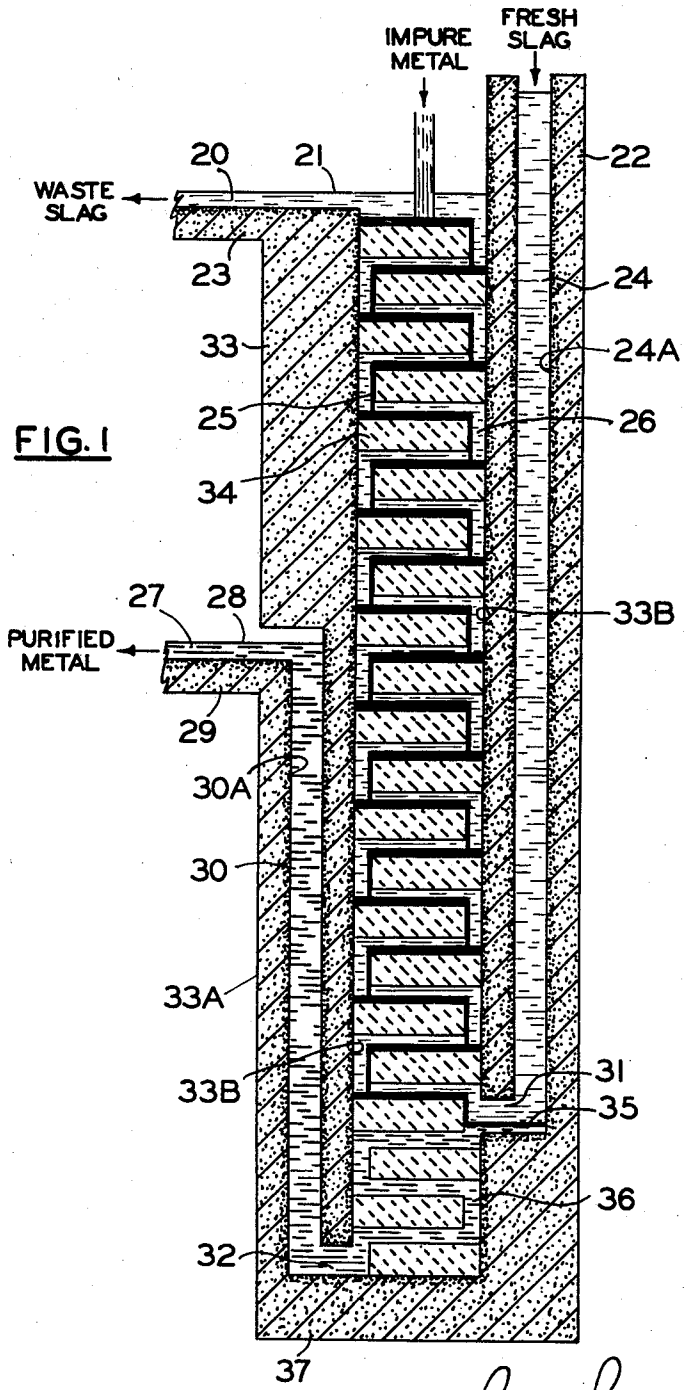
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REFINING TOWER

