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# DESCRIPTION

**[0001]** This application claims priority to and the benefit of U.S. Provisional Patent Application Number 60/732,618, filed November 01, 2005, the disclosure of which is now expressly incorporated herein.

## **Field Of The Invention:**

**[0002]** The present invention relates generally to heat exchange devices, and more specifically to heat exchange devices for use in the processing of metals.

## **BACKGROUND AND SUMMARY OF THE INVENTION**

**[0003]** The steel, foundry and metal refining industry has challenges with water cooled and non-water-cooled equipment operating in high mechanical wear, high corrosive, high temperature, high electrically conductive and thermally stressing environment within the melting furnace. In some process applications, it is advantageous for a foreign substance such as for example slag, which is a by-product of the melting process, to collect on the operating side ("hot side") or operating portion of the equipment to harness the non-conductive and insulating properties of slag in order to protect the equipment from damage, wear and premature failure during operation. The collected or retained slag also protects against the accidental and potential catastrophic effects of inadvertent splashing of liquid metal against the operating side of the equipment caused by excessive boiling or slopping of the molten metal during the melting process. A suitable example of cooling pipes designed to encourage slag retention is found in commonly owned U.S. Patent Number 6,330,269. Other examples are also described in JP H04 132400 U, WO 1/63193 A1, and US 6 257 326 B1.

**[0004]** The steel, foundry and metal refining industry also has challenges with water cooled and non-water-cooled equipment collecting slag and/or other foreign materials on the hot face of the equipment during operation. This slag, siliceous, metallic and/or other foreign materials that enter the process can be detrimental to the operation should it become detached and fall into the liquid steel that is contained within the furnace or duct structure. For example, the accidental intrusion of such material into the molten metal could cause the molten metal in the vessel to become off-specification resulting in its being scrapped or require additional high cost of processing to refine the molten metal back to its acceptable composition. The accidental dropping of this material into the furnace could cause excessive boiling or slopping of the molten metal creating a safety hazard in and around the vessel. In addition, the detaching of the foreign materials can be a safety issue should it fall when the equipment is offline and either damage equipment or hurt workers in the area.

**[0005]** What is needed is a pipe or series of pipes that either encourage or discourage the retention of slag on operating surfaces as desired.

**[0006]** The present invention may comprise one or more of the features identified in the various claims appended to this application and combinations of such features, as well as one or more of the following features and combinations thereof.

**[0007]** According to the present invention, there is provided a heat exchange apparatus according to claim 1.

According to a third aspect of the present invention, there is provided a method of cooling the interior wall of a metallurgical furnace according to claim 13.

**[0008]** One illustrative embodiment comprises an extruded, drawn or cold rolled tube or pipe that has notches or indentions in its conduction surface to promote the adhesion of slag, siliceous or other foreign materials during normal operations in a metal processing device. A plurality of the illustrative tubes or pipes may be coupled, butted and/or welded together to form a notched surface that promotes adhesion of slag, siliceous or other foreign material.

**[0009]** Another illustrative embodiment comprises an extruded, drawn or cold rolled tube or pipe that has a substantially flat surface configured to deter or resist the adhesion of slag, siliceous or other foreign material during normal operations of a metal processing device, system or equipment. A plurality of the illustrative pipes may be coupled, butted and/or welded together to form a generally smooth planar surface configured to deter or resist the adhesion of slag, siliceous or other foreign material.

**[0010]** Illustratively, any combination and configuration of the notched and the generally smooth-surface pipes may be used as appropriate in the various areas of the metal processing device, system or equipment.

**[0011]** Illustratively, the pipes can be cold rolled, hot rolled, drawn, extruded or cast. The pipes can be manufactured from ferrous metals, steel, copper, steel/ferrous alloy or copper alloys, nickel, titanium, bronze alloys including aluminum-bronze and nickel-bronze alloys, and other suitable materials. The pipes can be seamless or welded in design.

**[0012]** These and other objects of the present invention will become more apparent from the following description of the illustrative embodiment.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0013]**

FIG. 1 is a cross-sectional view of an illustrative pipe having a conduction section having a plurality of notches.

FIG. 2 is a cross-sectional view of the illustrative pipe of FIG. 1 but having thicker walls.

FIG. 3 is a cross-sectional view of an illustrative pipe having a conduction section having a substantially flat surface.

FIG. 4 is a cross-sectional view of the illustrative pipe of FIG. 3 but having thicker walls.

FIG. 5 is a cross-sectional view of an array of illustrative pipes depicted in FIG. 3 or FIG. 4 illustratively coupled to the roof of a metal processing device.

