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CONTAINER HAVING A COMPOSITE REFRACTORY WALL

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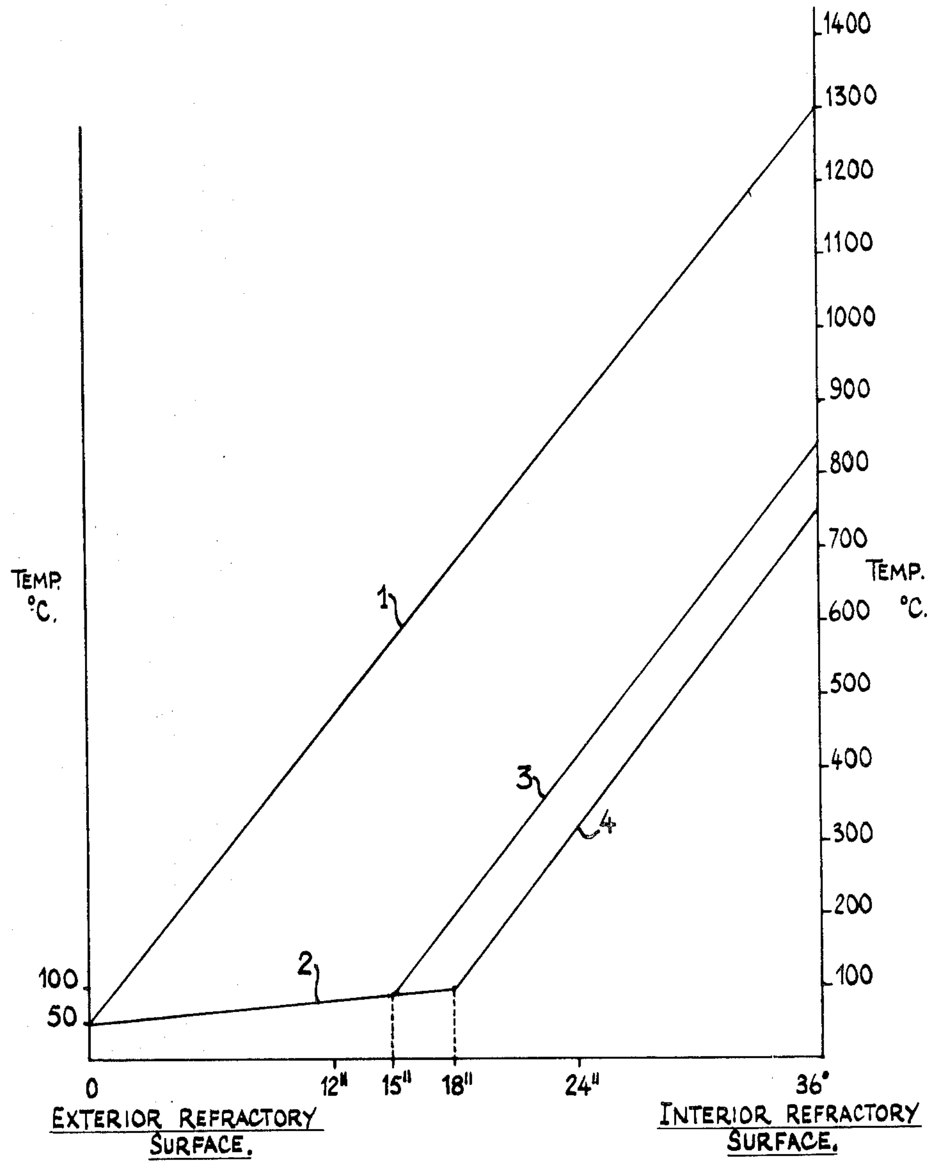

Fig. 1.

