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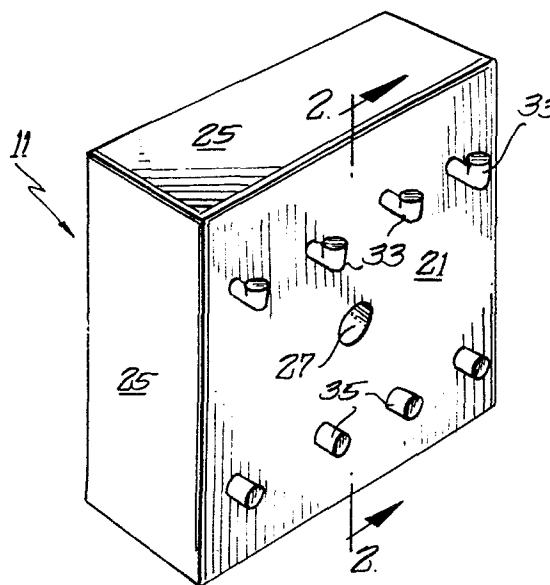
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**Electric furnace thermal insulating module and forming thereof.**

A terminal-insulating module for use in an electric furnace consists of a refractory fibre mat (11) formed of discrete refractory fibres bonded together by an inorganic bonding agent and having a hot face (21), a cold face, and a plurality of side faces (25). A plurality of individual ceramic supports are partially embedded in the mat (11) and protrude outward from the hot face (21). The embedded portions are shaped so as to be firmly anchored within the mat (11), and the protruding portions (33, 35) are shaped to support an electrical resistance heating ribbon in the interior of the furnace.

The modules are preferably formed in a felting box where the ceramic supports extend horizontally from cavities in the front wall. The layers of fibres build up upon a bottom screen in planes perpendicular to the hot face (21) of the module (11).



ELECTRIC FURNACE THERMAL-INSULATING MODULEAND FORMING THEREOF

The invention relates to improved thermal-insulating modules for high-temperature applications, and to a method of making such modules, and more particularly relates to ceramic fibre modules which not only provide thermal insulation for a high-temperature enclosure but which also support electrical resistance heating elements.

Firebrick has typically been used for the insulation of electrically heated furnaces; however, in recent years, it has become desirable and advantageous to utilize panels of ceramic fibre materials for high-temperature insulation purposes. Examples of such heat-insulating fibrous panels are shown in U.S. Patent No. 4 122 644, issued October 31, 1978 to Richard K. Woodruff, the disclosure of which is incorporated herein by reference. The panels disclosed in this patent include foraminous metal supporting clips embedded within a fibrous mat generally adjacent the cold face, which clips facilitate the attachment of such panels to an outer metal wall of a furnace enclosure or the like. Such panels, however, are not designed to support the electric resistance heating elements necessary for heating an electrical furnace or the like.

U.S. Patent No. 4 249 888, issued February 10, 1981, discloses ceramic fibre modules for employment in an industrial furnace, which modules are designed to incorporate a rectangular frame formed from four pieces of metal rod with threaded hanging rods welded in place at the four corners. A ceramic fibrous mat is felted about the support frame by locating it in a mould, suspended downward from the four hanging rods, and forming a mat about the structure by supplying a slurry

of fibres plus a binder to the top of the mould. The threaded hanging rods extend out of the cold face of the module and pass through holes drilled in longitudinal members which support the sides and roof of the furnace. When the modules are used in an electric furnace, provision is made for embedding an electric resistance heating coil in the hot face of the module, which coil is connected to a source of power through anchoring ribbons embedded in the module and connecting pins that extend from the ribbons through the cold face of the panel.

The concept of embedding an electrical resistance heating coil in an insulating panel is considered to have the disadvantage of providing somewhat of an insulating barrier between all surfaces of the coil and the interior of the furnace which is to be heated and of also shortening the path of heat leak-out of the ceramic fibre module, by a distance equal to the depth of the recess. Accordingly, improvements in such insulating modules were sought.