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FIG. 1



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FIG. 2

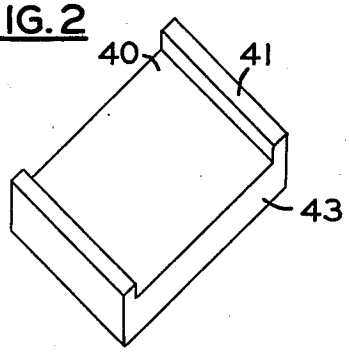


FIG. 3

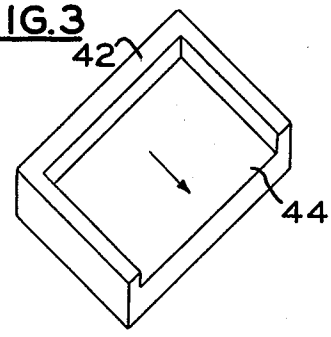


FIG. 4

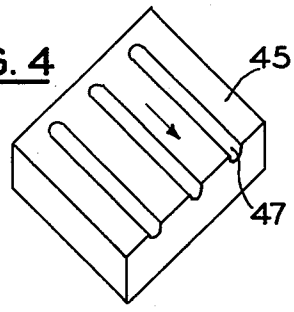


FIG. 5

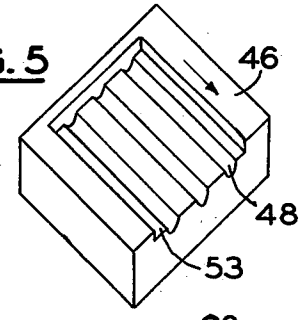


FIG. 6

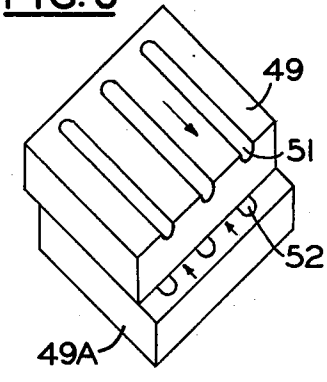


FIG. 7

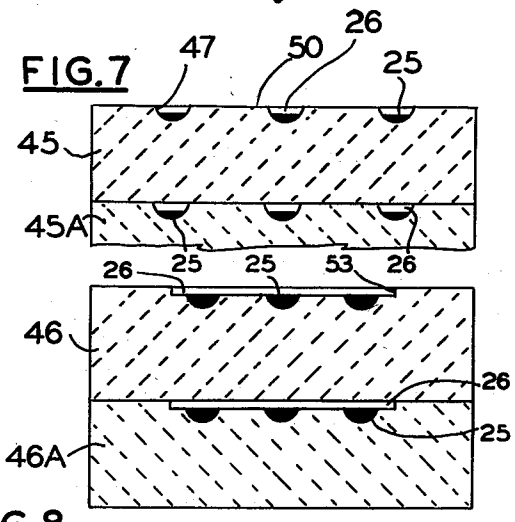


FIG. 8

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FIG. 9

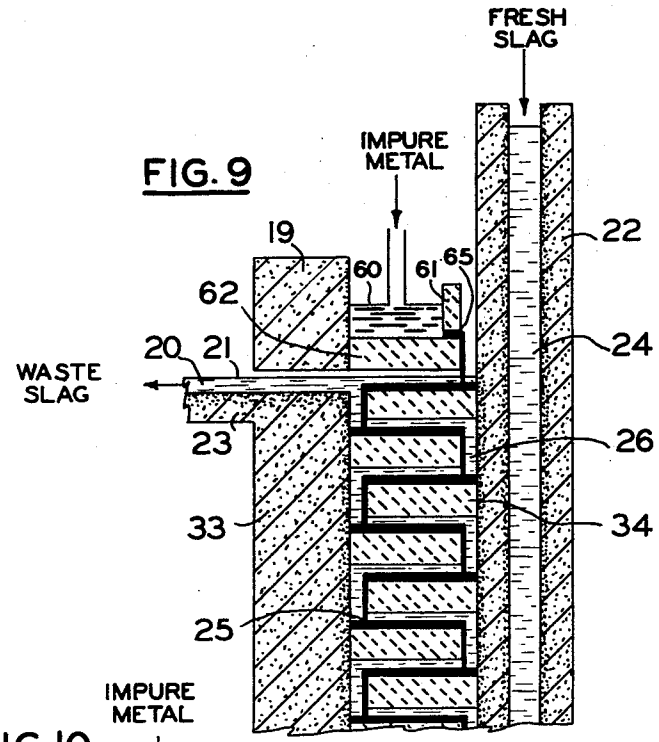


FIG. 10

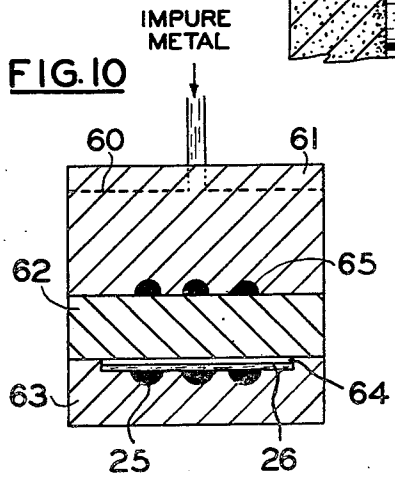
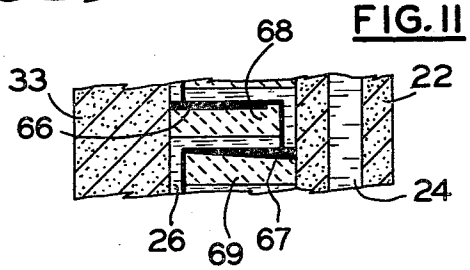


