United States Patent [19]

Hanas et al.

[11] **3,883,677**

[45] **May 13, 1975**

[54] **ELECTRIC ARC FURNACE HAVING SIDE-WALL LINING PROTECTION**

[75] Inventors: **Bertil Hanas; Jan Marchner,** both of Vasteras, Sweden

[73] Assignee: **Allmanna Svenska Elektriska Aktiebolaget,** Vasteras, Sweden

[22] Filed: **Apr. 5, 1974**

[21] Appl. No.: **458,353**

[30] **Foreign Application Priority Data**

Apr. 5, 1973 Sweden 7304776

[52] **U.S. Cl.** **13/35;** 13/9

[51] **Int. Cl.** **F27d 1/00**

[58] **Field of Search** 13/9, 35

[56] **References Cited**

UNITED STATES PATENTS

3,619,467	11/1971	Goodman	13/35
3,743,752	7/1973	Furuhashi	13/35 X
3,777,043	12/1973	O'Neill	13/35 X
3,829,595	8/1974	Nanjyo et al.	13/35 X

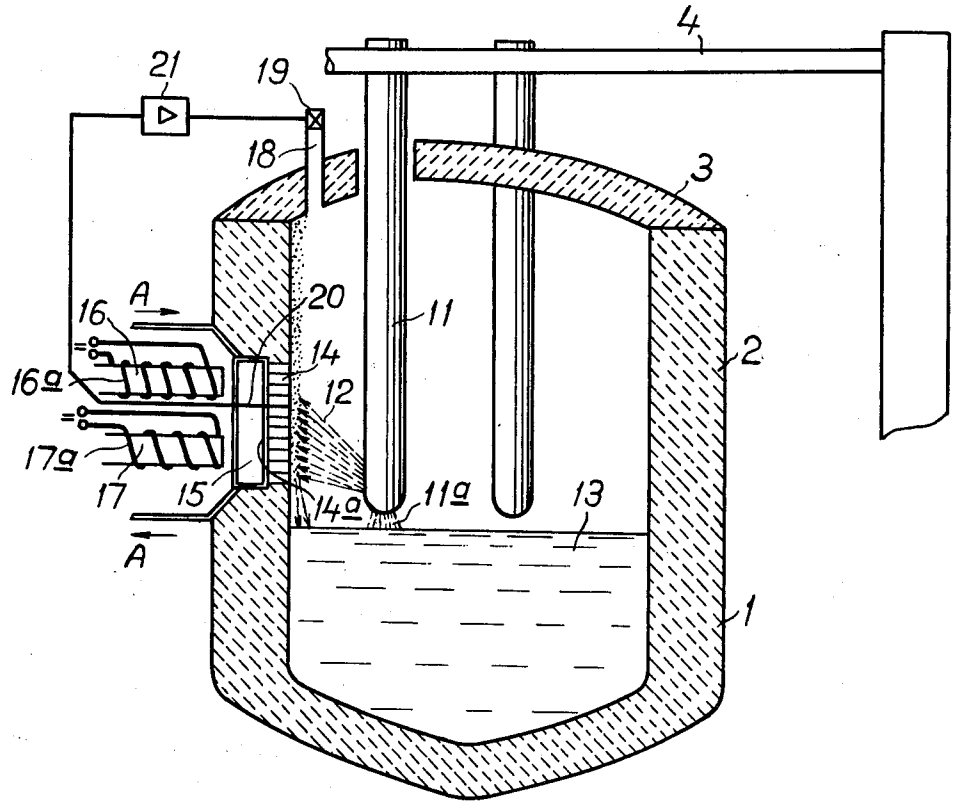
Primary Examiner—G. Harris

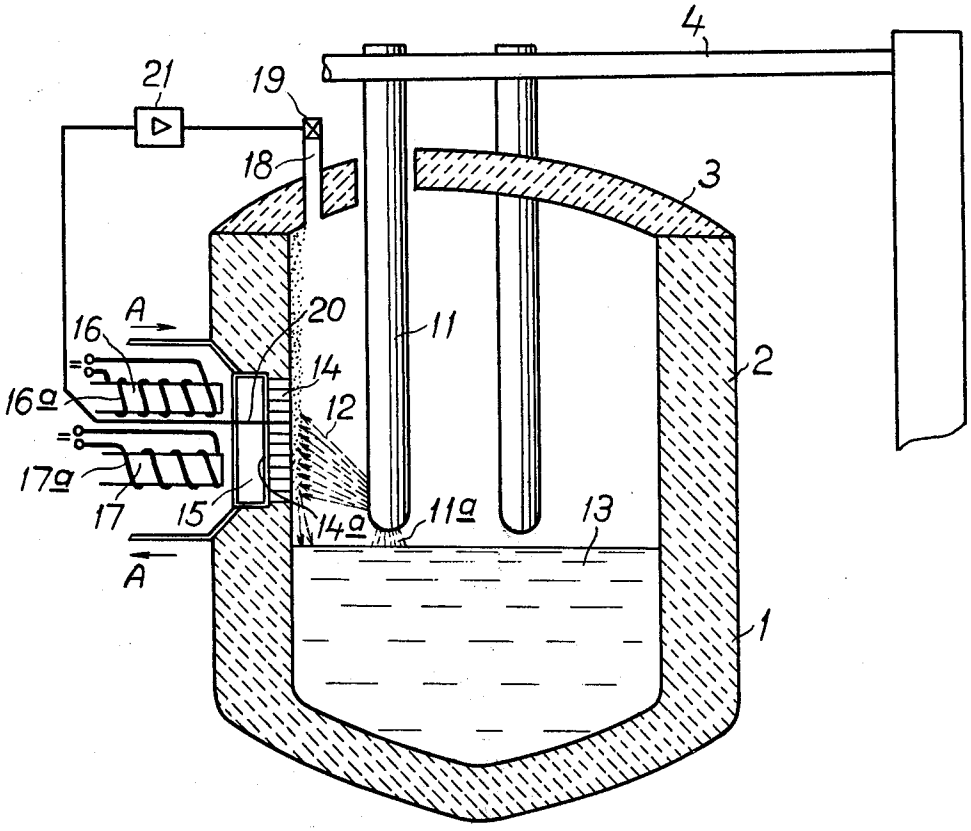
Attorney, Agent, or Firm—Kenyon & Kenyon Reilly Carr & Chapin

[57] **ABSTRACT**

An electric arc furnace has a side wall lining with at least one portion bombarded by the arc flare from one of the furnace arcing electrodes. A magnet is positioned on the outside of this portion and ferro-magnetic particles are fed to its inside, the magnet forming a magnetic flux field traveling through this lining portion and on the latter's inside magnetically holding the particles to form an arc flare shield protecting this portion's inside from the arc flare. As the particles heat to their Curie point temperatures, they become non-magnetic and fall into the melt of the furnace, a supply of fresh and relatively cold particles being fed to the flux field as required to maintain the effectiveness of the arc flare shield formed by the particles. The wall thickness of this portion is reduced from its outside inwardly to form a recess in its outside and in which the magnet is positioned to reduce the distance the flux field must travel to the inside to hold the ferro-magnetic particles. Between the magnet and this thin wall portion a water cooled plate is positioned to cool the thin wall portion of the lining. In this way the travel path of the magnetic flux is reduced in length without risking possible overheating of the lining, permitting the use of a less powerful magnet construction, this being an electromagnet and requiring electric solenoids, a core or cores with pole pieces and a suitable mounting arrangement. A temperature measurement sensor is installed in the thin wall of the lining portion protected by the flare shield, and equipment is provided for controlling the feed rate of the ferro-magnetic particles which form the shield, automatically in response to the temperature measurements obtained from this sensor, this assuring maintenance of the effectiveness of the shield. The water-cooled plate may be made of non-magnetic metal to avoid interference with the flux travel through the plate.

