

March 31, 1925.

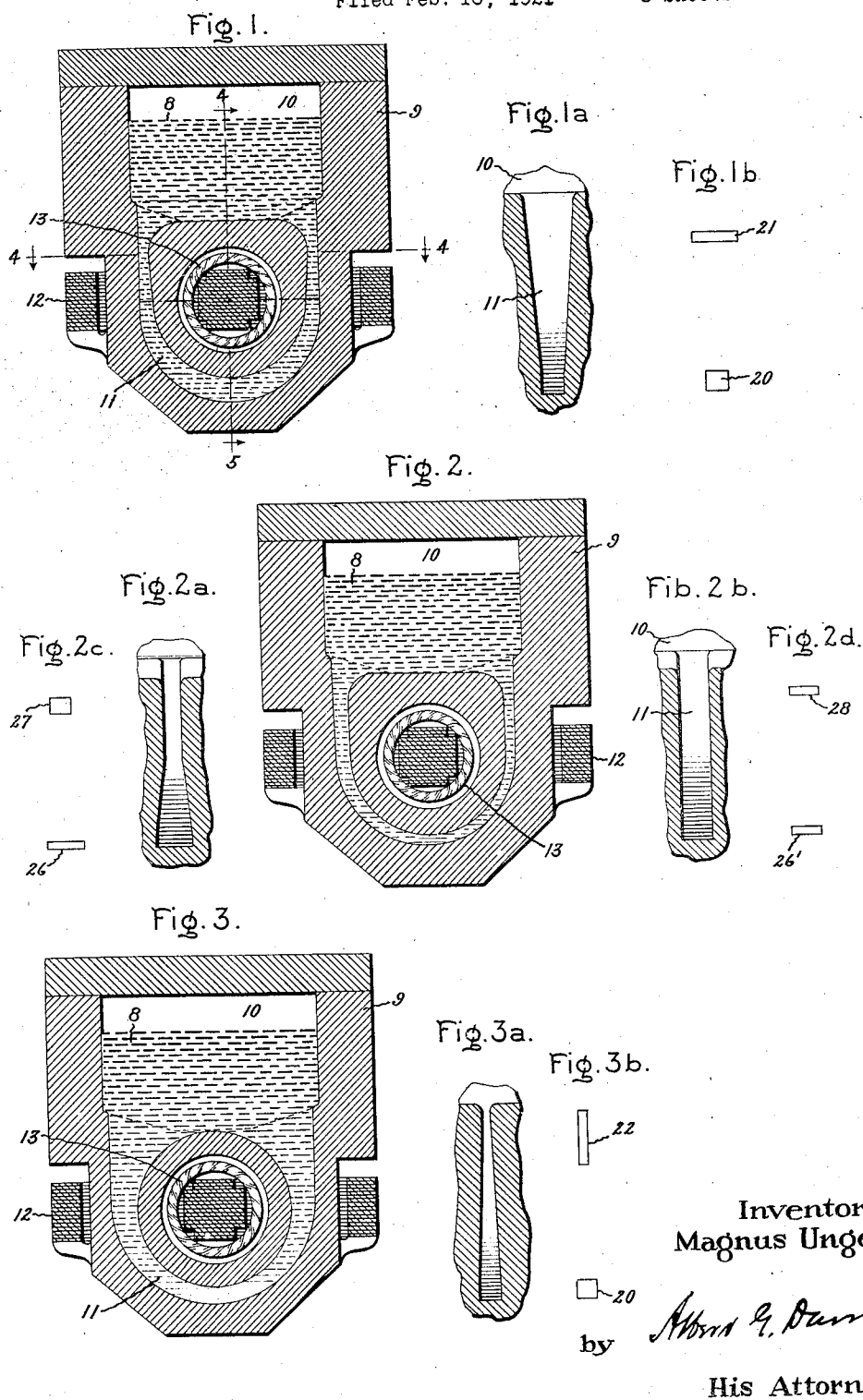
1,532,090

M. UNGER

INDUCTION FURNACE

Filed Feb. 16, 1921

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 6.

