center of the tundish and carry with them slag or other impurities that have floated to the surface of the bath within the tundish. As a result, these impurities are drawn toward the incoming ladle stream and are then forced downwardly into the bath and toward the outlet or outlets of the tundish. This tends to cause more of these impurities to exit the tundish into the molds thereby decreasing the quality of the products produced within the molds.

While numerous other types of tundish pads have been proposed and used in the past, none of these fully address all of the problems noted above. Examples of prior tundish pads are disclosed in U.S. Pat. Nos. 5,131,635 and 5,133,535 both issued to Soofi and U.S. Pat. No. 5,169,591 to Schmidt et al. The tundish pads disclosed in the above patents to Soofi and Schmidt et al., however, are inadequate solutions to the above-mentioned problems at least because of the fact that they each direct the incoming ladle stream too directly toward the drain or drains of the tundish. Also, these pads do not slow the incoming ladle stream enough to completely address the problems associated with high velocity flows as mentioned above. In this regard, since each of these patents disclose impact pads which direct the incoming stream in either one or two lateral directions toward the drain or drains of the tundish, the speed of the ladle stream is not reduced enough to prevent many of the problems mentioned above. Moreover, directing the ladle stream toward the drain or drains of the tundish, as taught by these patents, leads to the previously explained problems of "bugging", "flaring" and "short circuiting".

SUMMARY OF THE INVENTION

The present invention provides a turbulence inhibiting tundish impact pad formed with a bottom impact surface and including an endless annular side wall extending upwardly therefrom and fully enclosing an interior space or cavity having an upper opening into which the molten metal is directed from a ladle shroud. The endless annular side wall of the pad includes an annular inner surface having at least a portion extending upwardly with respect to the bottom impact surface and inwardly toward the opening of the pad. The endless annular side wall fully encloses the interior space of the pad such that the incoming stream of metal is redirected back into itself and a flow pattern is created which directs the reversed flow of metal away from the ladle shroud.

In the first embodiment the pad is circularly shaped as viewed from the top as is the inner surface of the annular side wall. The inner surface of the side wall is concavely curved first outwardly and upwardly from the bottom impact surface and then inwardly and upwardly to a vertically disposed surface which defines the opening of the pad. The inner side wall surface preferably

curves continuously from the bottom impact surface to the vertical wall defining the opening of the pad.

In a second embodiment of this invention the impact pad is formed with a rectangular shape while still retaining the feature of having a fully enclosed interior space defined by an endless annular side wall. In this regard, the term "annular" as used throughout the specification and claims is not meant to denote any particular shape but is meant to indicate a fully enclosing, endless boundary structure. In the second embodiment the inner side wall surface includes at least a portion which extends upwardly and inwardly toward a central opening in the top of the impact pad. The same desirable flow pattern is created within a tundish using a pad constructed according to either the first or second embodiments of the invention.

The tundish pouring pads of the present invention not only withstand the impact of the incoming ladle strain but also dampens the associated turbulence usually created by the stream. To this end, and in solving the previously mentioned problems in the prior art, a pad constructed in accordance with the present invention redirects the pouring stream back into itself causing the counter current flows to slow each other down thereby minimizing turbulence and inhibiting high velocity flow within the tundish. The fully enclosed cavity of the pad changes the path of the incoming stream from vertically downwards to vertically upwards. The flow pattern created by the pad forms a path of molten metal which travels slowly upwards toward the surface of the metal bath and then radially outwardly in all directions toward the walls of the tundish. This is not only a favorable flow condition for flotation of impurities but also contributes to temperature homogeneity in the tundish. Most importantly, it minimizes the harmful effects of excessive turbulence and high flow velocities within the tundish.

The turbulence inhibiting pads of the present invention provide a much more advantageous flow pattern than the prior pads mentioned above which direct the incoming ladle stream to one or more sides or ends of the tundish immediately upon impact. In this regard, using a pad of the present invention, the incoming ladle stream is reversed by the pad and travels vertically upwardly and then radially outwardly near the top of the bath. This pushes slag or other impurities away from the incoming ladle stream. For this reason and for the reason that the resulting flow is much slower than the flow created with past impact pads, less slag or other impurities and inclusions are entrained within the bath. A tundish pad of the present invention is especially advantageous during start-up, while changing grades of steel within the tundish, or when casting at low tundish levels.

It will therefore be appreciated that numerous advantages are presented by the tundish impact pad of the present invention. These advantages include the following:

1. The incoming ladle stream is contained and dampened to cause a slower flow of molten metal in the tundish for effectively allowing inclusions to float to the top surface of the molten metal bath.