5 Claims, 1 Drawing Figure




4
21
19
18
3
A
20
11
16
14
2
16a
12
17a
17
15
14a
11a
13
A
1

ELECTRIC ARC FURNACE HAVING SIDE-WALL LINING PROTECTION

BACKGROUND OF THE INVENTION

An electric arc furnace conventionally comprises a shell containing a non-metallic refractory lining, and it has a cover or roof through which electrodes pass with lower ends reaching down to form arcs between the lower arcing ends of the electrodes and a metal in the bottom or hearth portion of the lining. Although other electrode arrangements are possible, when the furnace is powered by three-phase alternating current, there are three electrodes usually arranged in triangular formation. This positions the electrodes close enough to the furnace side wall lining above the melt, so that the adjacent portions of the lining are bombarded by the arc flares. These flares are in the form of both radiation and particles which bombard the portions of the side wall lining adjacent to the arcs. If the electrodes are positioned to form a straight line of electrodes, it is the flares from the end electrodes which bombard the adjacent portions of the side wall lining.

Any portion of the side wall lining bombarded by an arc flare, is subjected to more heat and more rapid erosion and wear than the balance of the lining. It is, of course, undesirable to have portions of the lining rendered unserviceable prior to the balance of the lining.

One proposal to protect such bombarded portions of an electric arc furnace side wall lining, is disclosed by the Daniel J. Goodman U.S. Pat. No. 3,619,467, dated Nov. 9, 1971, the disclosure of which is hereby incorporated into the present disclosure, by this reference to that patent. The Abstract of that patent is quoted below:

"Damage to the lining of the shell of an electric arc furnace by arc flare during steel making is reduced by providing a powerful magnetic field in the vicinity of the lining sidewall area subjected to the intensive heat from the arc flare and then feeding pieces, pellets or fragments of magnetically attracted ferrous material, such as iron ore or metal pieces, pellets or fragments past the magnetized lining area to the molten metal and slag bath in the bottom or hearth of the furnace. This magnetic flux causes the falling fragments, such as concentrated iron ore pellets, to be captured by and to adhere temporarily to the lining of the furnace until their temperatures reach the so-called Curie point of about 700°C. at which their capability of being magnetically attracted ceases. Thereupon the pellets fall into the molten bath but are immediately replaced by fresh pellets falling past the magnetized wall and thus providing a continuous shield of pellets or other magnetizable fragments which provide substantial protection to the sidewalls or lining of the furnace. The portions of the furnace between the electromagnets providing the magnetic flux and the furnace lining at the locations subjected to damaging arc flare are preferably formed of non-magnetic material, so as to maintain the magnetic flux flow through the furnace wall and lining at its maximum value."

In the above proposal, the magnetic flux produced by the electromagnets must travel through the thick non-metallic refractory side wall lining before forming the flux field useful for holding the magnet particles forming the flare shield. This makes it necessary to use undesirably large electromagnet assemblies and, of course, requires an undesirably high consumption of current. Even so, as indicated by the patent, the magnetic particles must be in the form of pellets or fragments, such as concentrated iron ore pellets. It has been considered that concentrate iron ore in powdered form cannot be used satisfactorily.

Another prior art approach to protecting the bombarded portions of the furnace side wall lining, has been to apply water cooled plates to the outside of the metal furnace shell which conventionally contains the furnace lining, the object being to in this way remove heat from the affected lining portions more rapidly through the lining and the metal shell. An example of this is shown by Swedish patent specification 328,599. However, with large electric arc furnaces using powerful arcs, the improvement effected leaves further improvement desirable.

SUMMARY OF THE INVENTION

The present invention may be regarded as an improvement on the patented proposal using the electromagnets on the outside of the furnace side wall lining, at the bombarded portions, in conjunction with the feed of ferro-magnetic particles into the flux fields thus created on the insides bombarded by the arc flares.