According to one aspect of the invention a thermal insulating module for use in an electric furnace comprises a refractory fibre mat, formed of discrete refractory fibres interconnected and bonded together by an inorganic bonding agent, and having a hot face, a cold face and a plurality of side faces, and a plurality of individual ceramic supports partially embedded in the mat and partially protruding outward from the hot face thereof, the embedded portions being shaped so as to be firmly anchored by the interconnected fibres of the fibrous mat, and the protruding portions being shaped to support an electrical resistance heating ribbon in the interior of the furnace generally adjacent the hot face.

The electrical resistance heating ribbon is preferably supported on the protruding portions of the ceramic supports generally out of contact with the hot face of the mat so that more efficient heating of the interior of the furnace is obtained than when the heating element is embedded within the module.

Preferably, the module is provided with a foraminous metal supporting member embedded within the mat and individual fibres of the mat extend through holes in the supporting member to firmly anchor the member. The metal supporting member is provided to facilitate the attachment of the module to the wall of a furnace enclosure.

The embedded portions of the ceramic supports may comprise body portions which include a section of reduced diameter, and the protruding portions may comprise hook members which are horizontally aligned so that the ribbons can be arranged in a plurality of depending loops, each hanging between two adjacent hook members.

According to another aspect of the invention, a method of making a thermal-insulating module for use in an electric furnace comprises the steps of providing a mould having four generally vertical walls for forming the hot face, the cold face and a pair of side faces of a furnace insulation module, the wall for forming the hot face having aligned cavity means for holding end portions of a plurality of ceramic supports, inserting said end portions of individual ceramic supports in the cavity means so that a body portion of each of the supports extends into a central portion of the mould, supplying the mould with an aqueous slurry of refractory fibres plus an inorganic bonding agent and withdrawing

water to form a mat of discrete fibres having a hot face, a cold face and a plurality of side faces, in which mat the body portions of the ceramic supports are embedded, opening the mould by moving either the hot-face-defining wall or the cold-face-defining wall relative thereto, removing the wet fibrous mat, and drying the mat to form a module in which the embedded body portions of the ceramic supports are firmly anchored by the fibres of the mat which are interconnected and bonded together by the inorganic bonding agent and in which the end portions of the ceramic supports protrude from the hot face to provide support for an electrical resistance heating element in a furnace enclosure.

Preferably a foraminous metal supporting member is supported from the cold-face-defining wall so as to also become firmly embedded within the fibrous mat.

A felting screen conveniently forms the bottom of the mould and defines one of the faces of the module.

The cavity means may incorporate spring clips for holding the ceramic supports in generally parallel horizontal alignment.

An alignment rod may be inserted through two of the vertical walls of the mould and through horizontally extending holes provided in the body portions of the ceramic supports to maintain precise alignment while the slurry is being supplied.

According to a further aspect of the invention, a method of making a refractory product suitable for insulation use in a high temperature environment from an aqueous slurry of fibres plus a binder, in which the

product is elongated in at least one direction and has a major surface intended to constitute a hot face, comprises the steps of placing screen means in contact with the aqueous slurry, the screen means being generally rectangular in shape and proportioned to constitute a cross-sectional shape of the product in a direction substantially perpendicular to said one direction, depositing superimposed layers of refractory fibres upon the screen means by withdrawing water from the slurry through the screen means until a desired height is accumulated which is substantially greater than the smaller dimension of the screen means whereby the deposited fibres lie in planes perpendicular to the major surface of the product, and treating the accumulation of deposited fibre layers to set the binder and form a stable product having improved thermal-insulating properties when the hot face is exposed to a high temperature environment.

The invention will now be further described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view showing an insulation module embodying various features of the invention;

Figure 2 is a side sectional view through the wall of an electric furnace showing the module of Figure 1 mounted in an operative position;

Figure 3 is a perspective view of a plurality of insulation modules arranged side-by-side in a horizontal row, as they might be disposed within an electric furnace enclosure, and having an electric resistance heating ribbon supported thereon;

Figure 4 is a diagrammatic view showing a method for forming a module such as that shown in Figure 1 using a felting process;

Figure 5 is a perspective view depicting the opening of the mould shown in Figure 4; and

Figure 6 is an elevational view, reduced in size, showing an alternative method for removing the module from a mould such as that depicted in Figure 4.

