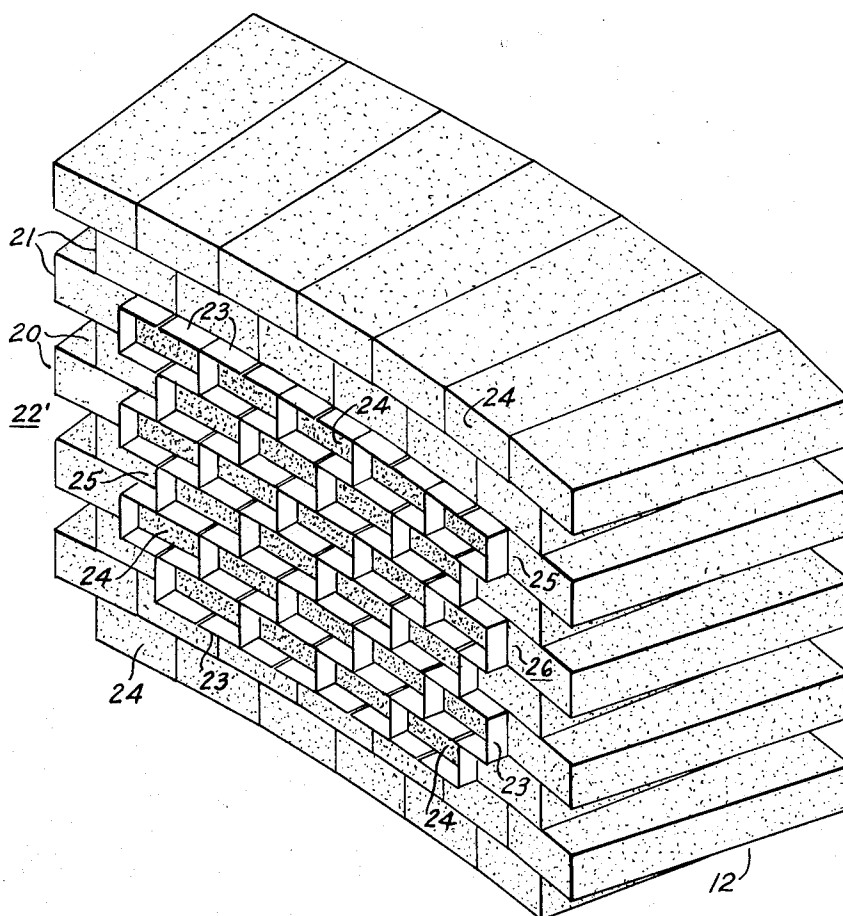


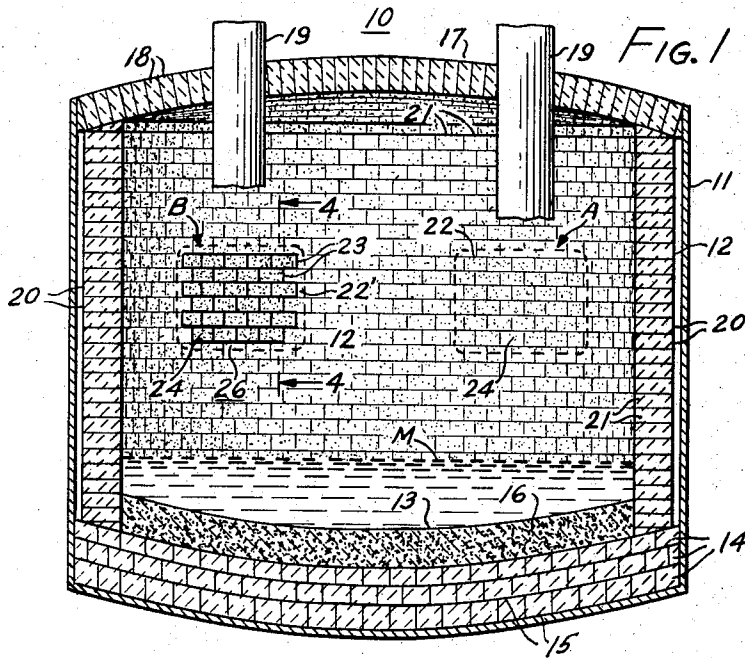
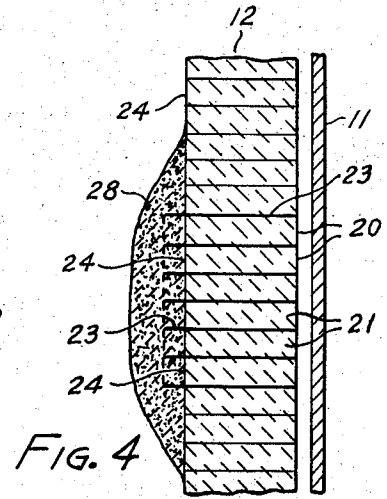
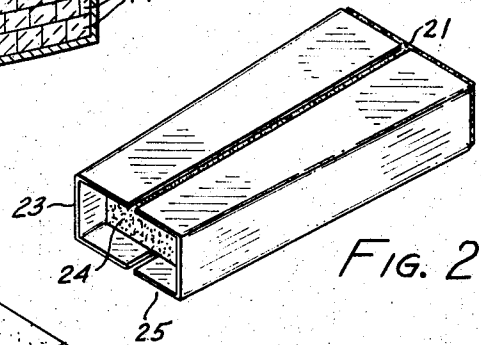
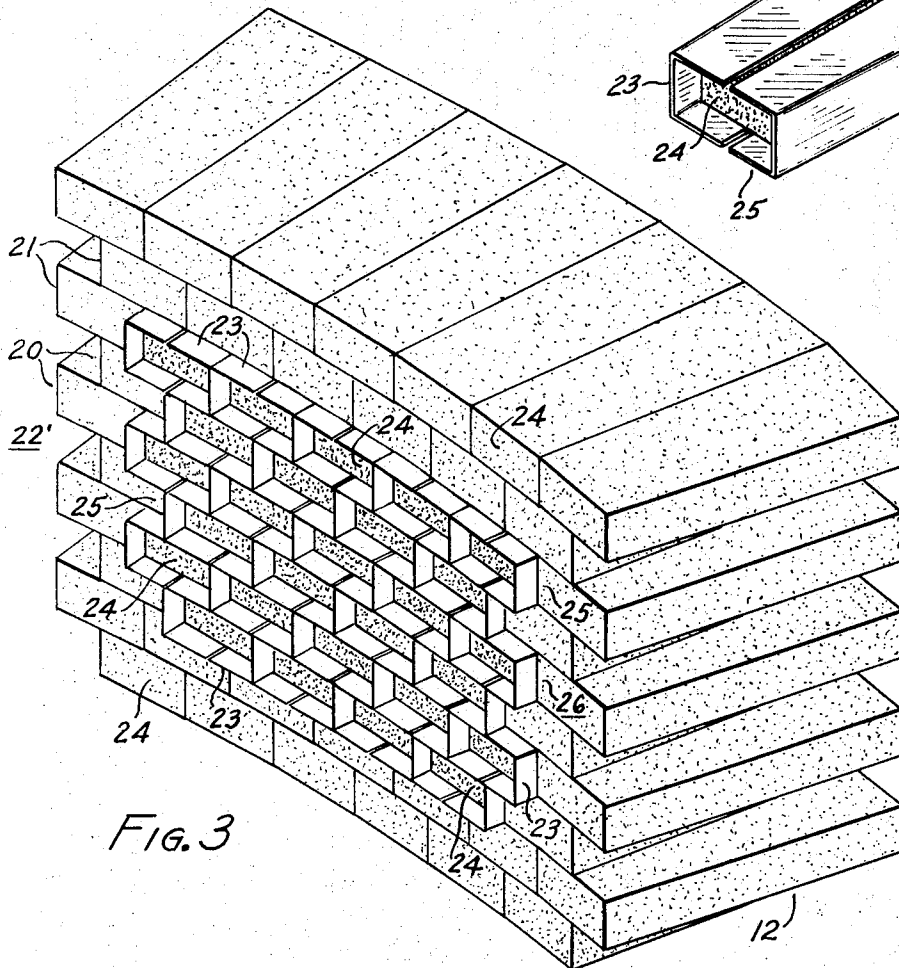
[54] **METHOD FOR PREVENTING EARLY
DAMAGE TO FURNACE REFRACTORY
SHAPES**[75] Inventor: **William C. Books**, Hellertown, Pa.[73] Assignee: **Bethlehem Steel Corporation**,
Bethlehem, Pa.[22] Filed: **Dec. 5, 1973**[21] Appl. No.: **422,036**[52] U.S. Cl. **13/35, 266/43, 432/252**[51] Int. Cl. **F27b 3/16, F27d 1/06**[58] Field of Search **13/35; 266/43; 432/248,
432/252**[56] **References Cited****UNITED STATES PATENTS**

