

July 11, 1933.

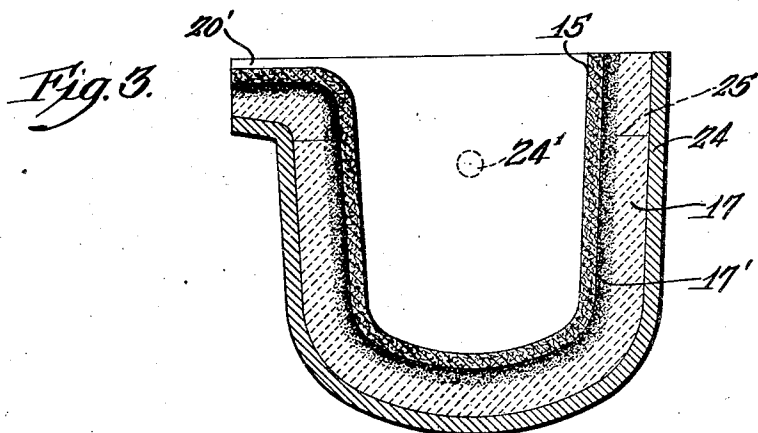
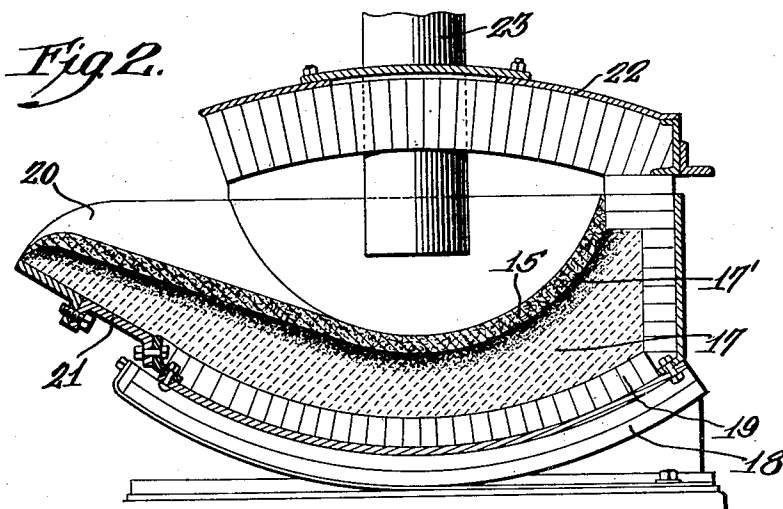
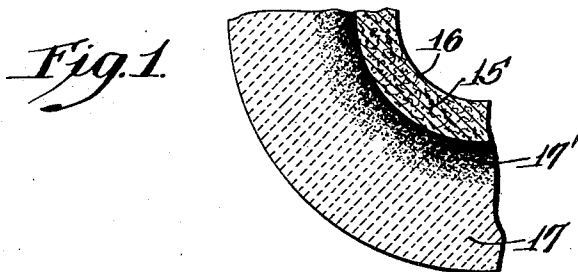
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1,917,849

