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[54] **ELECTRIC DIRECT-ARC FURNACE**

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Jan. 25, 1972 Japan ..... 47-10716[U]
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[52] **U.S. Cl.** **13/32,** 13/35, 165/169
[51] **Int. Cl.** **F27b 3/16,** F27d 1/12
[58] **Field of Search** 13/32, 35; 165/169; 432/252; 266/32

[56] **References Cited**

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Attorney, Agent, or Firm—Scrivener Parker Scrivener & Clarke

[57] **ABSTRACT**

A furnace proper of an electric direct-arc furnace characterized in that the furnace wall is constructed in a required form with a plurality of cooling blocks each of which comprises a cooling block proper made of a special metal the inner surface of which is lined with a refractory material and a cooling water tube embedded therein, so as to increase the life of the furnace wall.

5 Claims, 9 Drawing Figures

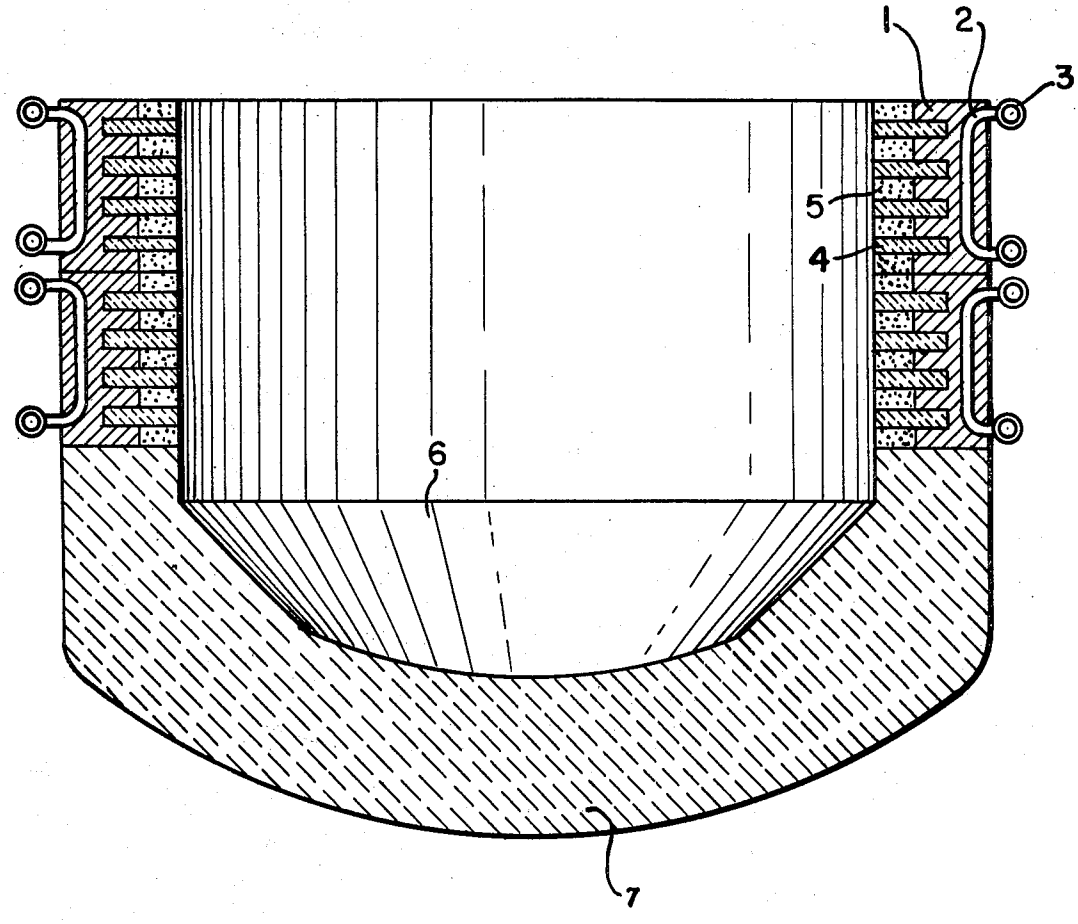