This improvement comprises the formation of a recess in the outer surface of each affected furnace side wall lining portion, so that this portion has a reduced wall thickness as compared to the balance of the lining. In this way the travel path of the flux through the lining is reduced in extent, permitting the use of smaller electromagnet structures to provide a flux field on the inside for holding the magnetic particles effectively and, of course, a reduction in the electric power consumption that was previously required. To protect this wall portion of reduced thickness against the possible risk of over-heating, a water-cooled plate is interposed between the electromagnetic structure and this wall portion and in contact with the latter's inside. The thickness of this plate need not be very great, permitting the electromagnet structure pole piece to be positioned inside of the recess and thus substantially closer to the inside of the bombarded lining portion.

To further protect the bombarded side wall portion from overheating, a temperature sensor is built into this portion and connected to a feed rate controller for the feed of ferro-magnetic particles. This is done in such a way as to make the feed rate of the particles into the magnetic field on the inside of the furnace lining side wall, increase as the temperature of the thinned wall portion increases, and to decrease when the temperature drops below a value indicating that the wall portion is at lower temperatures. As the ferro-magnetic particles are heated to their Curie points, become non-magnetic and fall, new fresh particles of lower temperatures are thus fed as replacements. With the thickness, and therefore protective effectiveness, of the flare shield maintained at a substantially constant value, the portion of reduced wall thickness can be relied on to have a service life substantially as long, if not as long, as the balance of the furnace lining.

With this invention the magnetic flux path length through the lining can be very substantially shortened, and with an electromagnetic structure or assembly of the size and power as formerly required, a very intensive flux field of great force may be maintained on the inside of the lining where the protection is needed against the arc flare. This makes it possible to use a

feed of powdered concentrated iron ore for the creation and maintenance of the arc flare shielding, although concentrated iron ore in the form of pellets or fragments of substantial size, as well as ferro-magnetic metal pieces, such as steel scrap particles, may be used, but such use is not to be considered mandatory as it was before.

The water-cooled plate may be made of non-magnetic metal to avoid interference with the flux travel.

BRIEF DESCRIPTION OF THE DRAWING

The presently preferred mode of carrying out the invention is schematically illustrated by the accompanying drawing in which the single view is a vertical section of an electric arc furnace to which the invention is applied.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the above drawing, the furnace vessel is indicated as having a lower portion or hearth **1** and a side wall **2** which extends upwardly from this portion **1**, a removable cover **3** covering the top of the vessel. Although not shown because of its familiarity in the prior art, the furnace vessel normally has a steel shell on its outside with the portions **1** and **2** formed by a non-metallic, refractory lining, only this lining being shown by the drawing. Cantilever arm **4** mounts the electrodes **11** which are suspended through openings in the cover **3.** Although shown for only one of the electrodes, each of the electrodes forms an arc **11***a*, the extremely hot lower end portion of the electrode producing the arc flare **12** consisting of thermal radiation and possibly particles, the intensity of the bombardment action depending on the power applied to form the arc **11***a*. The arcs are, of course, between the bottom ends of the electrodes and the metal melt **13** in the lower or hearth portion **1** of the vessel. The bombarded portion of the side wall, of which there are more than one, is indicated at **14** as being formed by refractory bricks from which the entire side wall lining **2** may also be formed. The inside surface of this portion **14** is flush with the generally cylindrical plane of the inside of the furnace side wall lining **2.**

However, on the outside of this bombarded portion, the furnace lining is formed with a recess **14***a* so that this portion **14** has a reduced wall thickness. As indicated by the drawing, this reduced wall thickness is very substantially thinner than the balance of the side wall lining **2.** For its protection against possible overheating, its inside is in contact with hollow water-cooled cooling plate or box **15.** A continuous circulation of cooling water is maintained in this plate or box **15** as indicated by the arrows A—A. For illustrative reasons, this plate or box **15** is shown as being possibly somewhat thicker than should be used; the plate or box **15** takes up as little space in the horizontal direction as is possible, consistent with adequate cooling of the thinned wall portion **14.**

The recess **14***a* and the relative thinness of the side wall portion **14** and of the plate or box **15,** permit the pole pieces **16** and **17** of an electromagnet assembly, to be positioned in the recess to provide the shortened flux travel previously described. These pole pieces are shown as provided with electrically powered solenoids **16***a* and **17***a* respectively. Prior art knowledge of electromagnet design may be used, but the pole piece ends which create the flux field should be positioned inside of the recess **14***a*, with the flux path travel distance shortened as much as possible. The furnace's steel shell should have openings or cutouts to provide the necessary clearance for the recess **14***a*, and for installation of the water-cooled plate **15,** and insertion of the pole piece ends, if not the major part of the electromagnet assembly, in the recess **14***a*.