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Primary Examiner—R. N. Envall, Jr.*Attorney, Agent, or Firm*—Joseph J. O'Keefe; Charles
A. Wilkinson; John S. Simitz[57] **ABSTRACT**

Method for preventing early damage to the refractory lining at critical wear areas in a metallurgical furnace, such as an electric arc furnace and the like, including laying-up the critical wear areas of the refractory lining with standard refractory shapes encased in metal. The metal cases extend a distance beyond the hot faces of the refractory shapes to form box-like configurations which act as receptacles and anchors to retain pulverulent refractory material which is subsequently sprayed over the hot faces of the refractory shapes prior to initial start-up of the furnace. The pulverulent sprayed refractory material insulates and protects the hot faces of the refractory shapes from a rapid rate of increase in temperature which occurs during initial melt down and heat up at the beginning of a campaign.

13 Claims, 5 Drawing Figures



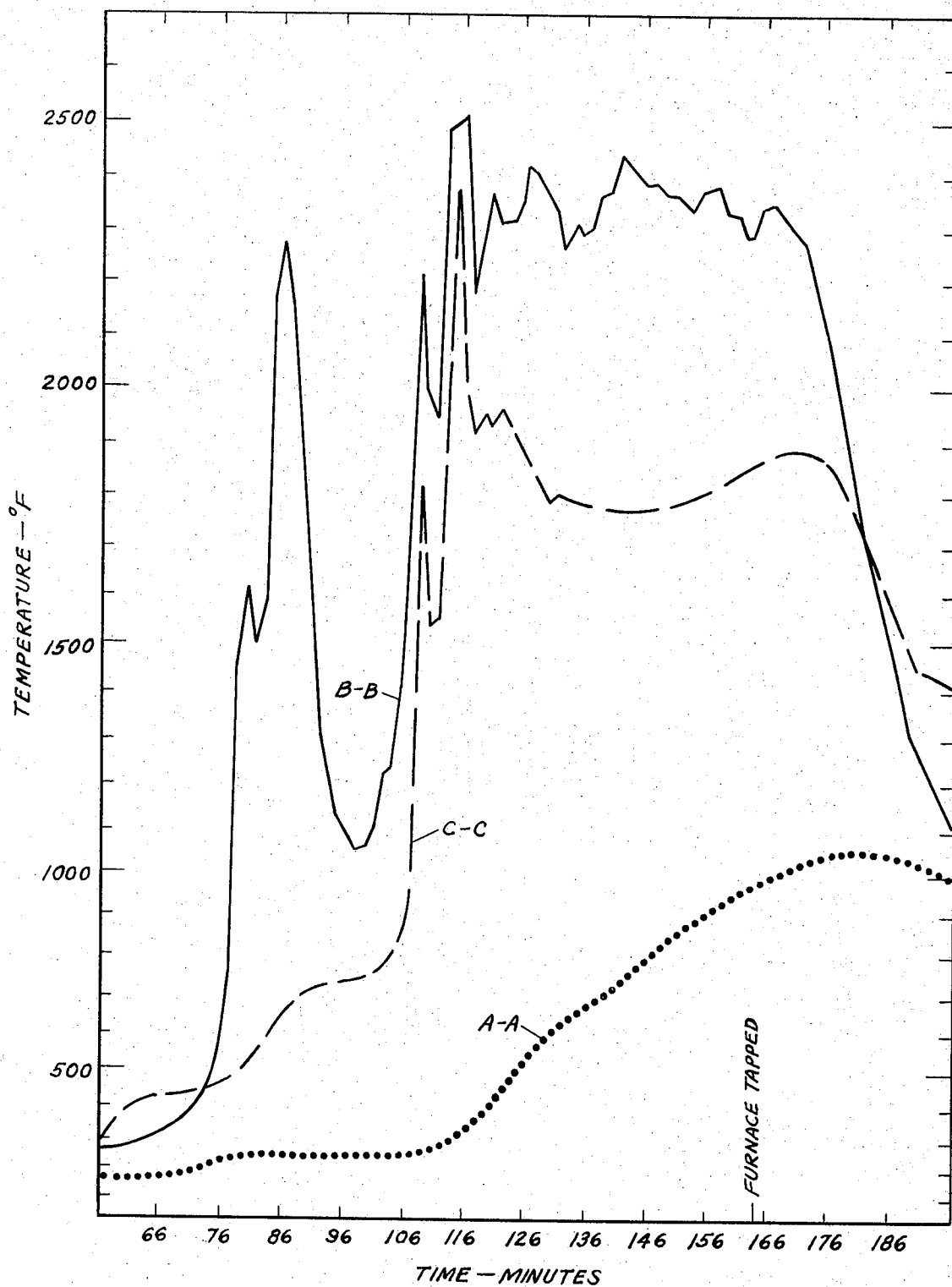


Fig. 5

METHOD FOR PREVENTING EARLY DAMAGE TO FURNACE REFRACTORY SHAPES

BACKGROUND OF THE INVENTION

This invention is directed to a method for preventing early damage to refractory shapes in critical wear areas of a refractory lining of a metallurgical furnace, such as an electric arc furnace. The critical wear areas are laid-up with refractory shapes encased in metal. A layer of pulverulent refractory material compatible with the material of the refractory shapes is sprayed over the hot faces of the refractory shapes.

Efficiency and increased production of steel in the electric arc furnace process has been increasing every year over the last several decades. The increase in output has deleteriously affected the internal environment in the furnaces during operation with respect to the effect of the environment upon the refractory linings of the furnace and has resulted in a need for improving the refractories used to lay-up the refractory lining in the furnace. Considerable effort has been directed to increasing lining life to a maximum while reducing lining costs to a minimum. In the direct arc electric furnace utilizing three-phase power, solid scrap is charged into the furnace. The solid scrap is melted and refined by electric power supplied by three electrodes extending downwardly into the furnace through the roof of the furnace. The electric current, which