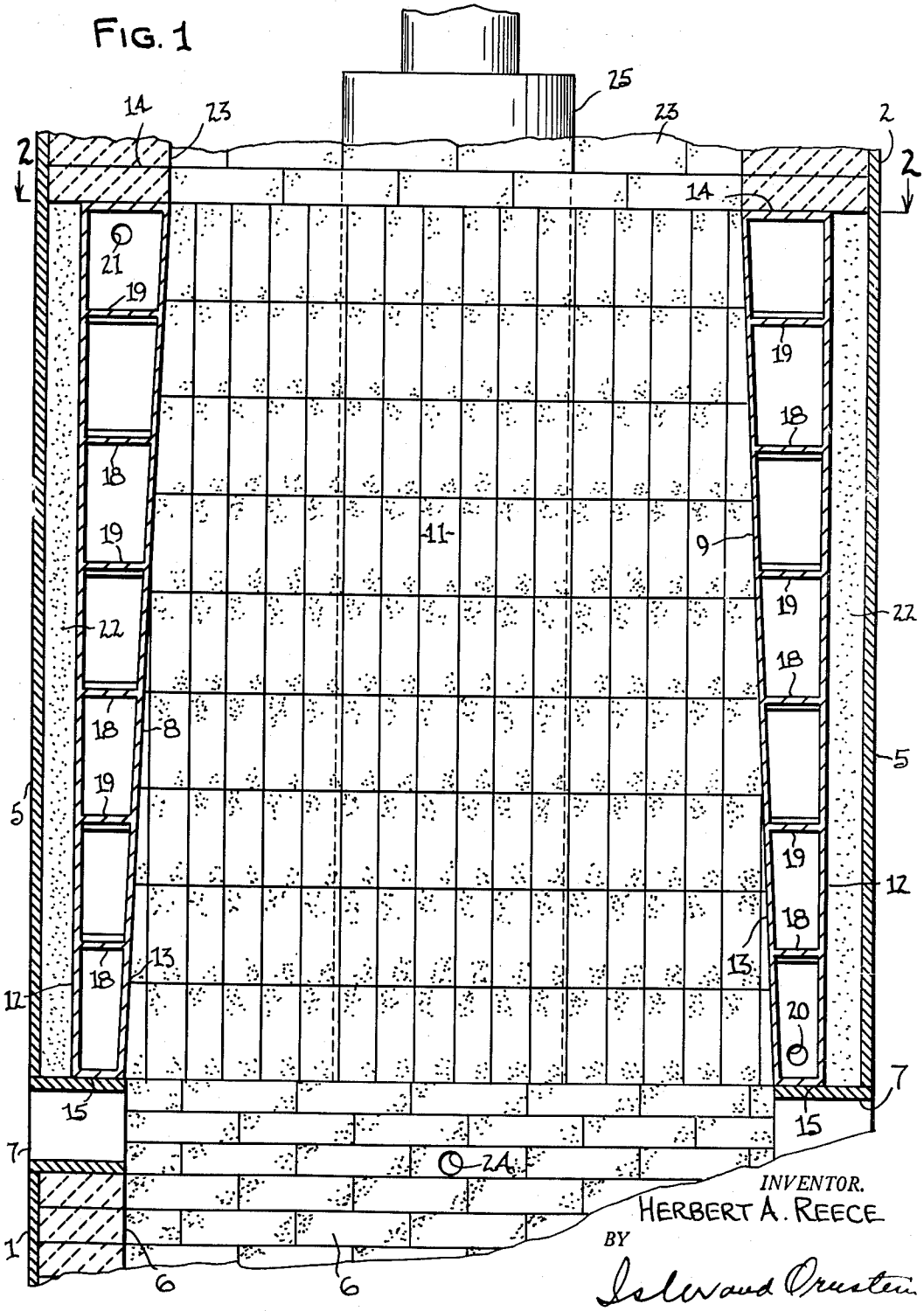
Oct. 25, 1955 H. A. REECE 2,721,736

WATER-COOLED CUPOLA

Filed July 21, 1951 3 Sheets-Sheet 1