REFRACTORY LINING

Filed July 26, 1930

2 Sheets-Sheet 1



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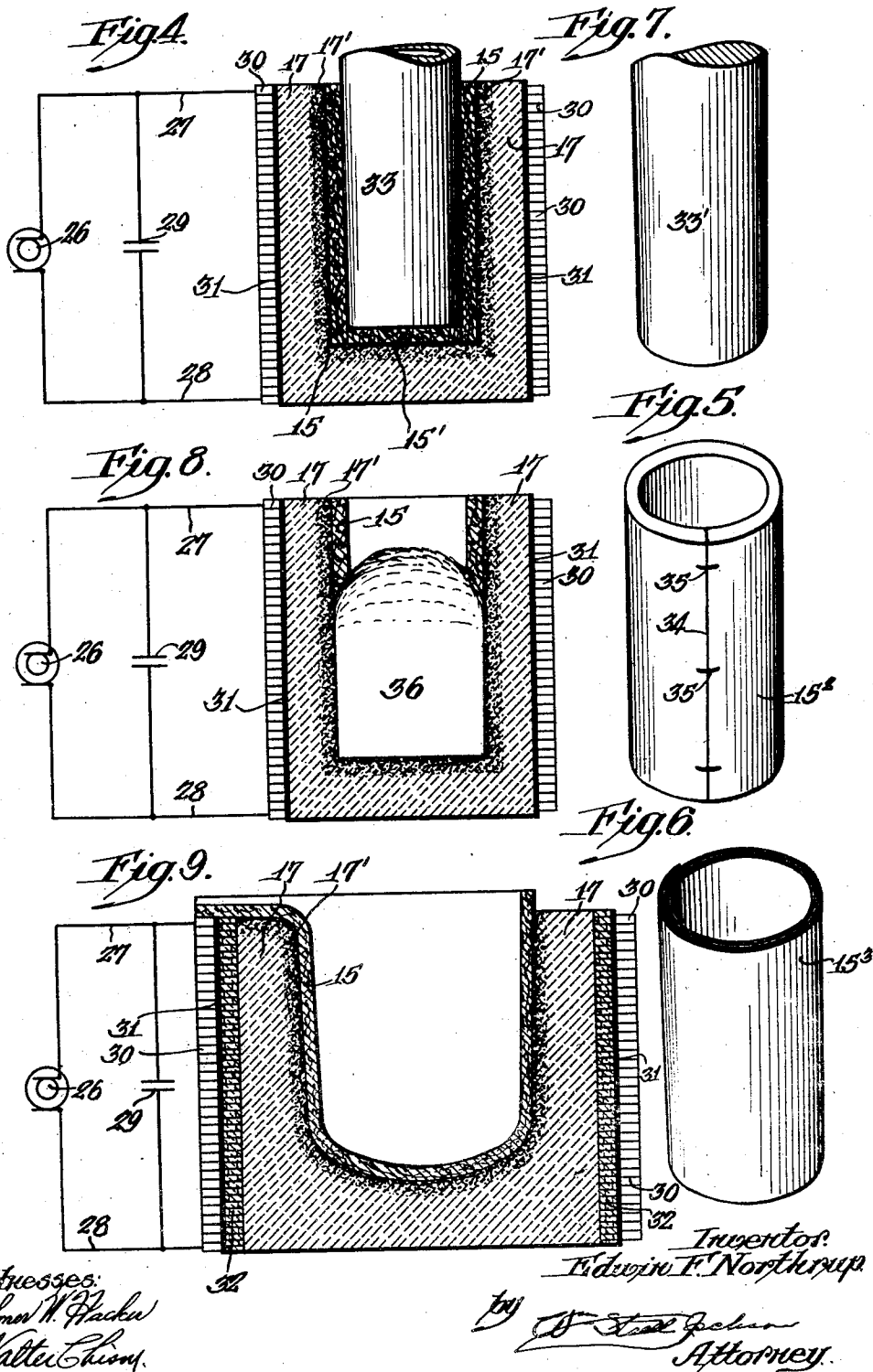
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UNITED STATES PATENT OFFICE

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REFRACTORY LINING

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My invention relates to metallurgical furnace linings and particularly to the sintering of a refractory to form a working lining.

One purpose of my invention is to use a nonmetallic shield as a form and protection or cover through which the adjoining surface of the refractory is sintered by the heat of molten metal within the shield.

A further purpose is to sinter a furnace refractory through a nonmetallic shield which retains its position and character up to a temperature above the sintering point of the refractory working lining and which subsequently melts and floats to the surface as a slag.

A further purpose is to use an asbestos shield immediately between the melt and the refractory in order to hold the melt while the refractory is being sintered to form a working lining and to back the working lining thus formed with a finely divided refractory into which the sintering is shaded off.

A further purpose is to provide a refractory of sinterable preferably finely divided dry material which may or may not be packed in use and to sinter it through a shield containing asbestos which holds a molten metal until sintering has progressed sufficiently to form a working lining for this purpose and which with higher temperatures melts and floats to the surface.

A further purpose is to back up a sintering shield internally by a form, plug or support while a finely divided refractory is packed about it to form an initial pool wall.

A further purpose is to sinter a lining through a shield made up wholly or in part of cement.

A further purpose is to sinter a lining through a shield of fibrous heat resisting material fusible above the sintering point of the lining.

A further purpose is to employ a hollow metallic form inside a nonmetallic shield during tamping of a refractory lining against the shield, desirably freeing the form from the shield by heating the form to expand the shield and the refractory, and allowing the form to cool and to contract before removal.

A further purpose is to line ladles and similar storage and transfer receptacles with refractory sintered in place while being protected by a nonmetallic shield.

A further purpose is to surface a refractory sintered in place by the melting of a non-

metallic shield containing asbestos and cement in contact with the face of the refractory.