As illustrated in Figure 1, a thermal-insulating module 11 is made primarily of a mat or felt of ceramic fibre material which may have one or more metal clips 13 integrally anchored in it to facilitate its mounting to an exterior wall 15 of a furnace enclosure. The clips 13 are formed of a foraminous material, for example, wire screening or expanded metal, and are preferably rectangular and bent to form a base plus a pair of wings which extend at similar angles from the base section, as disclosed in detail in U.S. Patent No. 4 122 644. A central aperture in the base section of the clip 13 allows for the passage therethrough of a threaded stud or bolt 17 by which the mounting is effected.

The module 11 may generally have the shape of a rectangular parallelepiped, as illustrated, having a major flat front face 21 which serves as the hot face of the insulation module and a parallel major rear or cold face 23. It also has four sides 25 which are perpendicular to the front and rear faces, with the top and bottom sides being parallel and with the two lateral sides being vertical, as generally employed in operative installation. One dimension of the front face will be

substantially larger than the thickness of the module 11, thus occasioning its being called a major face. As best seen in Figure 2, the mounting clip 13 is disposed adjacent the cold face 23 of the module, and a frusto-conical hole 27 extends through to the hot face 21 to facilitate the installation of the module. The hole 27 is then filled with refractory fibre material, similar to that which makes up the mat, after installation is completed. Depending upon the size of the module, two or more supporting metal clips 13 can be employed.

Each of the modules 11 includes eight ceramic supports 31 which are used for installing the electric resistance heating elements in the furnace. Four upper supports 31a terminate in protruding ceramic hooks 33 whereas four lower supports 31b terminate in protruding knobs 35. The upper and lower ceramic supports have similar body or shank portions 37 which are formed with an intermediate section 39 of reduced dimension. The body portions 37 are completely embedded within the fibrous mat and as a result of the reduced dimension intermediate sections 39, they are physically captured and securely anchored in the rigid fibre mat and provide excellent rigidity with respect to the protruding hooks and knobs of the module. The supports 31 are made from a suitable ceramic material, such as porcelain, steatite or some other suitable mineral material, and in this respect, the term "ceramic" is intended to include appropriate mineral materials having good electrical insulating properties.

Figure 3 shows several of the modules 11 mounted side-by-side as they would be along the vertical wall of an electrical furnace enclosure. The heat for such an electric furnace enclosure is provided by electrical

resistance heating elements 41 which are usually in the form of elongated ribbons. The ribbons are arranged in a plurality of depending loops 43, each of which hangs between two of the protruding hooks 33 of the upper ceramic supports. The protruding knobs 35 of the lower supports serve as spacers between the lower portions of the loops 43 and prevent contact that might result in shorting of the resistance heating elements.

Figure 4 of the drawings illustrates a felting box or mould 49 which might be employed to form the modules. Basically, the felting box 49 includes four vertical walls 51, 53, 55 and 57 and a felting screen 59 which constitutes the bottom of the box. A slurry of refractory fibres and water plus a colloidal inorganic binder is supplied to the felting box 49, usually through the open top via a feeder 61, and the water is withdrawn through the bottom screen 59 where it flows into a plenum 63 which connects to a line 65 that leads to a recirculation tank. Usually, either pressure or suction is employed to cause the water to drain downward at a satisfactory rate through the screen to deposit the fibres on the screen 59 and build up a layered mat of the desired thickness. Sufficient of the colloidal inorganic binder remains with the wet fibres to rigidly interconnect the fibres at their points of contact with one another after evaporation of the remainder of the water, which generally occurs during heating of the wet mat in a recirculation air over and/or a firing of the refractory fibre mat.

The felting box 49 is constructed so that the two lateral walls 55, 57 are stationary, and either the front wall 51 or the rear wall 53 is movable to permit the removal of the felted mat. As illustrated in Figures 4 to 6, the front wall 51, against which the hot

face is formed, is preferably hinged to the bottom of the felting box so that it swings downward about a hinge pin 67. Alternatively, the rear wall 53 could be hinged, and the front wall 51 made stationary.

To locate the metal clip 13 at the desired location adjacent the cold face of the module, a peg 69 is provided which is proportioned to receive the central hole in the middle of the base portion of the metal clip. The peg 69 extends sufficiently from the rear wall 53 to also support a frusto-conical filler or pin 71 which is made of a consumable material and which extends for the full depth of the mould to the front sidewall 51. The pin 71 fills the open region 27 during the felting process so that refractory fibres are excluded from it, and during subsequent heating, the pin 71 is consumed and leaves the void region 27 depicted in Figure 2 and described above.