FIG. 1



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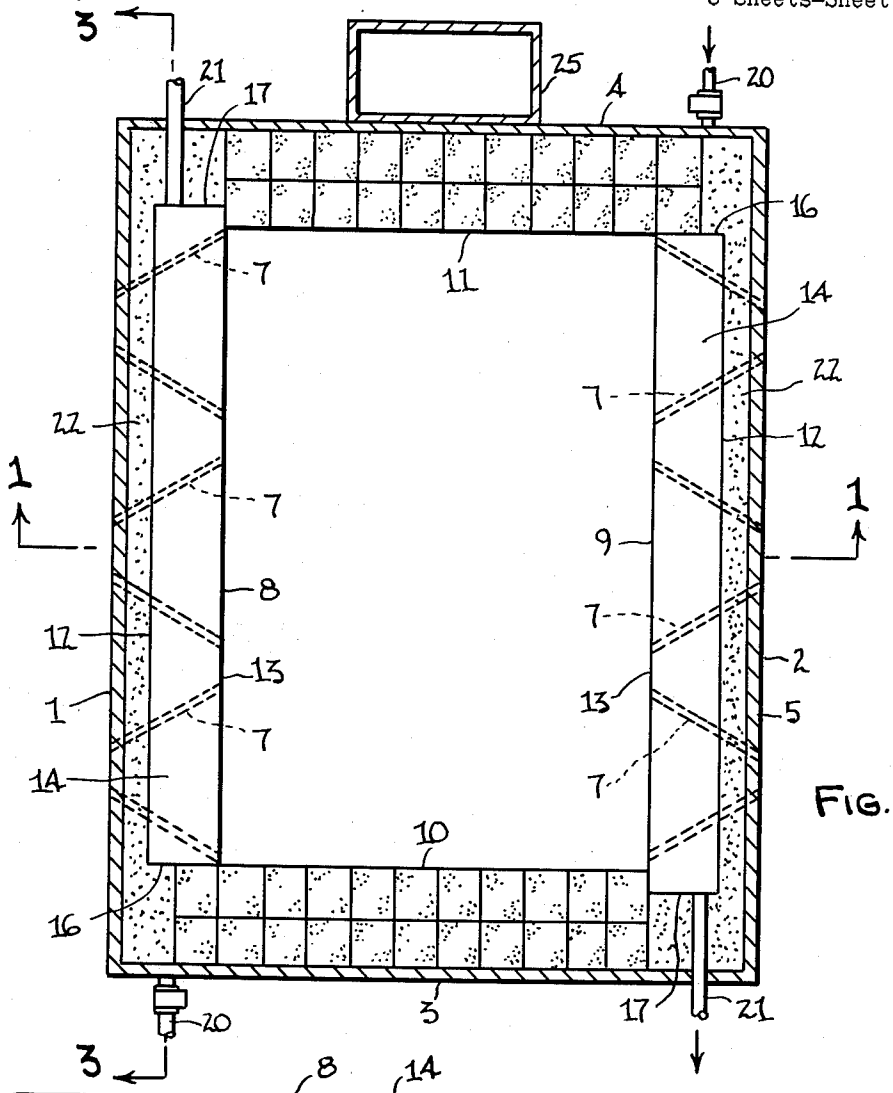