Further purposes will appear in the specification and in the claims.

I have preferred to illustrate my invention by a few slightly different forms among the many in which it may appear.

Figure 1 is a central section of a lining of a metallurgical furnace to which my invention has been applied. I intend this lining to represent any lining capable of holding molten metal, whether during heating, or storage, and, if during heating, no matter what the means by which heat is applied.

Figure 2 is a vertical central section, largely diagrammatic, of an arc furnace in which the lining of my invention is used.

Figure 3 is a central vertical section of a conventional transfer ladle lined in accordance with my invention.

Figure 4 is a vertical central section of an electric induction furnace embodying my invention showing a core in place within the furnace. Permissible electric connections are shown diagrammatically in the figure.

Figures 5 and 6 are perspective shield cylinders which may be used in practice in my invention.

Figure 7 is a fragmentary perspective of a core generally similar to that shown in Figure 4, but constructed from solid instead of hollow material.

Figure 8 is a section corresponding generally to Figure 4, but omitting the core, and showing an assumed condition of the shield after molten metal has come in contact with it.

Figure 9 is a section corresponding generally to Figure 1, but showing an inductively heated ladle instead of a normal type of furnace and using a pouring spout. A pouring spout of this or other character may or may not be used in connection with the structures seen in the other illustrations.

In the drawings similar numerals indicate like parts.

The normal difficulty of holding a molten metal within a crucible or other container is much accentuated with increase of temperature of the molten metal. For example, a refractory which without difficulty will hold a metal such as iron at its melting point in many cases will not hold this metal when it is superheated to say 3000 or 3200° F. This

has led to a great deal of trouble in properly holding superheated metals or molten metals having a very high temperature of fusion, particularly cast iron.

5 My invention is applicable to any type of container which must hold molten metals at high temperature, but it finds its best application in electric induction furnace linings, because of the great difficulty often experienced in the past in finding a suitable refractory for such furnaces.

10 One of the best forms of refractory available in the past for such a furnace comprises a magnesia crucible backed with electrically sintered sand. The thickness of the crucible differs somewhat according to the size of the furnace. With a furnace of one ton capacity, the crucible thickness has been one inch.

20 The use of this crucible with the backing has given serious difficulty because of the fact that the crucible must be too thick for the sand to become properly sintered and whenever the crucible breaks it lets molten metal come into contact with sand which has not been properly sintered.

Another existing furnace uses a metal shield to sinter sand, the shield melting and disappearing in the molten bath. This offers difficulty in the necessity to have the metal of the same character material as that in the melt or to suffer alteration in the character and chemical composition of the melt. Furthermore, metal lining is costly.

35 My invention has owed its origin to my effort to find a more satisfactory lining to serve this purpose, which will be cheaper than any of those above indicated, will be thoroughly reliable and at the same time will take care of any temperature required and be free from contaminating effect upon the melt.

40 I have discovered that a very simple and effective lining may be made by sintering a suitable refractory working lining while protected by a non-metallic shield which is destroyed by the heat of the melt. In general, I propose to sinter a finely divided refractory working lining by heat conducted through this temporary shield from the molten charge. During sintering the finely divided refractory (whether compressed or not) is supported by the shield placed between the refractory and the charge. After the inner surface of the refractory has been sintered, the shield is fused, and, because of its lower density, forms upon the surface of the charge as a slag.

50 As well as acting to support the refractory working lining during sintering, the shield serves to improve the surface of the refractory lining produced by sintering in a manner not fully clear to me.

65 The one requirement for sintering a refractory by my method is that molten metal come in contact with the lining, which has been

suitably prepared and shielded. It is therefore evident that my invention can be applied to any metallurgical lining, whether or not it is possible to heat the charge in the lining, and without regard to the purpose for which the lining is to be used when it has once been prepared.

70 For the refractory working lining (the lining which eventually will come in direct contact with the charge), I may use any one of a number of suitable materials. For low temperatures (below 1550° C.) silica sand is satisfactory. For higher temperatures I may use zircon sand, powdered magnesite, powdered chrome or powdered electrically fused magnesia. These materials must be dry when they are sintered.