The front wall 51 includes eight cavities 73 which are proportioned to receive the protruding hooks 33 and knobs 35 of the eight ceramic supports. Preferably, the cavities are fitted with closures 75 to prevent excess draining of the slurry therefrom during the felting operation. To secure the ceramic supports 31 in the desired horizontal alignment during the felting operation, spring clips 77 are preferably provided in association with the cavities 73 so as to grasp the ends of the hooks and knobs and hold them in place while the mat of refractory fibres is built up from the bottom of the mould.

With the metal clip 13 and the filler cone 71 in place on the rear wall 53 and with the eight ceramic supports 31 positioned in the cavities 73 in the front wall 51, the felting operation is begun by supplying an

aqueous slurry of refractory fibres and binder to the top of the felting box 49. Suction is applied to the bottom outlet line 65 causing the water to drain through the felting screen 59 and layers of wet fibres to build up across the bottom of the box which gradually increase in height. The height will be at least about 3 inches, and heights of about 12 inches or more can be used. Alternatively, the mould 49 can be immersed in a tank containing the slurry, and suction can be similarly applied to the drain line for a sufficient time.

As illustrated in Figure 4, the body portions 37 of the ceramic support may optionally be provided with one or more holes 81 which extend therethrough in a horizontal direction. These holes 81 not only add somewhat to the anchoring of the supports in the rigid mat, because of the entry of fibres during the felting process, but also provide the opportunity to further stabilize the supports during the felting process. As best seen in Figure 5, the lateral walls 55, 57 of the felting box are provided with aligned pairs of holes 83 that line up with the holes 81 in the body portions remote from the protruding ends so that a pair of temporary alignment rods 85 can be inserted therethrough to maintain the ceramic support in precise position during the felting operation. The rods 85 are of course withdrawn from the wet felted mat before it is removed from the felting box.

The refractory fibres which are usually employed are formed from inorganic oxides or the like, such as silica, zirconia, alumina, beryllia, titania and mixtures thereof. The major portion of the fibres preferably have a length of about 1 inch or less. One type of suitable fibres are alumina-silicate fibres, such as those available under the trademark "Fiberfrax",

from the Carborundum Company, which have an approximate composition, by weight, of aluminium oxide 51.3%, silicon dioxide 47.2%, boron oxide 0.5% and sodium oxide 0.15%, with the remainder being trace inorganics. For very high temperature operations, a minor percentage of alumina fibres are usually included, such as those sold under the trademark "Saffil" which are about 95% alumina. Colloidal silica, which is commercially available as an aqueous dispersion of small spherical particles of silicon dioxide that are negatively charged, is the preferred inorganic binder. However, similar aqueous dispersions of other colloidal particles, such as colloidal alumina or colloidal zirconia, may also be employed. Colloidal silica is commercially available as an aqueous dispersion in amounts up to about 50% by weight of silica, and this feature, plus its relatively inexpensive price, makes it attractive for use in mass production operations.

When the mat has built up to the desired level within the felting box 49, supply of the slurry is halted, and the mould is opened by swinging the pivotable front wall 51 downward. Magnetic latches (not shown) or the like may be used to hold the hinged wall 51 in its closed position during the felting operation. The cavities 73 may be formed so as to easily release, and to clear, the protruding pins and knobs during the swinging movement, as depicted in Figure 5. The wet fibre mat can then be removed from the felting box through the opening provided by the front wall, by sliding the conical filler 71 and the metal clip 13 off the peg 69 that extends from the rear wall. Alternatively, the spring clamps 77 associated with the cavities 73 can be made slightly stronger and the rear peg made slightly shorter, and the fibrous mat can be pivoted downward with the front wall, as depicted in Figure 6, and then separated by lifting upward.