FIG. 2

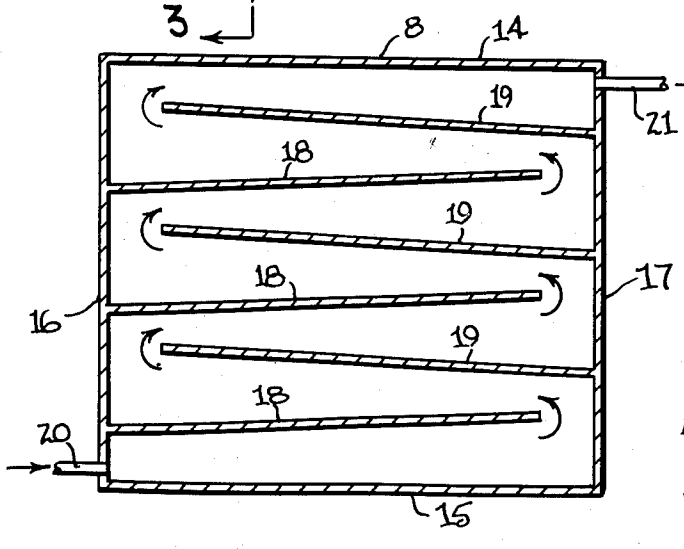


FIG. 3

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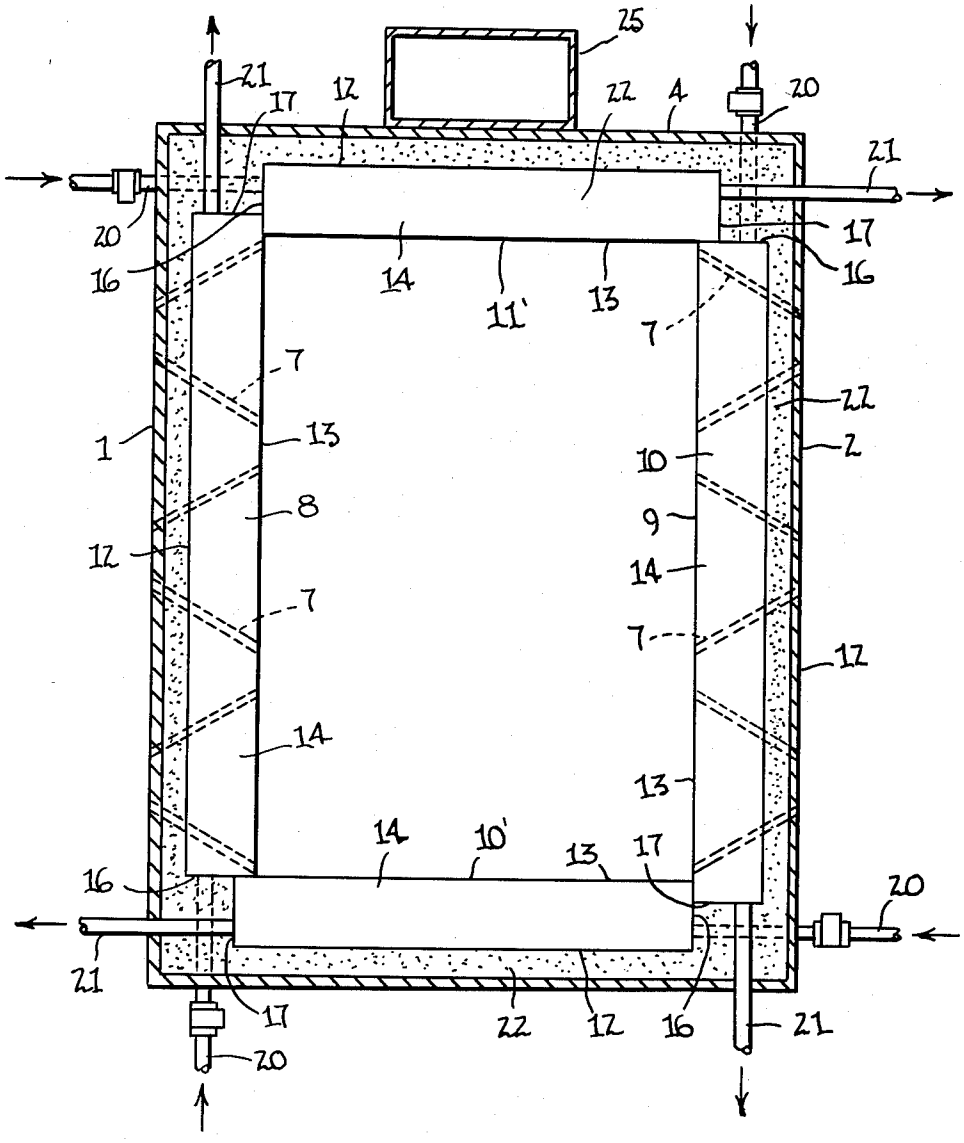