The feed for the ferro-magnetic particles which in the case of this invention may be powdered concentrate iron ore as well as iron ore pellets or fragments, is through a suitable feeder **18** in the furnace cover **3.** There may be a plurality of these feeders, or feeders in the form of circular segments may be used. The feed of the material is under the control of a feed controller **19** which may be an electrically controllable valve. With the controllable valve or feed controller, the temperature sensor is shown at **20** as controlling this valve or controller **19** via a proportional or proportional integrating type of amplifier **21.** The sensor **20** may be of the type disclosed by the Otto von Krusenstierna et al U.S. Pat. No. 3,512,413, dated May 19, 1970. The control circuitry is such that the feed through the feeder **18** increases if the wall temperature of the portion **14** increases, with the feed of particles decreasing if the wall temperature at **14** decreases. In this way the supply of ferro-magnetic particles, required to replace particles heated above their Curie points and falling, is made automatically responsive to the wall temperature of the portion **14,** assuring the maintenance of an arc flare shield adequate to protect the thinned portion **14** against overheating; this protection is in addition to that afforded by the cooling plate or box **15.** If powdered iron ore concentrate is used, this feed, via the feeder or duct **18,** may be reinforced by a stream of carrier gas of suitable composition and under the pressure of a compressor or blower (not shown), in which case, assuming the compressor or blower is powered by an electric motor, the motor speed may be varied under the control of the sensor **20.**

Because of the possibility of providing a very strong flux field in the inside of the wall portion **14,** a relatively high speed stream of the ferro-magnetic particles in powdered form, for example, can be used to advantage. The magnetic adhesive force drawing the particles against the wall portion **14** in its inside, may be made very intense.

The foregoing reference to Curie points is to be understood as meaning that for the composition of the ferro-magnetic material used, this reference is intended to mean the temperature or temperatures where there is change from a magnetic phase to a non-magnetic phase. Under practical furnace operating conditions, the points can be detected because the particles will fall into the melt and require replacement. It is well known that the length of the path through which magnetic flux must travel determines the intensity or strength of the flux field at the location where this field is to do useful work, which in the present instance is the attraction and holding of the ferro-magnetic particles.

As explained by the previously referred to patent, any metal between the magnet and the lining inside, should preferably be non-magnetic. With this in mind, the water-cooled plate or plates **15** may be made of non-magnetic metal.

What is claimed is:

1. An electric arc furnace comprising at least one electrode having an end forming an arc producing an arc flare, a side wall lining having at least one portion having an inside positioned to be bombarded by said flare, said portion having an outside, a magnet having pole-piece ends on said outside forming a magnet flux field traveling through said portion and beyond said inside and on said inside holding ferro-magnetic particles forming a flare shield until the particles are heated to their Curie point temperatures, and a feeder for feeding said field with replacement ferro-magnetic particles at temperatures lower than their Curie point temperatures; wherein the improvement comprises said lining having an outer surface in which a recess is formed at said portion so that said portion has a reduced wall thickness through which said flux field must travel, and

means between said magnet and recess for water-cooling said portion of reduced wall thickness.

2. The furnace of claim 1 in which said flare shield is formed by iron ore particles in powder form.

3. The furnace of claim 1 in which said magnet pole piece ends are inside of said recess.

4. The furnace of claim 3 in which said means is a water-cooled non-magnetic plate positioned against said outside between the latter and said magnet pole piece ends.

5. The furnace of claim 4 in which said feeder has a feed rate controller and means for actuating said controller automatically in response to the temperature of said portion.

* * * * *