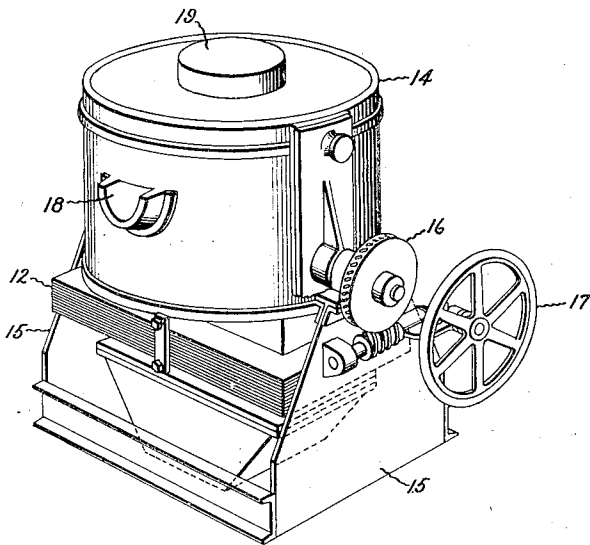


Fig. 7.

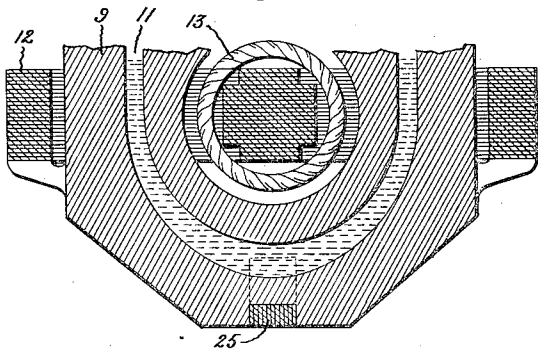


Fig. 8.

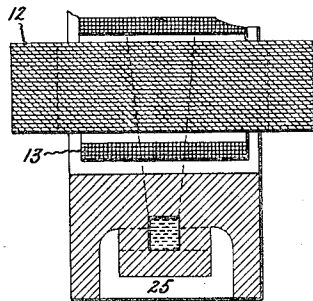


Fig. 4.

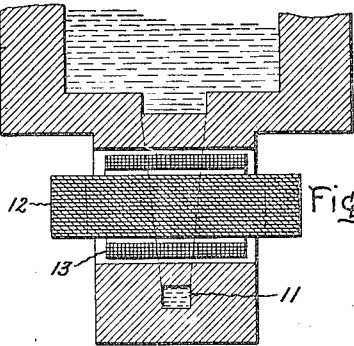
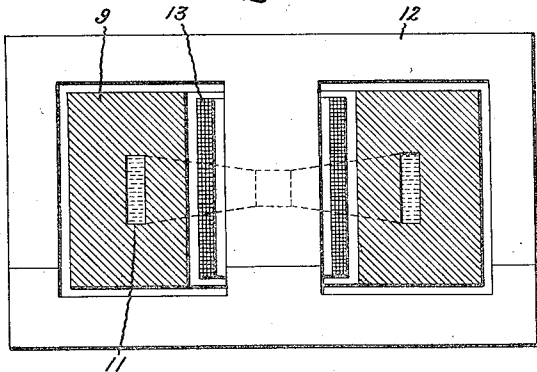


Fig. 5.

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3 Sheets-Sheet 3

Fig. 9.

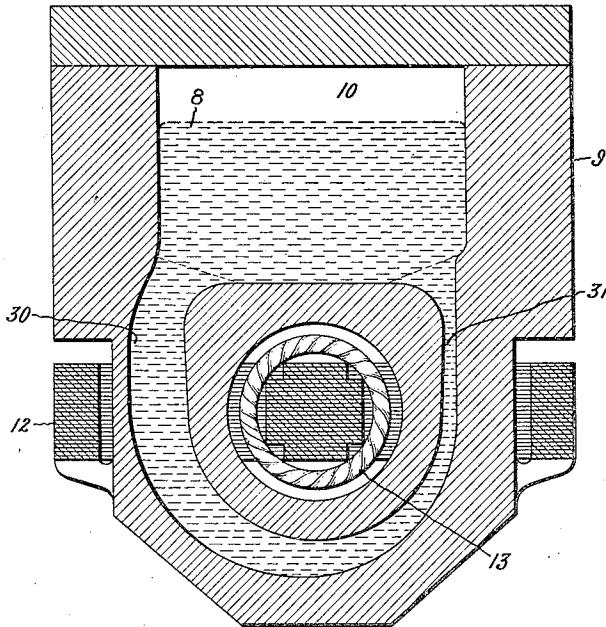
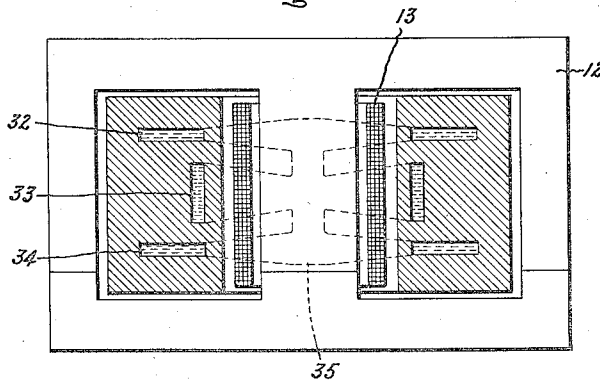


Fig. 10.