The felted mat will obtain its desired strength by drying at any temperature; however, preferably firing is carried out at an elevated temperature so as to simultaneously dry the felt to set the inorganic binder while the consumable filler pin 71 is removed by disintegration or the like. In this respect, the temperature is dependent upon the material from which the consumable filler is made. For example, a filler formed from core-moulding sand should crumble after heating at a fairly low temperature to deteriorate its binder; while an oxidizable wood fibre material could be burned out in a circulating air oven at a temperature of 400°F. or above. Generally an oven temperature of between about 400°F. and about 600°F. is used to dry the mat and remove the consumable filler in a reasonable time, such as an hour or less.

The resultant modules are ready for installation in a furnace enclosure of any type, such as a closed furnace chamber or an open tunnel or the like. The metal clip 13 adjacent the cold face 23 facilitates attachment to the structural member of the furnace, as by inserting a threaded bolt 17 through the central hole, via the access provided by the frusto-conical hole 27, and securing it in place by a nut and a lock washer. The upper and lower supports 31 are securely anchored in the now rigid fibre mat and provide secure points of support for the ribbon-like electric resistance heating element 41. When the aligned modules 11 have been installed, the electric resistance heating ribbon 41 is draped in the fashion shown in Figure 3. The hooks 33 are long enough so as to accommodate the ribbon 41 in a location wherein it is lying adjacent to, but just out of contact with, the hot face 21 of the fibrous module.

The preferred felting process illustrated in Figure 4 produces an additional advantage in the performance of the modules. It has been found that the disposition of the layers of refractory fibres in planes perpendicular to the hot face 21 of the module will provide superior insulation performance and lifetime, as opposed to modules formed in the conventional manner wherein the planes in which the fibres are laid down in the felting process lie parallel to the hot face. Previously, attempts have been made to utilize this property of the fibres by cutting a fibrous mat in strips and then rearranging the strips edgewise so as to orient the layer planes perpendicular to the hot face. The preferred felting method disclosed in Figure 4 achieves this desired fibre orientation because, by employing the felting screen 59 to define one of the sides 25 of the modules, the planes of the fibres that are laid down will be perpendicular to the hot face 21. As a result, a module 11 made of a mixture 70 weight % Fiberfrax fibres and 30% Saffil fibres will withstand a temperature of upwards of about 2700°F. on its hot face 21 for an extended lifetime, and a module about 6 inches thick will have heat-transfer characteristics such that temperature at the cold face 23 of the module which is against the support member 15 will be about 165°F.

If it is not desired to provide a consumable pin 71, access to the metal clip 13 from the front surface 21 of the module can be provided by drilling or the like.

Whereas the arrangement of hooks 33 and knobs 35 is adequate to support electric resistance heating ribbons from the wall of a furnace, and although normally heating will not be provided at the roof of a furnace

enclosure, if it should be desired to provide heating at the interior of the roof, similar modules could be provided having a second set of hooks in substitution for the knobs which could then support such ribbons in a horizontal orientation.

CLAIMS

1. A thermal-insulating module for use in an electric furnace comprising a refractory fibre mat (11) formed of discrete refractory fibres interconnected and bonded together by an inorganic bonding agent and having a hot face (21), a cold face (23), and a plurality of side faces (25), characterised in that the mat (11) has a plurality of individual ceramic supports (31) partially embedded therein and partially protruding outward from the hot face (21) thereof, the embedded portions (37) being shaped so as to be firmly anchored by the interconnected fibres of the fibrous mat (11), and the protruding portions (33, 35) being shaped to support an electrical resistance heating ribbon (41) in the interior of the furnace adjacent the hot face (21).

2. A module as claimed in Claim 1, further characterised in that a foraminous metal supporting member (13) is embedded within the fibrous mat (11) and has holes through which individual refractory fibres extend firmly to anchor the supporting member therewithin.

3. A module as claimed in Claim 1 or Claim 2 further characterised in that the embedded portions of the ceramic supports (31) comprise body portions (37) which have a section (39) of reduced dimension relative to the remainder.

4. A module as claimed in any of the preceding claims further characterised in that the protruding portions of the ceramic supports comprise hook members (33) which are generally horizontally aligned.

5. A module as claimed in Claim 4 further characterised in that a protruding knob (35) is located vertically spaced below each hook member (33).