FIG. 4

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WATER-COOLED CUPOLA

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Application July 21, 1951, Serial No. 237,899

4 Claims. (Cl. 263—44)

This invention relates, as indicated, to water-cooled cupolas.

It has heretofore been proposed to replace the brickwork immediately above the tuyeres of a cupola by a system of cooling segments, water being supplied to the segments or jackets from a common main supply, but each jacket having a separate feed and exit for the water. Such a system is described in some detail in an article entitled "British Investigations of Modified Cupola Designs," which appears on pages 86–91 of the November, 1949 issue of The Iron Age.

The application of water cooling to cupola furnaces of the conventional cylindrical or conical design has, however, not proven practical nor economical, due, in part, to the fact that these geometrical shapes necessitate water entering and leaving the water jackets at right angles or nearly right angles to the direction or plane of the flow of water through the jackets.

Since the water flow through the jackets is in a circular or arcuate direction, and since the lengths of the arcs increase as the radial distance from the axis or center of the cupola increases, the water is required to traverse a longer path in the back or radially-outer portion of the jacket than in the front or radially-inner portion of the jacket. This means that the water flows faster in the back portion of the jacket than in the front portion thereof, thereby setting up layers of thermal stress which are deleterious to the jacket material.

Moreover, since the jackets are of arcuate horizontal cross-section, and are in edge-to-edge abutment with each other, a double thickness of metal is formed or provided at each abutment zone, thereby resulting in differentials in heat conduction which cause burning of the segments at the joints. Furthermore, since the segments are in circumferential abutment with each other, the segments are not free to expand or contract circumferentially, so that they become deformed or buckled, with consequent leaks at the joints.

When such burning or leaking necessitates replacement of a segment, it becomes necessary to tear out a substantial portion of the cupola lining, in order to extract the faulty segment and replace it with a new segment. It thus becomes necessary to "cast" rather than "fabricate" the segments, leading to both expense and additional metal on the face of the segment, which burns to the point of equalizing conduction of the heat. A vicious cycle is therefore ever present.

I have found that the aforesaid disadvantages and shortcomings of water cooling, as applied to cupolas of conventional circular or conical design, can be overcome in a relatively simple and inexpensive manner by utilizing water-cooled jackets in conjunction with a cupola of rectangular cross-section, as disclosed, for example, in my Patent No. 2,471,776.

A cupola of this rectangular shape lends itself readily to the incorporation therein of water-cooled jackets, which are of extremely simple construction and which can be installed and removed at a fraction of the cost

of installing and removing water-cooling equipment in cupolas of circular or conventional design.

A cupola of this rectangular shape also lends itself readily to the utilization of basic refractory linings, in combination with such water-cooled jackets, to form the wall of the cupola above the tuyeres, because the combination, as will be presently explained, permits expansion of the bricks forming the refractory lining without rupturing such bricks.

By utilization of water-cooling devices in accordance with my invention, I am able to have the water enter and leave the jackets in substantially the direction or plane of the flow of water through the jackets, to avoid the setting up of layers of thermal stress which are deleterious to the jacket material, to avoid differentials in heat conduction which cause burning of the jackets at the joints, and to avoid deformation or buckling of the jackets, with consequent leaks at the joints.

Other objects and advantages of the invention will become apparent during the course of the following description, when read in conjunction with the drawings forming a part of this specification, and in which like numerals are employed throughout to designate like or corresponding parts.