FIG. 6 is a cross-sectional view of an array of illustrative pipes depicted in FIG. 3 or FIG. 4 illustratively coupled to the roof of a metal processing device.

FIG 7 is a cross-sectional view of a plurality of pipes of FIG. 3 coupled to one another and to a plate, the plate being disposed within a metal processing device.

## **DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS**

**[0014]** For the purposes of promoting an understanding of the principles of the invention, reference will now be made to a number of illustrative embodiments illustrated in the drawings and specific language will be used to describe the same.

**[0015]** Illustratively, the heat exchange apparatus comprises a pipe 10, 10A, 20, 20A having walls defined by an outer boundary 12a and an inner boundary 12b, the inner boundary defining a core section 22. The pipe further comprises a support portion and a conduction portion or section 16 which is generally opposite the support portion 14. The hollow core 22 defined by the inner and outer boundaries 12a, 12b illustratively may generally be a tube or tubular section and has a core center. Illustratively, the support portion 14 is arcuate, although it need not be. For example and without limitation it may be planar, and may even have protrusions formed on the outer boundary 12a. The pipe has a vertical axis 31 running generally through the support section center 31c, the core center 31b and the conduction portion center 31a. The conduction portion 16 illustratively is generally tangent to the outer boundary 12a, and has protrusions extending generally laterally or horizontally on either side of the conduction center 31a. Illustratively, the combined length of the horizontally extending protrusions is greater than the length of any such support section protrusions, if any.

**[0016]** One or more pipes 10, 10A, 20, 20A illustratively may be coupled together with one or more other pipes 10, 10A, 20, 20A in any suitable configuration and combination of pipes 10, 10A, 20, 20A to form a heat exchange apparatus 30, 35, 40. One or more of the pipes can be replaced. The conduction section 16 illustratively may but need not include protruding ends 24, which may be configured to couple with the protruding ends 24 of adjacent pipes 10, 10A, 20, 20A. The support section 14 may be configured to couple directly with any suitable part,

portion or area of a metal processing system, or to couple with a mounting plate (not shown), which in turn may be coupled with the metal processing system, such as for example and without limitation a furnace. For example and without limitation the pipe 10, 10A, 20, 20A may be coupled with or mounted within the operating portion or area 25 of a metal processing apparatus, system, or equipment including attachment to the system's roof, sidewall, duct, burner gland or other equipment or areas required for metallic melting and refining in for example and without limitation an electric arc furnace (EAF), a foundry furnace, a metallurgical furnace, a ladle metallurgy device, and/or a degassing (VAD AOD, etc) device. The pipe is positioned in the equipment between an interior and a wall of the system. In other words, the conduction portion 16 of the pipe is exposed to the hot metal or gases emanating therefrom while the support portion 14 is attached directly to the wall 27, roof or other interior structure of the system or to a plate 26 that is attached to the system. The support portion 14 may be attached or coupled to the system directly, or it may be attached to a mounting plate 26 or other suitable component, which in turn mounts or couples with a wall, roof, or the like 27 of the system such as for example and without limitation an EAF. Thus, the conduction portion 16 is generally positioned so as to be exposed to the internal, operating or working area 25 of the metal processing apparatus, system, or equipment.

**[0017]** The conduction portion or section 16 may comprise a substantially smooth surface 19. The substantially smooth or flat section may be configured to deter the formation or retention of any foreign material including for example and without limitation slag and siliceous. Similarly, the conduction section 16 may comprise one or more indentations or notches, which may be configured to encourage or promote the retention of any foreign material including for example and without limitation slag and siliceous. Any suitable fluid, such as for example and without limitation any gas or liquid, may be directed through the core 22 in order to facilitate heat transfer.

**[0018]** According to the invention, a heat exchange apparatus 30, 35, 40 generally consists of one or more of the illustrative pipes 10, 10A, 20, 20A coupled together in any combination as for example and without limitation in a butted configuration next to one another to establish a continuous matrix of notches or indentations 18 that promote slag adhesion to the surface of pipes 10, 10A, and to establish a generally smooth, anti adhesion surface 19. As best seen in FIG. 8, the pipes may be coupled using any suitable method including spot welding 4a, 4b, 4c on either or both sides of the conduction portions, or other suitable methods 4d known to those skilled in the art. Similarly, the support sections 14 can be attached or coupled to the system's support structure 27 or to the plate 26 using any suitable method, including for example and without limitation welding. The notches or indentations 18 can be for example and without limitation steeped, rectangular, serrated, oval, etc. The thickness of the exposed smooth/indented surface 18, 19 of the pipe 10, 10A, 20, 20A may be designed to optimize the heat transfer and mechanical requirements of the process. The support portion 14 of the pipe 10, 10A, 20, 20A illustratively may have any suitable geometric configuration including for example and without limitation round, square or obround or otherwise. The tubes/pipe can have any fluid, including for example and without limitation, a liquid such as for example water, or a gas such as for example air directed or flowing through them to create a heat transfer and

cooling of the equipment, if needed by the process.