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UNITED STATES PATENT OFFICE.

MAGNUS UNGER, OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

INDUCTION FURNACE.

Application filed February 16, 1921. Serial No. 445,513.

To all whom it may concern:

Be it known that I, MAGNUS UNGER, a citizen of the United States, residing at Pittsfield, county of Berkshire, State of Massachusetts, have invented certain new and useful Improvements in Induction Furnaces, of which the following is a specification.

The present invention relates to induction furnaces, and comprises a furnace particularly adapted for melting highly conductive non-ferrous metals, such, for example, as brass, copper, aluminum and the like. It is one of the objects of my invention to provide a furnace in which the power factor will be high, and in which the permissible power input will be greater than in furnaces now in use.

Heretofore induction furnaces having a pool of molten charge communicating at the bottom with a vertically disposed channel or loop in which current is induced, have been constructed with a channel of substantially constant shape or circumference. In such a furnace the power input is limited by the magnetic field breaking the current-carrying molten conductor at the upper end of the channel where the hydrostatic force of the molten column is less than at the bottom of the loop.

I have provided a furnace in which the shape of the channels is varied to equalize the danger of circuit interruption. In accordance with one of the features of my invention, I have provided a furnace in which the channel is constructed with a substantially uniform cross-sectional area, but shaped to transfer the power input limitation to the lowermost part of the loop where the compressive effect of the magnetic field, or pinch force, is counteracted to the maximum degree by the hydrostatic head of metal.

The novel features of my invention will be set forth with greater particularity in the appended claims.

In the accompanying drawing, Figs. 1, 2, 3 and 9 are vertical sectional views of different forms of induction furnaces embodying my invention; Figs. 1^a, 1^b, 2^a, 2^b, 2^c, 2^d, 3^a, 3^b, are sectional views of different channels; Fig. 4 is a horizontal sectional

view taken on the line 4—4, Fig. 1; Fig. 5 is a vertical section (part broken away) of the furnace shown in Figs. 1 and 4 taken on lines 4—5, Fig. 1 at right angles to the plane of Fig. 1; Fig. 6 is a perspective view of a furnace embodying my invention; Figs. 7 and 8 are vertical sections taken in planes at right angles to each other of a modification; Fig. 9 is a vertical section of a modification in which the respective channel arms are oriented at right angles, and Fig. 10 is a horizontal section of a furnace having a plurality of channels.

A furnace embodying my invention, as shown in Figs. 1 to 3, inclusive, comprises in the main a housing or crucible 9 consisting of refractory material, which constitutes the main part of the furnace body, and is adapted to contain a charge to be heated. In my improved furnace the charge is contained both in a main chamber 10, adapted to contain a considerable body or pool of molten charge 8, and also in a looped channel 11 communicating with the chamber 10 at two places, preferably at the bottom. This channel 11, which preferably extends vertically downwards in the working position of the furnace, is interlinked with a magnetic core 12 carrying a primary winding 13. The transformer core 12 preferably, but not necessarily, is of the shell type. The primary winding 13 is mounted on the central leg of the core which passes through the channel loop 11, and the core and primary winding preferably are concentric with the channel.

As shown in Fig. 6, the furnace is provided with an external casing 14 and is mounted upon trunnions 15. A suitable tilting mechanism may be provided; for example, the gearing 16 and hand wheel 17. The furnace is provided with a pouring spout 18 and a suitable charging door (not shown). A hole in the furnace roof having a cover 19 is sometimes provided to observe the charge and give access to the furnace interior but for simplicity this cover has not been shown in Figs. 1, 2, 3 and 9.