85 Where the sintering is to take place at a relatively low temperature, and preferably in all cases, I will mix with the refractory to be sintered a small quantity of a fluxing ingredient such as boric acid. Of the available materials for use in forming my shield, I prefer fibrous materials containing asbestos. I have secured good results with asbestos board or asbestor paper of commercial forms, of which one example is sold under the name of "Transite". This is a mixture of asbestos and Portland cement. As other materials available for this purpose instead of asbestos and cement, I may employ asbestos, with or without other ingredients, cement, with or without other ingredients, or porcelain. I consider porcelain to be less desirable than the other materials suggested because of its high cost and fragile nature.

100 In general the shield should be composed of a nonmetallic material which is sufficiently infusible to retain its characteristics at the sintering temperature of the refractory lining and yet sufficiently fusible to melt above the sintering temperature and within the range obtainable from heat transmitted by the molten charge. The shield should ordinarily be non-reactive with respect to the charge.

110 The shield is useful even when it is quite thin and it can be molded or otherwise formed to approximate the shape of the desired inner surface of the lining.

115 In Figure 1, I show a fragment of a furnace lining formed according to my method. The shield 15 of suitable non-metallic material, preferably asbestos board, is placed against the inner surface of the refractory lining. The charge of metal will initially come in contact with the surface 16, and heat will be transmitted through the shield to the refractory 17. As the temperature increases the inner surface of the refractory will begin to sinter and the sintering will progressively extend toward the portion of the lining more remote from the source of the heat. This sintered portion of the lining is indicated by 17'.

After the sintering of the portion 17' has proceeded to a greater or lesser extent, the temperature of the shield 15 will rise to the melting point of the shield, and the shield 5 will melt out and collect as a slag upon the surface of the metal. When this has happened, the metal will come in direct contact with the inner surface of the sintered refractory 17'.

10 There will then be a relatively thin sintered portion 17' backed by a partially sintered or unsintered portion 17 of the refractory lining. The relative thinness of the sintered refractory 17' is advantageous because it is 15 conducive to the resilience of the lining during expansion and contraction. In fact I have actually turned a spray of water upon such a lining made of zircon sand immediately after pouring a charge of superheated 20 iron, and have quickly brought the lining down to room temperature without the development of a single crack.

Should the lining crack for any reason, however, and a fin of metal penetrate the 25 crack, the fin will immediately sinter additional refractory back of the crack and thus preclude further penetration of the lining.

In Figure 2, I show a conventional arc furnace to which my lining has been applied. 30 The cradle 18 supports brick work 19 upon which the finely divided refractory 17 has been placed. The sintered refractory 17' and the shield 15 appear as in Figure 1.

In this furnace I show a pouring spout 35 20 supported at 21 and covered by an extension of the lining proper.

The roof 22 of the furnace may be of conventional design. An electrode is shown at 23.

40 While it will ordinarily not be desirable to employ the lining of my invention in parts of the furnace which do not come in contact with the charge, it will be understood that I might do so where conditions of high 45 temperature or highly oxidizing atmosphere make it desirable. In such instances the roof 22 might be formed of sintered material, in which case it would have the general appearance of Figure 1.

50 In Figure 3, I show a conventional ladle such as is common in open hearth practice. In this form of lining all heat for the sintering must come from the metal itself, whereas in a furnace such as that of Figure 2 55 heat might be supplied by the furnace itself.

The outer ladle casing 24 supports the refractory 17 whose inner surface 17' has been sintered. The shield 15 appears as before, conforming to the desired inside 60 dimensions and shape of the lining. The ladle is designed to pour from a spout 20', which in this case has been formed of somewhat different material from that used in the lining proper. Above the level of the line 25 65 the powdered refractory, whether consisting

of zircon sand, powdered magnesite, chrome ore, electrically fused magnesia, silica sand (in the case of relatively moderate temperatures), or any other suitable material, may be 70 desirably mixed with a suitable sintering agent such as boric acid, to reduce the sintering temperature of this portion of the lining. The line 25 is approximately at or a little 75 below the uppermost proposed level of the charge, and therefore the material above this line will not be heated to as high an extent as below this line. The refractory below the line 25 may desirably be ordinary dry finely 80 divided refractory without any addition of sintering agent.

The ladle may be tilted on trunnions 24'.

The shield is most conveniently prepared with a separate bottom in the forms of Figures 4 and 8. In Figure 4, I illustrate the 85 shield 15 having a disc bottom 15', which supports the refractory 17 until the inner surface 17' has been sufficiently sintered.