is necessary to melt and refine the solid scrap charged into the furnace, flows from one of the electrodes through the solid scrap or through the bath formed by melting the solid scrap to another one of the electrodes. The current flow is essentially circular and is between two of the electrodes at any one time. The flow of electric current causes an electric arc or a flare at one or more of the electrodes. This flare causes excessive heat which is transmitted to the hot faces of the refractory shapes in the refractory lining adjacent the electrodes, causing hot spots in the refractory lining. The hot faces of the refractory shapes in the hot spots are subject to severe thermal shock because of the rapid rate of increase in temperature caused by the flare. Spalling of the hot faces of the refractory shapes consequently occurs. The life of the refractory shapes is thereby shortened and early repair of the refractory lining at the hot spots is required. The hot spots, therefore, are regarded as critical wear areas in the refractory lining. Refractory shapes, such as burned magnesia, magnesia-chrome ore type refractories having a good combination of mechanical properties, are used to lay-up the refractory lining in the critical wear areas.

Prior art practices to alleviate the foregoing problem include, as noted previously, laying-up the critical wear areas with refractory shapes which have a good combination of mechanical and physical properties. Unfortunately, the basic refractory shapes made from basic materials such as magnesite, magnesia, magnesia-chrome ore mixtures and the like are all susceptible to thermal shock caused by a rapid rate of increase in temperature. In an effort to protect the refractory shapes in the critical wear areas from a rapid rate of increase in temperature, a portion of the charge of metal scrap is customarily charged against the refractory lining adjacent the hot spots. Unfortunately, the scrap is often heavy and charging the scrap against the refractory lining can cause physical damage to the hot faces of the refractory

shapes, thus actually decreasing the life of the refractory lining. On the other hand, charging light scrap against the refractory lining at the critical wear areas does not significantly aid in protecting the hot faces of the refractory shapes from a rapid rate of increase in temperature during melt-down and in the early stages of refining because light scrap melts too quickly.