In said annexed drawings,

Fig. 1 is a fragmentary vertical cross-sectional view through my cupola, utilizing a preferred combination of water jackets and refractory lining above the tuyeres, taken on the line 1—1 of Fig. 2;

Fig. 2 is a transverse cross-sectional view, taken on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary cross-sectional view through one of the jackets, taken on the line 3—3 of Fig. 2, and

Fig. 4 is a view similar to Fig. 2, but showing a form of the invention utilizing only water jackets above the tuyeres.

Referring more particularly to Figs. 1 to 3 inclusive of the drawings, the cupola will be seen to comprise an upright hollow cupola body of substantially rectangular cross-section, having opposed substantially flat side walls 1 and 2, and opposed substantially flat end walls 3 and 4. The side and end walls are formed of an outer metallic shell 5, and below the tuyeres, the cupola is provided with a basic refractory lining 6.

Directly above the tuyeres, generally indicated by reference numeral 7, the cupola is provided at the inner portions of the side walls thereof with upstanding water-cooled jackets, and at the inner portions of the end walls, with refractory linings, the jackets and linings arranged to form a rectangle corresponding to the rectangular shape of the cupola. The jackets are designated by reference numerals 8 and 9, and the linings by reference numerals 10 and 11.

Each jacket, which in the average installation, is about 63 inches in height, is tapered in vertical cross-section, from a thickness of about 2 inches at the bottom to a thickness of about 4 inches at the top, the outer wall 12 of each jacket being substantially vertical, but the inner wall 13 being inclined outwardly, in a downward direction, so as to prevent vertically moving drops of molten iron from impinging directly on the inner walls of the jackets in the course of the gravitation of said drops to the hearth or well of the cupola, it being understood, of course, that drops ricocheting from the coke within the cupola will strike the jackets.

Each jacket is of hollow construction, consisting of an outer wall 12, an inner wall 13, a top 14, a bottom 15, and sides or ends 16 and 17.

Each jacket also includes a series of vanes or baffles 18 and 19 extending between the walls 12 and 13, and spaced from each other vertically, the vanes 18 extending from the wall 16 to points spaced from the side 17, and the

vanes 19 extending from the side 17 to points spaced from the side 16, thereby forming a tortuous passageway for the water through the jacket, as indicated in Fig. 3. It will also be noted that each vane is inclined upwardly from the side 16 or 17 from which it extends, for a purpose to be presently described.

Each jacket further includes a water inlet pipe or conduit 20 adjacent the lower end of the side 16 thereof, and a water outlet pipe or conduit 21 adjacent the upper end of the side 17 thereof. These inlet and outlet pipes extend through the end walls of the cupola, and in order to compensate for thermal expansion and contraction of the jackets, provision may be made for these pipes to slide relatively to the cupola walls as the jackets expand or contract, or to slide relatively to the walls of the jackets as the latter expand or contract, without, of course, breaking the water-tight seal between the pipes and jackets.

The linings 10 and 11 are preferably in the form of walls made from basic refractory bricks, laid on end, and for this purpose, bricks of magnesite, periclase, Magnex (a chemically bonded magnesite-chrome brick), Thermag (also a magnesite-chrome brick), chrome brick, and in special cases (air-setting ramming materials or mixtures). Repairs can be effected with dolomite or magnesite or magnesia groutings.

It will be noted that each jacket, as seen in Fig. 2, has endwise abutment with one of the lining walls extending rectangularly thereto, but has sidewise abutment with or overlaps the other lining wall which extends rectangularly thereto. This leaves each jacket free to expand or contract thermally without buckling, since the overlapping end of the jacket is free to slide relatively to the adjacent lining wall during such expansion or contraction.

Similarly, each lining wall, 10 and 11, has endwise abutment with one of the jackets extending rectangularly thereto, but has sidewise abutment with or overlaps the other jacket which extends rectangularly thereto. This leaves each lining wall free to expand or contract thermally without buckling, cracking or spalling, since the overlapping end of the wall is free to slide relatively to the adjacent jacket during such expansion or contraction.