FIG. 11



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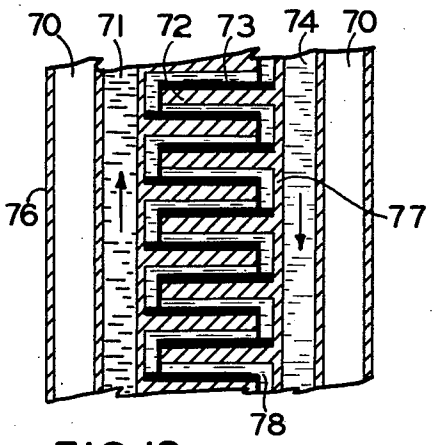


FIG. 13

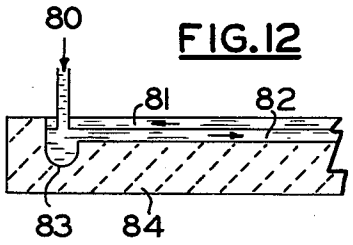


FIG. 12

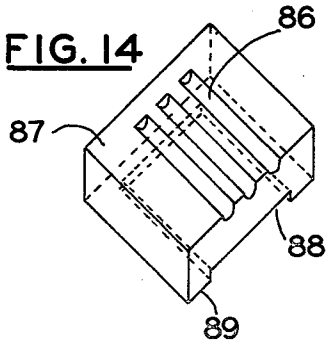


FIG. 14

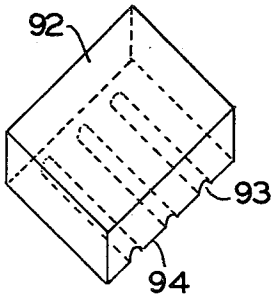


FIG. 15

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Patented Oct. 23, 1951 2,572,489

UNITED STATES PATENT OFFICE

2,572,489

REFINING TOWER

James Fernando Jordan, Huntington Park, Calif.

Application February 1, 1949, Serial No. 73,993

2 Claims. (Cl. 266—34)

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My invention relates to metallurgy wherein it is desirable to flow two reactant metallurgical liquids counter-current with respect to each other.

The physico-chemical advantages of counter-current flow of immiscible reactant liquids are widely-known and widely-employed within the chemical and petroleum industries. The use of the principle of counter-current flow is practically unknown within refining metallurgy, due, in part, to the difficulties associated with the development of equipment that is capable of entertaining a counter-current flow of reactant metallurgical liquids. In the main, these difficulties center around the high temperatures generally employed in metallurgy, and the highly erosive character of most metallurgical liquids.

My invention concerns a refining tower that is capable of entertaining a counter-current flow of two reactant metallurgical liquids.

Figure 1 shows my refining tower.

Figures 2 through 5 show several refractory shapes that are suitable for use in my refining tower.

Figure 6 shows my preferred method of stacking the refractory shapes in said tower.

Figures 7 and 8 show a cross section of two of said shapes, so as to picture how the immiscible reagent liquids flow through the stacked refractory shapes.

Figure 9 shows a modification of my refining tower, equipped to distribute the incoming metal into the refining slots.

Figure 10 shows a cross section of the distribution dam shown in Figure 9.

Figure 11 shows several methods of modifying the upper surface of a rafrectory shape, so as to delay the passage of the molten metal through the tower.

Fig. 12 shows a refractory shape adapted to cushion the fall of metal.

Fig. 13 shows another modification of my refining tower made entirely of iron or steel.

Figs. 14 and 15 show modifications of the refractory shapes having a channel or channels in the bottom surface of the refractory shape.

In Figure 1, steel shell 33A supports refractory lining 33, said refractory lining 33 being composed of a rammed-in refractory material whose thermal and chemical characteristics are compatible with the temperature and composition of incoming fresh slag 24 and used slag 26. Said refractory lining 33 is rammed into shell 33A so as to form refining chamber 33B. Said refining chamber 33B may be round, square, rectangular, or any other convenient shape in cross section, and said chamber 33B should be of uniform shape

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and size throughout its entire height. Said chamber 33B is closed at its bottom by rammed-in refractory bottom 37. Said bottom 37 may be arranged so that it can be easily removed, so as to facilitate the removal of refractory lining 33 from shell 33A.