Included in the prior art practices for protecting the refractory lining in critical wear areas is a method for providing an opening in the steel shell of a furnace in the areas immediately behind the critical wear areas in the refractory lining of the furnaces. The openings relieve dead air space between the refractory lining and the shell of the furnace thereby changing the thermal gradient in the refractory shapes in an attempt to prevent the rapid increase in temperature at the hot faces of the refractory shapes. However, the removal of a portion of the furnace shell necessitates the use of additional frame members around the opening in the shell and also additional structural steel to support the frame members, thereby increasing the cost of furnace installation. Then, too, the rapid rate of increase in temperature of the hot faces of the refractory shape may not be at all alleviated during the initial heatup.

It is, therefore, the object of this invention to provide a method for preventing early damage to the refractory shapes at critical wear areas in the refractory lining in a direct electric arc furnace by laying-up the critical wear areas with standard refractory shapes encased in a metal sheath which extends a distance beyond the hot faces of the refractory shapes and subsequently spraying pulverulent refractory material over the hot faces of the metal-cased refractory shapes to protect the refractory shapes from a rapid rate of increase in temperature, particularly during the initial heat-up of the furnace.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a direct electric arc furnace incorporating a composite refractory lining laid-up by the method of the invention.

FIG. 2 is a view of a metal-cased refractory shape used in laying-up the composite refractory lining of the furnace in accordance with the present invention.

FIG. 3 is an enlarged view of a critical wear area in a furnace showing the method of laying-up metal cased refractory shapes in the refractory lining according to the method of the present invention.

FIG. 4 is a section along 4—4 through a critical wear area of the furnace after a pulverulent refractory material has been applied to the refractory lining.

FIG. 5 is a graph comparing the temperature profiles of the hot face of a pulverulent refractory material sprayed over the hot faces of refractory shapes, the hot face of the refractory shapes so sprayed and hot faces of refractory shapes not protected by pulverulent refractory material in critical wear areas of an electric furnace.

PREFERRED EMBODIMENT OF THE INVENTION

Early damage to the refractory lining in critical wear areas, i.e. hot spots in an electric arc furnace, can be prevented by protecting the hot faces of the refractory shapes in these critical wear areas from a sudden rapid rate of increase in temperature caused by arcing between an electrode and the raw material charged into

the furnace. We have found that the hot faces of the refractory shapes can be protected from the rapid rate of increase in temperature by spraying a pulverulent refractory material onto the hot faces thereof and forming a coating of the pulverulent refractory material thereon.

As shown in FIG. 1, a direct current electric arc furnace 10 generally comprises an outer metallic shell 11, a refractory lining 12 laid-up inside the metallic shell 11 to protect it from the heat generated during melting and refining processes, a dished hearth or bottom 13 made up of several courses 14 of refractory shapes 15 and a refractory rammed or sprayed portion 16 forming the hearth portion in contact with the molten metal M in the furnace 10. The furnace 10 is covered by a roof 17 made of refractory shapes 18. The roof 17 has at least three ports (not shown) through which three carbon electrodes 19 (two of which are shown) can be lowered into the furnace 10 to provide electric power to melt and refine raw materials (not shown) such as solid scrap charged therein. The refractory lining 12 in the furnace 10 is formed by laying-up a plurality of courses 20 of conventional refractory shapes 21 made from appropriate basic refractory mixes containing magnesite, magnesia, magnesia-chrome ore, chrome ore-magnesia, and the like in all areas of the refractory lining 12. Two critical wear areas 22 and 22' of the refractory lining 12 are shown enclosed within the dotted lines A and B, respectively. The critical wear areas 22 and 22' are formed by laying-up a plurality of courses 20 of refractory shapes 21 which are substantially encased in a metal case or sheath 23. The metal case or sheath 23 extends along the sides of the refractory shapes and beyond the inner or hot face 24 of the refractory shapes to form an open box-like structure which when laid-up adjacent to other similarly sheathed refractory shapes forms a grid-like pattern as shown in enlarged view, FIG. 3. The grid-like pattern is filled with pulverulent refractory material as seen in FIG. 4.

Turning now to FIG. 2, the refractory shape 21 is shown substantially completely encased in metal 23. The metal case 23 extends a distance beyond the hot face 24 of the refractory shape 21 to form a box-like structure 25 extending beyond the hot face 24 of the refractory shape 21. The metal case 23 can extend from about 2½ inches to about 4 inches beyond the hot face 24 of the refractory shape 21.