Fig. 1

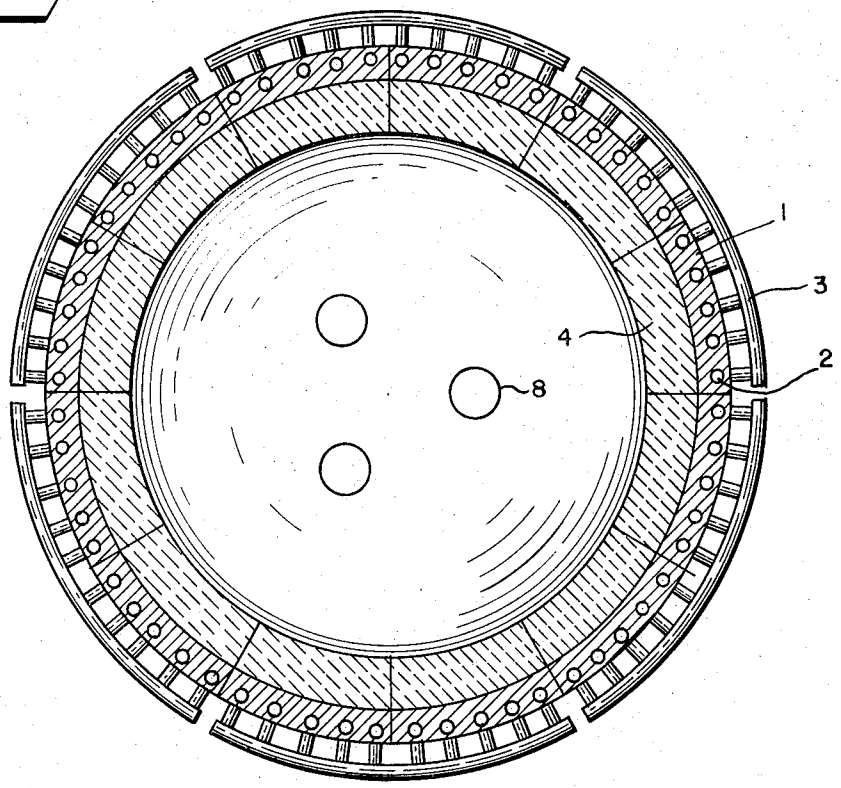


Fig. 2

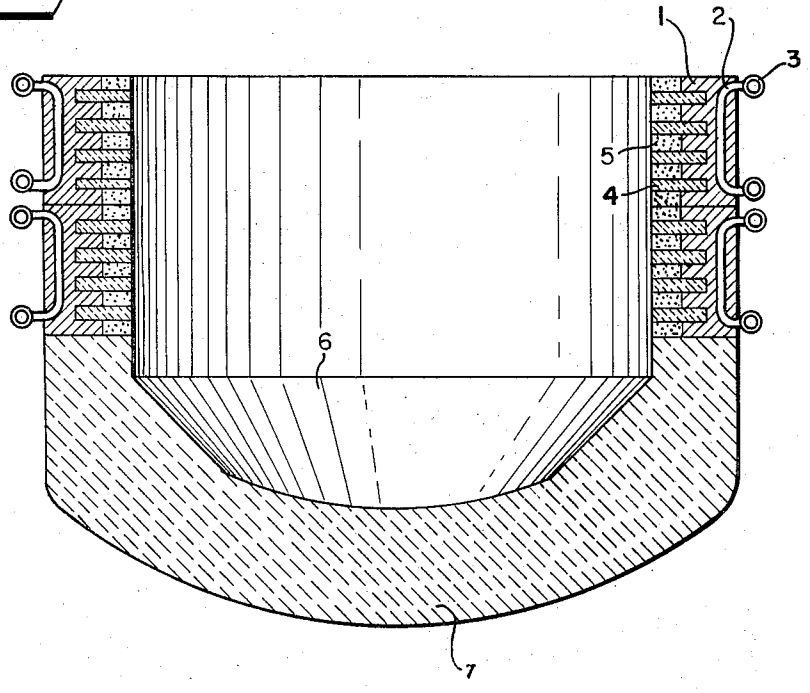


Fig. 3

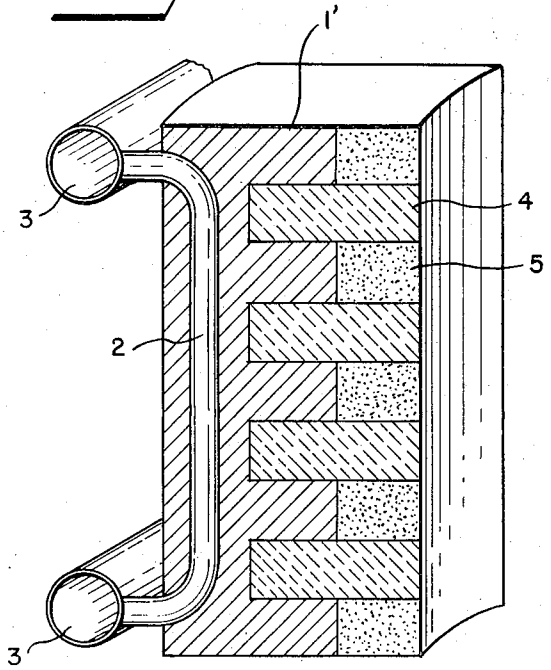


Fig. 4

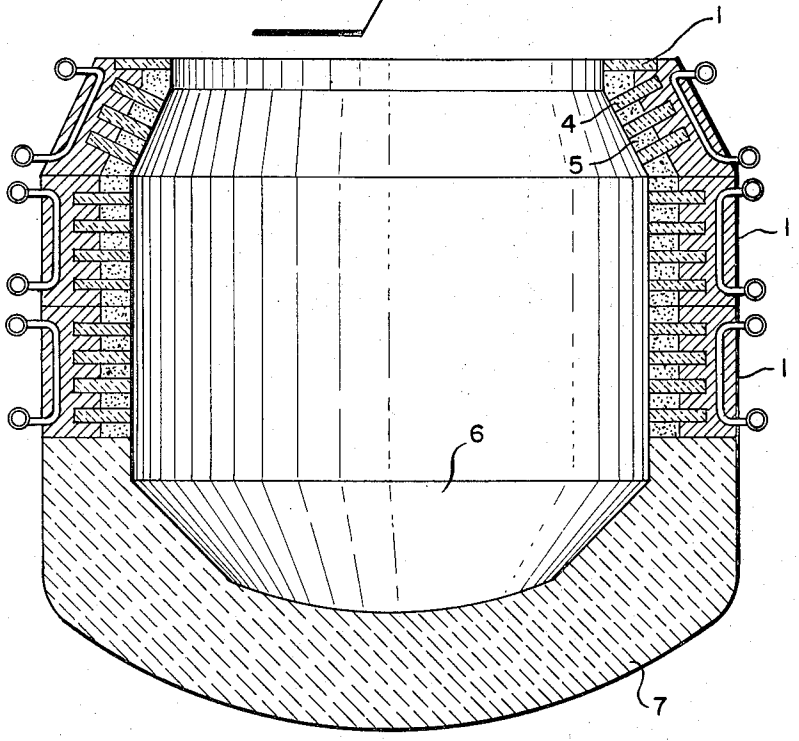


Fig. 5

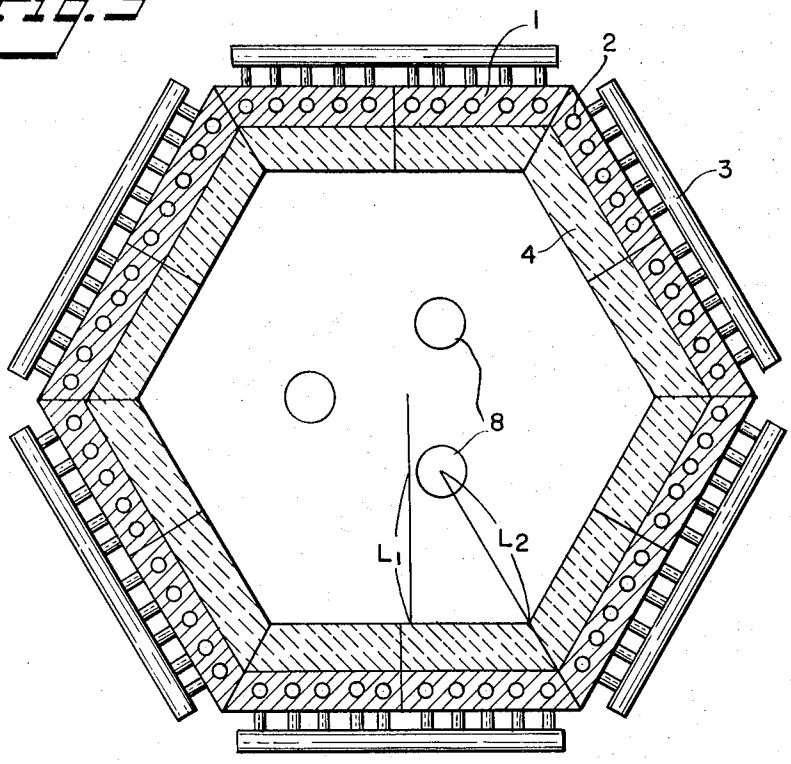


Fig. 6

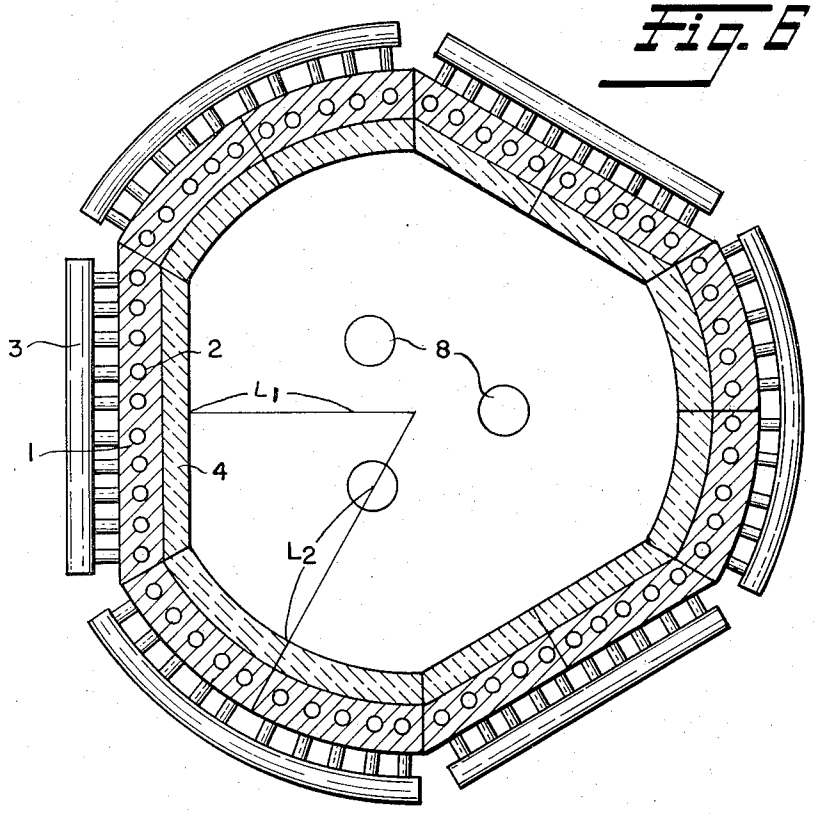


Fig. 7

