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(54) **Foamed ceramic filter**

(57) A ceramic filter of open-celled foam structure, for filtering molten metals, has at least one side face 2, parallel to the direction of filtering flow, rendered impervious to a depth of 0.5 to 3 mms. The foam plastic starting piece may be saturated with ceramic slip and then squeezed to urge the surplus slip into a solid peripheral layer, or the impervious layer may be formed of a different ceramic in a separate stage. A further coating 7 may be applied to cell wall edges at the upstream and downstream faces 3 to reduce erosion in use.

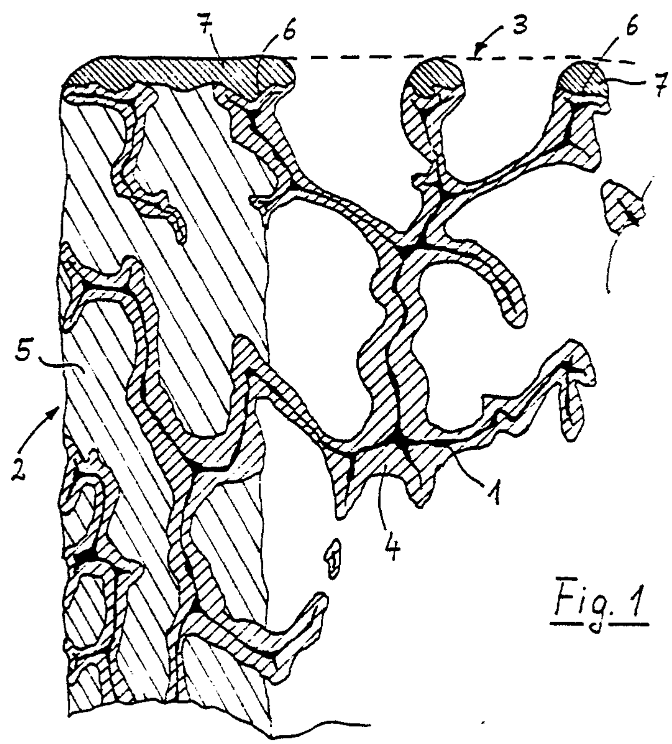

Fig. 1

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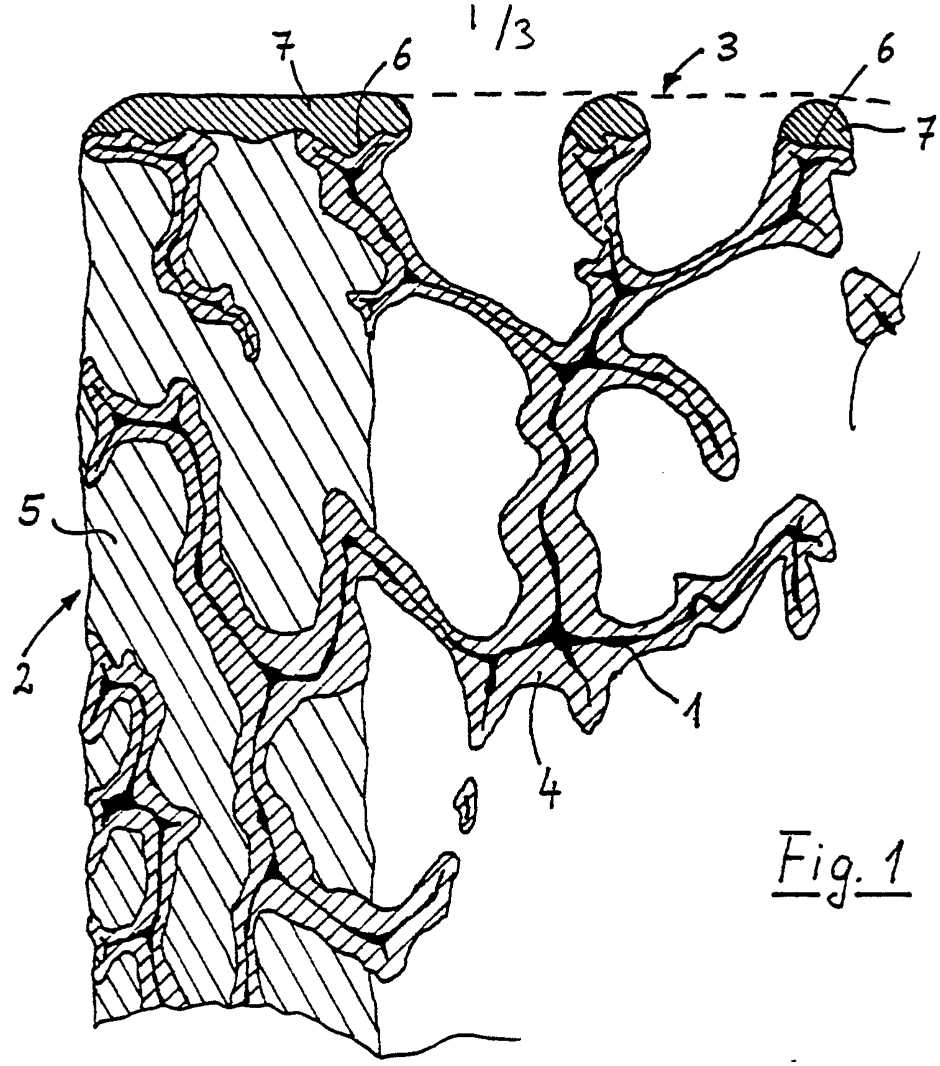