As noted previously, basic refractory shapes, made from the above mentioned basic materials, are susceptible to thermal shock. Thermal shock occurs when the hot face of a basic refractory shape is exposed to an exceedingly rapid rate of increase in temperature and a sharp thermal gradient between the hot face and the remainder of the refractory shape is produced. Cracking occurs between the heated portion and the cold portion of the refractory shape immediately in back of the hot face. As much as five inches of the outer portion of the refractory shape can be severely cracked during the initial heat-up in the first heat of a campaign. While the cracked portion of the refractory shape may not necessarily slab, spall or break off immediately, the refractory shape is damaged and the cracked portion can slab or spall off at any given moment. The useful life of the refractory shape is consequently drastically reduced. The early damage to the refractory shape requires early maintenance wherein pulverulent refrac-

tory material is applied to the damaged refractory shape to prolong the life of the refractory lining. Early damage also causes a shortened campaign because of the necessity of relining the furnace in the damaged area. Subsequent maintenance or repair of the lining in an attempt to prolong the life of the lining once it is damaged is seldom if ever really satisfactory and it is much preferable if possible to prevent initial damage to the lining.

In these specifications, a heat of steel is to be understood as the quantity of steel which can be produced in a single charging, heating and tapping operation of the furnace which is not operated continuously. A campaign is the number of heats which can be produced in a furnace from start-up of the furnace until it must be reversed from service for replacement of the refractory lining.

Turning now to FIG. 3, which is an enlarged view of a critical wear area 22' in FIG. 1, and to FIG. 4, which is a section taken along 4—4 through critical wear area 22' in FIG. 1 after a pulverulent refractory material has been sprayed over the hot faces of the refractory shapes in the refractory lining, the refractory lining 12 is formed by laying-up contiguous courses 20 of refractory shapes 21. A plurality of contiguous courses 20 of refractory shapes are formed by laying-up refractory shapes 21 encased in metal 23. Of course, all the refractory shapes 21 used to form the refractory lining 12 in an electric furnace 10 are made from the same basic refractory material or compatible basic refractory material. A grid-like pattern or structure 26 is formed by the box-like structures 25 extending outwardly from the hot faces 24 of the refractory shapes 21. The box-like structures 25 are both containers and anchors for pulverulent basic refractory material sprayed over the hot faces 24 of the refractory shapes 21. The pulverulent refractory material compatible with the material in the refractory shapes 21 is sprayed into the grid-like structure 26 and is held in place by the box-like structure 25 to form an insulating coating 28 which covers the hot faces 24 of the metal-cased refractory shapes 21. The hot faces 24 of the refractory shapes 21 are protected from a rapid rate of increase in temperature caused by arcing in the electric furnace. We have found that the coating 28 can be between three inches to about six inches in thickness to achieve the results of the invention. The use of the coating 28 of pulverulent material changes the temperature profile at the hot face 24 of the refractory shape 21 as shown in FIG. 5 and explained in the following specific example of the invention.

In a specific example of the invention, a composite refractory lining was laid-up against the metallic shell of an electric arc furnace. A first critical wear area, B in FIG. 1, adjacent one of the electrodes was laid-up with metal-cased refractory shapes of the magnesia-chrome ore type. The first critical wear area measured 6 feet long by 4 feet high. The metal case extended 2½ inches beyond the hot face of the refractory shapes. The refractory shapes were 15 inches in length. A first thermocouple was placed in the critical wear area B to detect the temperature of the hot face of the refractory shape. A second critical wear area, A in FIG. 1, was laid-up with regular refractory shapes, each 15 inches long. A second thermocouple was placed in the critical wear area A to detect the temperature of the hot face of the refractory shapes. A 5-inch thick layer of a mix-

ture of magnesia and dolomite was sprayed over the metal-cased refractory shapes in critical wear area B. A third thermocouple was positioned to detect the temperature of the hot face of the magnesia and dolomite mixture sprayed over the metal-cased refractory shapes.