Paralleling said chamber 33B, and rammed into or alongside of refractory lining 33, is located the overflow channel 30A by which the purified metal 27 leaves chamber 33B. Said channel 30A connects with chamber 33B at or near the base of said chamber 33B, said connection being made via opening 32, and said channel 30A terminates at overflow spout 29. Column 30 within channel 30A terminates at surface 28 in spout 29, and said column 30 communicates with metal bath 36 via opening 32. Slag column 26 within chamber 33B and metal column 30 in channel 30A form a communicating column system. The height of slag column 26 above datum line 35—the slag-metal interface, and the height of metal column 30 above said datum line 35, may be calculated by means of the equation, where, at equilibrium

$$\frac{A}{B}=\frac{C}{D}$$

wherein A is the density of the molten metal, B is the density of the molten slag, C is the height of slag column 26 above datum line 35, and D is the height of metal column 30 above said datum line 35. In other words, the heights of the two liquid columns above their common plane of separation vary inversely as their densities.

Paralleling said chamber 33B, and rammed into or alongside of refractory lining 33, is located the inflow channel 24A by which the incoming fresh slag 24 enters refining chamber 33B. Said channed 24A connects with said chamber 33B by means of opening 31, said opening 31 being located above and near slag-metal interface 35. Said channel 24A terminates at a position that is well above the level of said bath 26 within chamber 33B, so that a hydraulic head may be built up within channel extension 22 by carrying said slag column 24 within said extension 22 above slag level 21 within chamber 33B.

Channels 30A and 24A are shown in Figure 1 built into lining 33. Said channels need not be arranged in this fashion, but may be formed in a refractory body that is attached to the outside of said lining 33, similar to the outside spouts in tea-pot ladles.

At the top of refining chamber 33B is located a waste slag overflow spout 23. Said spout 23, acting in concord with refined metal overflow spout 29, controls the elevation of slag-metal interface 35.

Within refining chamber 33B are stacked refining shelves 34, one shelf upon another. Said shelves 34 are all substantially the same size and shape, and are stacked upon one another in a staggered fashion—that is, so that each shelf 34 is overlapped at one end by both of the shelves 34 in contact with which it lies, being thereby caused to overlap both of said shelves 34 at the end of said shelf 34 that is opposite to the end that is overlapped. In other words, in any group of three shelves 34 that are stacked upon one another, the middle shelf 34 overlaps the other two shelves 34 at one side of the refining chamber 33B, and said middle shelf 34 is, in turn, overlapped by said other two shelves 34 at the opposite side of said chamber 33B.

Shelves 34 are all substantially the same size and shape, and should be individually preformed and prefired. During the preforming operation, the top faces of said shelves 34 are grooved with one or more channels, in the manner shown in Figures 2–5 and 12. During the stacking operation, said shelves 34 are oriented so that said channels in said top faces of said shelves 34 connect the alternately overlapping edges of shelves 34, so as to provide the flowing liquids with the means for flowing between the stacked shelves 34.

With shelves 34 stacked and staggered, and with said channels oriented so the flowing metal is led from one overlapping edge to another, said flowing slag and metal pass counter-current to each other as they pass thru the refining tower. Thus, the incoming impure metal flows along the channels on the top of the first shelf 34, overflowing the end of said shelf 34 to fall into the channels in the top of the next shelf 34; and so it goes. The flowing metal 25 is introduced at a rate that results in said channels being only partly filled up, see flowing metal 25 in Figure 7. The balance of the space in said channels is occupied by the counter-current flow of reagent slag 26. Thus each of the channels on the top of each shelf 34 is filled with molten slag and molten metal—each liquid being confined to a separate layer, and each liquid layer flowing in counter-current relationship to the other layer.

The shelves 34 illustrated in Figures 1, 9 and 11 are constructed in the manner shown in Figure 2. In Figure 2, channel 40 is formed by sidewalls 41 and base 43. The shelf 34 shown in Figure 3 is a modification of the one shown in Figure 2, in that sidewall 42 is extended entirely around channel 44, save at the overflow edge. The arrow indicates the normal direction of flow of the metal. The shelf 34 of Figure 3 has the advantage of preventing the molten metal from contacting the walls of refining chamber 33B.