The furnaces shown in Figures 4, 8 and 9 are illustrated very diagrammatically, 90 omitting the frame structures by which the parts are supported and handled and showing the structures themselves in their simplest form. In all three a diagrammatic source of energy is shown in an alternating 95 current generator 26, supply lines 27 and 28 and condenser power factor correction at 29 bridged across the supply lines. As far as my present invention is concerned, the frequency may be low or high including commercial frequency. 100

In all of the forms conventional coils 30 are shown with suitable electrical insulation at 31, which is desirable but not necessary, since my refractories are themselves good 105 electrical insulators. In the larger forms the refractory may include an outer layer 32 of preformed bricks or blocks. Within this, or within the coil if bricks be not used, is held my finely divided refractory 17, the inner surface of which is shown as being 110 sintered at 17'.

Electrically fused powdered magnesia, as well as some of the other refractories can be 115 packed into a compacted mass by the use of a power hammer.

For packing the refractory, I normally insert a core or form within the shield 15. The form may ordinarily be of wood, continuous or discontinuous as desired. A discontinuous 120 form has the advantage of being somewhat easier to remove after the packing has been completed.

In Figure 4, I show a hollow metallic form 33, which has the advantage that it may be 125 removed quite easily no matter how tight the packing of the refractory. To remove this metallic form I will simply heat it by induction to cause it to expand and further pack the refractory. I will then allow the form to cool and will remove it, since it will 130

then be free from the surface of the shield. The shield may desirably be formed of asbestos board which has been previously shaped into a cylinder 15, Figure 5. The cylinder need not be continuous, but may have an open seam, shown at 34. The cylinder may be held together at the seam by wire stitches 35. Porcelain or other materials could be used.

The cylinder may be formed of asbestos paper (Figure 6), which may be pre-formed or actually formed in the furnace as desired. The pre-formed cylinder 15³ will desirably consist of a plurality of layers of asbestos paper, preferably united with sodium silicate.

The form placed inside the shield need not be hollow as indicated in Figure 4, but may be solid as shown at 33' in Figure 7.

In Figures 2, 3 and 9 the shield, whether of asbestos board, cement, asbestos, porcelain, or other material, has been molded in the shape which it is finally to hold prior to the insertion into the furnace. Where the shield is to be backed with a form 33 or 33' the shield should desirably have a bore tapered outward to facilitate the removal of the form without injury to the surface of the shield.

For mechanical reasons it may be desirable to build the spout as a separate unit from the body of the shield, or to build the spout of any well recognized construction well known in the art. Spouts of other forms will especially be permissible where the metal is not intended to come up to the height of the spout except in pouring.

The brick work will not ordinarily be used in the smaller furnaces. In the case of the coreless induction furnace, it has been found good practice to make the internal diameter of the melting chamber approximately seven-tenths of the internal diameter of the coil. With a big furnace this leaves plenty of room for a full layer of brick which forms a good basis for a lining of zircon sand.

Since zircon sand flows very freely even through a pin-hole opening I find it of advantage to "slow" the sand by a small percentage of very finely ground sand which fills the interstices and stops the flow. This effect has been secured to great advantage with as little as 10% of finely ground sand.

The bricks when used may be placed with their broad faces vertical where the space is small and with their broad faces horizontal where the space for them is ample. The bricks are set in cement.

In Figure 8, I show a supposed condition of the lining and shield after the charge has been in the furnace for some time. Where the shield 15 has come in contact with the charge 36, the shield has been melted and is formed upon the top, leaving the charge in contact with the sintered refractory 17'.

The upper part of the shield 15 is still intact, and may remain for several heats. The lining back of the shield 15 will be less completely sintered than the lining at the points where the shield has been melted away.

This will not be harmful, because the remaining portion of the shield will support the lining. By the time the shield has been completely melted, the lining previously supported by the shield will be fully sintered.

Figure 9 shows an inductively heated ladle or storage furnace of considerably larger capacity than the furnaces of Figures 4 and 8. Brick work 32 has been added for mechanical reasons. The ladle of Figure 9 is generally similar to that shown in Figure 3 with the exception of the provision for inductive heating.

My invention is especially applicable to the linings of induction furnaces because the charge may be inserted into the furnace at a suitable sintering temperature, and allowed to sinter the lining thoroughly before the temperature is raised by inductive heating to the melting point of the shield.

So effective has the asbestos board proved for my purpose that I have been able to reduce the thickness of the shield when made of asbestos board in smaller furnaces to as little as one-eighth inch and even in larger furnaces to three-sixteenths or one-fourth of an inch.

