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FURNACE HEARTH

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FIG. 1

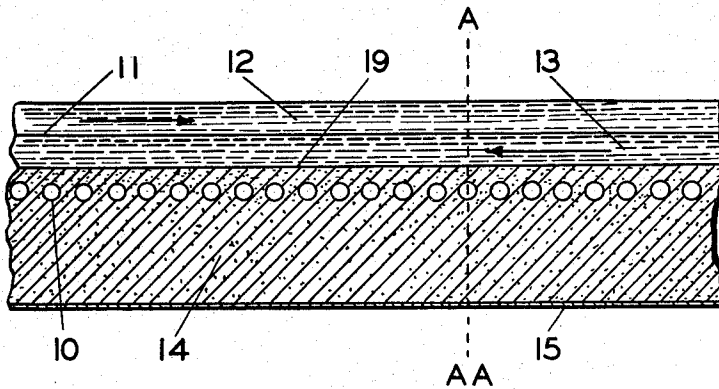
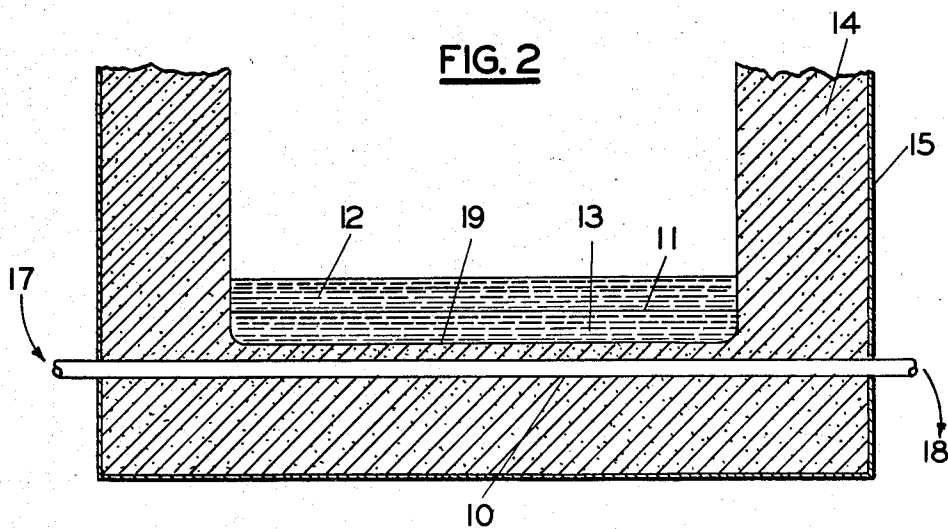


FIG. 2



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FURNACE HEARTH

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1 Claim. (Cl. 263—44)

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My invention relates to the hearth of my continuous refining furnace, Serial No. 578,742, filed on Feb. 19, 1945, later abandoned.

My objective concerns an improvement in the operating characteristics of the hearth of my furnace.

Figure 1 shows a section of the hearth of my furnace, with the thermal dams 10 located along, and within, the hearth.

Figure 2 shows section A—AA, indicated in Figure 1.

Due to the fact that my furnace is a continuous furnace, the refractories which constitute the hearth are not subjected to the rather drastic thermal shocks which the hearths in ordinary batch-type furnaces are subjected. In spite of this improved refractory situation, however, the refractories which constitute the hearth in my continuous furnace may be expected to suffer erosion by the metallurgical liquid that lies in contact with, and flowing by, the surface of the hearth.

As the hearth of my furnace erodes, the erosion may be expected to take the form of elongated channels or grooves, with their longitudinal axis lying parallel to the direction of flow of the contacting liquid. In an ordinary batch-type metallurgical furnace, the actual shape or form that the erosion takes does not necessarily have a bearing on the outcome of the reactions being carried out within the furnace; but in my continuous furnace, the development of longitudinal channels along the hearth will quickly lead to a serious breakdown in the refining action.

My furnace is a metallurgical reaction vessel wherein the reactants are brought into turbulent contact with each other by superimposing a flowing filament of one reactant upon a flowing filament of another reactant, as both reactants flow in a substantially horizontal manner through the furnace. The principal flow direction of the liquids being longitudinal, the molten reactant metal lying in any given longitudinal plane of the metal bath must depend upon the reactant power of the molten reagent slag that lies within this selfsame longitudinal plane. Thus, little dependence can be placed upon any appreciable movement of the reactant liquids in a plane that lies transverse to the flow direction.

Inasmuch as economy dictates that no more reagent be employed than necessary, it follows that the reagent that will be available to any given longitudinal plane or section of the molten metal bath will not be much more than is necessary to carry the reaction to the desired state

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of completion. True, in the counter-current furnace, there exists an artificial excess of the reactants at each end of the zone of reaction—the so-called "ghost excesses." My application, Serial No. 688,927, filed on Aug. 7, 1946, now abandoned, discussed these "ghost excesses," established a phraseology concerning the operational characteristics of the thin-layer refining furnace, and showed the importance of the "ghost excesses" to the smooth operation of the unit.

Serial No. 688,927 depended for its novelty on the uniform composition of the advancing transverse reactant filaments, that is, the chemical composition of any transverse cross section of the reacting liquids must exhibit a substantially uniform character. If this were not so, it would not be possible to accurately define such phenomena as the zone of reaction, the planes of completion, or the zones of excess reagent; furthermore, without uniform transverse reaction fronts, these thin-layer furnaces become metallurgically useless.