A scrap charge of about 164 tons of scrap metal and raw materials required to produce a heat of steel was charged into the furnace. The roof of the furnace was placed atop the furnace and the electrodes lowered into place in the furnace. Power was applied to melt and refine the charged materials. The history of the temperatures produced in the furnace was recorded by the three thermocouples as shown in the graph — FIG. 5. The temperature detected by the first thermocouple at the hot face of the metal-cased refractory shapes is identified as A—A. The temperature detected by the second thermocouple positioned to detect the temperature of the hot face of the mixture of magnesia and dolomite is identified as B—B. The temperature detected by the third thermocouple at the hot face of the refractory shapes in critical wear area A (FIG. 1) is identified as C—C. The temperature of the hot face of the mixture of magnesia and dolomite increased to about 2,500°F. at a maximum rate of 463°F. per minute during the early stages of the melt down curve B—B. The temperature of the hot face of the metal cased refractory shapes in the critical wear area (B in FIG. 1) increased to about 1,050°F. at a rate of 15°F. per minute as shown by curve A—A. The mixture of magnesia and dolomite covering the hot faces of the refractory shapes insulated the hot faces from a rapid rate of increase in temperature and prevented early damage to the refractory shapes. The temperature at the hot face of the refractory lining in initial wear area, wall A, FIG. 1, also had a rapid rate of increase as shown by curve C—C. Visual inspections of the refractory lining in the furnace after the first, second, and third heats of steel were made, showed that substantially all of the mixture of magnesia and dolomite had been removed from the center section of the refractory shapes in critical wear area B, but a thin coating remained around the perimeter of the critical wear area. The refractory shapes began to show slight wear after six heats of steel had been produced. The composite refractory lining in the furnace was used to produce 118 heats before it was necessary to reline the furnace.

Based on the relationship between the refractory lining life of refractory shapes in the critical wear areas of a furnace, which refractory shapes are not covered with a pulverulent refractory material prior to the start of a campaign and the percentage of heats in which rapid rates of increase in temperature occurred in critical wear areas, the composite refractory lining, in which critical wear areas are laid-up with refractory shapes encased in metal and a coating of pulverulent refractory material is applied to the hot faces of the refractory shapes, exceeded by 23 heats the number of heats which were expected to be produced by a refractory lining.

While we have shown a composite refractory lining comprising courses made by laying-up metal-cased refractory shapes only at the critical wear areas in an electric arc furnace, it is within the scope of this invention to lay-up the entire refractory lining in the furnace with metal encased refractory shapes or to lay-up alter-

nate layers of metal-cased refractory shapes and regular refractory shapes.

It is also within the scope of this invention to provide a composite refractory lining in basic oxygen furnaces wherein the critical wear areas, such as the trunnion areas, can be laid-up with metal-cased refractory shapes which can be sprayed with pulverulent refractory material to prevent early failure of the refractory lining therein.

I claim:

1. In a method for preventing early damage to the refractory lining in a metallurgical furnace having an outer metallic shell, a basic refractory lining laid-up in courses against the interior of said shell, a basic refractory bottom and a refractory roof, the improvement comprising:

- a. laying-up a plurality of basic refractory shapes in a plurality of courses in non-critical wear areas of said refractory lining,
- b. laying-up a plurality of metal encased basic refractory shapes in a plurality of courses in critical wear areas of said refractory lining, said metal extending a predetermined distance beyond the hot faces of the refractory shapes, and
- c. forming a layer of pulverulent basic refractory material on the surfaces of said basic refractory shapes laid-up in critical wear areas of said refractory lining.

2. The method for preventing early damage to the refractory lining in a metallurgical furnace as claimed in claim 1 wherein the basic refractory shapes in steps (a) and (b) are made from at least one material taken from the group consisting of magnesia-chrome ore and chrome ore-magnesia.

3. The method for preventing early damage to the refractory lining in a metallurgical furnace as claimed in claim 1 wherein the metal surrounding the basic refractory shapes in step (b) extends at least 2½ inches beyond the hot faces of the refractory shapes.

4. The method for preventing early damage to the refractory lining in a metallurgical furnace as claimed in claim 1 wherein the layer of pulverulent basic refractory material in step (c) is about 3 inches to about 6 inches in depth.