**[0019]** Illustratively, the pipes may be manufactured using any suitable process including being cold rolled, hot rolled, drawn, extruded or cast. Illustratively, the pipes can be manufactured from ferrous metals, steel, copper, steel/ferrous alloy or copper alloys, nickel, titanium, bronze alloys including aluminum-bronze and nickel-bronze alloys, and other suitable materials. The pipes can be seamless or welded in design. Illustratively, for example if the pipes are extruded, the mass on either side of the center line 29 is substantially equal. That is, the pipe comprises a first half including the conduction portion and having a first mass and a second half including the support portion and having a second mass, the first mass and the second mass being substantially equivalent. Thus, the walls defined by the inner and outer boundaries 12a, 12b may have thickened portions on the side containing the support portion 14 in the illustrative embodiments.

## **REFERENCES CITED IN THE DESCRIPTION**

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### **Patent documents cited in the description**

- [US73261805P \[0001\]](#)
- [US6330269B \[0003\]](#)
- [JPH04132400U \[0003\]](#)
- [WO163193A1 \[0003\]](#)
- [US6257326B1 \[0003\]](#)

**Patentkrav**

**1.** Metallurgisk ovn med et varmevekslerapparat, der danner en køleplade omfattende:

- 5 en flerhed af integreret udformet enhedsrør (10, 10A; 20, 20A) hver defineret af en indre grænseflade (12b) og en ydre grænseflade (12a), hvor hvert rør inkluderer:
- en hul kerne (22) defineret af den indre grænseflade og med en kernemidte;
- 10 en støttedel (14) på den ydre grænseflade, hvilken støttedel har en støttemidte (31c) og en støttelængde defineret af en kumulativ afstand støttedelen strækker sig lateralt på hver side af støttemidten;
- en planar ledningsdel (16) dannet generelt tangentielt på den ydre grænseflade generelt modsat støttedelen og strækkende sig generelt lateralt af røret, hvor ledningsdelen har en ledningsmidte (31a) og en ledningslængde defineret af en kumulativ afstand ledningsdelen strækker sig generelt lateralt på hver side af ledningsmidten, hvor ledningslængden er større end støttelængden; og
- 15
- 20 hvor røret har en vertikal akse (31) strækkende sig generelt igennem kernemidten, når set i tværsnit og hvor hver af støttedelen, den hule kerne og ledningsmidterne er forskudt fra og generelt justeret med hinanden langs den vertikale akse, og støttedelen og den planare ledningsdel er det samme materiale; og
- 25
- 30 hvor støttedelen er monteret i den metallurgiske ovn, der har en driftsdel (25) således, at ledningsdelen eksponeres for det varme metal eller de varme gasser udstrømmende fra ovnen og ledningsdelen er anbragt vendende indad mod driftsdelen af ovnen og støttedelen er koblet til ovnvæggen (27) og støttedelen er anbragt vendende udad væk fra driftsdelen af ovnen,.

hvor rørene af kølepladen er i fluidforbindelse med hinanden; og

hvor kølepladen er anbragt i den metallurgiske ovn med ledningsdelen af hvert rør vendende indad mod driftsdelen af ovnen, og

5 hvor ledningsdelen af mindst et rør omfatter en i alt væsentligt glat overflade og ledningsdelen af mindst et andet rør omfatter mindst et indsnit.

**2.** Den metallurgiske ovn ifølge krav 1, hvor rørene omfatter metalrør.

10 **3.** Den metallurgiske ovn ifølge krav 2, hvor rørene er fremstillet af et metal valgt fra gruppen bestående af et jernmetal, stål, kobber, en stål-jernlegering, en kobberlegering, nikkel, titanium, en bronzelegering, en aluminium-bronzelegering, og en nikkel-bronzelegering.

15 **4.** Den metallurgiske ovn ifølge krav 2, hvor rørene er fremstillet ved en proces valgt fra gruppen bestående af koldvalsning, varmvalsning, trækning, ekstrudering og støbning.