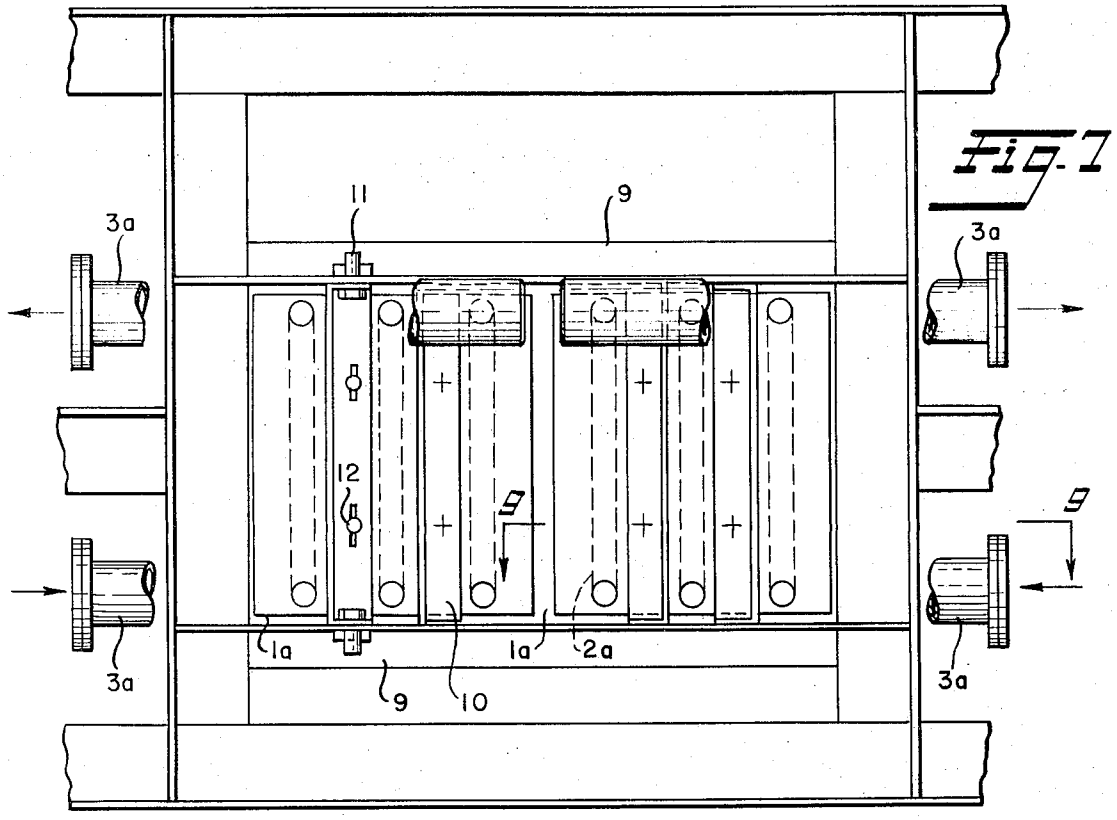


Fig. 8

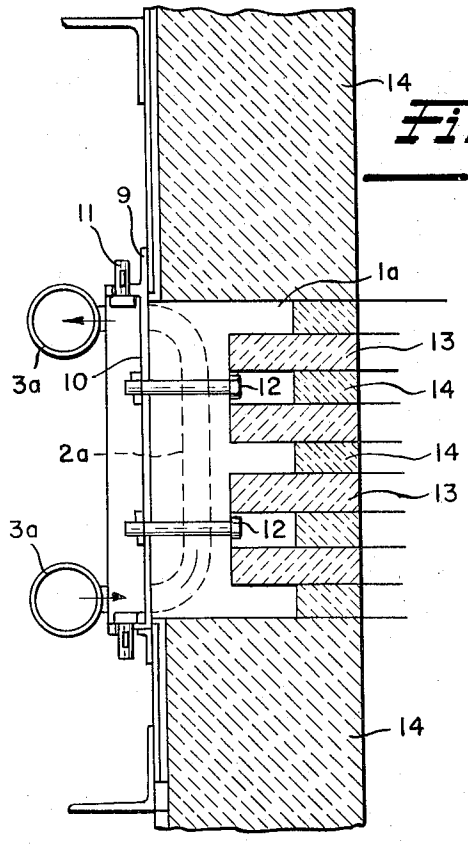
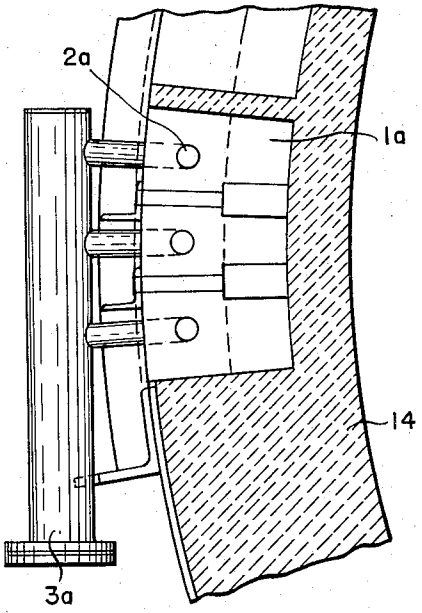


Fig. 9



ELECTRIC DIRECT-ARC FURNACE

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a furnace proper of an electric direct-arc furnace in which the durability of the furnace wall may be made semipermanent.