6. A method of making a thermal-insulating module for use in an electric furnace which comprises providing a mould (49) having four generally vertical walls (51, 53, 55, 57) for forming the hot face, the cold face and a pair of side faces of a furnace insulation module, supplying the mould (49) with an aqueous slurry of refractory fibres plus an inorganic bonding agent and withdrawing water to form a mat of discrete fibres, removing the wet fibrous mat, and drying the mat to form a module (11), characterised in that the wall (51) for forming the hot face has aligned cavity means (73) for holding end portions (33, 35) of a plurality of ceramic supports (31), and said end portions (33, 35) of individual ceramic supports (31) are inserted in the cavity means (73) before the aqueous slurry is supplied to the mould (49) so that a body portion (37) of each of the supports (31) extends into a central portion of the mould (49), the body portions (37) being embedded in the mat after the water is withdrawn, the embedded body portions (37) being firmly anchored by the fibres of the mat which are interconnected and bonded together by the inorganic bonding agent when the mat is dried to form the module (11), and the end portions (33, 35) of the ceramic supports (31) protruding from the hot face (21) of the module (11) to provide support for an electrical resistance heating element in a furnace enclosure.

7. A method as claimed in Claim 6 further characterised in that a foraminous metal supporting member is supported from the cold-face-defining wall (53) before the aqueous slurry is supplied to the

mould (49) so as to also become firmly embedded within the fibrous mat.