5. In a method for preventing early damage to the refractory lining in an electric arc furnace including a metallic shell, a basic refractory lining laid-up in courses of refractory shapes along the interior of the metallic shell, a refractory-lined hearth, a movable refractory-lined roof having a plurality of ports formed therein, and a plurality of electrodes vertically movable into or out of said furnace through said ports, the improvement comprising:

- a. initially laying-up a plurality of basic refractory shapes having a hot face and a cold face made from at least one material taken from the group consisting of magnesia, magnesia-chrome ore mixtures, and magnesite, in non-critical wear areas in said refractory lining,
- b. laying-up a plurality of basic refractory shapes having hot faces and cold faces, made from at least one material taken from the group consisting of magnesia, magnesia-chrome ore mixtures, chrome ore-magnesia mixtures, and magnesite, encased in metal, which metal extends a predetermined distance beyond the hot faces of said refractory

shapes in a grid-like pattern, in critical wear areas in said refractory lining, and

- c. forming a layer of initially pulverulent basic refractory material compatible with the basic refractory shapes, over the hot faces of the basic refractory shapes and within the confines of the metal grid extending beyond the hot faces of the basic refractory shapes whereby the pulverulent refractory material serves to protect the hot face of the metal encased refractory shapes from a detrimental heat gradient during initial operation of the furnace.

6. The method for preventing early damage to the refractory lining in an electric arc furnace as claimed in claim 5 wherein the basic refractory shapes laid-up to form the refractory lining in said furnace are made from at least one material taken from the group consisting of the magnesia-chrome ore mixtures and chrome ore-magnesia mixtures.

7. The method for preventing early damage to the refractory lining in an electric arc furnace as claimed in claim 5 wherein the metal case of step (b) extends between about 2½ inches to about 4 inches beyond the hot faces of the refractory shapes.

8. The method for preventing early damage to the refractory lining in an electric arc furnace as claimed in claim 5 wherein the layer of pulverulent refractory material formed in step (c) is between about 3 inches to about 6 inches in depth.

9. A composite refractory lining the interior of the wall of an electric arc furnace, said furnace including an outer metallic shell, a refractory-lined hearth, a refractory-lined removable roof having a plurality of ports, a plurality of electrodes vertically movable into or out of said furnace through said ports in said roof, said refractory wall comprising:

- a. a plurality of basic refractory shapes laid-up in a plurality of courses in non-critical wear areas in the refractory lining,
- b. a plurality of basic refractory shapes encased in metal, said metal extending outwardly a predetermined distance from a hot face of the refractory shapes, said shapes being laid-up in a plurality of courses in critical wear areas in the refractory lining, and

- c. a coating upon said hot face of said metal-cased refractory shapes with a predetermined thickness of a pulverulent basic refractory material compatible

with the materials in the refractory shapes.

10. The composite refractory lining as claimed in claim 9 wherein the metal case enclosing the refractory shapes in step (b) extends a distance of about 2½ inches to about 4 inches beyond the hot faces of the refractory shapes.

11. In an electric arc furnace having an outer metallic shell, a refractory lining laid-up against the inner surface of the intermetallic shell, a refractory-lined hearth, a refractory-lined roof and electrodes whereby raw materials charged into the electric arc furnace are melted and refined, an improved composite refractory lining comprising:

- a. a plurality of courses of basic refractory shapes taken from the group consisting of magnesia, magnesia-chrome ore mixtures and magnesite, laid-up in non-critical wear areas of the refractory lining, and
- b. a plurality of courses of basic refractory shapes encased in metal taken from the group consisting of magnesia, magnesia-chrome ore and magnesite, said metal extending a predetermined distance beyond the hot face of said refractory shapes to form a box-like extension and adapted to receive a spray coating of a pulverulent refractory material compatible with the refractory material in the refractory shapes into the box-like extensions.

12. In a refractory lining in a metallurgical furnace having a metal outer shell, a refractory hearth and a refractory lining, said metal outer shell an improved composite refractory lining comprising:

- a. a plurality of courses of refractory shapes laid against the outer metallic shell, said refractory shapes being selected from the group consisting of magnesia, magnesia-chrome ore and magnesite,
- b. said plurality of refractory shapes being encased in metal, the metal case extending from the inner surface of the refractory shapes to form a grid-like pattern adapted to receive a coating of pulverulent refractory material.

13. The refractory lining as claimed in claim 12 wherein the metal case surrounding the refractory shapes in step (b) extends a predetermined distance of about 2½ inches to about 4 inches beyond the hot faces of the refractory shapes.

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