The conventional arc furnace comprises generally a steel shell the inner wall of which is lined with the refractory material. The durability of the refractory material is generally about 200–350 heats for refractory brick, and the bed of the hearth and the slag line must be repaired by the stamping machine for every heat while they are still hot. The life of the refractory brick at the hot spot in opposed relation with the electrodes and subjected to the high-temperature arcs are shorter and about 30 – 100 heats.

The recent trend in the operation of the arc furnace operations is toward the high power or ultra-high power operation in order to improve the productivity so that the life of the brick or the furnace wall is considerably reduced. Therefore there arises a serious problem that the efficiency of the arc furnace operation is considerably lowered because of the short life of the refractory material which leads to the increase in cost and in time required for the repair of the furnace wall and the like.

In order to overcome this problem there has been devised and demonstrated the method in which the hot spot coolers are mounted in the furnace so as to prevent the local temperature rise of the furnace wall. The hot spot coolers may be generally divided into two types, one type being such that water cooling steel pipes or tubes are embedded in the furnace wall and the other being the water jacket type in which cooling water passes through the steel box fabricated by welding. In the steel water cooling pipe type cooler, the repair for leakage of cooling water is extremely difficult because the steel water cooling pipes are embedded in the furnace wall or refractory brick. Furthermore specially shaped brick must be used so as to surround the steel water cooling pipes so that the construction of the furnace becomes difficult. In the water jacket type cooler there is a great temperature difference between the surface which is directly irradiated by the heat of arc and the inner surface (which is cooled by the cooling water) so that the cracking tends to start in the welded joints of the steel jacket due to the thermal stress. Therefore the accident due to the leakage of cooling water tends to occur.

The conventional hot spot coolers of the types described above only serve to increase the life of the brick at the hot spot to that of other brick of the furnace wall so that the problem of the short life of the furnace wall has not been solved. In view of the recent technical level it is impossible to increase the life of the furnace wall only by the selection of the refractory materials. Therefore there has long been a need for satisfactorily overcoming the above problem.

One of the objects of the present invention is therefore to provide a furnace proper of an electric direct-arc furnace which has a semipermanent furnace wall life whereby the problems encountered in the prior art arc furnaces may be eliminated.

Another object of the present invention is to provide a furnace proper of an electric direct-arc furnace in which the life of a furnace roof may be increased and the faster refining may be effected.

Another object of the present invention is to provide a furnace proper of an electric direct-arc furnace in which the charge may be uniformly melted.

Another object of the present invention is to provide a furnace proper of an electric direct-arc furnace in which the accident due to leakage of cooling water may be eliminated and which is provided with hot spot coolers which have a long durability and are easy to mount on or dismount from the furnace proper.

Briefly stated according to the present invention the furnace wall above the level of molten steel is constructed with a plurality of cooling blocks, each of which comprises generally a cooling block proper made of a special metal whose inner surface is lined with a refractory material and a cooling tube embedded therein.

The present invention will become more apparent from the following description of some preferred embodiments thereof taken in conjunction with the accompanying drawings.

FIG. 1 is a cross sectional view of a first embodiment of an electric direct-arc furnace in accordance with the present invention;

FIG. 2 is a vertical sectional view thereof;

FIG. 3 is a sectional view, on enlarged scale, illustrating a cooling block thereof;

FIG. 4 is a sectional view of a second embodiment of the present invention;

FIGS. 5 and 6 are cross sectional views of a third embodiment of the present invention;

FIG. 7 is a front view of a hot spot cooling block used in the construction of an arc furnace in accordance with the present invention;

FIG. 8 is a vertical sectional view thereof; and

FIG. 9 is a sectional view looking in the direction indicated by the arrows X in FIG. 7.