**5.** Den metallurgiske ovn ifølge krav 1, hvor støttedelen omfatter en generelt  
20 planar del.

**6.** Den metallurgiske ovn ifølge krav 1, hvor støttedelen er generelt ikke-planar.

**7.** Den metallurgiske ovn ifølge krav 6, hvor støttedelen er bueformet.  
25

**8.** Den metallurgiske ovn ifølge krav 1, hvor hvert rør omfatter en første masse, der inkluderer ledningsdelen på en første side af midterlinjen og en anden masse, der inkluderer støttedelen på en anden side af midterlinjen, hvor den første masse og den anden masse er i alt væsentligt ækvivalente.

**9.** Den metallurgiske ovn ifølge krav 1, hvor rørene af flerheden af rør er koblet sammen.

**10.** Den metallurgiske ovn ifølge krav 9, hvor ledningsdelen af hvert rør af flerheden af rør inkluderer et par af modstående fremspring strækkende sig fra ledningsmidten og sluttende i en spids, hvor spidsen af hver af de modstående fremspring er koblet til den tilsvarende spids af det tilstødende rør dannende en kontinuerlig overflade.

**11.** Den metallurgiske ovn ifølge krav 1, hvor den støttende del af hvert rør er forbundet direkte til den metallurgiske ovn.

**12.** Den metallurgiske ovn ifølge krav 1, hvor den støttende del af hvert rør er forbundet til en plade og pladen er forbundet til ovnen.

15

**13.** Fremgangsmåde til at afkøle den indvendige væg af en metallurgisk ovn omfattende trinnene:

at danne en køleplade omfattende en flerhed af enhedsrør med hvert rør omfattende et rørformet afsnit, en generelt bueformet støttedel defineret af en ydre grænseflade, og en generelt planar ledningsdel udformet integreret med den ydre grænseflade og generelt modsat til støttedelen, hvor mindst et rør af pladen har en i alt væsentligt glat ledningsdel for at modvirke tilbageholdelsen af transient stof fra ovnen på den i alt væsentligt glatte ledningsdel, og mindst et rør har en ledningsdel med indsnit for at tilbageholde transient stof fra ovnen på ledningsdelen med indsnit, og hvor støttedelen og den generelt planare del er det samme materiale;

at montere kølepladen i den metallurgiske ovn således, at de generelt planare ledningsdele af røret kobles og anbringes vendende indad mod driftsdelen af ovnen således, at de generelt planare ledningsdele af rørene danner en generelt planar del eksponeret for det varme metal eller de varme gasser udstrømmende fra ovnen og hver rør-støttedel kobles til

30

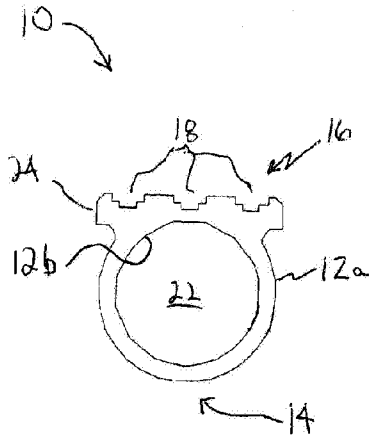
ovnvæggen og støttedelen anbringes vendende udad væk fra driftsdelen af ovnen;

at lede en kølevæske igennem rørene.

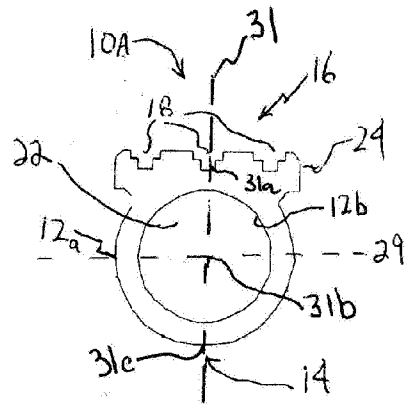
5 **14.** Fremgangsmåden ifølge krav 13, hvor den generelt planare del er kontinuerlig mellem rør.

**15.** Fremgangsmåden ifølge krav 13, hvor den generelt planare ledningsdel af hver af flerheden af rør inkluderer et par af modstående fremspring strækkende sig fra en ledningsmidte og endende i en spids, og yderligere omfattende trinnet at lægge spidsen af de modstående fremspring an og koble de tilstødende tilsvarende spidser af tilstødende rør for at danne en kontinuerlig overflade.