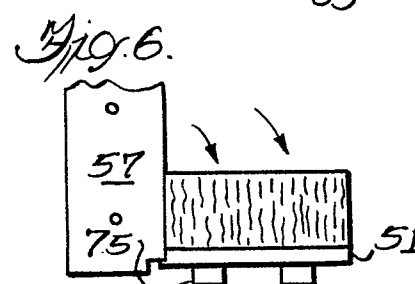
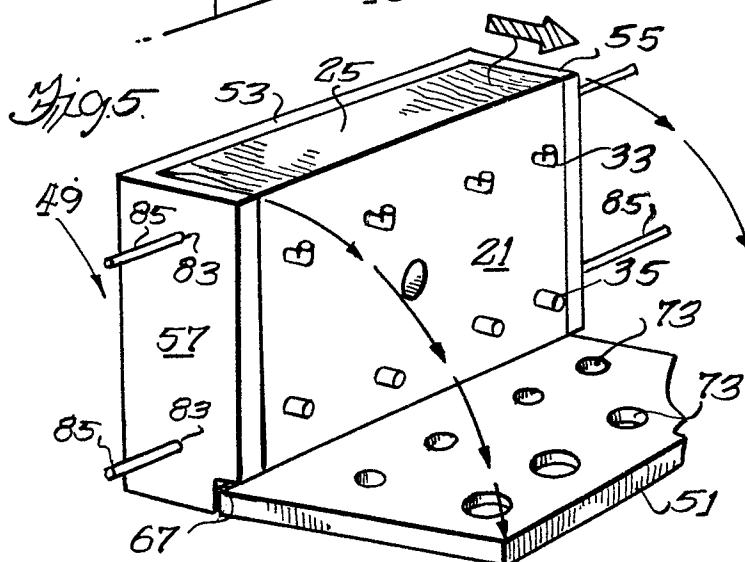
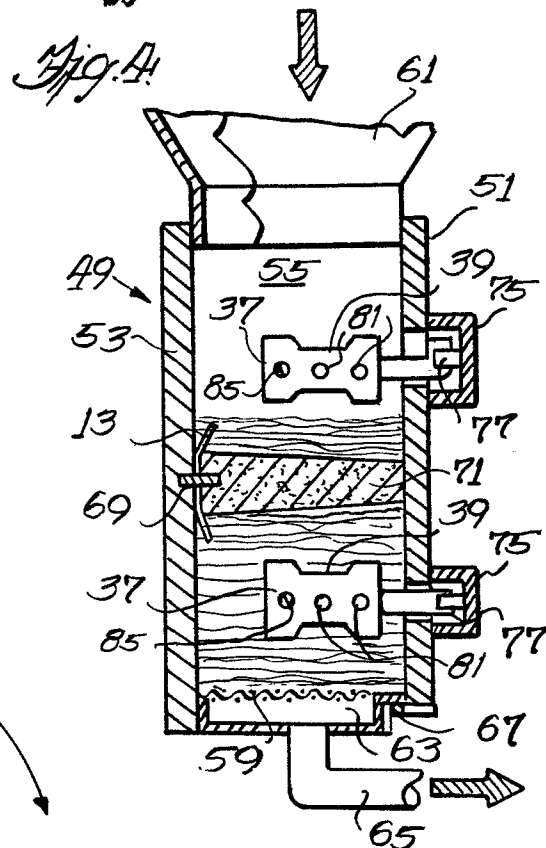
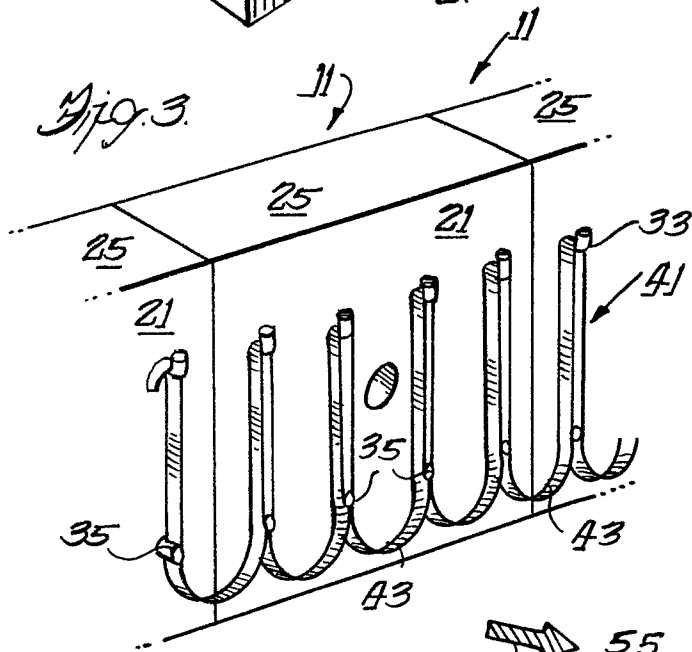
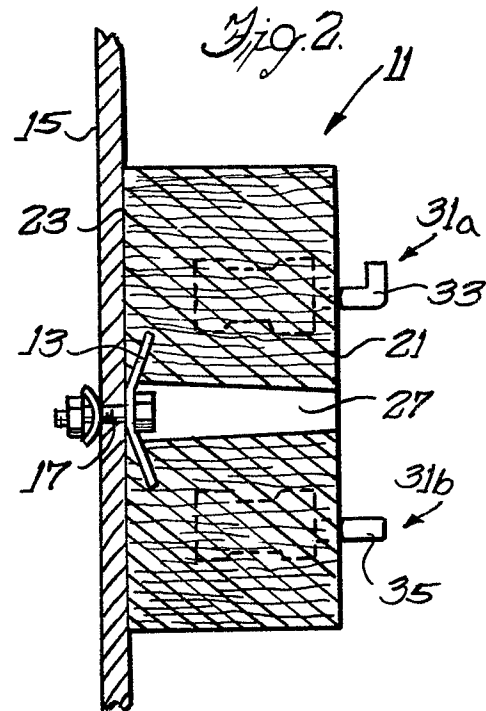
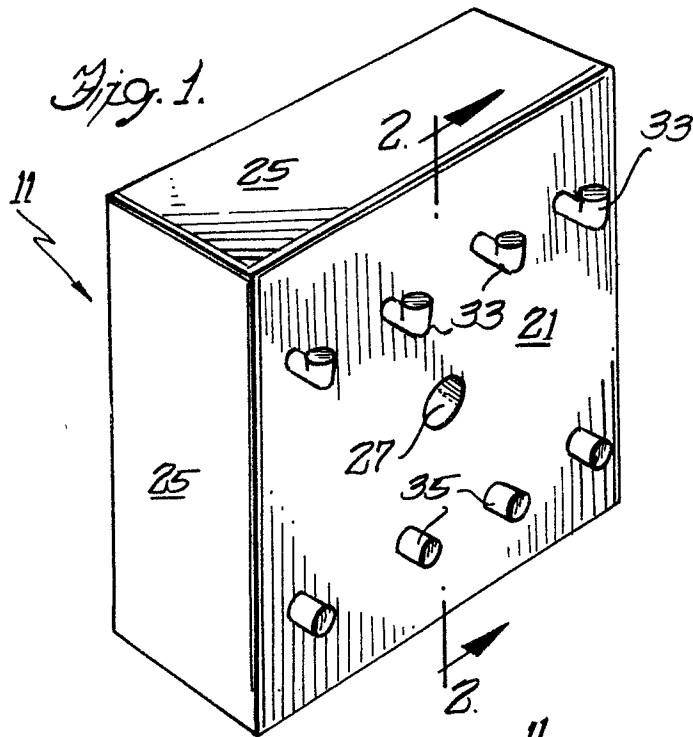
8. A method as claimed in Claim 6 or Claim 7 further characterised in that a felting screen (59) forms the bottom of the mould and defines one of the faces of the module.