It will further be noted that the conduits 20 and 21 enter or leave the jacket in the direction or general plane of the jacket.

The spaces between the jackets and lining walls and the shell 5 of the cupola may be filled with a suitable granular refractory material, indicated by reference numeral 22, this material being sufficiently fluid to permit expansion of the jackets and lining walls without injury to the cupola walls.

Above the water jackets and lining walls, the cupola may be lined with regular firebrick, or fireclay refractory material, as indicated at 23.

The sulfur fumes at the slag hole 24 are obnoxious to the cupola workmen and are carried off to the atmosphere by a sulfur fume hood 25.

It will be apparent from the foregoing description that the water jackets are cooled by continuous circulation of cold water through the jackets, the water entering the jackets through the inlet pipes 20 and leaving the jackets through the outlet pipes 21.

The jackets, for the reasons already stated, are free to expand and contract thermally, without becoming distorted or buckled.

Moreover, the points at which the joints between the jackets and lining walls are exposed to the interior of the cupola are not of double thickness, so that differentials in heat conduction which cause burning of the jackets at the joints are avoided.

Since the water inlet and outlet pipes enter and leave the jackets in substantially the direction or plane of the flow of water through the jackets, and the flow of water is in straight lines, the setting up of layers of thermal stress, which are deleterious to the jacket material is avoided.

The flow of water through the jackets is facilitated by the upward inclination of the vanes 18 and 19 in the direction of the water flow, and the widening in the cross-sectional area of the jackets upwardly compensates for expansion of the water as the temperature of the water increases during its movement from the lower to the upper portion of the jacket.

Each jacket is removable without interfering with the other jacket or either of the lining walls.

The construction of the jacket is such as to facilitate manufacture or fabrication thereof by welding together sheets or strips of rolled steel, thereby providing economies in manufacture, and permitting the jackets to be made from stainless or austenitic steel of any desired thickness, in the knowledge that the lighter the steel sections used, the lesser the thermal stresses encountered.

Normally basic cupolas are operated with magnesite linings, with repairs being made by blowing on a magnesia compound, such as Gundol.

Such linings require "spacers" (cracks between the magnesite brick) to take care of expansion of the brick, and when the expansion of the brick exceeds the space allowance, rupture of the brick occurs due to compressive forces. At times, this expansion can be cumulative, with consequent deterioration of the brick.

The utilization of lining walls, such as the walls 10 and 11, which can expand and contract, thermally, eliminates the need for "spacers," and provides a number of other advantages. The walls and bricks are not subject to rupture or deterioration. Straight brick can be used to construct such walls, whereas keys and arches, which are considerably more expensive than straight brick, must be used in round cupolas. The use of such walls, in combination with water-cooled jackets, reduces the cost of linings, without excessive thermal losses common to water-cooled cupolas. Moreover, the desulphurizing slag is not interfered with by the lining, and the slag basicity is controlled.

A basic cupola, as thus constructed, has the following other advantages:

(*a*) It cools off in very short time for repairs, due to the fact that the jackets do not require cooling periods.

(*b*) It is more economical to operate than the conventional basic cupola.

(*c*) The metal does not suffer from lack of temperature common to water-cooled cupolas.

(*d*) It does not present expansion problems common to basic cupolas in which the entire lining is basic.

(*e*) It substantially desulphurizes the iron melted to the degree provided by the volume of slag formed in the cupola. For example, 5.0% limestone and .50% fluorspar, charged as a flux, will desulphurize more than 3.0% limestone and .30% fluorspar.

Referring now to Fig. 4 of the drawing, there is disclosed a modified form of the invention, which is similar in all respects to that shown in Figs. 1 to 3, except that in this case water-cooled jackets 10′ and 11′ are utilized instead of the basic refractory lining walls 10 and 11.