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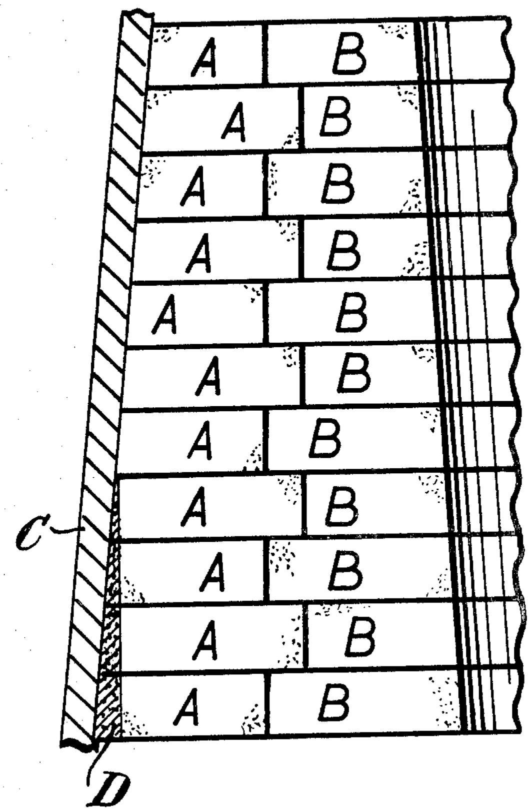

Fig. 2.

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CONTAINER HAVING A COMPOSITE REFRACTORY WALL

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ABSTRACT OF THE DISCLOSURE

Apparatus for containing material at high temperature, for example a blast furnace, has a composite refractory lining comprising an inner layer, facing the apparatus interior, of conventional refractory material and an outer layer, backing the inner layer and in thermal contact therewith, of refractory material having a higher thermal conductivity than the conventional material of the inner layer. Cooling of the inner, exposed surface of the lining is thus more effective, the consequent temperature reduction giving longer lining life.

This invention relates to linings of manufacturing structures, in particular to refractory linings, such as those of blast furnaces.

The efficient use of a blast furnace demands that it be kept in continuous operation without being allowed to cool down, for as long as possible. Interruptions of the operation of a blast furnace should be for as short a time as possible, and as infrequent as possible. Accordingly, since one of the most common reasons for requiring the shut-down of a blast furnace is failure of the refractory lining, modifications tending to lengthen the life of the lining are of substantial economic value.

The reasons for failure of refractory linings are various, and are not entirely understood, but generally it is attributable to one or more of the following causes:

(a) disintegration at the high working temperatures encountered, normally 1300° C. or more.
(b) chemical attack arising from slags and other products produced in the furnace,
(c) abrasion by materials charged into the furnace, and
(d) erosion by the gases blown at high velocity into the furnace.

It has now been found that the life of a refractory lining may be significantly increased without adverse effects on the furnace operations if the interior surface can be maintained at a temperature appreciably below those normally encountered. It is presumed that at lower temperatures the effects at least of causes (a), (b) and (d) are materially decreased.

According to the invention, therefore, apparatus for containing material at high temperature is provided with a composite lining comprising an exposed inner layer of refractory material facing the apparatus interior, and an outer layer of refractory material backing the inner layer and in thermal contact therewith said outer layer having a higher thermal conductivity than the inner layer. Preferably the material of the outer refractory layer (referred to herein as "high thermal conductivity material") has a thermal conductivity not less than five times, more preferably at least ten or even twenty times that of the material of the inner layer (referred to herein as "low thermal conductivity material"). The thickness of the outer layer is suitably at least one third of that of the inner layer, and preferably it is from 0.8 to 1.2 times that

of the inner layer. Desirably the two layers are of substantially equal thickness.

This invention is particularly applicable to blast furnaces, where it may be used to especial advantage in the region of the lower stack, though it may also be used in the Bosh, hearth wall and hearth pad. It is found that the temperature gradient in the conventional refractory lining of blast furnaces is generally of the order of 35° C. per inch, and thus with a refractory lining 36 inches thick, the temperature difference between the interior and exterior surfaces is around 1250° C., and with a thickness of 30 inches, the temperature difference is approximately 1050° C. It has thus been found that when using a lining 36 inches thick, if nonforced cooling is applied, the interior surface temperature is of the order of 1400 to 1500° C., while the exterior surface temperature is around 200° C. The only practicable system of forced cooling that is available is the use of cooling water, and it will be apparent that this can only be expected to reduce the exterior surface temperature to around 50° C. Consequently the reduction in temperature of the interior surface can at most only be of the order of 150° C., to e.g. 1300° C. Such a reduction has not been found to have any substantial effect on the life of the refractory lining, but further reductions in temperature have not been attempted, in the hitherto widely held belief that greater cooling of the interior surfaces of the refractory lining would prevent the adequate functioning of the blast furnace reactions. It has now surprisingly been found that by using the present invention, in which part of the conventional refractory lining is replaced by material of higher thermal conductivity, the interior surface of the blast furnace lining can be maintained at a substantially lower temperature than hitherto, and that this temperature reduction does not deleteriously affect the efficient operation of the blast furnace.