When a current is flowing in any conductor, the magnetic field which is set up exerts a compressive action on the conductor, known as the pinch force which in a liquid

conductor may be great enough to break the continuity of the circuit. When the conductor has a minimum circumference, this pinch force is most concentrated and hence
 5 with a given current its effect is greatest in a circular conductor and becomes reduced in the same degree that the conductor departs from the circular form. In furnaces embodying my invention, I have provided for
 10 a circulation of the molten charge by varying the pinching effect of the secondary field by reason of an inequality of circumference of the channels containing the charge. The channels may or may not be
 15 of uniform cross-sectional area, but in either case the relative dimensions and orientation of the channels are so varied throughout their length as to vary or reduce the pinch force in a desired manner. The particular
 20 shape and cross-section of the channel throughout its length will depend upon the characteristics desired in the furnace. In some cases it may be important to get a maximum resistance whereas in other cases
 25 all other considerations should be sacrificed to get good circulation.

In the modification illustrated by Fig. 1, the cross-section of the channel 11 is substantially square at the bottom, as indicated
 30 in Fig. 1^b at 20. Other compact shapes may be used. The channel section becomes elongated at its upper portion in a direction parallel to the axis of the primary winding. The section of the channel adjacent its junction
 35 with the chamber 10 is indicated in Fig. 1^b at 21, the gradual widening of the channel in a vertical direction parallel to its axis being shown in Fig. 1^a. The cross-sectional area of the channel is uniform
 40 throughout. The pinch force is a maximum at the bottom where the section is of lesser circumference than at the vertical portions. At this lowermost point the opposing hydrostatic pressure of the molten charge also
 45 is a maximum. As the hydrostatic pressure decreases in an upward direction, the pinch force correspondingly decreases due to the change of shape so that the two forces will
 50 be substantially equally counterbalanced throughout. In this way more power may be applied to the furnace than would be the case were the channel of uniform circumference throughout.

In the modification illustrated in Figs. 3, 3^a and 3^b, the channel section likewise is
 55 square at the bottom (see 20 Fig. 3^b), and becomes elongated in an upward direction, (see 22, Fig. 3^b) but in this case the longer axis is oriented at right angles to the winding axis of the channel loop, as best shown
 60 in Fig. 3. In a direction parallel to the axis the channel becomes narrower as shown in Fig. 3^a, the cross-sectional area remaining substantially the same. The construction shown in Figs. 3, 3^a and 3^b will give

better circulation of molten charge than the form of furnace shown in Figs. 1, 1^a and 1^b, but the power factor will be somewhat lower. In the form of furnace of Fig. 3 the centrifugal force is greater and the friction of the circulatory currents is less than for the form shown in Figs. 1, 1^a and 1^b.

Due to the pinch force and also the repulsion between the primary and secondary, molten metal, or other charge in the channel
 75 is ejected into the chamber 10 from the channel along the outer surface of the loop, and as a result a continuous circulation of charge occurs. This circulation may be increased if desired by placing a yoke or core
 80 25 of magnetic material (conveniently, iron) near the bottom of the channel, as shown in Figs. 7 and 8.

When it is desired to get unidirectional flow of metal in the loop, I prefer to make
 85 one arm of the loop of different cross sectional shape than the other arm. For example, as illustrated in Fig. 2, and the adjoining detail views, the bottom of the loop is rectangular or flat, as shown at 26 and
 90 26'. The left arm of the loop has a square section at the upper part, as shown at 27, which flattens out toward the bottom in a direction parallel to the axis of the loop. The right arm of the loop is of constant
 95 rectangular section, a section of the upper part being shown at 28. The maximum pinch force occurs in the square part of the loop. As it is easier for the metal to be ejected directly into the pool than through
 100 the length of the loop, a unidirectional flow is set up, the metal entering the looped channel from the pool at the right hand arm, and leaving the channel at the left hand arm. In addition to the unidirectional flow, there
 105 will be superimposed thereon some incidental local circulation. For example, where the channel enters the pool, metal will be ejected and run back but there will be more metal ejected at one channel outlet than at
 110 the other outlet, hence a unidirectional flow results.

In Fig. 9 I have shown a modification of my invention in which the geometric construction of the channel results in a greater
 115 repulsive force in one arm than in the other, thereby causing unidirectional flow. The channel is constructed to equalize the danger of circuit interruption due to pinch effect. As in the case of the furnace illustrated by
 120 Fig. 1, the cross-sectional area of the channel is substantially equal, the lowermost part of the channel being square and each arm flaring out to an elongated rectangle in an upward direction. Unlike the furnace
 125 shown in Fig. 1, the longer dimension of the lefthand channel arm 30 is oriented at right angles to the winding axis of the channel. The longer dimension of the righthand channel arm 31 is oriented parallel to the
 130

winding axis. Consequently the repulsive force is greater in the left-hand arm than in the right-hand arm. Downward flow of metal from the chamber 10 occurs through the arm 31 and upward flow into the chamber through the arm 30.