FIGS. 1 – 3 show the first embodiment of the present invention. A plurality of cooling blocks 1 for an electric arc furnace are stacked from the position about 200 – 500mm higher than the level of molten steel 6 or slag so as to form a furnace wall substantially circular in cross section. The cooling blocks 1 are spaced apart from the level of molten steel so that they may be free from splash of molten steel 6. The bottom 7 which defines a hearth is constructed with fire clay brick in the conventional manner using the stamping machine.

The detail of the cooling block 1 is best shown in FIG. 3. The cooling block 1 generally comprises a cooling block proper 1′ made of a specially cast steel, a steel water cooling tube 2 embedded into the cooling block proper 1′, headers 3 hydraulically connected to the water cooling tube 2, refractory brick 4 one halves of which are embedded into the cooling block proper 1′, and refractory material 5 placed in the spaces between the refractory brick 4.

The electric arc furnace with the construction described above has the following features and advantages:

i. Since one half of the refractory brick is embedded into the cooling block having the cooling tube embedded therein, the refractory brick may be cooled very effectively. Furthermore the cracking of the cooling block proper may be eliminated. Even if it should be cracked cooling water leakage may be prevented because cooling water flows through the cooling tube.

ii. The brick is very efficiently cooled so that splash of molten metal is cooled and adheres to the brick and

refractory material to form a sort of protective wall. Thus, the semipermanent durability may be ensured.

iii. Since the furnace wall is constituted from the cooling blocks of the type described above, the furnace operation efficiency may be considerably increased, thus resulting in the reduction in overall cost.

The second embodiment shown in FIG. **4** is substantially similar in construction to the first embodiment shown in FIGS. **1, 2** and **3** except that the furnace wall is slightly converged at the top. In addition to the novel features and advantages of the first embodiment described above, the second embodiment has the following additional features and advantages:

iv. Since the furnace wall is converged at the top, the small roof may be used. The number of fire clay brick used for constructing the furnace roof may be reduced so that it may be fabricated at low cost. Furthermore melting of scraps may be much facilitated and scaffold phenomenon may be prevented.

v. Since the furnace roof is light in weight only the furnace roof hoisting machine with a small capacity may be used.

vi. Since the construction is similar to that of the converter, oxygen injection or blasting may be effected so that the time required for refining steel may be shortened.

vii. When used as an electric arc furnace for melting reduced iron, reduced iron is scatterd over the molten steel. Therefore the flat bath operation time is increased so that the brick of the furnace roof is irradiated by the heat from the molten steel for a longer time, thus resulting in the shorter service life. However since the furnace roof is small in size, the loss of the fire clay brick may be minimized.

The arc furnaces of the third embodiment shown in FIGS. **5** and **6** are substantially similar in construction to those of the first and second embodiments except that the cross sections are hexagonal in the furnace shown in FIG. **5** and triangular in the furnace shown in FIG. **6** so that the furnace walls (hot spots) in opposed relation with three electrodes **8** which are generally disposed at the vertices of a triangle may be spaced apart therefrom as far as possible. In FIGS. **5** and **6** $L_2 > L_1$. Thus the charge may be uniformly melted.

The third embodiment has the following features and advantages in addition to those described hereinbefore:

viii. The electric direct-arc furnace polygonal in cross section may be constructed in a simple manner, and the hot spots may be located as far as feasible from the electrodes so that the charge of scraps may be uniformly melted.

ix. The damages to the furnace wall is uniform. (In case of the electric direct-arc furnace using the three-phase AC power, the arc is directed toward the furnace wall under the electromagnetic force. Therefore the jet of exceedingly high-temperature gases is directed toward the furnace wall so that the scraps in opposed relation with the electrodes are melted faster, thus resulting in non-uniform melting. The furnace wall in opposed relation with the electrodes are subjected to the local damages or hot spot phenomena due to the high-temperature flames).

According to the present invention the electric direct-arc furnaces constructed with the cooling blocks as shown in FIGS. **1 – 6** may be further provided with a removable hot spot cooler which may be mounted on the furnace proper from the exterior.