Fig. 1

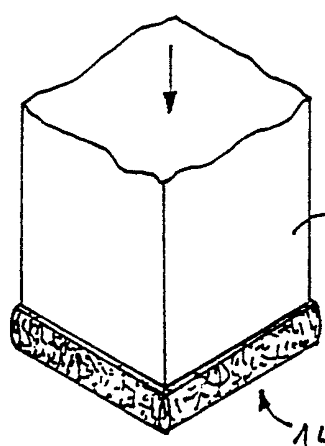

Fig. 2a

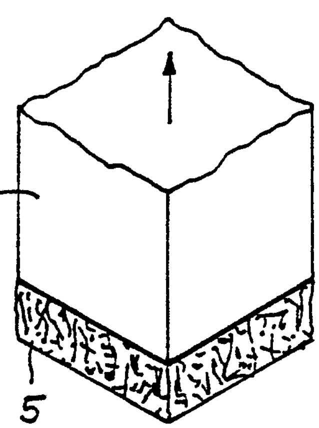

Fig. 2b

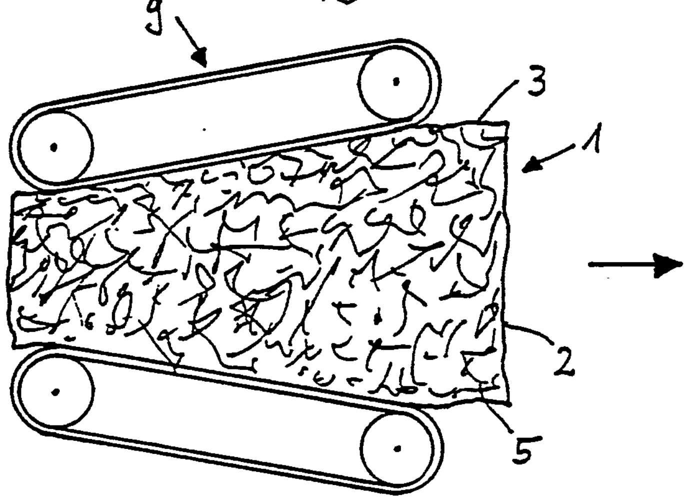

Fig. 3

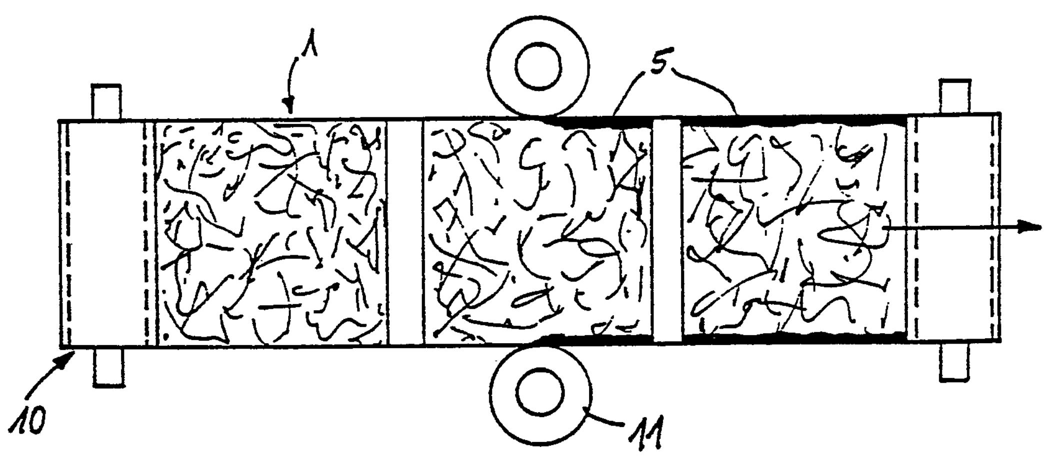

Fig. 4

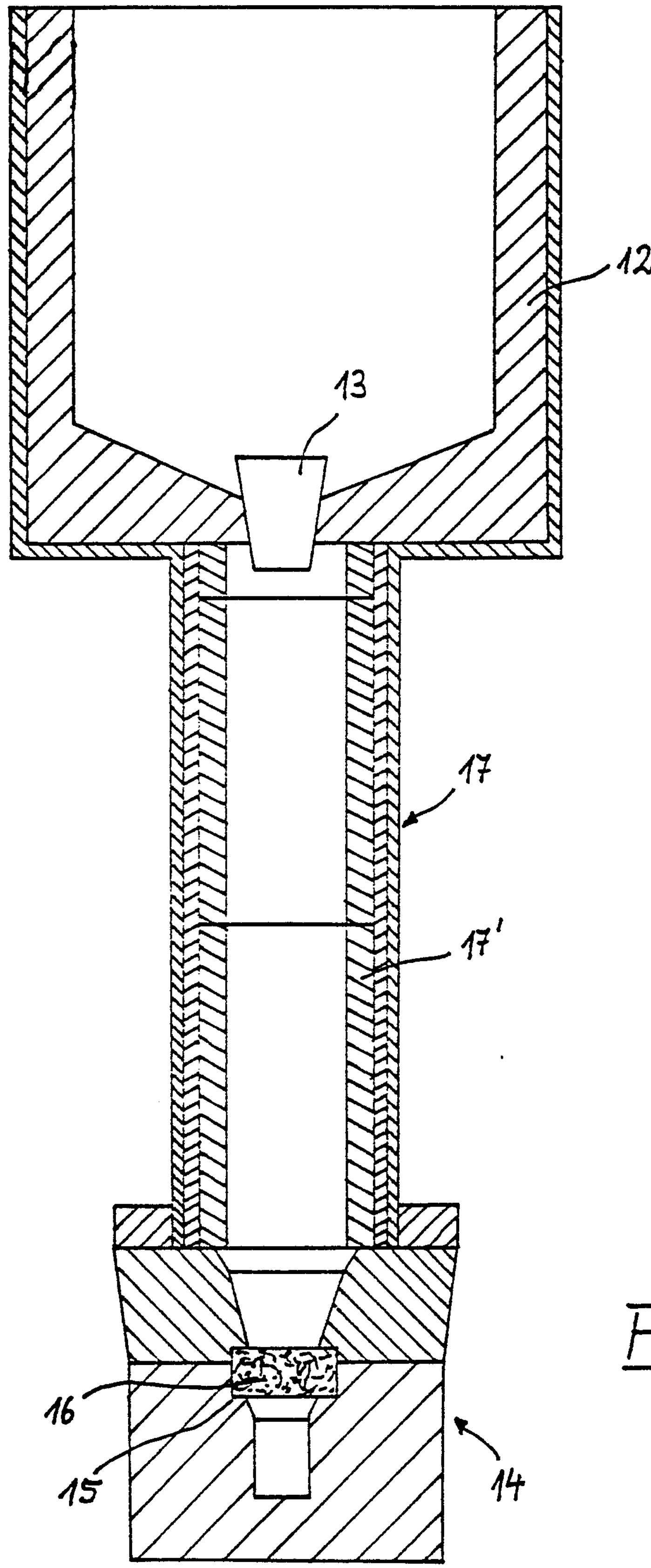

Fig. 5

DESCRIPTION

CERAMIC FILTER FOR FILTERING MOLTEN METALS

The present invention relates to a ceramic filter for the filtering of molten metals and to a method for manufacturing the same.

Such ceramic filters are currently successfully used in foundries to prevent the access of impurities such as slag, sand and refractory materials into the castings to be produced.

Ceramic filters with open-celled foam structure are usually produced by impregnating organic foam, for example polyurethane foam, with a low-viscosity ceramic slip or by impregnating with a high-viscosity slip and squeezing out the excess slip by means of pairs of rollers. If a low-viscosity slip is used, a uniform distribution of the ceramic material with the foam is obtained. If a high-viscosity slip is used, accumulation of slip material can occur inside the foam or on the side extending parallel to the direction of conveyance of the foam through the rollers. The extent of such accumulation depends on the crushing strength of the foam, the roller setting and the rheology of the slip.