Figure 4 shows the use of a number of channels, instead of the single channel of Figures 2 and 3. The advantage of the use of a number of channels 47 in a shelf 45 lies in the distribution of the slag and metal streams so that the proper amount of said liquids flows in contact with each other; for, the shelves of Figures 2 and 3 must be absolutely level if the two interacting liquids are to be properly distributed on said shelves. The use of a number of such channels has the effect of minimizing the adverse results arising from shelves 34 which are not level, but only if the proper amount of said slag and metal is distributed to each channel. Figure 6 shows the shelves of Figure 4 stacked in the staggered manner previously described. Shelves 49 and 49A are shown staggered so that the liquid metal which might be flowing in the indicated direction along channel 51, for example, is caused to flow out of said channel 51 and into channel 52.

Figure 7 shows a section thru two of the stacked shelves—a section cut at right angles to the direction of flow of the metal thru the channels. Here, shelf 45 is shown imposed upon shelf 45A, exposing three channels 47 in top face 50 of shelf 45, together with three similar aligned channels on the top face of shelf 45A. Molten metal streams 25 are shown occupying the lower half of said intersected channels, and molten slag streams 26 are shown occupying the upper half of said intersected channels. In a cross section, such as this, if metal streams 25 in shelf 45 are flowing towards the viewer, then metal streams 25 in shelf 45A are flowing away from the viewer, and the slag streams 26 are flowing away from the viewer in shelf 45 and towards the viewer in shelf 45A.

Figure 5 shows my preferred refining shelf. Here, shelf 46 is shown containing three channels 48 in a sunken section 53 of the top face of said shelf 46. Figure 8 shows a cross section of several of the shelves of Figure 5. By feeding into the refining tower only sufficient impure molten metal to fill the three channels 48 up, the distribution of the molten metal as it flows over the shelves is simplified, and the flowing slag layer 26 is retained in a well distributed relationship to said flowing metal streams 25. In Figure 8, sections 46 and 46A are shown with the metal streams 25 in shelf 46 flowing towards the viewer and metal streams 25 in shelf 46A flowing away from the viewer, while slag stream 26 in shelf 46 is flowing away from the viewer and slag stream 26 in shelf 46A is flowing towards the viewer.

In the arrangements shown in Figures 4, 6 and 7 it is necessary to uniformly distribute the incoming molten metal between the channels. One way in which this distribution may be achieved is by means of the arrangement shown in Figure 9. Here, the device of Figure 1 is built up by means of wall 19, and an additional shelf 62 over the free surface of the overflowing slag 20. This arrangement permits the incoming metal to be dammed up on shelf 62 by means of refractory dam 61, thus forming pool 60. Dam 61 is penetrated by as many orifices as corresponds to the number of channels to be fed, thus permitting the molten metal in pool 60 to flow in the required amount into each of said channels in said shelves 34. A cross section of the damming arrangement of Figure 9 is shown in Figure 10, save that the type of shelves being fed in Figure 10 are of type shown in Figures 5 and 8. In Figure 10, dam 61 is shown damming metal pool 60, said pool 60 being retained on shelf 62. Orifices 65 are shown disposed to feed metal streams 25 in refining shelf 63, metal streams 25 being shown flowing in contact with outgoing slag 26—gaseous space 64 being located above the free surface 21 of said flowing slag 26.

As has been previously described, the refining shelves may be arranged so that the molten metal flows down thru the tower in free flow; that is, without any attempt being made to dam the flowing metal in any way. If it is desired to prolong the contact between the slag and metal within the tower, the refining shelves may be designed to meet this requirement. Thus, in Figure 11, the flowing metal stream 66 may be slowed up in its passage across shelf 68 by damming said stream 66 at the overflow end of said shelf 68, forming a more or less uniform depth of metal across said shelf 68, in the indicated

manner; or, a damming action may be arranged by sloping the upper surface of a shelf **69** from the overflow end of said shelf **69** to the metal-entry end of said shelf **69**, thus forming a wedge-shaped body of molten metal on said shelf **69**, in the manner shown.

When the molten metal overflows a shelf and falls onto the shelf next below it, it may be desirable to cushion the fall of said metal, so as to avoid splashing the metal. The arrangement shown in Figure 12 may be utilized in any of the illustrated shelves. Here the metal-entry end of a refining shelf **84** is provided with a basin **83** that cushions the shock of liquid fall as metal stream **80** meets said shelf **84**. Slag stream **81** and metal stream **82** are shown flowing counter-current to each other in the usual manner.