The effect obtained by use of the present invention may be best appreciated from a consideration of FIG. 1 of the accompanying drawings, in which the temperature, plotted in degrees centigrade on the ordinate, is given as it varies through the thickness, plotted on the abscissa, of a refractory lining for three separate cases in which the linings differ.

In each case, water cooling is applied to the exterior of the blast furnace, so as to maintain the exterior refractory surface temperature at 50° C. Line **1** represents the steady variation in temperature through the thickness of a conventional refractory lining up to 1300° C. at the interior surface. In the other two cases, the outer part of the conventional refractory lining is replaced by material of higher thermal conductivity, and the temperature through this latter material is shown by line **2**. In the second of the three cases illustrated, the outer lining material is 15 inches thick, and is in thermal contact with a 21 inch thickness of conventional refractory lining. The temperature gradient throughout this latter, as shown by line **3**, is a little higher than that of line **1**, being approximately 45° C. In the third of the three cases, the outer lining material extends for 18 inches, and is in thermal contact with a further 18 inches of conventional refractory material. The temperature throughout this latter is shown by line **4**, of which the gradient is slightly higher than that of line **3**.

It will be seen that line **2** is substantially flat, having a gradient of merely 3.5° C. per inch, with the result that the temperature halfway through the composite lining in the second and third cases is not significantly different from that of the exterior surface. This temperature is substantially below that found in the middle of the conventional refractory lining, and this results in an appreciable decrease in the temperatures at the interior refractory surfaces. Thus in the first case, the interior surface temperature is around 1300° C., whereas in the second case it is approximately 840° C., and in the third case it is approximately 750° C. Temperature reductions of this magnitude are responsible for substantial improvements in the life of the refractory lining.

One suitable conventional refractory material is that sold in bricks and blocks by Morgan Refractories Limited under the name MR 2. This is made from china clays, and has the following chemical analysis

	Percent
Al_2O_3	43.1
SiO_2	53.8
Fe_2O_3	0.86
TiO_2	0.06
CaO	0.26
MgO	0.25
K_2O	1.4
Na_2O	0.1

There can also be used other alumino-silicate based refractory materials which have the necessary properties required for successful operation of the apparatus in which the lining is used, which in the case of blast furnaces include high strength, high density, low porosity good abrasion resistance and resistance to carbon monoxide. It has been found that the thermal conductivity of such conventional lining materials is normally from 0.002 to 0.006 g. cal./cm./sec./° C.

A suitable high thermal conductivity material for use in the outer layer may be obtained by incorporating in a mix of conventional refractory material heat conductive materials such as natural graphite or silicon carbide using, for example, clay or carbon as bonding agents. The high thermal conductivity material may then be made up into bricks for construction of the composite lining in the manner used for conventional linings. While the prime purpose of the high thermal conductivity material is to promote cooling of the inner surface of the composite lining, so that the higher the thermal conductivity the better, it is also important that the material should be refractory so that in the event of unforeseen wear or failure of the inner layer it must be capable of withstanding high temperatures and possible attack by the furnace burden and gases. Furthermore it must also have reasonable compressive strength so as to be able to assist in supporting the weight of refractory lining above it in the blast furnace or other apparatus. Preferred materials are based on refractory clays of the kaolinite type which include from 30 to 40% by weight of the total of natural flake graphite and from 9 to 15% by weight of the total of silicon carbide. Such materials are made and sold by Morganite Crucible Limited under the trademark "Salamander," Plumbago refractories, these having a grained structure with a thermal conductivity along the grain of about 0.1 g. cal./cm./sec./° C. and of about 0.03 g. cal./cm./sec./° C. across the grain. Other materials of high thermal conductivity which may be used include electrographite and self-bonded or ceramic-bonded silicon carbide. These latter materials have satisfactory thermal conductivity, though in the event of failure of the inner conventional refractory lining, they might not be found capable of adequately withstanding the conditions to which they would be liable to be subjected for long.

It will be clear that any increase in the thermal conductivity of the outer layer of the composite lining increases the cooling efficiency of the whole. Generally it is desirable for the thermal conductivity of the outer layer to be at least 0.03 g. cal./cm./sec./° C., values of substantially 0.05 g. cal./sec./° C. or higher being preferred. When using the "Salamander" material, for maximum efficiency the grain should be aligned with the direction of maximum thermal gradient.