In order for filtering to be ensured, the thermal and mechanical properties of the filter must have a high degree of reliability with regard to the liquid metal being filtered. With known filters, a certain percentage thereof - depending on loading - is affected by fractures and erosion of the ceramic material by the liquid metal. This occurs, in particular, in the region of the side faces extending essentially in the direction of through-flow of the molten metal, even if that region has an increased accumulation of material, due to the rolling, and also at the outer regions comprising outwardly open hollow membranes of the foam structure. The latter are caused, in impregnation of the foam, by some of the slip being removed again during conveyance of the impregnated foams and by vapour pressure occurring during burning out of the foam leading to more or less slit-shaped openings at the exposed cell membranes.

Published International application WO 82/03339 discloses a ceramic filter having an open-celled foam structure, based on a high-melting point ceramic, produced by impregnating an organic foam material with a high-viscosity ceramic slip, drying the structure and heating for removal of the foam material and calcining. Excess slip is removed from the foam, after the impregnation, by passing the foam through a system of pairs of rollers. In addition, exposed cell membranes lying at the surface of the filter can be protected against breaking off by the dried impregnated foam additionally being subjected, at the surface, to a further impregnation with a ceramic slip. As a result, the temperature resistance of the filter is also increased. However, this afterimpregnation is, on the one hand, disadvantageous to the extent that not only the exposed cell membranes but also regions of the filter lying thereunder are provided with an additional coating of slip, which impairs the permeability of the filter. On the other hand, the afterimpregnation results in a strength which is not adequate for many applications, in particular, in situations where a relatively great drop height of the molten metal exists, so that fractures and erosion still occur relatively frequently.

The present invention therefore seeks to provide a ceramic filter without the above disadvantages and which, in particular, has an increased mechanical and thermal stability with respect to molten metals to be filtered.

According to one aspect of the present invention there is provided a ceramic filter having an open-celled foam structure for filtering molten metal, the filter having two opposed through-flow faces extending transversely to the direction of through-flow of molten metal to be filtered, and at least one side face extending substantially in the direction of through-flow, wherein the at least one side face has a closed layer of refractory material of a depth of 0.5 to 3 mm.

Such a structure achieves the effect that the filters have a closed frame in the region of the peripheral side faces. In particular, the free cell membranes at the through-flow faces are hereby closed by a coating which does not impair the porosity of the filter.