9. A method as claimed in any of the Claims 6 to 8 further characterised in that the cavity means (73) incorporates spring clips (77) for holding the ceramic supports (31) in generally parallel horizontal alignment.

10. A method as claimed in any of the Claims 6 to 9 further characterised in that the body portions (37) of the ceramic supports each contain a hole (81) extending horizontally therethrough and an alignment rod (85) is inserted through two of the vertical walls (55, 57) of said mould and through the holes (81) of the body portions (37) to maintain precise alignment while the slurry is being supplied.

11. A method of making a refractory product suitable for insulation use in a high temperature environment from an aqueous slurry of fibres plus a binder, in which the product is elongated in at least one direction and has a major surface intended to constitute a hot face, characterised by the steps of placing screen means (59) in contact with the aqueous slurry, the screen means (59) being generally rectangular in shape and proportioned to constitute a cross-sectional shape of the product in a direction substantially perpendicular to said one direction, depositing superimposed layers of refractory fibres upon the screen means (59) by withdrawing water from the slurry through the screen

means (59) until a desired height is accumulated which is substantially greater than the smaller dimension of the screen means whereby the deposited fibres lie in planes perpendicular to the major surface (21) of the product, and treating the accumulation of deposited fibre layers to set the binder and form a stable product having improved thermal-insulating properties when the hot face is exposed to a high temperature environment.





| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                  |                                                                                                                                                                                                                                                                                  |                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Category                                                                                                                                                                                                                                               | Citation of document with indication where appropriate, of relevant passages     | Relevant to claim                                                                                                                                                                                                                                                                | CLASSIFICATION OF THE APPLICATION (Int. Cl. <sup>3</sup> )                    |
| X                                                                                                                                                                                                                                                      | US-A-3 987 237 (PHILLIPS)<br>*Claim 1; figure 2*                                 | 1,4                                                                                                                                                                                                                                                                              | F 27 D 11/02<br>H 05 B 3/66<br>F 27 D 1/06                                    |
| Y                                                                                                                                                                                                                                                      | ---<br>US-A-3 705 253 (W.GERALD)<br>*Column 4, lines 15 to 24; figure 10*        | 4,5                                                                                                                                                                                                                                                                              |                                                                               |
| Y                                                                                                                                                                                                                                                      | ---<br>GB-A-2 033 559 (McKECHNIE<br>REFRACTORY FIBRES LTD)<br>*Claims; figure 4* | 2                                                                                                                                                                                                                                                                                |                                                                               |
| A                                                                                                                                                                                                                                                      | ---<br>GB-A- 468 193 (GROGAN)<br>*Page 1, lines 74 to 99; figure 1*              | 4,5                                                                                                                                                                                                                                                                              |                                                                               |
| A                                                                                                                                                                                                                                                      | ---<br>DE-A- 736 092 (HANSEN)<br><br>-----                                       |                                                                                                                                                                                                                                                                                  | TECHNICAL FIELDS<br>SEARCHED (Int. Cl. <sup>3</sup> )<br><br>F 27 D<br>H 05 B |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                  |                                                                                                                                                                                                                                                                                  |                                                                               |
| Place of search<br>THE HAGUE                                                                                                                                                                                                                           |                                                                                  | Date of completion of the search<br>29-09-1982                                                                                                                                                                                                                                   | Examiner<br>COULOMB J.C.                                                      |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                  | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br><br>& : member of the same patent family, corresponding document |                                                                               |