Referring to FIGS. **7, 8** and **9,** a hot spot cooling block generally comprises a cooling disk **1***a* made of a cast steel whose inner wall (directed toward the furnace) is embedded with a plurality of grooves (four grooves being shown in FIG. **7**) for fitting therein brick, a plurality of cooling tubes **2***a* (three cooling tubes being shown in FIG. **7**) embedded in the cooling disk **1***a* in spaced apart relation and headers **3***a* communicated with the upper outlets and lower inlets of the cooling tubes **2***a*. The hot spot cooler is assembled as follows: A plurality of hot spot cooling blocks being inserted into the spaces formed in the furnace wall **14** as best shown in FIG. **8.** Therefore the ends of the brick **13** remote from the hot spot cooling block are exposed in the furnace. Furthermore frames **10** are securely attached to the cooling disk **1***a* with cotter pins **12** and are joined with cotter pins **11** to frames **9** on the side of the furnace wall. Thus the hot spot cooling block may be securely held in position.

In the hot spot cooling brick the cooling water is made to flow from the lower header **3***a* through the cooling tubes **2***a* in the hot spot cooling block to the upper header **3***a* in the direction indicated by the arrows in FIG. **8.** Cooling water is discharged from the upper header **3***a*.

The hot spot cooling block may be removed from the furnace proper by loosening the cotter pins **11.** The hot spot cooling block disk **1***a* may have such a shape to that the construction of the furnace wall **14** may be facilitated. The material of the hot spot cooling block is not limited only to a cast steel, but any other suitable metal may be used.

The electric direct-arc furnace with the hot spot cooler of the type discribed above has the following features and advantages in addition to those described hereinbefore:

x. Since the brick **13** are embedded into the grooves of the cooling block disk **1***a* made of a cast steel and the temperature gradient due to the arc heat becomes very gentle. Therefore the cracking of the hot spot cooling disk may be prevented, and even if the cracking is started the accident due to the leakage of the cooling water may be prevented.

xi. Since the cast steel and brick are combined, the durability of brick may be increased.

xii. The hot spot cooler may mounted on or removed from the furnace wall from the exterior thereof in a simple manner within a short time because it consists of hot spot cooling blocks. Therefore the maintenance and repair may be much facilitated.

xiii. It is not required to use specially-shaped brick in order to construct the furnace wall around the hot spot coolers. Therefore the furnace construction may be much facilitated.

So far only the essential features of the present invention has been described with reference to the preferred embodiments thereof, but it will be understood that various modifications and variations can be effected with the scope of the present invention.

We claim:

1. An electric arc furnace comprising a wall and a bottom forming a receptacle for molten metal, the wall comprising at least one hot spot cooling block, said block comprising an outer shell of cast steel having a continuous outer surface, the inner surface of said shell being provided with a plurality of vertically spaced grooves, a refractory brick positioned in each groove

with a part protruding inwardly of the furnace from the inner surface of the cast steel shell leaving a space between the protruding parts of each pair of adjacent refractory bricks, refractory material filling the spaces between the protruding parts of adjacent refractory bricks and the spaces adjacent the protruding bricks at the ends of the block, and a tube embedded in the cast steel outer shell of the block with its ends exterior to the shell whereby cooling fluid may be passed through the tube.

2. An electric arc furnace according to claim **1,** in which the entire wall comprises said hot spot cooling blocks.

3. An electric arc furnace according to claim **1,** in which the inner surfaces of the refractory bricks and the refractory material are aligned to provide a smooth inner surface for the block.

4. As a new article of manufacture, a hot spot cooling block for incorporation into the wall of an electric arc furnace, said block comprising an outer shell of cast steel having a continuous outer surface, the inner surface of said shell being provided with a plurality of vertically spaced grooves, a refractory brick positioned in each groove with a part protruding inwardly of the furnace from the inner surface of the cast steel shell leaving a space between the protruding parts of each pair of adjacent refractory bricks, refractory material filling the spaces between the protruding parts of adjacent refractory bricks and the spaces adjacent the protruding bricks at the ends of the block, and a tube embedded in the cast steel outer shell of the block with its ends exterior to the shell whereby cooling fluid may be passed through the tube.

5. A new article of manufacture according to claim **4,** in which the inner surfaces of the refractory bricks and the refractory material are aligned to provide a smooth inner surface for the block.

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