The closed layer may extend over at least 50% of the side face or faces and may be distributed symmetrically.

In the region of the peripheral side face or faces (in the case of a filter with round or oval base area there is only one peripheral side face) of the foam provided in the dimensions of the filter to be produced, so much material with refractory properties is introduced into the foam that a closed layer having a depth of 0.5 to 3 mm is obtained in that region of the entire length in the circumferential direction. Also, an aftertreatment of the form, comprising coating the free cell membranes at the through-flow faces of the foam structure is performed with a material with refractory properties.

The remaining ceramic material can be, of course, calcined to achieve an increased mechanical and thermal stability.

The coating of the free cell membranes preferably takes place in a thickness of 0,1 to 1 mm, the coating material being applied in particular in a quantity of 40 to 400 mg/cm^2.

As with the coating of the free cell membranes, the closed layer at the side faces is preferably produced from the ceramic slip used for impregnation. Materials used for this are known per se. For example, substances with a principal component of Al_2O_3 or other highly refractory substances, in particular containing high proportions of alumina, such as sillimanite, mullite or chamotte, are considered suitable. The viscosity of the slip used is advantageously in the range from 10^4 to 2.10^4 cps at 20 rpm. If appropriate, instead of the slip used for impregnation, a different slip of refractory material or an agent setting in air with refractory properties, such as for example water glass, silica sol, resins, aluminum phosphates, zirconium oxide dichloride or ethyl silicate, may also be used for the production of the closed layer and/or the coating of the free cell membranes.

Thus, according to another aspect of the present invention there is provided a method of forming a ceramic filter comprising impregnating an organic foam member, having at least one first surface for forming a side face of the filter, and two substantially opposed second surfaces for forming through-flow faces of the filter, with a high-viscosity slip of high-melting point ceramic material and forming a closed layer having a depth of 0.5 to 3 mm of refractory material in the region of said first surface, drying the member and heating the member to remove the organic foam.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a schematised, enlarged, segmented section through a ceramic filter according to an embodiment of the present invention, before firing;

Figs. 2a and 2b are a diagrammatic illustration of one embodiment of a process for the production of a peripheral closed layer of a filter of the present invention;

Figs. 3 and 4 illustrate two embodiments of a process for the production of two opposite closed outer layers of a filter of the present invention; and

Fig. 5 shows a test set-up apparatus for such ceramic filters.

In Fig. 1, an uncalcined filter, before firing, is illustrated in section, in which a foam structure 1 of organic material, such as for instance polyurethane foam or the like, which is for example cuboid with four adjoining peripheral side faces 2 and two mutually opposite parallel through-flow faces 3, has first been impregnated with a high-viscosity ceramic slip 4. As set out in detail below, a closed layer 5 of a depth of 0.5 to 3 mm of refractory material, in particular the impregnation slip 4 is provided on all the side faces 2. In addition, free cell membranes 6 at the through-flow faces 3 are provided with a coating 7 of refractory material, in particular, comprising the impregnation slip 4. After firing, the foam structure is burned out and the slip is solidified.

According to Figs. 2a and 2b, in order to form the peripheral closed layer 5 in the region of the side faces 2, the foam structure 1, impregnated with the slip, is compressed, for example by means of a ram 8 having the same base area as the foam structure 1. The compression is provided to such an extent that excess slip is formed in the region of the side faces 2 and partially accumulates on the outside in the manner of a bead, as indicated in Fig. 2a. During relaxing of the compressive force on the foam structure 1, by raising of the ram 8, a frame of slip forms, which is closed on all sides, since the excess bead of slip at the side faces distributes itself uniformly over the side faces 2 during this relaxation. Subsequently, the impregnated foam is dried and fired and can be provided with the coating 7 either before or after firing.