In Fig. 10 I have shown in horizontal section a furnace having a plurality of channels 32, 33 and 34 having a common connection 35 at the bottom. Both arms of each of the channels 32, 34 are oriented with the longer dimension at right angles to the axis of the primary 13 but the longer dimension of both arms of the channel 33 is parallel to the axis of primary 13. As a consequence of the unequal repulsive force, downward flow of molten charge occurs from the pool (not shown) through the arms of the channel 33 and an upward flow into the pool through the channel arms 32, 34. The cross-sectional area of the channels of the modifications illustrated by Figs. 9 and 10 is substantially equal.

I have described and claimed an induction furnace having a plurality of channels interlinked with the same magnetic field in my copending application Serial No. 445,514 filed February 16, 1921.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. An electric induction furnace comprising a core of magnetic material, a primary winding and refractory walls constituting a furnace chamber adapted to contain a pool and a looped channel communicating at the ends thereof with said chamber, said channel having a substantially uniform cross-sectional area throughout but being shaped to counterbalance substantially equally throughout the pinch force of the magnetic field upon a liquid charge when carrying current by the hydrostatic pressure of said charge.

2. An electric induction furnace comprising a core of magnetic material, a primary winding therefor and refractory walls forming a furnace chamber and a looped channel interlinked with said core, said channel having a substantially uniform cross-sectional area, but one section of said channel differing in shape with respect to another section of said channel.

3. An electric induction furnace comprising a core of magnetic material, refractory walls forming a furnace chamber adapted to contain a molten charge or pool and a channel of substantially uniform cross-sectional area communicating with said chamber below the surface of said pool, said channel normally extending downwardly during the operation of said furnace, and being shaped to reduce the pinch force in the upper part of the channel arms where the hydrostatic pressure of the charge is less than at the bottom.

4. An electric induction furnace comprising a magnetic core, heat-resisting walls forming a furnace chamber adapted to contain a molten charge and a looped vertical channel communicating with the chamber at the bottom thereof, said channel having a substantially uniform cross-sectional area but unsymmetrical shape, the upright part of at least one arm of said channel being flattened in a plane extending through said loop at right angles to the axis thereof and the lowermost part of said channel being substantially square.

5. An electric induction furnace comprising a magnetic core, refractory walls forming a furnace chamber adapted to contain a molten charge, and a looped vertical channel of substantially uniform cross sectional area communicating with the chamber at the bottom thereof, the cross section of that part of said channel in which the hydrostatic pressure of molten charge is greatest having the least perimeter.

6. An electric induction furnace comprising a magnetic core, refractory walls forming a chamber for the charge and a looped channel having a uniform cross sectional area, but non-uniform cross sectional shape communicating with the chamber at the bottom thereof, the cross section of the lowermost part of said channel having the least perimeter.

7. An electric induction furnace comprising a magnetic core, a winding thereon and a refractory furnace body constituting a furnace chamber and a looped channel interlinked with said core, said channel communicating with said chamber and having a substantially uniform cross-sectional area, but being adapted to produce more effective expulsive force upon the charge in one channel arm than the other arm, thereby causing unidirectional circulation of charge through said channel.

8. An electric induction furnace comprising a refractory furnace body providing a furnace chamber and a looped channel of substantially uniform cross-sectional area communicating with said chamber, and means for inducing an electric current in a charge within said channel and chamber, the arms of said channel being shaped to produce a materially greater repulsive force upon said charge in one arm than in the other arm, thereby causing unidirectional circulation of charge through said channel.

9. An electric induction furnace comprising refractory walls providing a reservoir and a looped channel of uniform cross sectional area having legs of elongated cross-section disposed with the longer axes at right angles to each other, and means for inducing an electric current in a charge in said channel.

10. An electric induction furnace comprising

ing a magnetic core, a primary winding thereon, a refractory furnace body providing a reservoir, a looped open channel of uniform cross-sectional area interlinked
5 with said core and communicating with said reservoir, the legs of said channel being differently shaped to bring the center of one leg of said channel nearer to the center of said primary winding than the other leg.

In witness whereof, I have hereunto set
my hand this fourteenth day of February,
1921.

MAGNUS UNGER.