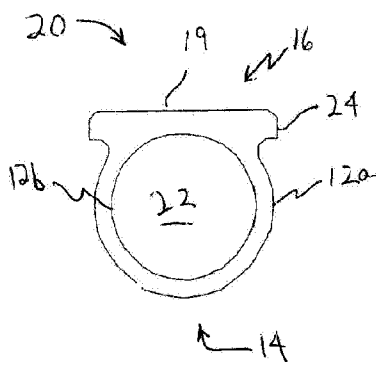
**DRAWINGS**



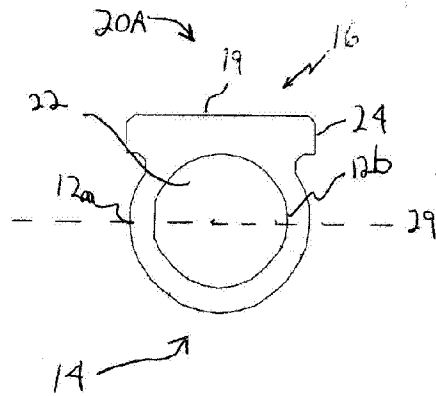
**FIG. 1**



**FIG. 2**



**FIG. 3**



**FIG. 4**

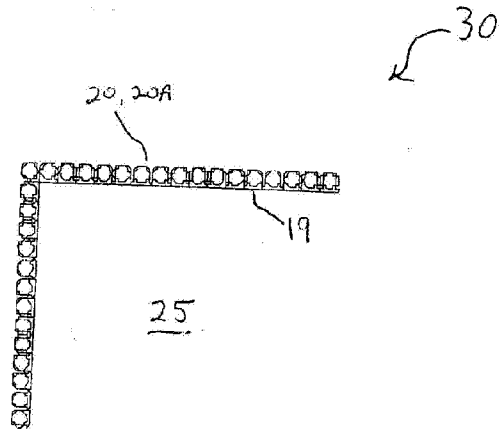


FIG. 5

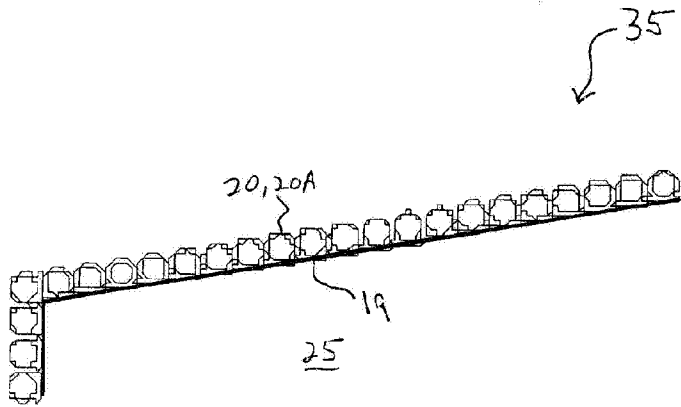


FIG. 6

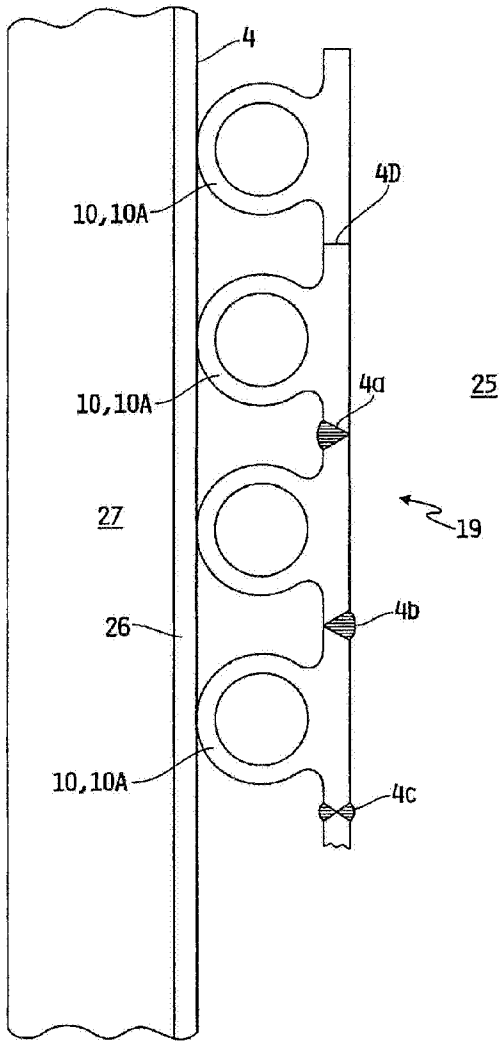


FIG. 7