As represented in Fig. 3, and also after drying, the foam structure 1, having had the slip applied can alternatively be passed through an opening pair of belts 9, diverging in the direction of travel of the structure, between which the impregnated foam structure 1 is firstly compressed. As a result, excess slip is forced out sideways and forms a bead. During further passage through the pair of belts 9, the compressive force on the foam structure 1 is relieved and the bead of slip distributed evenly over the two opposite side faces 2, so that two opposite closed layers 5 develop.

According to Fig. 4, the closed layers 5 are formed by passing the impregnated and dried foam structure 1 through a pair of vertically upright rollers 11, by means of a horizontal conveyor 10. Each of the rollers applies an appropriate refractory material, slip or material setting in air, to two opposite side faces 2 and forces it into the pore structure to the specified depth. In this process, an even layer thickness of material, on the surface of the rollers, is ensured, for example, by means of a doctor knife or a roll frame.

This method of producing closed layers 5 may be arranged downstream of those of Fig. 3, in order to provide all four side faces 2 with a closed layer 5. However, two sets of apparatus according to Fig. 4 or Fig. 3, with a station for turning the foam structure 1 through 90°, may also be arranged in series in order to provide all four side faces with a closed layer 5.

Instead, however, the closed layer 5 may also be produced by a layer of further foam material, having a plurality of pores, adhesively attached to the side faces 2 of the foam structure 1 or the said faces being provided with a web of fine plastic filaments. During impregnation with the slip, the small pores or intermediate spaces in the peripheral side edge region become, and remain, filled with slip, and the required peripheral closed layer 5 develops.

The method according to Fig. 4 may also be used to provide the side faces 2 of an already fired filter with a closed layer 5 of a material having refractory properties which is set in air.

In addition, the method of Fig. 4 may be used in order to apply the coating 7, either after drying and before firing, in the form of a slip or, after firing, in the form of a material setting in air with refractory properties.

If foam-ceramic filters are used for the filtration of molten metals such as cast iron (for instance lamellar graphite cast iron, nodular graphite iron, malleable cast iron Ni resist) a thermal and static loading of the filters suddenly occurs due to the liquid melt flowing onto them. The degree of the thermal loading is more or less dependent on the composition and nature of the fired slip which was used for the production of the ceramic filter.

Other features influencing the stability of the filter are the supporting surfaces (supports) of the filter in the mould and the structurally determined form of the filter itself. The latter can be improved, without adversely influencing the through-flow rate for the liquid material, by the design according to the present invention.

Accordingly, in contrast to conventionally produced filters, the filter according to the present invention can be exposed to far higher loads (drop heights and pressure levels). This can be demonstrated by the test set up illustrated in Fig. 5.

The illustrated test set-up comprises a reservoir 12, for receiving and storing liquid material, which is closed at the bottom by a plug 13. Underneath the reservoir 12 there is a filter receptacle 14, with a standardised core print 15, which receives a filter 16 to be tested and, for example, having dimensions 50 mm x 50 mm x 22 mm. Between the reservoir 12 and the filter receiver 14 there is a downpipe 17, which can be longitudinally extended, for example by sections 17' of predetermined length.

The filters 16 to be tested are placed in the test print 15 and, after pulling the plug 13, are subjected to a through-flow of a predetermined type and quantity of molten iron.

Ceramic filters produced according to the invention of the specified size (with peripheral closed layer 5 of a thickness of 2 mm and a coating 7 of a thickness of 0.5 mm) were compared with conventional ceramic filters having similar dimensions and consequently arranged to have the same through-flow resistance, using the test set-up represented in Fig. 5 and lamella graphite cast iron as the "material". The weight spectrum was essentially the same in the case of both types of filter. In addition, both types of filter were subjected to the same furnace campaign. The results of the comparative testing is illustrated below in the following table.

	Conv. produced	Produced according to the invention	Conv. produced	Produced according to the invention
Casting height	450 mm	450 mm	527 mm	527 mm
Casting temp. °C	1440 - 1379	1440 - 1379	1438 - 1380	1438 - 1380
Number of tested filters	5	5	5	5
of which number fractured	3	0	4	0
of which number intact	2	5	1	5

CLAIMS

1. A ceramic filter having an open-celled foam structure for filtering molten metal, the filter having two opposed through-flow faces extending transversely to the direction of through-flow of the molten metal to be filtered, and at least one side face extending substantially in the direction of through-flow, wherein the at least one face has a closed layer of refractory material of a depth of 0.5 to 3 mm.