2. The resulting flow patterns push slag and other impurities away from the incoming ladle stream thus preventing entrainment of these undesirable materials within the bath.

3. Surface directed flow of the molten metal is promoted and therefore inclusions or impurities must rise only a short distance before contacting the slag layer and becoming absorbed therein.

4. Erosion of the working lining on the side and end walls of the tundish is reduced as the incoming flow will not directly impact on these walls.

5. The amount of time that the molten metal remains in the tundish is increased since the path to the exit or exits of the tundish will be longer and more tortuous than with past impact pads.

6. As high velocity flows in the tundish will be minimized, the possibility of vortexing, which causes slag and inclusions to be drawn from the surface of the tundish down into the mold, will be reduced.

7. A much quieter metal surface is produced with less movement of the slag layer during steady state operation.

8. The unique flow pattern created by the pad promotes temperature homogeneity within the bath by creating full, slow circulation of molten metal throughout the tundish.

9. Splashing during start-up is significantly reduced.

10. The residence time for the metal within the bath is increased or, in other words, the time it takes for incoming metal to exit the bath into the mold or molds is increased. Impurities which, given sufficient time, will naturally float slowly to the top of the bath, are less likely to be included in the exiting stream as residence time is increased.

Further advantages of the present invention will become more readily apparent to those of ordinary skill upon review of the following detailed description of the preferred embodiment taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side cross-sectional view of a tundish including the turbulence inhibiting impact pad of the present invention disposed on the bottom surface thereof;

FIG. 2 is an enlarged cross-sectional view of the impact pad of FIG. 1;

FIG. 3 is an enlarged top view of the impact pad of the present invention;

FIG. 4 is a top view of the tundish of FIG. 1 showing the radial outward flow pattern created proximate the top of the molten metal bath in the tundish by the impact pad of the present invention;

FIG. 5 is a top view of an alternative embodiment of the tundish impact pad of the invention; and,

FIG. 6 is a side cross sectional view of the tundish impact pad of FIG. 5 taken along line 6—6.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, a conventional tundish 10 is shown and includes an inner lining 12 and a pair of well blocks or outlets 14 for allowing molten metal from a bath 16 contained in the tundish 10 to continuously exit the tundish 10 and enter molds (not shown) which form metal castings. As is also conventional, a ladle shroud 18 is positioned above the tundish 10 and continuously directs a stream of molten metal into the tundish 10. A tundish impact pad 20 constructed according to the present invention is placed centrally on the floor of the tundish 10.

As best illustrated in FIGS. 2 and 3, the tundish impact pad 20 is preferably circular in shape and includes a base 22 having a planar impact surface 24. The pad 20

further includes an endless, preferably circular outer side wall 26 having a correspondingly circular shaped inner wall surface 28. The annular inner wall surface is concavely shaped as shown in FIG. 2 and extends upwardly from the planar impact surface 24 to fully enclose a curved interior space or cavity 29. One annular portion 28*a* of the inner side wall surface 28 curves concavely outwardly and upwardly from the impact surface 24 and meets another annular portion 28*b* which curves concavely inwardly and upwardly to a vertical inner wall surface 30. The concave shape of the inner side wall surface 28 helps to reduce erosion of the pad 20. However, rather than forming one continuous curve as shown in FIG. 2, surface portions 28*a* and 28*b* may alternatively be separated by a flat surface portion. Also, one or both of the annular surface portions 28*a* and 28*b* may also be flat and angled outwardly and inwardly, respectively, instead of curved. Satisfactory operation of the pad 20 may also be obtained even when portion 28*a* is eliminated, i.e., such that portion 28*b* extends upwardly and inwardly from surface 24. Each of these alternative designs still includes an annular side wall inner surface portion extending inwardly and upwardly toward the opening 30 to create the desired flow pattern described herein. Vertical surface 30 defines a circular opening in the impact pad 20 for receiving the stream of molten metal from the ladle shroud 18 and for allowing the metal to exit the cavity 29 in an upward direction. The tundish impact pad 20 further includes a planar peripheral top surface 32 which surrounds the opening created by the vertically oriented circular surface 30.

The effect of using the tundish pad 20 of the present invention is schematically shown in FIGS. 1 and 4. As shown in FIG. 1, a downward vertical stream of molten metal represented by arrows 34 is directed out of the ladle shroud 18 and onto a central location of impact surface 24 of the base 22. The stream of molten metal disperses radially outwardly within cavity 29 from the center of the impact surface 24 as shown by arrows 35 and follows the continuous inner side wall surface 28 in an upward direction. The stream exits the pad 20 and travels generally vertically upwardly as shown by arrows 36. The vertical upward movement of the stream caused by the tundish pad 20 significantly slows down the stream of molten metal as the two opposed vertical streams 34, 36 have a partially cancelling effect on one another.