In describing its operation in connection with the melting of cast iron I wish to be understood as using this as an example only and not restricting to such use or to the practice there. In the melting of cast iron the practice is now to melt the iron preferably in a fuel furnace, heat it up to approximately 2600° F., and then to pour the iron into an electric furnace for superheating. It is there raised in temperature to from 3000 to 3200° F., where it is held for treatment.

The iron is finally cooled to approximately 2600° F. for pouring because the present ladles are unable to stand the superheated temperatures. Ladles having my lining may receive the iron poured immediately from the furnace and hold it at the desired superheated temperatures and subsequently cool it for pouring, as my shield makes it possible to sinter the ladle refractory so that the metal can be held in the ladle even when poured in at the superheated temperature.

The molten metal, whether superheated or not, acts in the furnace or ladle more effectively through the asbestos board or other shield than through a metal shield to sinter the lining used and sinters initially to a depth of one-eighth to one-fourth of an inch. This is very desirably thin as the thinness of the sintered wall is one of its greatest elements of strength in that it will not readily crack or break.

The asbestos board holds its position and

strength long enough to effect the sintering and then melts and floats on the surface.

By avoiding the use of a crucible there is a gain of approximately an inch of the refractory space about the melt, with consequently increased coupling.

The effect of an asbestos board shield upon the sintered refractory is notably different in that the inner sintered refractory is given a different color and a more highly "finished" surface than is the case where the sintering takes place through a metal shield. There may be a chemical action of the asbestos or of the cement upon the surface. Whatever the reasons a hard smooth skin is left which is highly protective against the metal of the melt.

My invention is not restricted to use with cast iron but is useful with various other metals including carbon and alloy steels and all of the special metals which require very high temperature.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain part or all of the benefits of my invention without copying the structure shown, and I, therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. In a container for a molten metal charge, a structural support, a sinterable refractory within the support and a self supporting non-metallic shield within the refractory adapted to be destroyed at the temperature of the molten metal but having stamina against the destroying effect of the hot metal sufficient to preliminarily act as a shield and perform the sintering function.

2. In a container for a molten metal charge, a structural support, a sinterable refractory within the support and a self supporting non-metallic shield within the refractory containing asbestos.

3. In a ladle, a supporting structure, a sinterable refractory and a self supporting non-metallic shield of fusible material within the refractory outlining the intended pool and melting at a temperature above the sintering point of the refractory and within the temperature range of the pool.

4. The method of packing and sintering a finely divided compressible refractory for a container for molten metal, which consists in supporting the refractory along the pool wall by electrically conducting material, packing

the refractory, inductively heating the conducting material to expand it and shove outwardly the packed refractory, cooling the conducting material away from the refractory, removing the conducting material and sintering the packed refractory.

5. The method of packing and sintering a finely divided compressible refractory for a container for molten metal, which consists in supporting the refractory along the pool wall by electrically conducting material, inserting a shield between the conducting material and the refractory, packing the refractory, inductively heating the conducting material to expand it and shove outwardly the packed refractory, cooling the conducting material away from the refractory, removing the conducting material and sintering the packed refractory by molten metal forming the pool.

6. The method of making a refractory furnace lining, using a self supporting non-metallic shield, which consists in packing finely divided sinterable refractory around the outside of the shield, pouring the first charge to be held by the new lining in molten condition directly into the inside of the shield, sustaining the position of the lining during the early stages of sintering of the refractory by the strength of the shield itself and, after sintering has advanced, reducing the shield to a slag due to the heat of the molten charge.

7. The method of making a refractory furnace lining, using a self supporting non-metallic shield, which consists in initially supporting the inside of the shield, packing finely divided sinterable refractory around the outside of the shield, removing the initial support after the packing, pouring the first charge to be held by the new lining in molten condition directly into the inside of the shield, sustaining the portion of the lining during the early stages of sintering of the refractory by the strength of the shield itself and, after sintering has advanced, reducing the shield to a slag due to the heat of the molten charge.

8. The method of making a refractory induction furnace lining, using a self supporting non-metallic shield, which consists in initially supporting the inside of the shield, packing finely divided sinterable refractory around the outside of the shield, removing the initial support after the packing, pouring the first charge to be held by the new lining in molten condition directly into the inside of the shield, inductively heating the charge, sustaining the position of the lining during the early stages of sintering of the refractory by the strength of the shield itself and, after sintering has advanced, reducing the shield to a slag due to the heat of the molten charge.

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