The water-cooled jackets 10′ and 11′ are of a construction similar to that of the jackets 8 and 9 and are disposed in the same relationship, relatively to the jackets 8 and 9 as the relationship between the refractory lining walls 10 and 11 and the jackets 8 and 9 of the preferred form of the invention.

In order to avoid spaces between the overlapping portions of the jackets and the sides of the jackets which are overlapped, which spaces are due to the inclination of the inner faces of the jackets, the walls 16 of each jacket shown in Figs. 4 and 5 may be inclined vertically to conform with or correspond with the inclination of the faces 13.

The construction shown in Fig. 4, while not as advantageous in all respects as that shown in Figs. 1 to 3,

may be used where a greater cooling effect is desired in the portion of the cupola above the tuyere level.

It is to be understood that the forms of my invention herewith shown and described, are to be taken as examples of the same, and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of my invention, or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. In combination with a cupola of substantially rectangular cross-section having a well provided with a basic lining, water-cooled jackets lining two opposite sides of said cupola above said well, each of said jackets being of substantially rectangular and flat form and being substantially parallel with the adjacent portion of the cupola shell, each jacket having a flat outer wall, a flat inner wall spaced from the outer wall, a top, bottom and side walls, vanes extending between and to said inner and outer walls and from one side wall to points spaced from the other side wall, and vanes extending between and to the inner and outer walls and from the other side wall to points spaced from the first-named side wall, in staggered arrangement vertically with the first-named vanes, whereby to provide a tortuous passageway for water through said jacket, each jacket having water inlet and outlet conduits, the axes of said conduits extending horizontally, the inlet conduit being attached to an opening in one side wall of the jacket and extending to a point externally of the cupola shell, and the outlet conduit extending from the other side wall of the jacket to a point externally of the cupola shell, the other opposite sides of the cupola above the well being formed of basic refractory material, one end of each of said jackets having endwise engagement with one of said other opposite cupola sides and overlapping or sidewise engagement with the other of said other opposite sides, one end of each of said other opposite sides having endwise engagement with one of said water jackets and overlapping or sidewise engagement with the other of said water jackets, whereby each of said jackets and sides is free to expand or contract without interfering with the expansion or contraction of the other jacket or side, said well being lined with basic refractory material and the portion of the cupola above the upper level of said water jackets and other opposite sides being lined with fire clay refractory.

2. The combination, as defined in claim 1, in which the interior of the water jacket progressively increases in cross-sectional area from the bottom to the top of the jacket.

3. The combination, as defined in claim 1, wherein each of said vanes extends between the inner and outer walls of the jacket and extend upwardly from one side wall of said jacket.

4. In a cupola furnace, a lining for said furnace extending from a level above the tuyeres of the furnace to a level above the melting zone of the cupola, said lining consisting of walls of basic refractory material and water-cooled jackets arranged alternately around the furnace, said walls and jackets having exposed faces facing the interior of the furnace, the areas of the faces of said walls being similar in extent to the areas of the faces of the jackets, and the walls and jackets contacting at their ends in sliding relationship with each other, whereby each is free to expand and contract without disturbing the others.

References Cited in the file of this patent

UNITED STATES PATENTS

91,447	Johnston	Jan. 15, 1859
452,607	Hunts	May 19, 1891
723,641	Boring	Mar. 24, 1903
842,663	Hixon	Jan. 29, 1907
1,015,361	Tibbals et al.	Jan. 23, 1912
1,126,028	Kekich	Jan. 26, 1915
1,758,478	Snyder	May 13, 1930
2,238,036	Clutts	Apr. 15, 1941
2,256,179	Thomson	Sept. 16, 1941
2,270,297	Hensel	Jan. 20, 1942

OTHER REFERENCES

Pages 287 and 288 of Trinks' Industrial Furnaces, vol. I, third ed., pub. by John Wiley and Sons, New York, N. Y., copyright 1934.

"Some Modifications in Cupola Design" by Renshaw and Sargood, pages 449–456, inclusive, of October 13, 1949 of Foundry Trade Journal.