A schematic cross-sectional view of part of the composite lining is shown in FIG. 2 of the accompanying drawings, wherein the bricks A are of high thermal conductivity refractory material, while the bricks B are of conventional low thermal conductivity material. The furnace case is shown at C.

As it will be seen from FIG. 2, in practice the bricks of high thermal conductivity and low thermal conductivity refractory material are keyed together to provide structural strength of the composite lining. It will thus be apparent that the invention extends to the use of two adjacent, interlocking linings of high thermal conductivity and conventional low thermal conductivity refractory material. Furthermore, it will be clear that beneficial results will still be obtained even if only a proportion of the bricks designated A are in fact of high thermal conductivity material. For example, adequate heat conduction may be provided by every alternate brick A being of high conductivity material, the remainder all being of conventional low thermal conductivity refractory material. Thus apparatus in which the outer layer of the composite lining is heterogeneous is within the scope of the invention if the average thermal conductivity of the outer layer is greater than the average thermal conductivity of the inner layer.

In an alternative construction, the layer of high thermal conductivity material may be sandwiched between the inner layer of conventional refractory material and a third layer enclosing the other two and also of refractory material. Furthermore, it will be clear that beneficial results it is likely to involve a reduction in thickness of the inner layer with a consequent reduced life and an increased risk of the high thermal conductivity material being exposed to the furnace interior. In addition, the introduction of a third layer of refractory material increases the work involved in overcoming thermal barriers throughout the composite lining, which is necessay for the advantages of the invention to be fully realised, and this raises the cost of the composite lining. Nevertheless, such a sandwich construction provides the beneficial cooling results discussed above.

It is important, to achieve the objects of the present invention, that an effective path for heat is provided between the interior surface of the refractory lining and the exterior of the furnace case C. There must therefore be good physical and thermal contact between the two types of refractory forming the composite lining, and also between the high thermal conductivity refractory material and the interior of the furnace case. For these purposes, a high thermal conductivity cement or ramming material, the latter being used to fill substantial voids, as at D, have been found most satisfactory. These are provided with high thermal conductivity, e.g. of at least 0.01 g. sec./cm./sec./° C., by having a substantial content of natural or artificial graphite or other heat-conducting material.

What is claimed is:

1. Apparatus for containing material at high temperature comprising apparatus casing and a composite refractory lining disposed on the interior of said casing and in thermal contact therewith, said refractory lining being comprised of an inner refractory layer exposed to the apparatus interior and an outer layer of refractory material backing the inner layer and in thermal contact therewith said outer layer having a higher thermal conductivity which is at least 0.03 g. cal./cm./sec./° C. and which is at least 5 times higher than that of the inner refractory layer.

2. Apparatus according to claim 1 wherein the thermal conductivity of the material of the outer layer is at least 0.05 g. cal./cm./sec./° C.

3. Apparatus according to claim 1 wherein the thickness of the outer layer is from 0.8 to 1.2 times that of the inner layer.

4. Apparatus according to claim 3 wherein the inner and outer layers are of substantially equal thickness.

5. Apparatus according to claim 1 wherein the material of the outer layer comprises a kaolinite refractory clay

containing from 30 to 40% by weight of the total of natural flake graphite and from 9 to 15% by weight of the total of silicon carbide.

6. A blast furnace comprising a furnace casing and a composite refractory lining disposed on the interior of said casing and in thermal contact therewith, said refractory lining being comprised of an inner refractory layer exposed to the apparatus interior and an outer layer of refractory material backing the inner layer and in thermal contact therewith, said outer layer comprising a kaolinite refractory clay containing from 30 to 40% by weight of the total of natural flake graphite and from 9 to 15% by weight of the total of silicon carbide, and the thickness of the outer layer being from 0.8 to 1.2 times that of the inner layer.

7. A blast furnace according to claim **6** wherein at least the inner and outer layers are joined by a thermally conductive cement and wherein voids in the composite lining and between the composite lining and the furnace casing are filled with thermally conductive ramming material, said cement and ramming material each having a thermal conductivity of at least 0.01 g. cal./cm./sec./° C.

8. Apparatus according to claim **1** wherein the outer

refractory layer has a thermal conductivity at least 10 times that of the inner refractory layer.

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