The slowed upward stream 36 of molten metal continues toward the upper surface of the bath 16 contained in the tundish 10 and disperses generally radially outwardly, as indicated by arrows 38 in FIGS. 1 and 4, proximate the top surface of the bath 16. The radially outwardly directed flow streams 38, best shown in FIG. 4, cause slag and other impurities at the top surface of the bath 16 to be moved outwardly away from the ladle shroud 18 and away from the incoming stream 34 such that slag and other impurities are much less likely to be directed downwardly into the bath 16 by the incoming stream 34 where they may become entrained therein and eventually directed out of the tundish 10 through outlet well blocks 14 thus contaminating the final castings.

FIGS. 5 and 6 illustrate a second embodiment of the present invention and specifically show one alternative shape for the endless, annular side wall construction which creates a fully reversed flow of metal from the pad. More specifically, a tundish impact pad 40 is shown and includes a base 42 having a planar impact surface 44. The pad 40 further includes an endless annular, and in this case rectangular, outer side wall 46 having an annular, rectangular inner wall surface 48 extending upwardly and inwardly from the planar impact surface 44 and fully enclosing an interior space or cavity 49.

More particularly, a vertically oriented annular portion 48*a* of the inner side wall surface 48 extends upwardly from the impact surface 44 and meets another inwardly angled annular portion 48*b* which extends inwardly and upwardly to a vertical inner wall surface 50. The vertically oriented portion 48*a* is not absolutely necessary to satisfactory operation of the pad to create a flow pattern in accordance with the present invention. That is, the angled portion 48*b* may instead extend upwardly and inwardly directly from surface 44. Vertical surface 50 defines a rectangular opening in the impact pad 40 for receiving the stream of molten metal from the ladle shroud 18 and for allowing the metal to exit the cavity 49 in an upward direction. The tundish impact pad 40 further includes a planar peripheral top surface 52 which surrounds the opening created by the vertically oriented rectangular shaped wall surface 50. Impact pad 40 creates the same general flow pattern within a tundish as pad 20 of the first embodiment and as specifically shown by arrows 35, 36 and 38 in FIGS. 1 and 4.

It will thus be appreciated that the tundish impact pads 20, 40 of the present invention cause the incoming ladle stream to be completely reversed in an upward direction thus significantly slowing the stream and preventing undesirable high velocity flows and turbulence within the tundish 10. Furthermore, opposed radially outwardly directed currents are created on all sides of the ladle shroud 18 or incoming stream to push slag and other impurities away from the incoming stream thereby significantly lessening the likelihood of entraining impurities within the bath 16.

The resulting flow pattern further promotes surface directed flow of molten metal which therefore necessitates a shorter distance through which inclusions must rise before contacting the slag layer and becoming absorbed therein. The resulting flow pattern also reduces erosion of the working lining 12 on the side and end walls of the tundish 10. This is because the incoming flow 34 as well as the flow pattern which results from the tundish impact pads 20, 40 will not directly impact on either the side or end walls of the tundish 10.

It will also be appreciated that the flow pattern which results from the tundish pads 20, 40 increases the residence time of the molten metal within the tundish 10 as the path to the exit nozzle or well block 14 will be longer and more tortuous than with past impact pads. More specifically, instead of flowing directly along the bottom of the tundish 10 to the exit nozzles 14, the flow of molten metal within the tundish 10 is first directed vertically upwardly toward the surface of the bath 16 and then is slowly circulated downwardly toward the exit nozzles or well blocks 14. The slow velocities created by the tundish pads 20, 40 of the present invention further minimize the possibility of vortexing and surface turbulence in the bath 16. The opposed radially outwardly directed currents created by the tundish impact pads 20, 40 further promote temperature homogeneity within the bath 16 by creating continuous flow within substantially the entire bath 16. The impact pads 20, 40 also significantly reduce splashing during start-up and

promotes greatly increased plug flow volume in the tundish **10** in the absence of other flow control devices such as dams, weirs and baffles.