My refining tower should be preheated before the reactant liquids are introduced thereinto. This may be done by passing hot gas therethrough.

Certain low temperature refining operations are carried out within metal refining vessels. An example of this is the refinement of molten lead by means of molten caustic soda in an iron vessel. When my refining vessel is being employed in such an operation, my refining tower may be constructed entirely of iron. Figure 13 shows a refining tower constructed in such a fashion. The general design of the all-metal tower of Figure 13 is similar to the non-metallic refractory tower shown in Figure 1; that is, downward-flowing metal stream **73** is flowing from shelf **72** to shelf **72** as stream **73** flows counter-current to upward-flowing slag stream **78**. Shelves **73**, refining chamber **77** and channels **74** and **71** are shown formed of sheet iron or steel. The method of construction may be by weldment or casting. Chambers **70** are formed by sheet **76**; said chambers **70** being hot-gas jackets built on the outside of the tower to maintain the temperature of the reactant liquids as said liquids pass thru chamber **77**. Hot-gas jackets **70** may also be used to preheat the refining tower to operating temperature.

Whether the refining shelves within my tower are made of a non-metallic refractory body that is preformed and prefired before being stacked within the tower in the described manner, or said refining shelves are metal shelves that are welded or cast inside of the refining chamber, the design of said refining shelves shall always substantially conform to the designs set forth in Figures 1–15, and shall always be operated substantially in the manner herein set forth and for the purposes disclosed.

While Figures 1–13 show the refining shelves with channels formed in their upper surfaces, variations on this arrangement are of course permissible without destroying the function of said shelves. Several such variations are shown in Figures 14 and 15. Figure 14 shows the refining shelf of the type shown in Figure 5, with the exception that slag-slot **53** is located in shelf bottom **89**, being identified as channel **88**, and the metal channels **48** are channels **86** in shelf top **87**—in other words, both the top and the bottom surfaces of the refining shelf may be caused to contain channels. Figure 15 shows the refining shelf of the type shown in Figure 4, but with channels **93** located in shelf bottom **94**, shelf top surface **92** being merely a flat surface that forms the base of channels **93** when a number of shelves are stacked.

The expression "refractory" is employed in the claims to denote any material, metallic or non-metallic, that exhibits a capacity to resist the chemical erosion of the liquids to be entertained within the refining vessel.

The counter-current refining vessel is designed for refining an impure molten metal by means of a molten reagent slag that is substantially immiscible in said molten metal. Ordinarily, the molten metal would flow down thru the molten reagent slag, as has been illustrated heretofore. However, I do not restrict the use of my refining vessel to such situations, but, rather, I intend that my invention cover all refining situations wherein a counter-current flow of substantially immiscible metallurgical liquids is feasible by virtue of a difference in density of said liquids. Thus, for example, the impure molten metal may be a silver-bearing lead metal that flows down thru a stream of molten zinc, for the purpose of desilverizing said lead metal; or, the impure molten metal may be a stream of molten pig iron that flows up thru a stream of molten lead, for the purpose of decopperizing said pig iron.

Having now described and illustrated several forms of my invention, I wish it to be understood that my invention is not to be limited to the specific form or arrangement of parts therein described and shown, except insofar as such limitations are specified in my appended claims.

I claim as my invention:

1. In a continuous refining vessel having two vertical, refractory passages adapted to communicate with a vertical, refractory, refining chamber so as to circulate in countercurrent contact within said refining chamber two substantially immiscible metallurgical liquids, the combination therewith of a staggered stack of refractory shapes resting upon one another within and unattached to said refining chamber, said shapes being arranged within said refining chamber so that each of said shapes is overlapped by the adjoining shapes at one side of said refining chamber while overlapping said adjoining shapes at the opposite side of said refining chamber; and a channel formed in a horizontal surface of each of said shapes and adapted to lead said liquids to the channels in said adjoining shapes, so that the heavy metallurgical liquid flows down through said refining chamber as a stream that partly fills said channels and in countercurrent contact with a stream of the lighter metallurgical liquid that fills the remaining part of said channels.

2. The apparatus according to claim 1 in which said horizontal surface of said shapes contains a plurality of substantially parallel channels, each of said channels being adapted to operate as described in claim 1.

JAMES FERNANDO JORDAN.

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