2. A ceramic filter as claimed in claim 1, wherein substantially all free cell membranes of the foam structure at the through-flow faces are closed by a cover layer of refractory material.

3. A ceramic filter as claimed in claim 2, wherein the cover layer has a depth of 0.1 to 1 mm.

4. A ceramic filter according to claim 1, 2 or 3, wherein the closed layer and/or cover layer of refractory material are formed of the same ceramic as the filter.

5. A ceramic filter as claimed in any preceding claim, wherein the closed layer extends around the whole lateral extent of the at least one side face.

6. A structure for forming a ceramic filter as claimed in any preceding claim, comprising an open-celled organic foam member having surfaces for forming said through-flow faces and said at least one side face, with said closed layer, and impregnated with a high viscosity ceramic slip.

7. A method of forming a ceramic filter comprising impregnating an organic foam member, having at least one first surface for forming a side face of the filter and, two substantially opposed second surfaces for forming through-flow faces of the filter, with a high-viscosity slip of high-melting point

ceramic material and forming a closed layer having a depth of 0.5 to 3 mm of refractory material in the region of said first surface, drying the member and heating the member to remove the organic foam.

8. A method as claimed in claim 7, wherein the refractory material comprises the ceramic slip.

9. A method as claimed in claim 7 or 8, wherein the free cell membranes of at least one of the second surfaces is coated with a material having refractory properties.

10. A method as claimed in claim 9, wherein the free cell membranes are coated to a thickness of 0.1 to 1 mm.

11. A method as claimed in claim 9 or 10, wherein the coating has a density 40 to 400 mg/cm^2.

12. A method as claimed in claim 9, 10 or 11 wherein the impregnated, dried and unheated foam is passed through a vertically upright pair of rollers so as to coat the free cell membranes with a high-viscosity slip.

13. A method as claimed in any of claims 9 to 12, wherein the heated filter is passed through a vertically upright pair of rollers and the free cell membranes are thereby coated with an agent having refractory properties and setable in air.

14. A method as claimed in any of claims 7 to 13, wherein the closed layer is formed by compression, after impregnation, of the organic foam by means of a ram, which has the same base area as the member, after which the foam is allowed to relax.

15. A method as claimed in any of claims 7 to 13, wherein the closed layer is formed by passing the impregnated organic foam through a pair of belts diverging in the direction of movement, for squeezing out excess slip.

16. A method as claimed in any of claims 7 to 13, wherein the closed layer is formed by reducing the number of pores of the organic foam at the at least one first surface so that the closed slip layer is formed therein during impregnation.

17. A method as claimed in claim 16, wherein the number of pores is reduced by adhesively attaching a foam material member having a lesser number of pores, according to the required layer thickness of the closed slip layer.

18. A method as claimed in claim 16, wherein the number of pores is reduced by applying a web of fine plastic filaments to the at least one first surface.

19. A method as claimed in any of claims 7 to 13, wherein the closed layer is formed by passing the impregnated, dried and unheated foam through at least one vertically upright pair of rollers, by which high-viscosity slip is applied and forced into the foam to the specified depth.

20. A method as claimed in claim 7 to 13, wherein the heated filter is passed through at least one vertically upright pair of rollers, which apply an agent with refractory properties and setable in air, and which force the agent into the filter to the specified depth.

21. A ceramic filter substantially as hereinbefore described with reference to and as illustrated in Fig. 1, Figs. 2a and 2b, Fig. 3 and Fig. 4 of the accompanying drawings.

22. A method of forming a ceramic filter substantially as hereinbefore described with reference to and as illustrated in Fig. 1, Figs. 2a and 2b, Fig. 3 and Fig. 4 of the accompanying drawings.

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