The impact pads **20** and **40** are constructed from conventional refractory compositions which are resistant to the high temperatures of molten metals such as iron and steel. These temperatures may reach up to about 3000° F. As known in the art, suitable refractory materials may include MgO, Cr_2O_3, Al_2O_3, ZrO_2, CaO, and SiO_2, and mixtures of these materials, however, other refractory compositions may also be used as long as the chosen composition can withstand continuous contact with molten metals such as iron and steel. Two preferred compositions break down as follows:

	75% Al_2O_3 Composition	MgO Composition
Al_2O_3	75	3
MgO	>1	89
SiO_2	21	6
CaO	1	1
Fe_2O_3	1	>1
Other Trace Amounts	2	1

It will be appreciated that further modifications and substitutions to the present invention will become readily apparent to those of ordinary skill in the art without departing from the inventive concepts disclosed herein. For example, while the impact pad of the present invention is preferably circularly shaped and while one alternative shape has also been shown and described, it will be appreciated that many shapes for the side walls of the impact pad are possible and fall within the scope of the present invention. Any geometric shape which fully encloses or defines and endless boundary for an interior space of the pad and redirects the incoming molten metal flow back into itself and creates a flow pattern away from the ladle shroud will perform similarly to the illustrated embodiments. Other modifications will become apparent upon review of the foregoing application and applicant therefore intends to be bound only by the scope of the claims appended hereto.

What is claimed is:

1. A tundish impact pad formed from a refractory composition capable of withstanding continuous contact with molten metal, said pad comprising a base having an impact surface and an endless outer side wall extending upwardly therefrom and fully enclosing an interior space having an upper opening for receiving a stream of said molten metal, said outer wall including an annular inner surface having at least a first portion extending inwardly and upwardly toward said opening, whereby when a downwardly directed stream of molten metal from a ladle outlet disposed above said impact pad strikes said impact surface, said stream is directed outwardly toward said annular inner surface and then redirected upwardly and inwardly toward the incoming ladle stream.

2. The pad of claim **1** wherein said annular inner surface further includes a second portion extending outwardly and upwardly from said impact surface toward said first portion.

3. The pad of claim **2** wherein at least one of said first and second portions is a concave annular surface.

4. The pad of claim **3** wherein said first and second portions form a continuously curving annular concave surface.

5. The pad of claim **4** wherein said curved interior space is circular in shape.

6. The pad of claim **5** further comprising a vertically oriented annular surface extending upwardly from said first portion and defining said opening.

7. The pad of claim **1** wherein said interior space is circular in shape.

8. The pad of claim **1** wherein said interior space is rectangular in shape.

9. The pad of claim **1** further comprising a vertically oriented annular surface extending upwardly from said first portion and defining said opening.

10. The pad of claim **1** wherein said annular inner surface further includes a second portion extending upwardly from said impact surface to said first portion.

11. In a tundish vessel for holding a volume of molten metal and having a floor and sidewalls enclosing a region of impact and a drain, the improvement comprising an impact pad located in the region of impact and including a base having an impact surface and an endless outer side wall extending upwardly therefrom and fully enclosing an interior space having an upper opening for receiving a stream of said molten metal, said outer wall including an annular inner surface having at least a first portion extending inwardly and upwardly toward said opening, whereby when a downwardly directed stream of molten metal from a ladle outlet disposed above said impact pad strikes said impact surface, said stream is directed outwardly toward said annular inner surface and then redirected upwardly end inwardly toward the incoming ladle stream.

12. The pad of claim **11** wherein said annular inner surface further includes a second portion extending outwardly and upwardly from said impact surface toward said first portion.

13. The pad of claim **12** wherein at least one of said first and second portions is a concave annular surface.

14. The pad of claim **13** wherein said first and second portions form a continuously curving annular concave surface.

15. The pad of claim **14** wherein said curved interior space is circular in shape.

16. The pad of claim **15** further comprising a vertically oriented annular surface extending upwardly from said first portion and defining said opening.

17. The pad of claim **11** wherein said interior space is circular in shape.

18. The pad of claim **11** wherein said interior space is rectangular in shape.

19. The pad of claim **11** further comprising a vertically oriented annular surface extending upwardly from said first portion and defining said opening.

20. The pad of claim **11** wherein said annular inner surface further includes a second portion extending upwardly from said impact surface to said first portion.

21. A method of preventing turbulence and high velocity flow of molten metal in a tundish, the method comprising the steps of:

providing an impact pad within said tundish, said impact pad including an endless outer side wall extending upwardly therefrom and fully enclosing an interior spacing having an upper opening for receiving a stream of said molten metal, said outer wall including an annular inner surface having at least a first portion extending inwardly and upwardly toward said opening,

directing an incoming stream of molten metal vertically downwardly into said tundish and against

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,358,551
DATED : October 25, 1994
INVENTOR(S) : Karl J. Saylor

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 8, Line 30, "end" should be -- and --.

Column 8, Line 62, "spacing" should be -- space --.

Signed and Sealed this

Seventh Day of March, 1995

Attest:

Attesting Officer

BRUCE LEHMAN

Commissioner of Patents and Trademarks

[redacted]