Assuming everything else to be equal, transverse uniformity is predicated upon the maintenance of a uniform depth of the reactant liquids. It will be understood that the upper liquid is of uniform depth in all cases, and that depth irregularities will be found only in the lower liquid layer. Naturally, depth irregularities in this lower layer can only result from irregularities in the surface of the furnace hearth.

For the sake of illustration, assume that any given metallurgical reaction between an impure metal and a reagent slag is proceeding normally within a counter-current unit of my refining furnace. With the layer depths and all other operating features uniform, the transverse composition of either liquid, at any given transverse section along the refining trough, will be substantially uniform, and the location of the planes of completion will be easy to find and maintain.

Assume, now, that a round hole were to develop in the hearth of the furnace within the zone of reaction. The reaction rate in the longitudinal section of the bath that is defined by the transverse diameter of this eroded hole will be below the normal reaction rate—for the simple reason that the hole increases the diffusion distance in the reaction area immediately thereover. The immediate result of this decreased reaction rate will be a projection of the planes of completion into the zones of excess in the plane defined by the hole's transverse diameter. This projection will not be, in itself, of serious concern to the operation unless the projection proceeds far

enough to throw the planes out of the furnace. This protection that the zones of excess give the operation against such simple breakdowns as hearth holes, serves to stress the importance of the novelties disclosed in my Serial No. 688,927.

But now assume that this simple round hole is slowly eroded into a longitudinal channel whose axis lies parallel to the direction of flow. All along this channel the reaction is inhibited and delayed by the increased diffusion distance, and, as the erosion continues, it is certain that the planes of completion are to be projected out of the furnace—a result that signals a serious breakdown in the operation.

To summarize: hearth holes need not be of immediate concern to the operating characteristics of the furnace, but longitudinal channels will cause a breakdown in the refining action.

Unfortunately, longitudinal channeling is a natural phenomenon connected with the flow of an erosive liquid. Thus, even if the erosion were to first evidence itself as a small round hearth hole, subsequent action of the flowing liquid against the hole would likely result in the formation of a longitudinal channel.

I have discovered a method of building the refractory hearth in my continuous refining furnace that prevents the formation of longitudinal channels during the refining action. My method consists of erecting a series of thermal dams across the hearth.

In Figure 1, rammed refractory hearth 14 is supported by shell 15. Interacting liquids 12 and 13 are shown flowing along and by surface 19, which surface 19 is the principal subject of my invention being herein disclosed. Embedded beneath surface 19 are a series of water pipes 10. Pipes 10 all lie at right angles to the direction of flow of liquids 12 and 13, and are all equidistant from, and parallel to, reaction interface 11.

Figure 2 shows section A—AA, indicated in Figure 1. Here, pipe 10 is shown to pass entirely through the body of the furnace. Pipe 10 carries cooling-water 17, and discharges waste-water 18.

Pipes 10 should be spaced from each other at frequent enough intervals to break up the channelling tendency of the hearth. In the ordinary case, a space between pipes 10 of from 2 to 12 inches will be suitable. In general, the more erosive the conditions are at surface 19, the closer pipes 10 must be spaced in order to break up channelling.

The distance that pipes 10 must be buried beneath surface 19 may be defined by stating the maximum and minimum distances. Pipes 10 must not be so far from surface 19 that the cooling effect of each pipe 10 is not demonstrated by the fact that the surface 19 that is immediately over each pipe 10 is cooler than the surface 19 that is not thereover. Pipes 10 should not be any closer to surface 19 than may be achieved without actually causing the cooling effect to interfere with the flow system that constitutes this refining method. Under normal conditions, pipes 10 will be buried with their upper edge from 1 to 3 inches below surface 19.

The refractory ram-mixture that surrounds

pipes 10, and constitutes surface 19, should be rammed-in in a transverse manner, that is, all ramming should be carried out in a manner that will cause ramming irregularities to evidence themselves as transverse defects, not as longitudinal defects.

The action of pipes 10 is as follows: the cooling effect of water 17, as it passes through pipes 10, creates narrow strips of surface 19 that are somewhat cooler than surface 19 as a whole. These narrow, cooled strips lie at right angles to the direction of flow of liquids 12 and 13. While erosion may take place between these cooled strips in the usual way, when the erosive action meets one of the cooled strips (hereinafter called, thermal dams), the eroding liquid meets a much more resistant refractory body than exists between the thermal dams. The resistance of the thermal dams to erosion is occasioned by the increased hardness exhibited by cooler refractories, and by the very steep temperature gradient in the refractory lying over pipes 10. Thus, as the eroding liquid penetrates into the hearth at the locale of the thermal dams, it immediately meets surfaces which are cooled so much that the eroding liquid is strongly handicapped by becoming viscous—and may, in fact, actually solidify. In any case, the creation of longitudinal channels is stopped by the thermal dams.

The strength of the thermal dams may be varied by varying the distance between pipes 10 and surface 19, and by varying the amount of water that is passing thru pipes 10.

I claim as my invention:

In a continuous refining furnace wherein a horizontally-flowing stream of molten metal is being refined by a horizontally-flowing stream of molten slag that is floating on and in contact with said stream of molten metal, the method of preventing the erosion of the hearth of said furnace from interfering with said refining operation, which comprises: burying a series of substantially parallel pipes beneath the surface of said hearth, each of said pipes being substantially parallel to and at a substantially equal distance from said surface and substantially at right angles to the direction of flow of said stream of molten metal through said furnace; and circulating water through said buried pipes, so as to cool strips of said surface, so as to prevent said metal stream from eroding longitudinal channels in said hearth.

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